NASA SP-7085 (03)
December 1991

P-324

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

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NASA SP-7085 (03)
December 1991

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 1991

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

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

INTRODUCTION

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

This literature survey lists 1221 reports, articles, and other documents announced between January 1, 1991 and June 30, 1991 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

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

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

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

References appear in each category in this order:

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

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

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

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

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

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CORPORATE SOURCE

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

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

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

CONTRACT NUMBER → (Contract NCC9-16) — AVAILABILITY SOURCE

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

COSATI CODE → CSCL 05/2

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

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

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

TITLE → **A SPACE PARASOL AS A COUNTERMEASURE AGAINST THE GREENHOUSE EFFECT** — AUTHOR'S AFFILIATION

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

CONTRACT NUMBER → (Contract NSG-7161)

Copyright

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

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA

A Bibliography (Suppl. 03)

DECEMBER 1991

01

OVERALL DESIGN AND EVOLUTIONARY GROWTH

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

A91-10009*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION TRANSITION THROUGH SPACELAB
HARRY G. CRAFT, JR. and THOMAS G. WICKS (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p. refs
(AIAA PAPER 90-3540) Copyright

It is appropriate that NASA's Office of Space Science and Application's science management structures and processes that have proven successful on Spacelab be applied and extrapolated to Space Station utilization, wherever practical. Spacelab has many similarities and complementary aspects to Space Station Freedom. An understanding of the similarities and differences between Spacelab and Space Station is necessary in order to understand how to transition from Spacelab to Space Station. These relationships are discussed herein as well as issues which must be dealt with and approaches for transition and evolution from Spacelab to Space Station. Author

A91-10179#
FUTURE SCIENCE AND TECHNOLOGY FOR MILITARY SPACE
ALLEN E. FUHS (Monterey Consulting Services, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 18 p. refs
(AIAA PAPER 90-3827) Copyright

The space technology base and materials applications for space systems are examined including launch and orbital transfer vehicles, and space structures for large or small spacecraft. Launch vehicle technology, thermal and attitude controls, aerothermodynamics, life support, autonomy and telerobotics, stealth and deception, and computers, software and intelligence are all discussed. Systems, missions, and operations are also treated by presenting information from the Discriminate Deterrence report, Long Term Strategy which addresses such topics as reconnaissance, communications, electronic warfare, antisubmarine warfare from space, and joint civil-military space missions such as ocean monitoring. L.K.S.

A91-10908*# NASA Space Station Program Office, Reston, VA.
SPACE STATION FREEDOM - CONFIGURATION MANAGEMENT APPROACH TO SUPPORTING CONCURRENT ENGINEERING AND TOTAL QUALITY MANAGEMENT
RAYMOND B. GAVERT (NASA, Space Station Freedom Program Office, Reston, VA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 13 p. refs
Copyright

Some experiences of NASA configuration management in providing concurrent engineering support to the Space Station Freedom program for the achievement of life cycle benefits and total quality are discussed. Three change decision experiences involving tracing requirements and automated information systems of the electrical power system are described. The potential benefits of concurrent engineering and total quality management include improved operational effectiveness, reduced logistics and support requirements, prevention of schedule slippages, and life cycle cost savings. It is shown how configuration management can influence the benefits attained through disciplined approaches and innovations that compel consideration of all the technical elements of engineering and quality factors that apply to the program development, transition to operations and in operations. Configuration management experiences involving the Space Station program's tiered management structure, the work package contractors, international partners, and the participating NASA centers are discussed. R.E.P.

A91-12213
THE SPACE STATION IS LOSING FRIENDS
M. MITCHELL WALDROP Science (ISSN 0036-8075), vol. 250, Oct. 19, 1990, p. 364-366.
Copyright

NASA's proposed Space Station Freedom has begun to draw criticism for a number of apparently fundamental technical shortcomings. Quite apart from the large number of Space Shuttle payloads required for construction and the extensive EVA maintenance program the completed structure will require, it is alleged by critics that Freedom will be so great a leap beyond current practice that only failure can follow the inability to assemble and test the station prior to launch. The present discussion of representative criticisms and responses to them gives attention to computerized truss structure vibration simulations, thermal control methods, and the housekeeping tasks entailed by continuous operation over the 30-year projected service life of the Space Station. O.C.

A91-12276
SPACE DYNAMICS; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, TOULOUSE, FRANCE, NOV. 6-10, 1989 [MECANIQUE SPATIALE; SYMPOSIUM INTERNATIONAL, TOULOUSE, FRANCE, NOV. 6-10, 1989, PROCEEDINGS]
Symposium organized by CNES. Toulouse, France, Cepadues-Editions, 1990, 1025 p. In French and English. For individual items see A91-12277 to A91-12341.
Copyright

The conference presents papers on mission analysis and design, attitude dynamics, orbit determination, maneuvers and orbit control, station keeping in GEO, and space debris. Particular attention is given to the influence of aerodynamic forces on LEOs, error estimation in the propagation of orbits of low-altitude artificial satellites, and a system for the autonomous navigation and attitude determination in geostationary orbit. Consideration is also given to inflight results of active nutation damping on board Skynet 4B, the application of power series to orbit computation and determination of geostationary orbits, and real-time geostationary orbit determination. K.K.

A91-13771*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM OVERVIEW
RICHARD H. KOHRS and CAROLYN S. GRINER (NASA, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 4 p.
(IAF PAPER 90-060) Copyright
The status of the Space Station Freedom project is briefly reviewed. The multilateral agreements achieved to this point are summarized, and the results of preliminary design reviews are discussed. Progress being made in implementing improvement recommendations and in meeting weight and power allocations is addressed. C.D.

A91-13794*# NASA Space Station Program Office, Reston, VA.
OPERATIONS INFLUENCE ON SPACE STATION FREEDOM
ANNE L. ACCOLA (NASA, Space Station Freedom Program Office, Reston, VA), DAVID WALKER (NASA, Johnson Space Center, Houston, TX), and LAYNE SIMMONS IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-091) Copyright
The Space Station Freedom is the first experience for NASA and its international partners in building a spacecraft that will be operated and maintained over a multi-year lifetime and that will be permanently manned. To ensure it functions safely and effectively, the operations community has become involved much earlier than in previous U.S. programs. This involvement has taken the form of defining requirements and analyzing the configuration, systems, and elements in terms of operations suitability and supportability. This early participation has had many effects on the definition and design of the Freedom Station. Examples of operations participation include the development of various operations concepts, design reference missions, contingency operations scenarios, and assembly operations assessments. Author

A91-14375
THE NEXT 40 YEARS IN SPACE - 40TH INTERNATIONAL ASTRONAUTICAL CONGRESS OF THE IAF, TORREMOLINOS, SPAIN, OCT. 7-13, 1989, REPORT
JAMES HARFORD, ED. and RAY WILLIAMSON, ED. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, 61 p. No individual items are abstracted in this volume.
Copyright
Overviews are given of the plenary events and technical sessions of the conference. The main topics addressed include astrodynamics, automation and robotics, space commercialization, communication satellites, earth observations, economics in space operations, education, history, international plans and policies, interstellar exploration, the life sciences, Mars exploration, materials and structures, and microgravity sciences and processes. Also discussed are power systems, propulsion, safety and rescue, SETI, small scientific satellites, solar-system exploration and resources, the social and environmental impacts of space activities, space-based astronomy, space law, space stations, space systems, and space transportation. T.K.

A91-19334#
APPLICATION OF AI-BASED TECHNIQUES FOR SYSTEM-LEVEL ANALYSIS OF SPACE STATION FREEDOM
KENNETH J. LASKEY and ALFRED H. KROMHOLZ (Grumman Corp., Reston, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p.
(AIAA PAPER 91-0502) Copyright
A technique for applying AI-based methods to the systems engineering of large complex systems is presented. Engineering aspects of the Space Station Freedom Program are used to demonstrate the combined use of modeling and expert systems to obtain a successful design. An overview is presented of the uniform systems engineering environment system, which uses the mixed decomposition approach to system modeling. K.K.

A91-20485#
SPACE STATION CHANGES ITS COURSE
ERIC J. LERNER Aerospace America (ISSN 0740-722X), vol. 29, Jan. 1991, p. 12-15.
Copyright
The series of complications that has beset the Space Station project, culminating in a Congressional order for NASA to redirect the entire project, is reviewed. In addition to cutting $6 billion from the Station's budget over the next five years, the House and Senate have written clear directives into NASA's FY91 appropriations bill stating that the Station be built one stage at a time, not all at once as NASA had intended. Congress has directed that the first phase be devoted to microgravity research and should be only human-tended, visited periodically by astronauts, but otherwise flying unmanned with automated experiments. Advantages and complications incurred by such changes are discussed. One suggested way for NASA to operate long duration human biology experiments in the absence of a fully developed Space Station program is to place appropriate U.S. instrumentation and/or astronauts aboard the space station Mir. L.K.S.

A91-27358
A SPACE-BASED SOLAR SCREEN AGAINST CLIMATIC WARMING
M. MAUTNER (Canterbury, University, Christchurch, New Zealand) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, March 1991, p. 135-138. refs
Copyright
The expected global warming may be reversed by a space-based screen that would intercept a fraction of the solar radiation incident on earth. Warming by 2-5 C could be prevented by intercepting 3-7 percent, respectively, of the incident solar radiation. The screen may be constructed for example of a thin film, a grid of film supported by a mesh, or fine-grained dust deployed in orbit about the earth. For an average film thickness or particle radius of 0.001 cm, the required mass is (1-10) x 10 to the 14th g, equivalent to a medium-sized lunar mountain or asteroid. The material may be deployed and processed using existing technology, similar to methods proposed for space habitat construction. The cost may be substantially lower than the economic and human damage caused by a significant climate change. Author

A91-27359* California Univ., La Jolla.
A SPACE PARASOL AS A COUNTERMEASURE AGAINST THE GREENHOUSE EFFECT
H. S. HUDSON (California, University, La Jolla) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, March 1991, p. 139-141. refs
(Contract NSG-7161)
Copyright
It is suggested that the deployment of a 'space parasol' at the L1 Langrangian point of the earth-sun system would serve to intercept some desired fraction of the solar radiant energy, thereby lessening the impact of the greenhouse effect. The parasol satellites are described and possible orbit configurations are discussed. Orbital possibilities include Low Earth Orbit, Geosynchronous orbit, and L1 which appears to be the best option. Structural strength, control, and use of extraterrestrial material in the construction of the parasol are discussed. L.K.S.

A91-27719
PROBABLE IMPACTS OF SPACE OPERATIONS ON AIR FORCE CIVIL ENGINEERING
JOHN W. MOGGE, JR. (USAF, Engineering and Services Center, Tyndall AFB, FL) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1443-1451. refs
Copyright
Consider the bridge from today's space programs and systems to tomorrow's space reality. Current space policy is revolutionary in nature. Selected space related programs such as transportation

systems, space control, space weapons and power have potential to effect change. Revolutionary characteristics are present in many of these programs and activities. Support concepts, specifically space logistics, engineering and space facilities, relate to these space programs and have evolutionary and revolutionary potential. Future considerations include an approach for civil engineers to develop their space support missions. The approach has four basic tenets: visualization of space as the basis of global power, focusing attention on the linkages between space policy and technology, acceptance of a bias for action in space, and the normalization of space functions in civil engineering mission areas. Author

A91-29717#
SPACE STATION FREEDOM VERIFICATION
JOSEPH A. JOHNSON (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 201-209.

One of the four NASA work package centers charged with the responsibility of developing the Space Station, the Johnson Space Center (JCS), has developed a plan to integrate and verify the end-to-end functionality of the flight hardware and software associated with basic Space Station utilities and services. This is referred to as the core station, which consists of the port and starboard integrated truss assembly, resource nodes 1 and 4, mobile transporter, attached payload simulator, and electrical power support from the project at the Lewis Space Center. The core station will be integrated on the ground utilizing a high fidelity verification fixture (VF) since the flight truss structure is not capable of supporting itself in a 1-G environment. The VF simulates the flight truss attachment interfaces and supports the attached flight hardware in the proper relative spatial orientation. Data management system kits and ground support equipment will be used to simulate absent hardware and software. L.K.S.

A91-30420
THE SOVIET YEAR IN SPACE - 1990
NICHOLAS L. JOHNSON (Teledyne Brown Engineering, Colorado Springs, CO) Colorado Springs, CO, Teledyne Brown Engineering, 1991, 176 p. refs
Copyright

Soviet space activities during 1990 are surveyed on the basis of press reports, articles in scientific journals, and unclassified satellite tracking data and illustrated with drawings, diagrams, and photographs. Consideration is given to support systems; photographic reconnaissance, communication, navigation, geodetic, meteorological, remote-sensing, scientific, and military satellite programs; the Mir space station; solar-system exploration. The launches of 1990, the current satellite constellations, and the radio frequencies used by Soviet spacecraft are listed in tables. T.K.

A91-30656
TABES 90 - ANNUAL TECHNICAL AND BUSINESS EXHIBITION AND SYMPOSIUM, 6TH, HUNTSVILLE, AL, MAY 15, 16, 1990, SUBMITTED PAPERS
Exhibition and Symposium sponsored by Huntsville Association of Technical Societies. Huntsville, AL, Huntsville Association of Technical Societies, 1990, 252 p. For individual items see A91-30657 to A91-30672.
Copyright

Among the topics considered are joint electronic combat, supercomputing in the 1990's, business development, education, space exploration initiatives, and information into the 1990's. Papers on the Space Station are also presented. B.J.

N91-10576*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE STATION
DONALD F. STEWART and JUDITH HAYES (Krug International, Houston, TX.) *In its* Workshop on Exercise Prescription for Long-Duration Space Flight p 15-18 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 22B

The history of American space flight indicates that a space station is the next logical step in the scientific pursuit of greater knowledge of the universe. The Space Station and its complement of space vehicles, developed by NASA, will add new dimensions to an already extensive space program in the United States. The Space Station offers extraordinary benefits for a comparatively modest investment (currently estimated at one-ninth the cost of the Apollo Program). The station will provide a permanent multipurpose facility in orbit necessary for the expansion of space science and technology. It will enable significant advancements in life sciences research, satellite communications, astronomy, and materials processing. Eventually, the station will function in support of the commercialization and industrialization of space. Also, as a prerequisite to manned interplanetary exploration, the long-duration space flights typical of Space Station missions will provide the essential life sciences research to allow progressively longer human staytime in space. Author

N91-11785*# Bionetics Corp., Hampton, VA.
ADVANCED-TECHNOLOGY SPACE STATION STUDY: SUMMARY OF SYSTEMS AND PACING TECHNOLOGIES Final Report, May 1986 - Oct. 1988
A. J. BUTTERFIELD, P. A. GARN, C. B. KING, and M. J. QUEIJO Nov. 1990 141 p
(Contract NAS1-18267)
(NASA-CR-181795; NAS 1.26:181795) Avail: NTIS HC/MF A07 CSCL 22B

The principal system features defined for the Advanced Technology Space Station are summarized and the 21 pacing technologies identified during the course of the study are described. The descriptions of system configurations were extracted from four previous study reports. The technological areas focus on those systems particular to all large spacecraft which generate artificial gravity by rotation. The summary includes a listing of the functions, crew requirements and electrical power demand that led to the studied configuration. The pacing technologies include the benefits of advanced materials, in-orbit assembly requirements, stationkeeping, evaluations of electrical power generation alternates, and life support systems. The descriptions of systems show the potential for synergies and identifies the beneficial interactions that can result from technological advances. Author

N91-12402*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
OVERVIEW OF SPACE STATION
CLAUDE C. PRIEST *In its* Measurement and Characterization of the Acceleration Environment on Board the Space Station 25 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

An overview of the Space Station program for workshop participants is given. Covered here are overall program guidelines, international involvement, the present baseline configuration, and development plans for the coming year. Author

N91-12737*# Lockheed Missiles and Space Co., Huntsville, AL. Astronautics Group.
GEOSTATIONARY PLATFORM STUDY: ADVANCED ESGP/EVOLUTIONARY SSF ACCOMMODATION STUDY Final Report
Aug. 1990 231 p
(Contract NAS8-36103)
(NASA-CR-184037; NAS 1.26:184037) Avail: NTIS HC/MF A11 CSCL 22/2

The implications on the evolutionary space station of accommodating geosynchronous Earth Orbit (GEO) facilities are assessed. These facilities include unmanned satellites and platforms, manned elements, and transportation and servicing vehicles/elements. The latest existing definitions of typical unmanned GEO facilities and transportation and servicing vehicles/elements are utilized. The physical design, functional design, and operations implications at the space station are determined. Various concepts of the space station from past studies are utilized ranging from the IOC Multifunction Space Station to a branched transportation node space station and the implications of accommodating the GEO infrastructure at each type are assessed. Where possible, parametric data is provided to show the implications of variations in sizes and quantities of elements, launch rates, crew sizes, etc. The use of advanced automation, robotics equipment, and an efficient mix of manned/automated support for accomplishing necessary activities at the space station are identified and assessed. The products of this study are configuration sketches, resource requirements, trade studies, and parametric data. Author

N91-12738*# Lockheed Missiles and Space Co., Huntsville, AL. Astronautics Div.
GEOSTATIONARY PLATFORM STUDY: ADVANCED ESGP/EVOLUTIONARY SSF ACCOMMODATION STUDY Final Report
Aug. 1990 232 p
(Contract NAS8-36103)
(NASA-CR-184036; NAS 1.26:184036; LMSC-F393987) Avail: NTIS HC/MF A11 CSCL 22/2

The implications on the evolutionary space station of accommodating geosynchronous Earth Orbit (GEO) facilities including unmanned satellites and platforms, manned elements, and transportation and servicing vehicles/elements. The latest existing definitions of typical unmanned GEO facilities and transportation and servicing vehicles/elements are utilized. The physical design, functional design, and operations implications at the space station are determined. Various concepts of the space station from past studies are utilized ranging from the IOC Multifunction Space Station to a branched transportation node space station, and the implications of the accommodation the GEO infrastructure of each type are assessed. Where possible, parametric data are provided to show the implications of variations in sizes and quantities of elements, launch rates, crew sizes, etc. The use of advanced automation, robotics equipment, and an efficient mix of manned/automated support for accomplishing necessary activities at the space station are identified and assessed. The products of this study are configuration sketches, resource requirements, trade studies, and parametric data. Author

N91-15216# MATRA Espace, Toulouse (France). Integration Div.
FINAL VALIDATION OF AUTONOMOUS SPACECRAFT
J. H. PICHON *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 31-34 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The ever increasing complexity of Earth observation spacecraft requires new verification methods and powerful test support equipments. An overall approach is presented for the spacecraft from electrical assembly and tests up to validation of flight operational procedures, together with guidelines for optimized design of the required check out and verification ground equipments. These test methods and verification steps were implemented on SPOT and ERS 1 programs. ESA

N91-15285# Aeritalia S.p.A., Turin (Italy). Space Systems Group.
EMC VERIFICATION APPROACH AND FACILITY ON COLUMBUS ATTACHED LABORATORY
A. CICCOLELLA, E. COMANDATORE, P. GROLL, and V. ROBERTO *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 511-520 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The overall problems of Electro Magnetic Compatibility (EMC) verification, as part of the environmental test phase, to be conducted on very large and technically complex space systems, are studied. The Columbus Attached Laboratory (CAL) was taken as the referenced program, where all the related problems and constraints are present. Major requirements and constraints with regard to the Attached Pressurized Module (APM) are outlined: EMC design and test requirements; overall EMC verification methodology; EMC analytical software tools/models; and external interface simulators. The overall CAL verification approach is summarized. ESA

N91-15974*# Management Services, Inc., Huntsville, AL.
HISTORICAL ANNOTATED BIBLIOGRAPHY: SPACE STATION DOCUMENTS
JESSIE E. WHALEN, comp., SARAH L. MCKINLEY, comp., and THOMAS G. GATES, comp. Dec. 1988 540 p
(Contract NAS8-35900)
(NASA-CR-184012; NAS 1.26:184012; MHR-13) Avail: NTIS HC/MF A23 CSCL 05/4

Information is presented regarding documentation which has been produced in the Space Station program. This information will enable the researcher to locate readily documents pertinent to a particular study. It is designed to give the historian the necessary data from which to compile the written histories and to preserve records of historically significant aspects of Marshall's involvement in Space Shuttle and Space Station. Author

N91-18121*# Universities Space Research Association, Houston, TX.
PROCEEDINGS OF THE 6TH ANNUAL SUMMER CONFERENCE: NASA/USRA UNIVERSITY ADVANCED DESIGN PROGRAM Final Report
Nov. 1990 319 p Conference held in Cleveland, OH, 11-15 Jun. 1990; sponsored by NASA. Lewis Research Center and USRA
(Contract NASW-4435)
(NASA-CR-187041; NAS 1.26:187041) Avail: NTIS HC/MF A14 CSCL 22/1

The NASA/USRA University Advanced Design Program is a unique program that brings together NASA engineers, students, and faculty from United States engineering schools by integrating current and future NASA space/aeronautics engineering design projects into the university curriculum. The Program was conceived in the fall of 1984 as a pilot project to foster engineering design education in the universities and to supplement NASA's in-house efforts in advanced planning for space and aeronautics design. Nine universities and five NASA centers participated in the first year of the pilot project. The study topics cover a broad range of potential space and aeronautics projects that could be undertaken during a 20 to 30 year period beginning with the deployment of the Space Station Freedom scheduled for the mid-1990s. Both manned and unmanned endeavors are embraced, and the systems approach to the design problem is emphasized.

N91-18146*# Ohio State Univ., Columbus.
PROJECT WISH: THE EMERALD CITY
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 165-168 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

When Project WISH (Wandering Interplanetary Space Harbor) was initiated as a multi-year project, several design requirements were specified. The space station must have a lifetime of at least 50 years, be autonomous and independent of Earth resources, be capable of traveling throughout the solar system within a maximum flight time of three years, and have a population of 500 to 1000 people. The purpose of the station is to provide a permanent home for space colonists and to serve as a service station for space missions. The orbital mechanics, propulsion system, vehicle dynamics and control, life support system, communication system, power system, and thermal system are discussed. Author

N91-18199* National Aeronautics and Space Administration, Washington, DC.
LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA: A BIBLIOGRAPHY WITH INDEXES
JOHN J. FERRAINOLO, ed. (National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.) Nov.

1990 350 p
(NASA-SP-7085(01); NAS 1.21:7085(01)) Avail: NTIS HC A16
CSCL 22/2

Bibliographies and abstracts are listed for 1372 reports, articles, and other documents introduced into the NASA scientific and technical information system between January 1, 1990 and June 30, 1990. 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. Author

N91-18201# European Space Agency, Paris (France).
MANNED SPACE STATIONS: THEIR CONSTRUCTION, OPERATION AND POTENTIAL APPLICATIONS
RODOLFO NERI (Secretaria de Comunicaciones y Transportes, Copacabana Beach, Mexico) and B. BATTRICK, ed. Nov. 1990 119 p Sponsored in part by EEC Original contains color illustrations
(ESA-SP-1137; ISBN-92-9092-124-2; ISSN-0379-6566; ETN-91-98802) Copyright Avail: NTIS HC/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 40 Dutch guilders

The following are discussed: the importance of manned space stations and the possibilities offered by performing experiments in microgravity; the characteristics and effects of the space environment; the basic architecture of manned space stations as well as the missions performed by the Salyuts, Skylab, MIR, the Space Shuttle and the Spacelab; the Space Station Freedom; and the financing of manned space stations and the pros and cons of multilateral cooperation.

N91-18202# European Space Agency, Paris (France).
THE IMPORTANCE OF MANNED SPACE STATIONS
In its Manned Space Stations: Their Construction, Operation and Potential Applications p 3-7 Nov. 1990 Original contains color illustrations
Copyright Avail: NTIS HC/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 40 Dutch guilders

The possibilities offered in performing experiments and microgravity tests on space stations are presented. The pros and cons of these space stations being 'manned' are discussed. An explanation of gravity and its effects is given. Space stations offer unique opportunities for long duration experiments and the manufacturing of rare materials. They offer scientists and engineers the opportunity to broaden their understanding of the Universe and the origin of life and their knowledge can be applied to important technical applications. People with financial objectives, pharmaceutical, chemical, computing, and telecommunication industries, can exploit the unique conditions for making new and rare products such as more effective high purity medicines, alloys, semiconductors and ceramics. Satellite communications and remote sensing are two space industries which are already successful. Despite the great differences in complexity in manned and unmanned space stations the former are more advantageous since man has capabilities machines can not match. They also enable a better understanding of the effects of weightlessness and isolation on human physiology and psychology. The movements of the crew in the space station are disadvantageous as they produce small disturbances in the simulated microgravity levels in the Earth orbit. The disadvantages of the hostile space environment, confinement, and safety are discussed. ESA

N91-18204# European Space Agency, Paris (France).
BASIC ARCHITECTURE OF MANNED SPACE STATIONS
In its Manned Space Stations: Their Construction, Operation and Potential Applications p 29-95 Nov. 1990 Original contains color illustrations
Copyright Avail: NTIS HC/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 40 Dutch guilders

Manned space stations are very complex structures. Adequate conditions and facilities for conducting experiments, material processing and scientific observations must be provided as well as safety and comfort for the crew. As a complex orbiting structure, a manned space station is divided into a set of major engineering systems to facilitate its design, construction and operation. All of these systems are closely interrelated in their working; therefore, they need to be defined, manufactured, and integrated together in a mutually coherent manner in order to guarantee safe and efficient operation. These systems include: structures; electrical power; thermal control; guidance navigation and control propulsion; automation and robotics; communications and tracking/data management; environmental control and life support/fluid management; crews systems and accommodations; and crew and payload transportation. Details of past, present, and planned manned space stations including the 7 Soviet Salyuts, the American Skylab, the Soviet MIR and the U.S. Space Shuttle and Spacelab are given. The experience gained, the launching of the station and crew, the electrical systems, the experimentation and research, and any problems encountered are discussed. ESA

N91-18205# European Space Agency, Paris (France).
SPACE STATION FREEDOM
In its Manned Space Stations: Their Construction, Operation and Potential Applications p 99-114 Nov. 1990 Original contains color illustrations
Copyright Avail: NTIS HC/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 40 Dutch guilders

The idea of constructing a modern manned space station in low Earth orbit had been considered by NASA for about two decades before its development was finally approved, at which time emphasis was put on the need to invite international participation. Political, economic, and human factors have shaped the course of events in relation to Space Station Freedom. The objectives and international participation including the United States, European, Canadian, and Japanese contributions are discussed as well as the construction, assembly sequence and future evolution. ESA

N91-19123*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION: THE NEXT LOGICAL STEP
ANDREW J. STOFAN 1986 12 p Original contains color illustrations
(NASA-TM-103398; NAS 1.15:103398) Avail: NTIS HC/MF A03; 5 functional color pages CSCL 22/2

The following topics with respect to the space station program are discussed: (1) unmanned free-flyers; (2) recent progress; (3) the space shuttle; (4) international participation; (5) science, commerce, and technology; and (6) private sector participation. K.S.

N91-20177*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BENEFITS FROM SYNERGIES AND ADVANCED TECHNOLOGIES FOR AN ADVANCED-TECHNOLOGY SPACE STATION
L. BERNARD GARRETT, MELVIN J. FEREBEE, JR., MANUEL J. QUEIJO, and ANSEL J. BUTTERFIELD (Bionetics Corp., Hampton, VA.) Washington Apr. 1991 25 p
(NASA-TP-3067; L-16618; NAS 1.60:3067) Avail: NTIS HC/MF A03 CSCL 22/1

A configuration for a second-generation advanced technology space station has been defined in a series of NASA-sponsored studies. Definitions of subsystems specifically addressed opportunities for beneficial synergistic interactions and those potential synergies and their benefits are identified. One of the more significant synergistic benefits involves the multi-function utilization of water within a large system that generates artificial gravity by rotation. In such a system, water not only provides the necessary crew life support, but also serves as counterrotator mass, as moveable ballast, and as a source for propellant gases. Additionally, the synergistic effects between advanced technology materials, operation at reduced artificial gravity, and lower cabin atmospheric pressure levels show beneficial interactions that can be quantified in terms of reduced mass to orbit. Author

N91-20189*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
UTILIZATION OF COMMON PRESSURIZED MODULES ON THE SPACE STATION FREEDOM
MARSTON J. GOULD, MICHAEL L. HECK, and DANIEL D. MAZANEK (Analytical Mechanics Associates, Inc., Hampton, VA.) Jan. 1991 90 p
(NASA-TM-102779; NAS 1.15:102779) Avail: NTIS HC/MF A05 CSCL 22/2

During the preliminary design review of Space Station Freedom elements and subsystems, it was shown that reductions of cost, weight, and on-orbit integration and verification would be necessary in order to meet program constraints, particularly nominal Orbiter payload launch capability. At that time, the Baseline station consisted of four resource nodes and two 44 ft modules. In this study, the viability of a common module which maintains crew and payload accommodation is assessed. The size, transportation, and orientation of modules and the accommodation of system racks and user experiments are considered and compared to baseline. Based on available weight estimates, a module pattern consisting of six 28 ft. common elements with three radial and two end ports is shown to be nearly optimal. Advantageous characteristics include a reduction in assembly flights, dual egress from all elements, logical functional allocation, no adverse impacts to international partners, favorable airlock, cupola, ACRV (Assured Crew Return Vehicle), and logistics module accommodation, and desirable flight attitude and control characteristics. Author

02

POLICIES AND INTERNATIONAL COOPERATION

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

A91-10037*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERNATIONAL STANDARDS FOR COST-OPTIMIZED SPACE MISSIONS AND INFRASTRUCTURE
MERLE MCKENZIE (JPL, Pasadena, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 4 p.
(AIAA PAPER 90-3586) Copyright

The establishment of international standards is essential for the success of multiagency space missions. Here, two key areas for international standardization are proposed: the development of standards for infrastructure and the development of multiagency standards. Such standards will ultimately enable cost-optimized small missions as well as a cost-optimized superset of space infractructures. V.L.

A91-10039#
SPACE STANDARDS FOR INTERNATIONAL COOPERATION
HUGH R. ANDERSON (Science Applications International Corp., Bellevue, WA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 4 p.
(AIAA PAPER 90-3589) Copyright

Environmental standards differ from performance or construction standards in that they describe something not man-made and hence variable. In the case of the natural and induced space environment, it is particularly difficult to write a standard because (1) it is difficult to decide what phenomena are important, and (2) not all of the enviornment is known. The role of an environmental standard is clarified by accurately labeling it a Standard Definition of the Space Environment. Properly written standards, whether national or international, serve both a usual and a special function. They encourage or compel builders to use design constraints, illuminating differences between assumed constraints, and the accepted level of performance and risks; and their preparation can show up those areas for which knowledge of the space environment is incomplete. Author

A91-10055#
COLUMBUS, THE EUROPEAN SPACE AGENCY'S ELEMENT OF THE SPACE STATION FREEDOM
F. LONGHURST (ESTEC, Noordwijk, Netherlands) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 14 p.
(AIAA PAPER 90-3624) Copyright

The objectives of the Columbus development program are described, and the specific content of the Columbus program is discussed. The development program covers the development, manufacture, and delivery to orbit of three space elements, an Attached Laboratory, a Free-Flyer, and a Polar Platform; buildup of the related ground infrastructure; and preparation for initial operations and subsequent utilization. B.J.

A91-10056#
THE MOBILE SERVICING SYSTEM (MSS) - CANADA'S CONTRIBUTION TO SPACE STATION 'FREEDOM'
DAVID F. FRANKLIN (Canadian Space Agency, Ottawa, Canada) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3625) Copyright

The paper describes the Mobile Servicing System (MSS), Canada's contribution to Space Station Freedom. It defines Canada's objectives for participation in this program and how it proposes to utilize its resources in order to meet these objectives. An overview of the MSS's configuration addressing space, ground, and support segments is provided. Detailed breakdowns of the space segment elements are discussed in order to provide the reader with an understanding of how the MSS functions with the Space Station Freedom. Functional requirements for both the Space Station Remote Manipulator System (SSRMS) and the Special Purpose Dexterous Manipulator (SPDM) are specifically addressed. Author

A91-10057#
CURRENT STATUS OF JAPANESE EXPERIMENT MODULE
N. SAITO and S. MATSUBARA (NASDA, Tokyo, Japan) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p.
(AIAA PAPER 90-3626)

The design and development activities of the Japanese Experiment Module (JEM) began after the Intergovernmental Agreement (IGA) was approved in June 1989. JEM will be launched by the Space Shuttle and will be attached to the international Space Station (SS) on orbit within this century. As a result of the SS rephasing in 1989, the assembly sequence and launch date of JEM have to be modified. The assembling, operations and utilization concept of JEM/SS have been studied multilaterally. The construction of a ground support facility for the JEM development and operation is planned to begin in early 1991. The Preliminary Announcement of Opportunity (pre A.O.) for JEM utilization was issued and the collected data will be used for selecting the generic experiment equipment installed in JEM. Author

A91-10059*# National Aeronautics and Space Administration, Washington, DC.
INTERNATIONAL PROGRAMS - A GROWING TREND
A. N. BUNNER (NASA, Astrophysics Div., Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 6 p.
(AIAA PAPER 90-3630)

The National Aeronautics and Space Administration has collaborated successfully in space science missions with a multiplicity of partners, including the European Space Agency, Federal Republic of Germany, the Netherlands, United Kingdom, Japan, and the Soviet Union, among others. These collaborations generally arise out of common scientific goals and in the interest of economizing to take advantage of skills and capabilities among the partners. A trend towards increased cooperation in space is expected to continue as the global scientific community works together to plan future space science missions and the missions become more sophisticated. Author

A91-13772#
OVERVIEW OF THE JEM PROGRAM
KAZUO MATSUMOTO and YASUSHI HORIKAWA (NASDA, Tokyo, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-062) Copyright

Japan is participating in the International Space Station Program and will provide a Japanese Experiment Module (JEM) which will be attached to the NASA Space Station core system. The phase C/D design and development of JEM was initiated in early 1990. An overview of the JEM program which includes program background, current status, funding situation, overall schedule, and some technical challenges and issues, is presented. In addition, JEM utilization and operation planning activities are described. Author

A91-13773#
SPACE STATION'S MOBILE SERVICING SYSTEM
K. H. DOETSCH (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-063) Copyright

As the space station concept is finalized, the many challenges in its assembly, maintenance and servicing are becoming crystallized. Canada, through the provision of the Mobile Servicing System, is intimately involved in providing solutions to some of the problems which are still to be resolved in this area of operations. The paper provides a status report on the progress for Canada's space station program and identifies some of the specific operational challenges in assembly, servicing and maintenance which are being addressed through the provision of this critical space station system. Author

A91-13776#
CONFIGURATION AND DESIGN OF THE MOBILE SERVICING SYSTEM
SAVI S. SACHDEV (Spar Aerospace, Ltd., Weston, Canada) and DOUG A. BASSETT (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 20 p.
(IAF PAPER 90-067) Copyright

The overall configuration of the space segment of the Mobile Servicing System (MSS), Canada's contribution to the Space Station Freedom program, is described for both the NSTS launch configuration and on orbit. Key function and performance requirements are summarized, and the architecture of the overall system and its power, data, video, and RF systems are described, indicating interfaces with the station's distributed systems. The hierarchy of processors and allocation of software functionality is described. The key design features of the flight elements and systems of the MSS are examined. C.D.

A91-13777#
DEVELOPMENT OF JAPANESE EXPERIMENT MODULE (JEM)
KAZUO MATSUMOTO, KUNIAKI SHIRAKI, YASUSHI HORIKAWA (NASDA, Tokyo, Japan), and NOBUYUKI TOMITA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-068) Copyright

The most recent JEM configuration, stowage allocation summary and launch configuration are presented. JEM system design activities and contractors are listed, and it is noted that system design began in early 1990. JEM major development items are listed and include power distribution unit, control processor, control system network, airlock, RMS control system elements, control system atmosphere, meteoroid/debris protection system, and payload attach mechanism. JEM project master and basic schedules are also presented. A number of major technological issues are briefly discussed including resource allocation, remote manipulator system operational feasibility test, air distribution and ventilation test, and an equipment exchange unit R&D test. L.K.S.

A91-13778#
THE COLUMBUS ATTACHED LABORATORY
LUIGI D'EMILIANO (Aeritalia S.p.A., Turin, Italy) and PATRICE AMADIEU (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 21 p.
(IAF PAPER 90-069)

The current Attached Laboratory architecture and the most significant technical features implemented in order to meet the overall performance requirements and to achieve compatibility with the Space Station Freedom are described. Major requirements behind the Attatched Laboratory design include compatibility with the Space Shuttle for launch and deployment; provision of a laboratory environment for experimenters; functional and physical compatibility with the Space Station Freedom and provided resources; operational support to the crew; and a 30-year life span. Emphasis is placed on system budgets and resources required from the Space Station as well as payload and crew accommodation. Payload rack interchangeability possibilities accross the Space Station's three laboratories, and its implications on the Columbus Laboratory design are discussed. The design and development plan and major steps to reach design qualification are also addressed. L.K.S.

A91-13788*# National Aeronautics and Space Administration, Washington, DC.
STRATEGIC PLANNING FOR THE INTERNATIONAL SPACE STATION
CAROLYN S. GRINER (NASA, Office of Space Flight, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-083) Copyright

The concept for utilization and operations planning for the International Space Station Freedom was developed in a NASA Space Station Operations Task Force in 1986. Since that time the concept has been further refined to definitize the process and products required to integrate the needs of the international user community with the operational capabilities of the Station in its evolving configuration. The keystone to the process is the development of individual plans by the partners, with the parameters and formats common to the degree that electronic communications techniques can be effectively utilized, while maintaining the proper level and location of configuration control. The integration, evaluation, and verification of the integrated plan, called the Consolidated Operations and Utilization Plan (COUP), is being tested in a multilateral environment to prove out the parameters, interfaces, and process details necessary to produce the first COUP for Space Station in 1991. This paper will describe the concept, process, and the status of the multilateral test case. Author

A91-13793#
STATUS OF SPACE STATION/JEM UTILIZATION PREPARATION IN JAPAN
Y. FUJIMORI, K. HIGUCHI, S. YODA, K. SHIBUKAWA, and K. MURAKAMI (NASDA, Tokyo, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p.
(IAF PAPER 90-089) Copyright

This paper briefly overviews the past and current activities on the mission requirement analysis, examination, planning, and implementation. These are being carried out in National Space Development agency of Japan under the name of Space Environment Utilization Promotion Project. Included in the project are utilization theme elaboration, utilization planning, generic experiment equipment evaluation, generic technology development, aircraft experiment, sounding rocket experiment, and spacelab missions. The progress status is to be reported. Author

A91-13799#
PREPARATION FOR JAPANESE EXPERIMENT MODULE OPERATION
YASUSHI HORIKAWA, HIDESHI KOZAWA (NASDA, Tokyo, Japan), and AKIRA TANAKA (Japan Manned Space System Corp., Tokyo, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-096) Copyright

Japan participates in the International Space Station Program by providing the Japanese Experiment Module (JEM) which will be launched in 1998 and attached to the Space Station (SS) core system. JEM will be launched by the two Space Shuttle flights and assembled to the SS core system. Japan is now preparing JEM operations, and some requirement analyses for the ground supporting system are conducted. This paper presents the JEM operations concept including the JEM assembly sequence and the outline of the ground support system for JEM operations. The methods of evaluating the system operability are also introduced, and an assessment of the operability of JEM operations is presented. Author

A91-14090#
COST IMPACTS OF SUPPORTING A FUTURE EUROPEAN SPACE STATION
R. C. PARKINSON and C. M. HEMPSELL (British Aerospace /Space Systems/, Ltd., Stevenage, England) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER 90-602) Copyright

Although the International Space Station represents an important facility, Europe has identified a long term aim of having an autonomous facility in addition to Freedom. A number of roles for a European Autonomous Station can be identified (in science, microgravity and/or servicing, transport). In all roles, affordability is critically dependent on reducing operating costs. A sheaf of scenarios determined by role and growth rate was studied. Growth rate is a bigger determinant of system requirements than role. Two factors that affect total lifetime cost are system architecture and transportation. Appropriate semi-independent modules. Transport dominates support and operational costs, The use of currently planned launch systems (Ariane 5/Hermes) and advanced future launch systems have been considered. Comparison between Hotol and Saenger as advanced transport elements indicates that there may be more than one route to cost-effective support. Author

A91-14124#
FUTURE INTERNATIONAL COOPERATION ON SPACE STATIONS
JOHN-DAVID BARTOE (Association of Space Explorers, San Francisco, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-639) Copyright

It is pointed out that the Space Station Freedom (SSF) program is offering the first sustained long-term opportunity for international cooperation in space. It is noted that any significant future increase in international cooperation would likely need to include both the U.S. and the USSR. Such cooperation would offer many opportunities, including interactions between SSF and Mir. It is concluded that the success of future manned exploration missions may depend on how well space-faring nations learn to cooperate with each other. B.J.

A91-14125#
INDUSTRY VIEWS ON INTERNATIONAL COOPERATIVE SPACE ACTIVITIES
SAM F. IACOBELLIS (Rockwell International Corp., El Segundo, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 4 p. refs
(IAF PAPER 90-642) Copyright

Internationally shared projects offer technical, political, and financial benefits. However, maintaining program continuity over an extended time period, with the potential of participants to change their priorities, is a major concern. This paper discusses the benefits and obstacles of cooperative programs. It reviews past and current cooperative space activities in an effort to identify appropriate cooperative strategies for the future. Since cooperation may take numerous forms, potential options for cooperative approaches are discussed. Finally, the potential for long-term international cooperation is evaluated. Author

A91-14129#
INTERNATIONAL SPACE - COOPERATION LESSONS FROM THE SPACE STATION EXPERIENCE
J. M. LOGSDON (George Washington University, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p. refs
(IAF PAPER 90-658) Copyright

The character of the agreements setting up the international partnership to design, develop, and operate a Space Station complex and the political realities underpinning those agreements are reviewed. The results of the Station partnership to date are discussed and suggestions are made concerning the formulation of further cooperative arrangements. The importance of consistency and commitment in an international partnership are stressed. L.K.S.

A91-16896
THE LEGAL HAZARDS OF TRANSATLANTIC COOPERATION IN SPACE
MICHEL BOURELY Space Policy (ISSN 0265-9646), vol. 6, Nov. 1990, p. 323-331. refs
Copyright

Transatlantic cooperation has played a key part in developing Europe's capabilities in space, but this has been despite serious drawbacks on the legal status of the agreements concerned. This article traces the history of transatlantic space relations and highlights the misunderstandings that have arisen. These stem from the precedence given in the USA to domestic laws and financial interests over all international agreements except formal treaties, which are generally not considered suitable for scientific and technical agreements. The article concludes with a discussion of how more stable and equitable relationships could be achieved. Author

A91-18375
INTERNATIONAL SPACE PLANS AND POLICIES - FUTURE ROLES OF INTERNATIONAL ORGANIZATIONS
STEPHEN E. DOYLE (Aerojet Corp., Propulsion Div., Sacramento, CA) Journal of Space Law, vol. 18, no. 2, 1990, p. 123-137. refs
Copyright

Potential roles of international organizations are considered and the possible coordination and monitoring of these roles by a new agency within the structure of the United Nations is examined in detail. Organizations affecting space activites which exist on the national, regional, and global levels are discussed such as ITU, Intelsat, and Inmarsat, ICSU, and COSPAR. It is suggested that a number of functions which these organizations perform will eventually require globally centralized and standardized monitoring, coordination, regulation, reporting, and control in such areas as standardization of astronautic cartography, standardization of mission safety practices, standardization of health and communications controls, the definition and policing of criminal activity, personal status and nationality issues, and management resource exploitation. It is proposed that a world space agency be created and its potential mission, organizational structure, budget requirements, and method of obtaining revenue are outlined. L.K.S.

A91-19957
THE LEGAL BASES FOR DECIDING ON THE TRANSITION TO PHASE 2 IN THE COLUMBUS AND HERMES ESA PROGRAMS [DIE RECHTSGRUNDLAGEN FUER DIE ENTSCHEIDUNG UEBER DEN UEBERGANG ZU PHASE 2 BEI DEN ESA-PROGRAMMEN COLUMBUS UND HERMES]
BIRGITTA STAUDT Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 39, Sept. 1990, p. 281-284. In German. refs
Copyright
The legal bases for deciding the roles of the states participating in Phase 2 of the Columbus and Hermes ESA programs are briefly discussed. The accomplishments of phase 1 and the goals of phase 2 are summarized. The economic contributions to be made by the various participants are pointed out. C.D.

A91-22191#
OPERATING EUROPE'S FUTURE IN-ORBIT INFRASTRUCTURE
U. CHRIST, W. FRANK, N. GARGIR, and R. VAN HOLTZ (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) ESA Bulletin (ISSN 0376-4265), no. 64, Nov. 1990, p. 21-26.
Copyright
The European In-Orbit Infrastructure (EIOI) consists of the Columbus elements, including the Attached Laboratory (AL), the Free-Flying Laboratory (FFL), and the Polar Platform; the Hermes spaceplane with its Ariane-5 launcher; and the Data-Relay System (DRS). The operating concept for the EIOI is based on a three-level hierarchical management structure that includes strategic, tactical, and execution management. Functions to be performed both centrally and decentrally are listed and discussed. Space-station AL, FFL, Hermes, and DRS operations are analyzed. Aspects of the overall system and its utilization are analyzed. It is noted that EIOI communications will involve numerous networks both in space and on the ground. The Communication Resource Management Center at ESOC will process all communication service requests centrally and coordinate the allocation of resources. The Interconnection Ground Subnetwork will provide the connectivity between the various terrestrial networks and with the space data links. L.K.S.

A91-26183
CHANGING PATTERNS OF INTERNATIONAL COOPERATION IN SPACE
JOAN JOHNSON-FREESE (Central Florida, University, Orlando, FL) Malabar, FL, Orbit Book Co., 1990, 130 p. refs
Copyright
The history and current status of U.S. policy on international cooperation (IC) in space projects are reviewed and analyzed. Topics addressed include the initial U.S. motivations for IC; the Soviet space program in 1958-1969, the early space programs in other countries, legal and organizational aspects of IC; the NASA-ESA Spacelab project, the Apollo-Soyuz mission, and the new emphasis on commercial exploitation in the Space Shuttle era. Also examined are the increase in competition after 1985, 'glasnost' in the space arena, IC in the NASA Space Station program, IC in programs with direct terrestrial applications, and the 1986 Comet Halley Inter-Agency Consultative Group as a model for future IC. It is argued that the ability to participate in and lead IC efforts is economically and politically essential, but that space IC should not be expected to produce better international relations and will probably remain limited to areas with fewer political implications. T.K.

A91-27567* George Washington Univ., Washington, DC.
INTERNATIONAL COOPERATION IN THE SPACE STATION PROGRAMME - ASSESSING THE EXPERIENCE TO DATE
JOHN M. LOGSDON (George Washington University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 7, Feb. 1991, p. 35-45. NASA-supported research. refs
Copyright
The origins and framework for cooperation in the Space Station program are outlined. Particular attention is paid to issues and commitments between the countries and to the political context of the Station partnership. A number of conclusions concerning international cooperation in space are drawn based on the Space Station experience. Among these conclusions is the assertion that an international partnership requires realistic assesments, mutual trust, and strong commitments in order to work. L.K.S.

A91-28978
MIR MISSION REPORT: NEW CREW LAUNCHED TO MIR - JAPANESE REPORTER IN SPACE
NEVILLE KIDGER Spaceflight (ISSN 0038-6340), vol. 33, March 1991, p. 91-97.
Copyright
The flight of the first Japanese citizen in space, reporter Toyohiro Akiyama, is discussed. The mission, launched from Tiuratam on November 30, 1990, carried the Soyuz TM-11 crew of three to a rendezvous with the Mir Space Station, where a crew of two was stationed. Various biotechnical, physiological, and astrophysical experiments and EVA activities, such as hatch repair of the Kvant-2 module, conducted are briefly reviewed. L.K.S.

N91-10378*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE 1990 REFERENCE HANDBOOK: EARTH OBSERVING SYSTEM
1990 154 p
(NASA-TM-102910; NAS 1.15:102910) Avail: NTIS HC/MF A08 CSCL 05B
An overview of the Earth Observing System (EOS) including goals and requirements is given. Its role in the U.S. Global Change Research Program and the International--Biosphere Program is addressed. The EOS mission requirements, science, fellowship program, data and information systems architecture, data policy, space measurement, and mission elements are presented along with the management of EOS. Descriptions of the facility instruments, instrument investigations, and interdisciplinary investigations are also present. The role of the National Oceanic and Atmospheric Administration in the mission is mentioned. M.G.

N91-12727# Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.).
PROJECTS OF THE EUROPEAN SPACE TRAVEL PROGRAM [PROJEKTE DES EUROPAEISCHEN RAUMFAHRTPROGRAMMS]
DIETMAR FRENZEL *In* Deutscher Industrie- und Handelstag, Space Travel Economics: Prospects for a Greater Participation of German Companies in Space Travel Research p 33-43 1989 In GERMAN
Avail: NTIS HC/MF A11
The balance sheet and the long term program decision are outlined. The application program, including Columbus, Ariane 5 and Hermes, the Hipparcos and ROSAT satellites, the microgravitation, the Spacelab, the Earth observation from satellites are presented. The costs and financing up to year 2000 are discussed. ESA

N91-12728# Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.).
PROJECTS OF THE EUROPEAN SPACE TRAVEL PROGRAM [PROJEKTE DES EUROPAEISCHEN RAUMFAHRPROGRAMMS]
GOTTFRIED GREGER *In* Deutscher Industrie- und Handelstag, Space Travel Economics: Prospects for a Greater Participation of German Companies in Space Travel Research p 45-62 1989 In GERMAN
Avail: NTIS HC/MF A11
The Ariane 5, Columbus and Hermes projects are reviewed in detail and the new scientific field of research using zero gravity are outlined. In this connection, the EURECA platform is presented. Annexed tables show the cost distribution among ESA European partners, and the industrial organization for Ariane 5, Hermes and Columbus. ESA

N91-12730# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
NATIONAL GERMAN HANDLING OF SPACE TRAVEL PROJECTS AND ACCESS POSSIBILITIES TO SPACE TRAVEL TASKS [NATIONALE FOERDERUNG VON RAUMFAHRTVORHABEN UND MOEGLICHKEITEN DES ZUGANGS ZU RAUMFAHRTAUFGABEN]
NORBERT KIEHNE *In* Deutscher Industrie- und Handelstag, Space Travel Economics: Prospects for a Greater Participation of German Companies in Space Travel Research p 85-94 1989 In GERMAN
Avail: NTIS HC/MF A11

The aims of the German space travel project are outlined, in particular innovation through space travel technique applications and increase in competitive ability for the German industry. The tender process is described. Advice is given to the small and medium size industries on how to gain access to the space travel market. ESA

N91-13376# Committee on Commerce, Science, and Transportation (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, FISCAL YEAR 1991
ERNEST F. HOLLINGS Washington GPO 1990 53 p
Report to accompany S. 2287 presented by the Committee on Commerce, Science, and Transportation, 101st Congress, 2d Session, 11 Sep. 1990
(S-REPT-101-455; GPO-39-010) Avail: Document Room, Senate, Washington, DC 20510 HC free

The Senate committee on Commerce, Science, and Transportation presents the NASA Authorization Act for fiscal 1991. This act authorizes appropriations to NASA for research and development, space flight, control and data communications, construction of facilities, research and programs management, and many aspects of the Space Transportation System. M.G.

N91-13377# Committee on Science, Space and Technology (U.S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MULTIYEAR AUTHORIZATION ACT OF 1990
ROBERT A. ROE Washington GPO 26 Sep. 1990 82 p
Report to accompany H.R. 5649 presented by the Committee on Science, Space, and Technology, 101st Congress, 2d Session, 26 Sep. 1990
(H-REPT-101-763; GPO-39-006) Avail: Document Room, House of Representatives, Washington, DC 20515 HC free

The House of Representatives' Committee on Science, Space, and Technology presents the NASA Multiyear Authorization Act of 1990. The act authorizes appropriations for research and development, space flight, control and data communications, construction of facilities, research and program management, and many aspects of the Space Transportation System. M.G.

N91-15119*# Management Services, Inc., Huntsville, AL.
CHRONOLOGY: MSFC SPACE STATION PROGRAM, 1982 - PRESENT. MAJOR EVENTS
JESSIE E. WHALEN, comp., SARAH L. MCKINLEY, comp., and THOMAS G. GATES, comp. Dec. 1988 135 p
(Contract NAS8-35900)
(NASA-CR-184014; NAS 1.26:184014; MHR-12) Avail: NTIS HC/MF A07 CSCL 05/4

The Marshall Space Flight Center (MSFC) maintains an active program to capture historical information and documentation on the MSFC's roles regarding Space Shuttle and Space Station. Marshall History Report 12, called Chronology: MSFC Space Station Program, 1982-Present, is presented. It contains synopses of major events listed according to the dates of their occurrence. Indices follow the synopses and provide additional data concerning the events listed. The Event Index provides a brief listing of all the events without synopses. The Element Index lists the specific elements of the Space Station Program under consideration in the events. The Location Index lists the locations where the events took place. The indices and synopses may be cross-referenced by using dates. Y.S.

N91-15192# European Space Agency, Paris (France).
SOME PAPERS FROM THE SEMINAR MIRANDO AL ESPACIO
NORMAN LONGDON, comp. Jun. 1990 89 p In ENGLISH and SPANISH Presented at Jornadas Euro-Mexicanas de Asuntos Especiales, Mexico City, Mexico, 7-10 Nov. 1989
(ESA-SP-309; ISBN-92-9092-078-5; ETN-91-98343) Copyright Avail: NTIS HC/MF A05; EPD, ESTEC, Noordwijk, Netherlands, HC 30 Dutch guilders

European and Mexican space activities are presented. To illustrate activities in Europe the following topics are included: activities of the German aerospace research organization; British programs concerning space exploration; SPOT products commercialization; perspectives of European activities; international activities of ESA and ESA retrieval system. Concerning Earth observation, the European meteorological satellite programs like EUMETSAT and Meteosat and the ERS-1 satellite and the Polar Platform are reviewed. The Mexican programs of communication satellite (SATEX and Morelos), astronomical satellites, space physics research and participation in manned space flights are presented.

N91-15193# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (Germany, F.R.).
ORGANIZATION AND ACTIVITIES OF THE DLR
ROLF DICK *In* ESA, Some Papers from the Seminar Mirando al Espacio p 5-10 Jun. 1990
Copyright Avail: NTIS HC/MF A05; EPD, ESTEC, Noordwijk, Netherlands, HC 30 Dutch guilders

The activities of the German aerospace research organization are described, including history, location of research centers, short discussion of the main tasks, astronautics and energy technology. The space activities include space vehicles, space applications, space missions, and space project management. Examples are given. ESA

N91-15194# British Aerospace Public Ltd. Co., Bristol (England).
GREAT BRITAIN IN SPACE
RAEFE M. SHELTON *In* ESA, Some Papers from the Seminar Mirando al Espacio p 11-12 Jun. 1990
Copyright Avail: NTIS HC/MF A05; EPD, ESTEC, Noordwijk, Netherlands, HC 30 Dutch guilders

The role of the United Kingdom in space exploration and exploitation is discussed. The primary purpose of British programs are to demonstrate and develop commercial application of space technology in cooperation with industry and commerce. The focus is now being tranferred to Earth observation. ESA

N91-15196# Construcciones Aeronauticas S.A., Madrid (Spain).
PERSPECTIVES OF EUROPEAN ACTIVITIES IN SPACE [PERSPECTIVAS SOBRE LAS ACTIVIDADES EUROPEAS EN ESPACIO]
ANTONIO FUENTESLLORENS *In* ESA, Some Papers from the Seminar Mirando al Espacio p 23-25 Jun. 1990 In SPANISH
Copyright Avail: NTIS HC/MF A05; EPD, ESTEC, Noordwijk, Netherlands, HC 30 Dutch guilders

The European space program's trends are analyzed to evaluate the economic potential for industrial growth. Reference is made to the most important projects, including Ariane, Columbus, Hermes, Earth observation, telecommunication and microgravity. The evaluation is highly positive at middle and long terms. The participation of Spain to the potential development is also described. ESA

N91-16848# Space Research Organization Netherlands, Utrecht.
ACTIVITIES REPORT OF THE SPACE RESEARCH ORGANIZATION NETHERLANDS Annual Report, 1989
Mar. 1990 241 p
(ETN-91-98473) Avail: NTIS HC/MF A11

The leading fields of research were x ray astronomy, infrared astronomy, solar research, ultraviolet and visual astronomy, gamma ray astronomy. The SRON scientific program is not limited to astronomy. It contains a substantial component on solid Earth research, as well as on the physics and the biology under conditions of (near) weightlessness. In 1989 the core instrument selection for XMM, the x ray observatory, took place. SRON contributed to the manufacture of the detector electronics for Hipparcos launching. The x ray instrument on board the Russian Space Station MIR operated satisfactorily. The Italian-Dutch x ray mission continued according to plan. ESA

N91-17829# National Space Development Agency, Tokyo (Japan).
ACTIVITIES OF THE NASDA INSTALLATIONS AND OFFICES
1991 47 p
Avail: NTIS HC/MF A03
NASDA is now capable of developing launch vehicles and satellites with indigenous technologies, which are internationally evaluated. Initially, space development began with the modus of launching satellites via launch vehicles, resulting in beneficial applications here on earth. As Japan's initial steps toward manned space activities, beginning in 1991, NASDA will commence performing 34 material processing and life science experiments with a Japanese payload specialist onboard the U.S. Space Shuttle. Space Station Freedom is currently being developed with international efforts. NASDA is responsible for the development and operation of the Japanese Experiment Module (JEM), which will be attached to the Space Station. Japan's participation in the Space Station will contribute to the establishment of manned support technologies and in-orbit assembling techniques for large space structures. In promoting the international collaborative efforts, NASDA seeks resolution to the scientific, medical, and commercial imperatives which make it so important to pursue opportunities in space development. NASDA space development program is thoroughly detailed. Author

N91-18206# European Space Agency, Paris (France).
SOME COMMENTS ON MULTILATERAL COOPERATION
In its Manned Space Stations: Their Construction, Operation and Potential Applications p 117-119 Nov. 1990
Copyright Avail: NTIS HC/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 40 Dutch guilders
The financing of manned space stations and the pros and cons of multilateral cooperation are discussed. Launching and operating these manned space stations is essentially a totally government funded venture, since no private company is prepared to invest in them until adequate revenues can be expected in the short term. However the government funded nature and very high costs involved means delays and budgetary cuts can seriously hinder and delay proceedings. When international cooperation is involved, for example the Space Station Freedom, one country's cut can seriously affect another country's budget. Naturally there are advantages to international cooperation from the scientific point of view since combining intellectual, technological, and economic resources allows advances to be made faster and more efficiently. It is stated that the need for every partner to receive 'reciprocal benefits' is the best formula for cooperation. ESA

N91-19113# Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.).
SPACE RESEARCH FOR THE SAKE OF ALL [WELTRAUMFORSCHUNG NUTZEN FUER ALLE]
ROLF D. GUENTHER, ed. 1990 46 p In GERMAN
(ETN-91-98807) Avail: NTIS HC/MF A03
A review of the present and future developments to be carried out in West Germany in the field of space research is given. Information on the numerous aspects of the space travel technique applications in daily life is given. The consideration of space research, which was looked on over 25 years as an exotic discipline, as a now genuine science and technique is demonstrated. Explanations are given in numerous illustrations and tables. ESA

N91-19124# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
SPACE VEHICLE FLIGHT MECHANICS
N. X. VINH (Michigan Univ., Ann Arbor.) Nov. 1990 16 p
Symposium held in Luxembourg, 13-16 Nov. 1989
(AGARD-AR-294; ISBN-92-835-0570-0; AD-A230434) Copyright
Avail: NTIS HC/MF A03; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive
In recent years, manned flights into low earth orbits were made both for scientific study and for the placement of unmanned satellites into geosynchronous orbits and also into interplanetary orbits. Efforts of many nations are currently under way to place man into orbit on a semipermanent basis through the use of a space station. At the same time, the aerospace industry worldwide is considering the extension from supersonic flight of advanced fighter aircraft to the hypersonic flight of a future aerospace plane. To meet the challenges of the many technical problems to be solved in this new area, the flight mechanics of vehicles in space and in the upper layer of the atmosphere are identified, and the areas of technology relevant to the Flight Mechanics Panel are indentified. Author

N91-19967# 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 Appropriation Bill, 1991 p 128-146 1990
Avail: Document Room, Senate, Washington, DC 20510 HC free
Following a general description of NASA's structure and a summary of each center's activities, NASA's mission and its objectives are presented. The Senate Committee on Appropriations lists its recommendations for funding. It also recommends cuts in several specific programs. J.P.S.

N91-19969# Committee on Appropriations (U.S. Senate).
PROBLEMS AT NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington GPO 1991 63 p Special hearing before the Committee on Appropriations, 101st Congress, 2d Session, 18 Jul. 1990
(S-HRG-101-1146; GPO-36-778) Avail: Committee on Appropriations, Senate, Washington, DC 20510 HC free; also available SOD HC $2.00 as 552-707-09795-3
Hearings before the Subcommittee on Veterans Affairs, Housing and Urban Development, and Independent Agencies of the Senate Committee on Appropriations are presented on problems at the National Aeronautics and Space Administration (NASA). The hearing focused on the Hubble telescope, the space shuttle, and the space station and effects that problems with these projects have on the Federal budget. The management structure of NASA was discussed and the need for adequate support not only for space operations but also for research. Various broad issues were discussed as they pertain to the Subcommittee's stated goal of an affordable, achievable space program. Senator Garn noted that the identification and open discussion of problems with space projects when they are in the design stage is a necessary step for a successful mission. He stressed that the identification and discussion of problems that need to be corrected before liftoff is not pointing a finger at NASA's failures, as media personnel seem to perceive it, but is a normal and essential procedure which should be understood as such by the American taxpayers. J.P.S.

N91-20155# Joint Publications Research Service, Arlington, VA.
DEVELOPMENT, FUNCTIONS OF KVANT-2 SUPPLEMENTARY EQUIPMENT MODULE
M. M. LEMELEV *In its* JPRS Report: Science and Technology. USSR: Space p 8-16 26 Nov. 1990 Transl. into ENGLISH from Zemlya i Vselennaya (Moscow, USSR), no. 3, May - Jun. 1990 p 3-11
Avail: NTIS HC/MF A06
In accordance with the outer space research program, a Proton

launch vehicle placed the specialized Kvant-2 supplementary equipment module into near Earth orbit on 26 Nov. 1989. The module docked with the Mir manned complex on 6 Dec. 1989. Diagrams and specifications are given of the Kvant-2 module.
Author

N91-20668*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ISSUES ASSOCIATED WITH ESTABLISHING CONTROL ZONES FOR INTERNATIONAL SPACE OPERATIONS
BLAIR A. NADER and KUMAR KRISHEN *In its* Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 207-225 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 05/4

Cooperative missions in Earth orbit can be facilitated by developing a strategy to regulate the manner in which vehicles interact in orbit. One means of implementing such a strategy is to utilize a control zones technique that assigns different types of orbital operations to specific regions of space surrounding a vehicle. Considered here are issues associated with developing a control zones technique to regulate the interactions of spacecraft in proximity to a manned vehicle. Technical and planning issues, flight hardware and software issues, mission management parameter, and other constraints are discussed. Also covered are manned and unmanned vehicle operations, and manual versus automated flight control. A review of the strategies utilized by the Apollo Soyuz Test Project and the Space Station Freedom Program is also presented.
Author

N91-21007# 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 1991, Part 2 p 239-548 1991
Avail: Subcommittee of the Committee on Appropriations, Senate, Washington, DC 20510 HC free; also available SOD HC 16.00 as 552-070-09823-2

Following opening statements of members of the Subcommittee of the Senate Committee on Appropriations, the National Aeronautics and Space Administration presents its fiscal year 1991 budget. Comments on the various budgeted items begin with a summary of previously approved programs. Also noted are proposed new initiatives, which amount to 2 percent of the total budget request. Programs discussed include expendable launch vehicles, the Hubble Space Telescope, the Space Station Freedom, planetary exploration, research and development, university programs, communications, observations of Earth, the moon-Mars initiative, and space shuttles, a series of written questions and answers follow the oral presentation.
J.P.S.

03

MANAGEMENT SYSTEMS AND LOGISTICAL SUPPORT

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

A91-10071#
SPACE STATION FREEDOM ALTITUDE STRATEGY
BRIAN M. MCDONALD and SCOTT B. TEPLITZ (McDonnell Douglas Space Systems Co., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 17 p. refs
(AIAA PAPER 90-3652) Copyright

The evolution of the past and current Space Station Freedom (SSF) altitude strategies is reviewed, and the development of a new altitude strategy, focusing on operation issues rather than on design, is discussed. The discussion covers basic approaches to defining rendezvous altitudes as part of an altitude strategy, a historical view of the SSF altitude strategy, and advantages and disadvantages of particular altitude strategies. The new operational attitude strategy is discussed with reference to the principal aspects of SSF operations, including on-orbit operations, logistics systems operations, and Space Shuttle mission planning.
V.L.

A91-10084#
EXPLORING DOMAIN LIMITING TECHNIQUES IN SPACE STATION RESOURCE ALLOCATION
MICHAEL N. GIBSON, DONNIE R. FORD, and JOHN S. ROGERS (Alabama, University, Huntsville) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 5 p.
(AIAA PAPER 90-3672) Copyright

Demand for space-based experimentation platforms currently greatly exceeds supply. Therefore, it is very important to maximize resource utilization in an effort to increase the number of experiments which can be flown. In this paper the Frontier of Feasibility system, which is designed to provide 'good' starting points for a scheduling program is presented. The system is a resource allocation program, not a scheduling program. The way the system handles activities and resources is discussed, and how when combined they can provide constraining factors for the system. The resource allocation problem is then explained in graphical terms using a tree graph, and using this example the search method is explained.
Author

A91-10169*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN OPTIONS FOR ADVANCED MANNED LAUNCH SYSTEMS (AMLS)
DELMA C. FREEMAN, THEODORE A. TALAY, DOUGLAS O. STANLEY, and ALAN W. WILHITE (NASA, Langley Research Center, Hampton, VA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 15 p. refs
(AIAA PAPER 90-3816)

Various concepts for advanced manned launch systems (AMLS) are examined for delivery missions to Space Station and polar orbit. Included are single- and two-stage winged systems with rocket and/or airbreathing propulsion systems. For near-term technologies, two-stage, reusable rocket systems are favored over single-stage rocket or two-stage airbreathing/rocket systems. Advanced technologies enable viable single-stage-to-orbit (SSTO) concepts. Although two-stage rocket systems continue to be lighter in dry weight than SSTOs, advantages in simpler operations may make SSTOs more cost effective over the life cycle. Generally, rocket systems maintain a dry weight advantage over airbreathing systems at the advanced technology levels, but to a lesser degree than when near-term technologies are used. More detailed understanding of vehicle systems and associated ground and flight operations requirements and procedures is essential in determining quantitative discrimination between these latter concepts. Author

A91-10901
SPACE LOGISTICS SYMPOSIUM, 3RD, COLORADO SPRINGS, CO, APR. 30-MAY 2, 1990, PROCEEDINGS
Symposium sponsored by the Society of Logistics Engineers and AIAA. Huntsville, AL, Society of Logistics Engineers, 1990, 464 p. For individual items see A91-10902 to A91-10945.

Topics presented include logistics for European manned space flight, the role of government property in the commercial space launch program, spares quantification for the Space Shuttle Orbiters, a Space Station location coding that makes sense, and a manned mission to the planet Mars. Also presented are some issues in space systems reliability and maintainability, a Satellite Servicer System flight demonstration program, a concept for an expendable launch vehicle logistics resupply/servicing carrier, and Space program survivability. Also addressed are some interconnecting devices conceived for on-orbit operations, applying QFD techniques to aerospace supportability, resource requirements determination using system-level reliability modeling, achieving on-board satellite reprogrammability in Ada, and the manned space systems utilization of product assurance and supportability technology.
R.E.P.

A91-10902#
INTEGRATED LOGISTICS SUPPORT - SUGGESTED APPROACH FOR COLUMBUS
G. F. DE LUCA, R. GRAZI, and S. MASULLO (Compagnia Italiana Servizi Tecnici S.p.A., Rome, Italy) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 10 p. refs

An overview is provided of how the Columbus logistics support is to be designed, focusing particularly on the engineering support centers, where major Columbus logistics tasks are to be undertaken. The functions necessary to ensure an effective logistics ground support, in compliance with the available set of requirements, are discussed. The necessary facilities and tools that take into account the previously foreseen and/or existing infrastructures are described. Interfaces with the other main functions in the Columbus ground segment are identified with the goal of achieving a logistics system properly integrated in the overall Columbus ground infrastructures. It is shown that the functions of the engineering support center are strictly correlated and it is not easy to define the boundaries comprising one function with the exclusion of the others. R.E.P.

A91-10904#
LOGISTICS FOR EUROPEAN MANNED SPACE FLIGHT
H. BARGL (ESG Elektronik System GmbH, Munich, Federal Republic of Germany) and R. GOERLICH (FEG-Gesellschaft fuer Logistik mbH, Munich, Federal Republic of Germany) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 6 p.

The results of an investigation into existing methods used in logistics for military aviation and their application in manned space flight programs are presented. For the Hermes and main Columbus elements, a multielement, multimanufacturer logistics system should be usable for all transportation and orbital systems, compatible with external logistics systems such as NASA systems, uniform with ESA-wide application of centralized logistics processes, and adaptable to future or additional components, elements and systems. It is shown that particular parallels exist when comparing the operational characteristics of military aviation and spaceflight, and, with appropriate modifications, these similarities in operational characteristics also apply to logistics. R.E.P.

A91-10905#
SIMULATION - A FUNDAMENTAL SUPPORT IN THE COLUMBUS LOGISTICS ACTIVITIES
G. F. DE LUCA, R. GRAZI, and S. MASULLO (Compagnia Italiana Servizi Tecnici S.p.A., Rome, Italy) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 12 p.

This paper illustrates how simulation can support the logistics activities in its multiple tasks for Columbus, allowing to meet its demanding requirements (such as training, on-board S/W updates, and spare management. The diverse types of simulators (such as S/W based tools, Engineering Models, and logistic models) are analyzed as potential support to logistics activities, in order to have an optimum apportionament of their capabilities. Reutilization of tools or part of them already developed for other Columbus tasks is assessed and proposed. Author

A91-10909*# National Aeronautics and Space Administration, Washington, DC.
EXPENDABLE LAUNCH VEHICLES IN SPACE STATION FREEDOM LOGISTICS RESUPPLY OPERATIONS
J. STEVEN NEWMAN (NASA, Office of Space Flight, Washington, DC), ROY L. COURTNEY, and PETER BRUNT (NASA, Space Station Freedom Program Office, Reston, VA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 14 p. refs
Copyright

The projected Space Station Freedom (SSF) annual logistics resupply requirements were predicted to exceed the 1988 baseline Shuttle resupply system capability. This paper examines the implications of employing a 'mixed fleet' of Shuttles and ELVs to provide postassembly, steady-state logistics resupply. The study concluded that ELVs supported by the OMV could provide the additional required resupply capability with one to three launches per annum. However, the study determined that such a capability would require significant programmatic commitments, including baseline SSF OMV accommodations, on-orbit OMV monoprop replenishment capability, and substantial economics investments. The study also found the need for a half-size pressurized logistics module for the increase in the efficiency of logistics manifesting on the Shuttle as well as ELVs. Author

A91-10911*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MESSOC CAPABILITIES AND RESULTS
ROBERT SHISHKO (JPL, Pasadena, CA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 9 p.

MESSOC (Model for Estimating Space Station Operations Costs) is the result of a multi-year effort by NASA to understand and model the mature operations cost of Space Station Freedom. This paper focuses on MESSOC's ability to contribute to life-cycle cost analyses through its logistics equations and databases. Together, these afford MESSOC the capability to project not only annual logistics costs for a variety of Space Station scenarios, but critical non-cost logistics results such as annual Station maintenance crewhours, upweight/downweight, and on-orbit sparing availability as well. MESSOC results using current logistics databases and baseline scenario have already shown important implications for on-orbit maintenance approaches, space transportation systems, and international operations cost sharing. Author

A91-10913*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE STATION LOCATION CODING THAT MAKES SENSE
LEONG W. LEW (NASA, Johnson Space Center, Houston, TX) and WILLIAM J. PRAUS (Johnson Engineering Corp., Houston, TX) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 9 p.

An alphanumeric interior and exterior location coding system for elements of the Space Station is presented as an aid in identifying specific locations aboard the Station and possibly in locating specific items of loose equipment stowed in these locations. Past experience with long-duration missions has demonstrated the difficulty of tracking loose equipment aboard spacecraft. Inasmuch as over 50,000 items of loose equipment must be accounted for aboard Space Station Freedom there is a high potential for continuing difficulties in this area. It is shown that the alphanumeric location coding system described is simple, logical, and easy to use. R.E.P.

A91-10917#
APPLICATION OF OBJECT-ORIENTED PROGRAMMING TO ON-ORBIT LOGISTICS SUPPORT
JOEL LUNA (Dynamics Research Corp., Andover, MA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 9 p. refs

Evaluation of on-orbit logistics support of space systems typically involves the examination of alternate support concepts and scenarios. Conventional programming techniques take into account these different concepts either by varying data inputs (a heavier OMV has an increase in its mass input value) or by selecting one of several sets of procedures each of which correspond to a different concept. This paper proposes an alternative approach to conventional programming methods using object-oriented programming techniques. Particular advantages of object-oriented programming versus conventional programming will be highlighted. It will be shown how changes in support concepts can more easily and clearly be implemented in an object-oriented environment. A tradeoff analysis of effectiveness and cost between the support concepts will be presented and discussed. Author

A91-10926#
ON-ORBIT SUPPORT - PAST, PRESENT, AND FUTURE
JOHN H. BURGER (Advanced Technology, Inc., Huntsville, AL) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 9 p. refs

The results of studies that have identified the need for an on-orbit support capability and confirmed the technical feasibility and cost effectiveness of performing on-orbit support missions are presented. The status and future direction of continuing studies and development work are assessed, and requirements for future development activities that will bring an on-orbit support capability to reality are identified. It is shown that the ability to accomplish on-orbit maintenance and support operations becomes increasingly attractive as a means to reduce the cost of supporting the current and future space systems to an affordable level and to provide user flexibility. R.E.P.

A91-10927#
CONCEPT FOR AN EXPENDABLE LAUNCH VEHICLE LOGISTICS RESUPPLY/SERVICING CARRIER
SAM M. DOMINICK (Martin Marietta Corp., Denver, CO) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 8 p. Research supported by Martin Marietta Corp.
Copyright

The concept for an ELV-launched expendable logistics carrier that can be utilized to both resupply useful cargo and to dispose of unwanted cargo after the mission is completed is presented. This system can carry out both of these operations on a single ELV launch that would be used to complement the STS-based Space Station Freedom logistics system, especially in a back-up mode if the STS launches are delayed. As the carrier is initially designed to be expendable, subsystems are kept to a minimum and maximum utilization of Freedom-provided services (e.g., avionics and electrical power) is made. Finally, the carrier can be manifested in different configurations depending on the mission requirements, making it a flexible alternative to the STS resupply system. R.E.P.

A91-10929*# Rutgers - The State Univ., Piscataway, NJ.
SPACE STATION PAYLOAD SCHEDULING
JAMES T. LUXHOJ (Rutgers University, Piscataway, NJ) and WILLIAM T. DAVIS (NASA, Langley Research Center, Hampton, VA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 11 p. refs

A solution algorithm is presented for the scheduling of payloads for NASA's proposed Space Station. The payload scheduling problem possesses some unique and unusual features that cannot be adequately addressed using static scheduling theory. The solution algorithm is demonstrated with a hypothetical Space Station example that involves 10 payloads and 3 crewmembers with a varied skill profile. A constrained version of the algorithm is compared with three other scheduling heuristics through use of the Space Station Operations Model which can simulate orbital activities. The constrained solution algorithm outperforms the three other scheduling heuristics in the minimization of makespan. Author

A91-10930#
CALS AND LOGISTICS MANAGEMENT - HOW LOGISTICS CAN IMPLEMENT THE CALS CONCEPT ON THE SPACE STATION
D. ALBERG HORTON (Honeywell, Inc., Minneapolis, MN) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 7 p.

The new computer-aided acquisition and logistics support (CALS) developments, intended to lead to weapons systems improvements, and how these developments will benefit the Space Station are presented. Methods by which logistics management, employing CALS focal points, can creatively implement logistics functions in the building and support of the Space Station are discussed. Costs are more likely to continue to decrease as factors in CALS implementation equations continue to change. As a driver, life cycle costs should be applied to CALS implementation. Logistics management at all levels should implement these processes in the Space Station development phases, with resulting savings in space, weight, documentation, and supply costs. R.E.P.

A91-10940#
PRIORITIZING THE STANDARDIZATION OPPORTUNITIES AVAILABLE TO LARGE SPACE SYSTEMS
ROSS A. DE JONG and DONALD M. KEITH (Dynamics Research Corp., Arlington, VA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 11 p. refs

A methodology for focusing the standardization efforts of a major space system in order to maximize logistics support benefits is presented. The methodology incorporates a nonparametric weighted-factor analysis to rank the design constraints in order to emphasize those that provide the greatest possibility for standardization benefits. Hardware form, function, and fit type standardization techniques can be used at the system, subsystem, system element, and component levels. These techniques and top-down standardization, when utilized together, foster the development of qualitative and quantitative standards for modular components. In addition, the traditional benefits of standardization, hidden benefits of standarization, and prioritization methodology are discussed. R.E.P.

A91-10944*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION LOGISTICS POLICY - RISK MANAGEMENT FROM THE TOP DOWN
GRANVILLE PAULES (NASA, Operations and Utilization Div., Washington, DC) and JAMES L. GRAHAM, JR. (Booz-Allen and Hamilton, Inc., Space Systems and Technology Div., Bethesda, MD) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 11 p.

Considerations are presented in the area of risk management specifically relating to logistics and system supportability. These considerations form a basis for confident application of concurrent engineering principles to a development program, aiming at simultaneous consideration of support and logistics requirements within the engineering process as the system concept and designs develop. It is shown that, by applying such a process, the chances of minimizing program logistics and supportability risk in the long term can be improved. The problem of analyzing and minimizing integrated logistics risk for the Space Station Freedom Program is discussed. R.E.P.

A91-12332
AN EXPERT SYSTEM FOR HERMES IN-ORBIT OPERATIONS GROUND SUPPORT
J. AMALRIC (Aerospatiale, Cannes; CNES, Toulouse, France), D. DE GABAI, F. PAOLI, S. POUGET (Aerospatiale, Cannes, France), and P. SENGENES (CNES, Toulouse, France) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 865-892.
Copyright

Application of a knowledge based system devoted to Ground Control Center support during the Hermes in-orbit phase is presented. Main functions of such a system are fault diagnosis and mission planning. This paper details the study first development step, aiming to design a mission planning mock-up. Object-orientated formalism, goal-orientated programming and algorithmic modules driven by heuristics are the main features of this mock-up modeling and architecture. Author

A91-13789*# National Aeronautics and Space Administration, Washington, DC.

AN INNOVATIVE APPROACH FOR DISTRIBUTED AND INTEGRATED RESOURCES PLANNING FOR THE SPACE STATION FREEDOM

RHODA S. HORNSTEIN (NASA, Washington, DC), GERALD L. SHINKLE (NASA, Johnson Space Center, Houston, TX), JERRY D. WEILER (NASA, Marshall Space Flight Center, Huntsville, AL), and JOHN K. WILLOUGHBY (Information Sciences, Inc., Englewood, CO) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-084) Copyright

This paper presents a planning approach to the Space Station Freedom program which takes into account the widely distributed nature of that program. The program management structure is organized into three major levels: a strategic level, a tactical level, and an execution level. For each level, resource availabilities are determined, the resources are distributed, schedules are built independently within the resource limits, the schedules are integrated into a single schedule, and conflicts are resolved by negotiating requirements and/or relaxing contraints. This approach distributes resources to multiple planning entities in such a way that when the multiple plans are collected, they fit together with minimal modification. The up-front distribution is planned in such a way and to a sufficient degree that a fit is virtually assured. C.D.

A91-13790#

THE MANNED SPACE-LABORATORIES CONTROL CENTRE - MSCC: OPERATIONAL FUNCTIONS AND IMPLEMENTATION

H. BROGL (ESA, European Space Operations Center, Darmstadt, Federal Republic of Germany), J. KEHR (DLR, Oberpfaffenhofen, Federal Republic of Germany), and M. WLAKA (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 22 p.
(IAF PAPER 90-086) Copyright

The functions of the Manned Space Laboratories Control Center (MSCC) during the operations of the Columbus Attached Laboratory (CAL) and the Free-Flying Laboratory (FFL) are described. Operational scenarios for MSCC are considered, including routine operations of the Space Station Manned Base, servicing operations at CAL, routine operation of the FF, and FF servicing at the Space Station and by Hermes. MSCC communication and management interfaces are examined, and implementation of the MSCC for the Spacelab Mission D-2 is examined. The MSCC detailed definition and qualification concept is discussed. C.D.

A91-13800#

AN EXPANDED SIMULATION OF SPACE STATION FREEDOM OPERATIONS

EDMUND T. DEJULIO and KELLY L. FURLONG (Boeing Aerospace Operations, Inc., Cocoa Beach, FL) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-097) Copyright

A description of the simulation tool developed to model various Space Station designs and operations plans is presented. The model, called Simulation of Manned Space Station Logistics Support, or SIMSYLS, allows designers and planners to cooperatively evaluate the complex relationship of design to operations. This paper describes the general features of the model, focuses on the enhancements developed within the last year, and suggests ways in which the simulation can be used to study and consequently improve system effectiveness. Author

A91-13801#

TRASYCOM, A TOOL FOR THE DETERMINATION OF SPACE TRANSPORTATION LOGISTICS REQUIREMENTS, DEMONSTRATED FOR A COLUMBUS FREE FLYER SERVICING SCENARIO

B. BRAND and J. PULS (DLR, Oberpfaffenhofen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p.
(IAF PAPER 90-098) Copyright

For predicting the suitability of a space transportation system to perform a given transportation-scenario a program system named TRASYCOM (TRAnsportation SYstem COMparison) has been developed. TRASYCOM carries out a superposition of the requirement- and flight-scenario with intent to identify the payload distribution to the single transportation system flights. The main result of these calculations is the identification of critical flights, i.e., the payload transportation capability is exceeded in mass or volume. In addition to this, the number of flights and payload capability required by a transportation system to accomplish a given requirement-scenario can be established. Mass and volume budgets, i.e., the determination of the actual mass and volume in orbit, resulting from up- and down-flights, can also be performed. A survey of the program structure is given, and a Columbus Free Flyer (CFF) servicing scenario is discussed as an example. Author

A91-13839*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

PERSONNEL LAUNCH SYSTEM DEFINITION

WILLIAM M. PILAND, THEODORE A. TALAY, and HOWARD W. STONE (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. refs
(IAF PAPER 90-160) Copyright

A lifting-body Personnel Launch System (PLS) is defined for assured manned access to space for future U.S. space missions. The reusable craft described is configured for reliable and safe operations, maintainability, affordability, and improved operability, and could reduce life-cycle costs associated with placing personnel into orbit. Flight simulations show the PLS to be a very flyable vehicle with very little control and propellant expenditure required during entry. The attention to crew safety has resulted in the design of a system that provides protection for the crew throughout the mission profile. However, a new operations philosophy for manned space vehicles must be adopted to fully achieve low-cost, manned earth-to-orbit transportation. R.E.P.

A91-13840*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

A PERSONNEL LAUNCH SYSTEM FOR SAFE AND EFFICIENT MANNED OPERATIONS

ANDREW J. PETRO (NASA, Johnson Space Center, Houston, TX), DANA G. ANDREWS, and ERIC D. WETZEL (Boeing Co., Seattle, WA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p.
(Contract NAS9-18255)
(IAF PAPER 90-161) Copyright

Several Conceptual designs for a simple, rugged Personnel Launch System (PLS) are presented. This system could transport people to and from Low Earth Orbit (LEO) starting in the late 1990's using a new modular Advanced Launch System (ALS) developed for the Space Exploration Initiative (SEI). The PLS is designed to be one element of a new space transportation architecture including heavy-lift cargo vehicles, lunar transfer vehicles, and multiple-role spcecraft such as the current Space Shuttle. The primary role of the PLS would be to deliver crews embarking on lunar or planetary missions to the Space Station, but it would also be used for earth-orbit sortie missions, space rescue missions, and some satellite servicing missions. The PLS design takes advantage of emerging electronic and structures technologies to offer a robust vehicle with autonomous operating and quick turnaround capabilities. Key features include an intact abort capability anywhere in the operating envelope, and elimination of all toxic propellants to streamline ground operations. Author

A91-13841#
EVOLUTION IN HOPE CONCEPT AND FLIGHT EXPERIMENT PLAN
HIROSHI MIYABA, TESTSUICHI ITO, YOSHISADA TAKIZAWA, TOSHIO AKIMOTO, MOTOYUKI INABA (NASDA, Tsukuba Space Center, Japan) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-162) Copyright

National Space Development Agency of Japan is conducting conceptual design of HOPE, H-II Orbiting Plane. The purpose of the current study is to establish the feasible concept of HOPE and to prepare the technical bases. The primary mission of HOPE is the Space Station Freedom/JEM logistics transportation. Besides previous concept of ten ton class orbiter launched by H-II rocket, extended size orbiter concept has been studied along with enhancement of H-II rocket. An orbiter derived from this study weights 20 tons at lift off and has three to five tons of payload capability. Subsystems design and technology development in such field as aerodynamics, structure and materials, guidance, navigation and control are in progress. In order to acquire the reentry flight data, orbital reentry experiment is planned and under development utilizing orbital flight opportunity of H-II test flight in 1993. Author

A91-13844#
ARIANE TRANSFER VEHICLE SCENARIO
NORBERT DEUTSCHER (MBB/ERNO, Bremen, Federal Republic of Germany) and CLAUDE COUGNET (Matra Espace, Toulouse, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-166) Copyright

ESA's Ariane Transfer Vehicle (ATV) is a vehicle design concept for the transfer of payloads from Ariane 5 launch vehicle orbit insertion to a space station, on the basis of the Ariane 5 program-developed Upper Stage Propulsion Module and Vehicle Equipment Bay. The ATV is conceived as a complement to the Hermes manned vehicle for lower cost unmanned carriage of logistics modules and other large structural elements, as well as waste disposal. It is also anticipated that the ATV will have an essential role in the building block transportation logistics of any prospective European space station. O.C.

A91-13845#
ARIANE TRANSFER VEHICLE STATUS
CHRISTOPHE BONNAL, FRANCIS THEILLIER (Aerospatiale, Division Systemes Strategiques et Spatiaux, Les Mureaux, France), and DAVID J. SALT (British Aerospace /Space Systems/, Ltd., Stevenage, England) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER 90-167) Copyright

ESA has since 1987 conducted studies for an Ariane Transfer Vehicle (ATV) that will be able to bridge the distance between the Ariane 5 launch vehicle and orbiting elements which must be serviced. ATV's reference mission involves the logistical support of the Space Station Freedom through transport of such items as unpressurized carriers or pressurized modules. After an attached period of up to six months at the Station, the ATV can remove a cargo of the Station's waste products for disposal. A conceptual development history of the ATV is presented with emphasis on the ESA/NASA common design criteria that had to be addressed to arrive at a suitable ATV architecture. O.C.

A91-13865*# National Aeronautics and Space Administration, Washington, DC.
HEAVY-LIFT LAUNCH VEHICLE OPTIONS FOR FUTURE SPACE EXPLORATION INITIATIVES
DARRELL R. BRANSCOME and RONALD J. HARRIS (NASA, Office of Space Flight, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-196) Copyright

A review of present heavy-lift launch vehicles (HLLV) capable of placing heavy payloads in earth orbit is presented and the basis for an emerging consensus that an HLLV will be required in the near future is discussed. Some of the factors for the policies governing the roles and requirements for these vehicles in the future, such as cost, technology development, and lead time to first use are addressed. Potential Space Station Freedom application is discussed as well as application to the proposed initiatives for human exploration of Mars and the moon. R.E.P.

A91-14449#
CONCEPT AND TECHNOLOGY DEVELOPMENT FOR HOPE SPACEPLANE
TESTSUICHI ITO, TOSHIO AKIMOTO, HIROSHI MIYABA, YASUOMI KANO, NORIO SUZUKI (NASDA, Tsukuba, Japan) et al. AIAA, International Aerospace Planes Conference, 2nd, Orlando, FL, Oct. 29-31, 1990. 9 p.
(AIAA PAPER 90-5223) Copyright

HOPE spaceplane has been studied for several years in NASDA. The purpose of the current study is to establish the feasible concept of HOPE and to prepare the technical bases. The primary mission of HOPE is the Space Station Freedom/JEM logistics transportation complementing with U.S. Space Shuttle fleet. Besides previous concept of ten ton class orbiter launched by H-II rocket, extended size orbiter concept has been studied along with enhancement of H-II rocket, which is called H-IID (derivative) rocket. An orbiter derived from this study weighs 20t at lift off and has three to five tons of payload capability, based on the H-IID configuration of H-II first stage with six solid boosters strapped on. Subsystems design and technology development in such field as aerodynamics, structure and materials, guidance-navigation and control, and Space Station interface are in progress. In order to acquire the reentry flight data, orbital reentry experiment is planned and under development utilizing orbital flight opportunity of H-II test flight in 1993. These concepts are under review and trade off in NASDA for establishing HOPE development scenario. Author

A91-14963*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
LESSONS LEARNED FROM THE HUBBLE SPACE TELESCOPE PLANNING AND SCHEDULING SYSTEM IMPLEMENTATION AND OPERATION
EDWARD O. RUITBERG and PAUL J. ONDRUS (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 7 p.
(AIAA PAPER 90-5039) Copyright

The major challenge of the NASA Hubble Space Telescope (HST) Ground System has been the implementation of the planning and scheduling system. This paper describes the operational flow of HST from science proposals to the actual execution of science observations on board the HST. The paper provides a collection of lessons learned over the 10 years that have covered the definition, development, test, and initial operation of HST's planning and scheduling system. Author

A91-15001*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DISTRIBUTED PLANNING AND SCHEDULING FOR INSTRUMENT AND PLATFORM OPERATIONS
LARRY G. HULL (NASA, Goddard Space Flight Center, Greenbelt, MD), ELAINE R. HANSEN, and THOMAS P. SPARN (Colorado, University, Boulder) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 11 p. refs
(AIAA PAPER 90-5090) Copyright

Distributed planning and scheduling for instruments and platform operations in resource constrained environments are discussed. NASA has repeatedly faced the situation of multiple users having differing goals, objectives, and requirements interacting with a

planning and scheduling system. Current examples include the Hubble Space Telescope and Space Station Freedom. The paper provides a brief description of the instrument and platform operations domain, discusses both traditional and distributed planning and scheduling in the context of this domain, and looks at examples of NASA environments in which planning and scheduling is or will be performed in a distributed system.
Author

A91-15002*# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
APPROACH TO TRANSACTION MANAGEMENT FOR SPACE STATION FREEDOM
C. R. EASTON (McDonnell Douglas Space Systems Co., Huntington Beach, CA), PHIL CRESSY (NASA, Washington, DC), T. E. OHNESORGE, and GARLAND HECTOR (NASA, Johnson Space Center, Houston, TX) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 9 p.
(AIAA PAPER 90-5091) Copyright
The Space Station Freedom Manned Base (SSFMB) will support the operation of the many payloads that may be located within the pressurized modules or on external attachment points. The transaction management (TM) approach presented provides a set of overlapping features that will assure the effective and safe operation of the SSFMB and provide a schedule that makes potentially hazardous operations safe, allocates resources within the capability of the resource providers, and maintains an environment conducive to the operations planned. This approach provides for targets of opportunity and schedule adjustments that give the operators the flexibility to conduct a vast majority of their operations with no conscious involvement with the TM function.
R.E.P.

A91-16048*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE PERSONNEL LAUNCH SYSTEM
WILLIAM M. PILAND, THEODORE A. TALAY, and HOWARD W. STONE (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 28, Nov. 1990, p. 18-21, 29.
Copyright
NASA has begun to study candidate vehicles for manned access to space in support of the Space Station or other future missions requiring on-demand transportation of people to and from earth orbit. One such system, which would be used to complement the present Shuttle or an upgraded version, is the Personnel Launch System (PLS), which is envisioned as a reusable priority vehicle to place people and small payloads into orbit using an experimental launch vehicle. The design of the PLS is based on a Space Station crew changeout requirement whereby eight passengers and two crew members are flown to the station and a like number are returned within a 72 hour mission duration. Experimental and computational aerothermodynamic heating studies have been conducted using a new two-color thermographic technique that involved coating the model with a phosphor that radiates at varying color intensities as a function of temperature when illuminated with UV light. A full-scale model, the HL-20, has been produced and will be used for man-machine research. Three launch vehicle concepts are being considered, a Titan IV, the Advanced Launch System, and a Shuttle equipped with liquid rocket boosters.
R.E.P.

A91-16280#
PREDICTING ACCELEROMETER ERRORS IN GROUND-BASED TESTING OF LARGE FLEXIBLE STRUCTURES
ROGER C. THOMPSON (Pennsylvania State University, University Park) AIAA and AAS, Astrodynamics Conference, Portland, OR, Aug. 20-22, 1990. 8 p. refs
(Contract F49620-86-K-0014)
(AIAA PAPER 90-2915) Copyright
The purpose of the study is to investigate the dynamic coupling effect for flexible structures in which the motion is not confined to a single mode. It is shown that an accelerometer can produce an erroneous signal that is a function of the frequency of excitation, the location of the sensor, and the mode shape of the structure. The signal errors are shown to be a dynamic effect resulting from the interaction of the sensor element and gravitational loading. An analysis of gravity-induced accelerometer-signal errors is performed for a thin uniform cantilevered beam in free and forced vibration modes, and the analytical model obtained is used for predicting the location where an accelerometer will produce a zero output.
V.T.

A91-21213* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE VIBRATION CONTROL ACTIVITIES AT THE LARC - PRESENT AND FUTURE
J. R. NEWSOM (NASA, Langley Research Center, Hampton, VA) IN: U.S.-Japan Workshop on Smart/Intelligent Materials and Systems, Honolulu, HI, Mar. 19-23, 1990, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1990, p. 211-228. refs
Copyright
The NASA Controls-Structures-Interaction (CSI) program is presented with a description of the ground testing element objectives and approach. The goal of the CSI program is to develop and validate the technology required to design, verify and operate space systems in which the structure and the controls interact beneficially to meet the needs of future NASA missions. The operational Mini-Mast ground testbed and some sample active vibration control experimental results are discussed along with a description of the CSI Evolutionary Model testbed presently under development. Initial results indicate that embedded sensors and actuators are effective in controlling a large truss/reflector structure.
R.E.P.

A91-27120#
INTER-OPERABILITY OF EUROPE'S HERMES SPACEPLANE WITH THE COLUMBUS FREE-FLYING LABORATORY, AND WITH 'FREEDOM' AND 'MIR'-TYPE SPACE STATIONS
F. DI MAURO, D. CORNIER, L. MARECHAL (ESA; CNES, Toulouse, France), W. FEHSE, and A. TOBIAS (ESTEC, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 14, no. 4, 1990, p. 369-388.
Copyright
The Hermes spaceplane is adaptable to visiting other space stations by using an expendable rear Hermes Resource Module (HRM), which can accommodate special docking ports, berthing mechanisms and utilities interfaces, as well as cargo for the station being visited. The rendezvous and docking strategies are described, with the focus on such related choices as the role of astronauts, safe approach corridors, and the sizing of docking ports. The interoperability makes space station operations less vulnerable and the presence of man in space much safer. The in-orbit rendezvous operations are discussed, and concepts for control zones, contamination control, common devices such as docking mechanisms, and communications packages used by the visiting and visited vehicles are proposed. Cooperation between the space community's members is suggested, recommending that space stations should standardize operations for visiting vehicles. Servicing the European Columbus Free-Flying Laboratory is one of Hermes's main task, but visits to Space Station Freedom and the Soviet MIR station are also discussed. The system configuration of Hermes, and its rendezvous and departure strategies are covered in depth. A series of flow diagrams, explanatory charts and interoperability rules is included.
O.G.

A91-27640
OPTIMAL SELECTION OF SPACE TRANSPORTATION FLEET TO MEET MULTI-MISSION SPACE PROGRAM NEEDS
GEORGE W. MORGENTHALER and ALEX J. MONTOYA (Colorado, University, Boulder) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p.

656-665. refs
Copyright
This paper presents a linear integer programming launch vehicle selection model and an example of a multimission space program which can serve as a guidance of a future space program choices. The space program considered is comprised of a LEO space station, a polar platform, a geosynchronous space station, a lunar base, a Mars astronaut fly-by, and a Mars base. This example points to large logistic launch costs associated with multimission space programs and emphasizes the need to minimize costs by using mathematical optimization methods. I.S.

A91-27675
A ROBOTICS TESTBED FOR IN-SPACE ASSEMBLY TASKS
JACK FABER (Colorado, University, Boulder), JOHN BLANCO, and NICK WILDE IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1025-1034.
Copyright
The operations testbed of the Center for Space Construction at the University of Colorado is described. This testbed serves as a centralized testing environment for interdisciplinary research in the problems of construction and assembly in space. The three main components are described: NoPumpG - a flexible user interface system; OASIS (Operations and Science Instrument Support) - a teleoperations package; and a SCORBOT robot with its associated assembly mock-ups. Finally, integration efforts involving all three components and some on-going robotics assembly tasks using the robotics testbed are described. Author

A91-27721
APPLICATION OF STATISTICAL DISTRIBUTION THEORY TO LAUNCH-ON-TIME FOR SPACE CONSTRUCTION LOGISTIC SUPPORT
GEORGE W. MORGENTHALER (Colorado, University, Boulder) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1462-1471. refs
Copyright
Actual unscheduled 'hold' data for various launch vehicles are used here in an attempt to determine suitable probability models which can describe historical data and can be used for inputs to broader simulations of launch vehicle logistic space construction support processes. The models can also be used to determine which launch operations cause the majority of the unscheduled holds and how the operations can be changed to improve launch-on-time. The ability of a compound distribution probability model to fit the data is examined. The model is manipulated to show how launch system changes can improve launch-on-time statistics. C.D.

A91-27722
COLUMBUS GENERIC ELEMENT MANAGEMENT CONCEPT
JOHN SVED (MBB/ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1472-1481.
Copyright
The concept for largely autonomous onboard management of the ESA Columbus project elements relies on the automation of operational procedures. Reconfigurable items are commanded in sequence during execution of automated procedures that ensure failure management during indeterminate system states. At other times a new form of generalized decision tables will deal with incomplete failure symptoms. Unacceptable operations are avoided by the management of execution of a planned timeline of predefined actions. The concept supports both unmanned and manned systems. Author

A91-27802*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPSMODEL, AN ON-ORBIT OPERATIONS SIMULATION MODELING TOOL FOR SPACE STATION
WILLIAM T. DAVIS and ROBERT L. WRIGHT (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Nov.-Dec. 1990, p. 569, 570. Abridged. Previously cited in issue 05, p. 639, Accession no. A89-18309.
Copyright

A91-29689
AEROSPACE TESTING SEMINAR, 12TH, MANHATTAN BEACH, CA, MAR. 13-15, 1990, PROCEEDINGS
Seminar sponsored by Institute of Environmental Sciences and Aerospace Corp. Mount Prospect, IL, Institute of Environmental Sciences, 1990, 239 p. For individual items see A91-29690 to A91-29721.
Recent developments in the technology and management of testing in the U.S. aerospace industry are discussed in reviews and reports. Sections are devoted to the impact of Total Quality Management on testing, risk and cost management, innovative testing and lessons learned, improved testing for launch systems, Space Station testing, and software issues in testing. Particular attention is given to eliminating waste in the test process, satellite environmental testing cost benefits, motion- and force-controlled vibration testing, Shuttle and Shuttle-C mixed-fleet processing operations, environmental interactions on the Space Station, integrated testing of the Space Station ECLSS at NASA Marshall, a comprehensive software package for thermal vacuum test monitoring, and real-time instrumentation control applications for satellite system tests. Diagrams, drawings, graphs, photographs, and tables of numerical data are provided. T.K.

A91-29715*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
INTEGRATION BY PARTS
THOMAS BARRY (NASA, Johnson Space Center, Houston, TX) and TERRANCE J. SCHEFFER (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 181-186. refs
This paper describes the unique integration and verification challenges associated with the Space Station Freedom and an approach to solve these problems using Data Management Systems (DMS) Kits. These DMS Kits will help alleviate the complex integration problems inherent in building, assembling and testing the Space Station. Particular emphasis has been placed on utilizing the capabilities and services of the on-board DMS to provide the integration and verification tools, not only for the DMS but for the other on-board distributed systems as well. DMS Kits are provided to system/software developers across the program. These DMS Kits provide a common set of integration and verification tools and hardware. Each system developer can then utilize, through the kits, a simulation of the complete data processing environment which will be available on orbit. The paper describes the evolution of the integration process from the system level to the final integration of multiple launch packages. DMS Kits are used throughout this process, which addresses both the ground and on-orbit aspects of the problem. Author

A91-29724
THE LEGACY OF THE LIFTING BODY
STEPHAN WILKINSON Air and Space (ISSN 0886-2257), vol. 6, Apr.-May 1991, p. 50-62.
Copyright
A review is presented of the lifting body programs that have developed out of the overall space program. The project conceived a ballistic capsule that could withstand the enormous forces and temperatures of hypersonic flight during reentry, then make the transition to supersonic and transonic speeds, but still maintain enough lift so that at some point the vehicle could go subsonic

and maneuver to a controlled landing rather than dropping into the ocean. An early lifting body, the M2-F1 was designed, wind tunnel tested, towed by car, and eventually towed in the air by a C-47 to be released and glided down to earth. Upgraded versions continued to be developed including the incorporation of rocket engines for propulsion so that eventually the lifting body program proved that wingless vehicles returning from orbital altitudes could routinely be landed on runways. Today, the lifting body shape seems to be the best way to handle the problems being encountered in the design of the National Aerospace Plane using scramjet engines at hypersonic speeds. Also, engineers at Langley Research Center are studying a lifting body, the HL-20, that could be launched to the Space Station atop an expendable booster and returned to earth with passengers or cargo. R.E.P.

A91-30668* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE VEHICLE CONTROL SYSTEMS BRANCH AT THE MARSHALL SPACE FLIGHT CENTER
CHRIS BARRET (NASA, Marshall Space Flight Center, Huntsville, AL) IN: TABES 90 - Annual Technical and Business Exhibition and Symposium, 6th, Huntsville, AL, May 15, 16, 1990, Submitted Papers. Huntsville, AL, Huntsville Association of Technical Societies, 1990, p. 212-216. refs
(TABES PAPER 90-1805) Copyright

This paper outlines the responsibility of the Vehicle Control Systems Branch at the Marshall Space Flight Center (MSFC) to analyze, evaluate, define, design, verify, and specify requirements for advanced launch vehicles and related space projects, and to conduct research in advanced flight control concepts. Attention is given to branch responsibilities which include Shuttle-C, Shuttle-C Block II, Shuttle-Z, lunar cargo launch vehicles, Mars cargo launch vehicles, orbital maneuvering vehicle, automatic docking, tethered satellite, aeroassisted flight experiment, and solid rocket booster parachute recovery system design. Author

N91-10091# Messerschmitt-Boelkow-Blohm/Entwicklungspring Nord, Bremen (Germany, F.R.). Dienstleistungsbereich.
COLUMBUS LOGISTICS SUPPORT. A CONCEPTIONAL DEFINITION OF THE OPERATIONAL PHASE
H. J. C. KOOPMANN and MIKE C. ATTWOOD 1990 9 p
(MBB-UO-0093-90-PUB; ETN-90-97837; OTN-027616) Avail: NTIS HC/MF A02

In order to logistically support the systems included in the Columbus program, logistic support concepts and facilities are developed. The logistics support functions for the Columbus operational phase includes the identification of major facility requirements and recommendations for support of the implementation planning. These tasks have to be complemented by the definition and implementation of a logistics support system and its related facilities and proceedings. Emphasis is given to the logistics functions which drive facility requirements, on general considerations for a long term support program, e.g., centralization aspects, and on the intended implementation approach. ESA

N91-10108# Messerschmitt-Boelkow-Blohm/Entwicklungspring Nord, Bremen (Germany, F.R.). Dienstleistungsbereich.
COLUMBUS ELEMENTS PROCESSING NEEDS AT KSC
DIETER HUSUNG 1990 10 p
(MBB-UO-0092-90-PUB; ETN-90-97836; OTN-027615) Avail: NTIS HC/MF A02

The Columbus Attached Laboratory will form an integral part of the Space Station Freedom and the Columbus Free Flying Laboratory will use the Space Station Freedom as a servicing base. The ground processing support for the initial delivery of the Columbus Attached Laboratory, payload outfitting launches, and the periodic resupply launches for both the Attached Laboratory and the Free Flyer is presented. The acceptance approach of flight hardware at the European facilities and the concepts for shipment to and essential processing at the launch site, are described. Primarily addressed is the intented use of the Space Station processing facility for these Columbus needs. A summary is presented in a scenario covering upload and download processing for the Columbus elements at KSC (Kennedy Space Center), Florida, U.S. ESA

N91-10793*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
THE INTEGRATED SCHEDULING SYSTEM: A CASE STUDY IN PROJECT MANAGEMENT
PETER C. BISHOP, DAVID B. LEARNED, and CISSY A. YOES Oct. 1989 117 p
(Contract NCC9-16)
(NASA-CR-187261; NAS 1.26:187261) Avail: NTIS HC/MF A06 CSCL 05A

A prototype project management system was developed for the Level III Project Office for the Space Station Freedom. The main goal was to establish a framework for the Space Station Project Office whereby Project and Office Managers can jointly establish and review scheduled milestones and activities. The objective was to assist office managers in communicating their objectives, milestones, schedules, and other project information more effectively and efficiently. Consideration of sophisticated project management systems was included, but each of the systems had limitations in meeting the stated objectives. Author

N91-11391*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DATA BASE ARCHITECTURE FOR INSTRUMENT CHARACTERISTICS CRITICAL TO SPACECRAFT CONCEPTUAL DESIGN
LAWRENCE F. ROWELL and CHERYL L. ALLEN Washington Nov. 1990 32 p
(NASA-TM-4213; L-16748; NAS 1.15:4213) Avail: NTIS HC/MF A03 CSCL 09B

Spacecraft designs are driven by the payloads and mission requirements that they support. Many of the payload characteristics, such as mass, power requirements, communication requirements, moving parts, and so forth directly affect the choices for the spacecraft structural configuration and its subsystem design and component selection. The conceptual design process, which translates mission requirements into early spacecraft concepts, must be tolerant of frequent changes in the payload complement and resource requirements. A computer data base was designed and implemented for the purposes of containing the payload characteristics pertinent for spacecraft conceptual design, tracking the evolution of these payloads over time, and enabling the integration of the payload data with engineering analysis programs for improving the efficiency in producing spacecraft designs. In-house tools were used for constructing the data base and for performing the actual integration with an existing program for optimizing payload mass locations on the spacecraft. Author

N91-12741# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.). Space Systems Group.
SPACECRAFT AUTONOMY CONCEPT VALIDATION BY SIMULATION: A FEASIBILITY ASSESSMENT
U. PAPE, A. N. PIDGEON (VEGA Space Systems Engineering, Saint-Albans, England), J. SVED, and R. WILKEIT 1990 6 p
Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H., Bremen, Fed. Republic of Germany
(MBB-UO-0100-90-PUB; ETN-90-98158) Avail: NTIS HC/MF A02

An assesment of the feasibility of simulating the functionality of an autonomous spacecraft and its ground control system by enhancing a simulator and control system is presented. The distributed, hierarchical onboard architecture based on an earlier ESA study, the Standard Generic Approach to Spacecraft Autonomy and Automation (SGASAA), is described. The architecture uses onboard tools for autonomous replanning and enhanced failure diagnosis. The ground control system will change to enable onboard event reconstruction and the implementation of the autonomous spacecraft simulator will reveal changes in the ground bases missions support role. ESA

N91-13363*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
FACTORS SHAPING THE EVOLUTION OF ELECTRONIC DOCUMENTATION SYSTEMS
CHRISTOPHER J. DEDE, TIM R. SULLIVAN, and JACQUE R. SCACE 1990 128 p
(Contract NCC9-16)
(NASA-CR-187257; NAS 1.26:187257) Avail: NTIS HC/MF A07 CSCL 05/2

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

N91-15212# European Space Agency, Paris (France).
INTERNATIONAL SYMPOSIUM ON ENVIRONMENTAL TESTING FOR SPACE PROGRAMMES: TEST FACILITIES AND METHODS
T. DUC GUYENNNE, ed. and JAMES J. HUNT, ed. Sep. 1990 535 p In ENGLISH and FRENCH Symposium held in Noordwijk, Netherlands, 26-29 Jun. 1990; sponsored by ESA
(ESA-SP-304; ISBN-92-9092-058-0; ISSN-0379-6566; ETN-91-98342) Copyright Avail: NTIS HC/MF A23

Organizational aspects cover verification concepts, product assurance, and safety and test centers. Thermal application facilities and electromagnetic testing facilities are described. Mechanical applications cover acoustics and dynamic testing. Facilities for special applications are included.

N91-15221# Aerospace Corp., El Segundo, CA.
THE EFFECTIVENESS AND COST BENEFITS OF SATELLITE ENVIROMENTAL ACCEPTANCE TESTS
O. HAMBERG, W. F. TOSNEY, and C. A. BRACKIN *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 69-73 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The effectiveness of satellite environmental acceptance tests in reducing early flight failures and the economic benefits of flight failure avoidances versus the cost of performing the tests are discussed. The results indicate that satellite early flight failures decrease with increases in the degree of environmental testing. For two programs used as case studies, the economic benefits due to environmental testing are shown to exceed the cost of the tests. Recommendations for future cost benefit studies using a predictive methodology are made. ESA

N91-15222# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Product Assurance Dept.
SAFETY ANALYSIS APPLIED TO TEST/VERIFICATION OF ESA SPACE SYSTEMS
T. A. MEAKER, C. PREYSSL, and N. WATTS *In its* International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 75-80 Sep. 1990
Copyright Avail: NTIS HC/MF A23

A safety analysis of test/verification of ESA space systems is presented. The system safety approach of ESA aims at the protection of life, and the minimization of risk of loss to space systems. Systematic safety analysis and hazard and risk reduction are drivers for the design and operation of ESA environmental test facilities and provide a major influence on the definition of test article specific operation procedures. ESA

N91-15225# Tsukuba Space Center, Ibaragi (Japan).
MANAGEMENT AND OPERATION OF ENVIRONMENTAL TEST FACILITY COMPLEX
T. OKUDA, M. TSUCHIYA, K. NOZAWA, T. YOSHIDA, K. TOMITA, and M. KINOSHITA (Advanced Engineering Services Co. Ltd., Isukuba City, Japan) *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 95-98 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The Spacecraft Integration and Test Building (SITE) was built by the National Space Development Agency of Japan (NASDA) in 1989, and is designed to perform developmental tests on future use large scale test objects such as large satellites which would be launched by H-2 rockets, space stations, space planes and so on. Many kinds of facilities are confined to one building with a fully sufficient test area which results in high test performance and parallel test plans availability. The operation and management of the SITE building and facilities are collectively controlled from an operation and control room. Test operations are carried out by contractors and supervised by NASDA to ensure safety and reliability. The management and operation of SITE are described. ESA

N91-15226# Academia Sinica, Beijing (China). Inst. of Environmental Test Engineering.
ENVIRONMENTAL TESTING FOR CHINESE COMMUNICATIONS SATELLITES
SHOU-QUAN KE and XUN-SHU JIN *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 99-101 Sep. 1990
Copyright Avail: NTIS HC/MF A23

An introduction to environmental testing program for Chinese communications satellites is presented. Some environmental tests at component, subsystem and system levels are described. The tests ensured successful entry and operation of communications satellites into geosynchronous orbits. ESA

N91-15227# Rotem Industries Ltd., Beer-Sheva (Israel).
THERMAL DESIGN AND CONTROL OF SPACE SIMULATION CHAMBERS IN ISRAEL
S. GRUNTMAN, E. KOCHAVI, J. OREN, E. TARAGAN, and M. ARAD *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 103-106 Sep. 1990
Copyright Avail: NTIS HC/MF A23

A set of space simulation chambers designed, manufactured, and constructed for Israeli space industry is considered. These chambers vary in size and in their thermal vacuum performances. Some of the thermal and control systems of these chambers are described and the considerations involved when determining the concepts of the thermal and control systems are discussed. ESA

N91-15228# Tsukuba Space Center, Ibaragi (Japan).
THIRTEEN METER DIAMETER SPACE SIMULATION TEST FACILITY
Y. NAKAMURA, T. TOMITA, N. ARATANI, S. IWASA, and S. SATOH *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 107-112 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The National Space Development Agency of Japan (NASDA) built a new spacecraft test center at Tsukuba Space Center (Japan) to cope with space activities in the next generation. The new test center called Spacecraft Integration and Test building (SITE) accommodates space simulation test facility, acoustic test facility, vibration test facility as main test facilities, and also alignment measuring system, mass properties measuring system, and integrated data handling system. The space simulation test facility has a usable volume of 13 m in diameter and 16 m in length, and has solar simulator of 6 m effective diameter. Design and performance of the facility is described. ESA

N91-15229# Tsukuba Space Center, Ibaragi (Japan).
SIXTEEN HUNDRED CUBIC METER ACOUSTIC TEST FACILITY
M. FUJITA and S. IIDE *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 113-116 Sep. 1990
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A new acoustic test facility, which is used for the acoustic test of the large spacecraft, was constructed in the Spacecraft Integration Test Building (SITE) at Tsukuba Space Center (Japan). The facility simulates the high intensity sound field, which is expected to occur during lift off and flight of the H-2 launch vehicle. After the facility was completed in September 1989, an acoustic test of the ETS-6 which is a 2 ton class geostationary satellite to be launched in 1993, was performed in October 1989. The design concept and the performance of the facility is described. ESA

N91-15230# Intespace, Toulouse (France).
SIMMER [SIMMER]
G. BOURES and G. VISIGNY *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 121-129 Sep. 1990 In FRENCH
Copyright Avail: NTIS HC/MF A23

The objectives of the SIMMER thermal vacuum chamber are outlined. SIMMER basically will consist of a horizontal cylinder 10 m in diameter incorporating the following general specifications: variable temperature of -173 to 100 C, vacuum 10 to 5 mbar, 1500 measuring lines. The SIMMER design and system is described. Thermal flexibility, integration with existing test facilities, simple pre and post tests, confidential testing, cost reduction in utilization and maintenance, availability and accessibility, are to be taken into account in optimization. ESA

N91-15234# Liege Univ. (Belgium). IAL Space.
IAL SPACE FACILITIES FOR THERMAL VACUUM TESTING
M. HENRIST, J. P. MACAU, I. DOMKEN, and A. CUCCHIARO *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 149-155 Sep. 1990
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The thermal vacuum facilities of IAL Space Research Center of the University of Liege (Belgium) for testing of the ESA payloads are addressed. They progressively upgraded for cryogenic payloads including 4 K (liquid helium temperature) experiments. The three vacuum chambers, ranging from 1.5 to 5 m diameter, including the corresponding capabilities in the vacuum, thermal and optical fields are reviewed. The various aspects of cleanliness, product assurance and quality control are presented. ESA

N91-15235# Liege Univ. (Belgium). IAL Space.
ISO OPTICAL CRYOGENIC TESTS IN THE IAL SPACE FOCAL-5 FACILITY
I. DOMKEN, P. GILSON, and A. CUCCHIARO *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 157-162 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Experimental constraints and set up for the ESA ISO (Infrared Space Observatory) payload cryogenic temperature tests are described. The cool down and warm up of the optics and telescope assembly without inducing of excessive material stresses is discussed. The support structure for maintenance of optical alignment is described. A general view of the FOCAL-5 facility is presented. The qualification of the payload measurement requirements are considered: image quality of the telescope through wave front error measurements and optical alignment of the scientific instruments with respect to the telescope axis and focus. ESA

N91-15236# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
IONOSPHERIC PLASMA SIMULATION IN A LARGE SPACE SIMULATOR
J.-P. LEBRETON, Y. ARNAL, and R. DEBRIE (Institut National des Sciences Appliquees, Routen, France) *In its* International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 163-164 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Environmental plasma tests which were carried out in the large space simulator are described. The mock up of the French/Soviet polar orbiting magnetospheric satellite ARCAD-3, equipped with its scientific payload and some subsystems, and the Spacelab-1 charged particle beam experiment PICPAB, were subjected to the tests. The characteristics of the plasma conditions which can be simulated in large space simulator are described; typically Low Earth Orbital (LEO) plasma conditions and the ionospheric environment of other planetary bodies, like Mars and Titan, targets of currently planned missions, are discussed. ESA

N91-15237# Fokker Space and Systems, Amsterdam (Netherlands). Thermal Control Dept.
REPRESENTATION OF EARTHSHINE IMPACT IN THE ERS-1 EM PAYLOAD TB/TV-TEST
W. KRUIDHOF, A. KAMP, and E. BOSLOOPER *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 165-171 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The ERS-1 EM (Electronics Module) payload was tested in the LSS (Large Space Simulator) facility in June/July 1989. The test included a Thermal Balance (TB) and a Thermal Vacuum (TV) test. For the thermal balance test an inventory was made of the need and the possibilities to compensate the missing earthshine during the test. A tradeoff taking into account all constraints on technical aspects (hardware and simulation) and cost and schedule aspects, was made, and resulted in the application of test heaters on the ERS-1. During the tradeoff period a radiometer was used in the ERS-1 EM thermal balance test to determine the radiative heat flux on some radiator areas of the payload electronics module. ESA

N91-15245# National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.
PERFORMANCE AND OPERATIONAL CAPABILITIES OF THE LARGE EUROPEAN ACOUSTIC FACILITY (LEAF)
F. SLINGERLAND, G. M. ELFSTROM, and W. E. GRUEN (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 241-247 Sep. 1990
Copyright Avail: NTIS HC/MF A23

LEAF is a 1677 cubic m reverberant chamber for the acoustic testing of satellites, recently installed at ESTEC. An extensive program of performance testing was just completed. Measured performance is compared with specifications and predictions in the areas of: nitrogen supply stability; sound field levels, uniformity and stability; chamber vibration; external disturbances during chamber operation. ESA

N91-15256# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. for Aeroelasticity.
EXPERIENCES WITH AND PROSPECTS FOR DYNAMIC MECHANICAL TESTING OF SPACECRAFT STRUCTURES
M. DEGENER and H. HUENERS *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 309-315 Sep. 1990
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Spacecraft structures are subjected to severe environmental mechanical loads especially during the launch phase. By means of flight load analysis using a dynamic mathematical model spacecraft have to be qualified to withstand all load events occurring during this phase. To verify the mathematical model of the spacecraft, system identification by means of experimental mechanical testing is a prerequisite. One of the most powerful methods for experimental system identification is the modal survey test based on the phase resonance method. The features of the modal survey test facility, with special emphasis on applications experiences, and improvements in the testing of current spacecraft structures are described. A second important field of mechanical testing is qualification testing by realistic simulation of the flight loads. In general, this is still being done by uniaxial shaker tests. Current trends in the development of multi axis vibration simulation systems are reviewed. ESA

N91-15261# Aeritalia S.p.A., Turin (Italy). Space Systems Group.
IRIS SPIN AND DEPLOYMENT TEST
P. MESSIDORO, M. BALLESIO, and M. MODENA *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 347-358 Sep. 1990
Copyright Avail: NTIS HC/MF A23

An attempt to simulate zero gravity effects in some particular tests is presented. The Italian research interim stage (IRIS) system characteristics and program, the test philosophy, the set up, and the instrumentation, are presented. Details on elaboration and evaluation criteria are included together with a presentation of test results. Judgement and final conclusions of these types of test, along with the relevant problems and possible improvements, are provided. A VHS system movie is provided as integrating documentation, in which a general overview of overall test activities is presented with an English commentary. ESA

N91-15262# Commissariat a l'Energie Atomique, Le Barp (France). CESTA Centrifuge Facility.
APPLICABILITY OF CENTRIFUGE TO TEST SPACE PAYLOADS
R. LABROT, Y. MARTIN, and C. PASCAL *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 359-362 Sep. 1990 In FRENCH; ENGLISH summary
Copyright Avail: NTIS HC/MF A23

Due to its technical performances and capacity, the centrifuge facility described remains the best adapted testing facility in Europe for static acceleration simulation for satellites or satellite elements during the propulsion phase. The facility makes it possible to create a field of uniform constraints highlighting possible structural failures that may arise. The model to be tested is placed at the end of a 10 m radius arm end subjected to the requested static acceleration. For space activities, the accelerations never go over 25 g but the centrifuge facility can take 2 T up to 100 g. A computer controlled measurement unit enables the acquisition of physical parameters (strain gage, shift, etc.), with a capacity of 200 chanels. The facility can test components under combined environments: climatic, vibration, and static acceleration. ESA

N91-15270# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
HIGH ACCURACY PHOTOGRAMMETRIC SYSTEM FOR THE LARGE SPACE SIMULATOR AT ESTEC
N. NIKOLAIZIG and W. WESTER-EBBINGHAUS (Technische Univ., Brunswick, Germany, F.R.) *In its* International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 409-412 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The inclusion of close range photogrammetry into the Large Space Simulator (LSS), as useful in three dimensional coordinate measurement of large spacecraft structures, is addressed. The basic principles of close range photogrammetry are outlined. The specific requirements imposed on a photogrammetry system to be employed in space simulation test facilities are reflected. Candidate photogrammetry systems comprising cameras, automated monocomparators as well as data reduction software are presented. Concepts to integrate such a system into the LSS and operational aspects are addressed. ESA

N91-15286# British Aerospace Public Ltd. Co., Stevenage (England).
AN RF ANECHOIC LOAD ASSEMBLY FOR USE DURING SPACECRAFT SOLAR SIMULATION TESTING
P. HINCHLEY *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 521-527 Sep. 1990
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With any multicarrier communications spacecraft it is important, once the connection of the high power RF interfaces have been made during the assembly and integration phase, that those interfaces are not disturbed if the RF integrity is to be maintained. However, an integral and important component of the protoflight and flight acceptance environmental test phases of a communications spacecraft is the on station Solar Simulation Test (SST). During this test the communications' performance parameters are required to be checked over the in orbit operational temperature range. To enable the on station SST to be conducted without demating the high power interfaces and thus allowing the transmit antenna arrays to develop the full designed Effective Isotropic Radiated Power (EIRP), the RF energy has to be absorbed. The design, development and subsequent use of the RF anechoic load used during the SST on the IMARSAT-2 program are described. ESA

N91-15287# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
RADIATING PAYLOAD TESTING IN THE LARGE COMPACT PAYLOAD TEST RANGE AT ESTEC
J. REDDY and P. BENGTSSON *In its* International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 529-532 Sep. 1990
Copyright Avail: NTIS HC/MF A23

As satellites and their payloads become more complex, the means by which the in orbit performance can be verified on the ground also become more complex. This is particularly true for radiating payloads where the satellite itself is a part of a complex system comprising ground, in orbit and ground/sea/air segments. The European Space Research and Technology Center (ESTEC) Compact Payload Test Range (CPTR) which was developed to allow RF performance measurements (including electromagnetic compatibility) for payloads including multibeam communications, reconfigurable antennas, phased arrays and synthetic aperture radars, is described. ESA

N91-15288# Physikalisch-Technische Studien G.m.b.H., Freiburg (Germany, F.R.).
A COMBINED TEST FACILITY FOR SPACE RESEARCH AND TECHNOLOGY
G. STASEK, R. WIRTH, and P. SEIDL *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 535-539 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The combined test facility IONospheric Atmospheric Simulator (IONAS), suitable for testing even large satellite subsystems in simulated low Earth orbital and geosynchronous Earth orbital space environments, is described. Numerous combinations with light, plasma, electron sources and various optical systems cover a wide range of potential experiment specific requirements. The most important technical aspects of the facility and of the various add on systems are summarized and typical applications are presented. ESA

N91-15289# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).

EVALUATION OF AIRBORNE AND SETTLED PARTICULATE CONTAMINATION IN A CONTROLLED ENVIRONMENT FOR SPACECRAFT TESTING AND MOLECULAR CONTAMINATION MEASUREMENTS DURING SPACECRAFT THERMAL VACUUM TESTS

H. ABELE and F. RESCH *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 541-546 Sep. 1990

Copyright Avail: NTIS HC/MF A23

The two kinds of particle contamination monitoring are airborne and settled particulate contamination measurement. The experiences gained with both methods in a controlled environment are presented. It is demonstrated that particle deposition is heavily dependent on the amount of activities even if the number of airborne particles remains unchanged. An attempt is made to compare the results of both measurement methods. Not only particulate contamination can become critical for spacecraft but also the effects of molecular organic contamination. Different methods for the detection of the molecular contamination exist but only few provide the capability of material species identification. Results obtained with the indirect method of molecular contamination measurement are described. Results of the molecular contamination measurements inside a space simulation chamber during tests and dry runs are presented. ESA

N91-15290# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).

PUMPDOWN AND REPRESSURIZATION PROCEDURE FOR THERMAL VACUUM TESTS

H. E. NUSS and I. STREUFF *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 547-550 Sep. 1990

Copyright Avail: NTIS HC/MF A23

Molecular contamination of spacecraft during assembly, integration and environmental testing is a continuing subject for the present and future programs because of its significant impact on spacecraft performance. The pumpdown and repressurization procedure for space simulation and thermal vacuum chamber WSA/TVA is described. The sequence was optimized with respect to potential contamination and to facility operation. ESA

N91-15714*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SUBSYSTEMS COMPONENT DEFINITIONS SUMMARY PROGRAM

A. DON SCOTT, CAROLYN C. THOMAS, LISA C. SIMONSEN, and JOHN B. HALL, JR. Feb. 1991 17 p

(NASA-TM-4247; L-16827; NAS 1.15:4247) Avail: NTIS HC/MF A03 CSCL 09/2

A computer program, the Subsystems Component Definitions Summary (SUBCOMDEF), was developed to provide a quick and efficient means of summarizing large quantities of subsystems component data in terms of weight, volume, resupply, and power. The program was validated using Space Station Freedom Program Definition Requirements Document data for the internal and external thermal control subsystem. Once all component descriptions, unit weights and volumes, resupply, and power data are input, the user may obtain a summary report of user-specified portions of the subsystem or of the entire subsystem as a whole. Any combination or all of the parameters of wet and dry weight, wet and dry volume, resupply weight and volume, and power may be displayed. The user may vary the resupply period according to individual mission requirements, as well as the number of hours per day power consuming components operate. Uses of this program are not limited only to subsystem component summaries. Any applications that require quick, efficient, and accurate weight, volume, resupply, or power summaries would be well suited to take advantage of SUBCOMDEF's capabilities. Author

N91-16832*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SPACE STATION FREEDOM RESOURCE ALLOCATION ACCOMMODATION OF TECHNOLOGY PAYLOAD REQUIREMENTS

DON E. AVERY, LISA D. COLLIER, and CHARLES F. GARTRELL (General Research Corp., Washington, DC.) Nov. 1990 32 p

(NASA-TM-102766; NAS 1.15:102766) Avail: NTIS HC/MF A03 CSCL 05/1

An overview of the Office of Aeronautics, Exploration, and Technology (OAET) Space Station Freedom Technology Payload Development Program is provided, and the OAET Station resource requirements are reviewed. The requirements are contrasted with current proposed resource allocations. A discussion of the issues and conclusions are provided. It is concluded that an overall 20 percent resource allocation is appropriate to support OAET's technology development program, that some resources are inadequate even at the 20 percent level, and that bartering resources among U.S. users and international partners and increasing the level of automation may be viable solutions to the resource constraint problem. Author

N91-18143*# Minnesota Univ., Minneapolis.

BICONIC CARGO RETURN VEHICLE WITH AN ADVANCED RECOVERY SYSTEM

In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 137-144 Nov. 1990

Avail: NTIS HC/MF A14 CSCL 22/2

The current space exploration initiative is focused around the development of the Space Station Freedom (SSF). Regular resupply missions must support a full crew on the station. The present mission capability of the shuttle is insufficient, making it necessary to find an alternative. One alternative is a reusable Cargo Return Vehicle (CRV). The suggested design is a biconic shaped, dry land recovery CRV with an advance recovery system (ARC). A liquid rocket booster will insert the CRV into a low Earth orbit. Three onboard liquid hydrogen/liquid oxygen engines are used to reach the orbit of the station. The CRV will dock to the station and cargo exchange will take place. Within the command and control zone (CCZ), the CRV will be controlled by a gaseous nitrogen reaction control system (RCS). The CRV will have the capability to exchange the payload with the Orbital Maneuvering Vehicle (OMV). The bent biconic shape will give the CRV sufficient crossrange to reach Edwards Air Force Base and several alternative sites. Near the landing site, a parafoil-shaped ARS is deployed. The CRV is designed to carry a payload of 40 klb, and has an unloaded weight of 35 klb. Author

N91-18144*# Minnesota Univ., Minneapolis.

WINGED CARGO RETURN VEHICLE CONCEPTUAL DESIGN

In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 145-151 Nov. 1990

Avail: NTIS HC/MF A14 CSCL 22/2

NASA is committed to placing a permanent space station in Earth orbit in the 1990's. Space Station Freedom (SSF) will be located in a 220 n.m. orbit at 28.5 degrees inclination. The Winged Cargo Return Vehicle's (CRV) primary mission is to support SSF crew by flying regular resupply missions. The winged CRV is designed to be reusable, dry land recoverable, and unmanned. The CRV will be launched inline on three liquid hydrogen/oxygen rocket boosters with a payload capacity of 113,000 lbs. The three boosters will take the CRV to an orbit of 50 by 110 n.m. From this altitude the orbital manuevering engine will place the vehicle in synchronous orbit with the space station. The winged CRV will deliver cargo modules to the space station by direct docking or by remaining outside the SSF command zone and using the Orbital Maneuvering Vehicle (OMV) to transfer cargo. After unloading/loading, the CRV will deorbit and fly back to Kennedy Space Center. The CRV has a wing span of 57.8 feet, a length of 76.0 feet, and a dry weight of 61.5 klb. The cargo capacity of the vehicle is 44.4 klb. The vehicle has a lift-drag ratio of 1.28

(hypersonic) and 6.0 (subsonic), resulting in a 1351 n.m. cross range. The overall mission length ranges between 18.8 and 80.5 hr. The operational period will be the years 2000 to 2020.
Author

N91-18455*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE LANGLEY RESEARCH CENTER CSI PHASE-0 EVOLUTIONARY MODEL TESTBED-DESIGN AND EXPERIMENTAL RESULTS
W. K. BELVIN, LUCAS G. HORTA, and K. B. ELLIOTT Jan. 1991 21 p Presented at the 4th NASA/DOD CSI Conference, Orlando, FL, 5-7 Nov. 1990
(NASA-TM-102762; NAS 1.15:102762) Avail: NTIS HC/MF A03 CSCL 20/11

A testbed for the development of Controls Structures Interaction (CSI) technology is described. The design philosophy, capabilities, and early experimental results are presented to introduce some of the ongoing CSI research at NASA-Langley. The testbed, referred to as the Phase 0 version of the CSI Evolutionary model (CEM), is the first stage of model complexity designed to show the benefits of CSI technology and to identify weaknesses in current capabilities. Early closed loop test results have shown non-model based controllers can provide an order of magnitude increase in damping in the first few flexible vibration modes. Model based controllers for higher performance will need to be robust to model uncertainty as verified by System ID tests. Data are presented that show finite element model predictions of frequency differ from those obtained from tests. Plans are also presented for evolution of the CEM to study integrated controller and structure design as well as multiple payload dynamics.
Author

N91-18798# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.
GROUND-BASED TESTING OF SPACE NUCLEAR POWER PLANTS
THOMAS G. MCDONALD 22 Oct. 1990 34 p
(Contract DE-AC07-76ID-01570)
(DE91-006179; EGG-ME-9338) Avail: NTIS HC/MF A03

Small nuclear power plants for space applications are evaluated according to their testability in this two part report. The first part introduces the issues involved in testing these power plants. Some of the concerns include oxygen embrittlement of critical components, the test environment, the effects of a vacuum environment on materials, the practically of racing an activated test chamber, and possible testing alternative the SEHPTR, king develop at the Idaho National Engineering Laboratory.
DOE

N91-19143*# National Research Council of Canada, Ottawa (Ontario). Inst. for Aerospace Research.
NON-LINEAR GENERATION OF ACOUSTIC NOISE IN THE IAR SPACECRAFT
R. WESTLEY, K. NGUYEN, and M. S. WESTLEY *In* NASA, Goddard Space Flight Center, 16th Space Simulation Conference Confirming Spaceworthiness Into the Next Millennium p 195-210 Nov. 1990
Avail: NTIS HC/MF A20 CSCL 20/1

The requirement to produce high level acoustic noise fields with increasing accuracy in environmental test facilities dictates that a more precise understanding is required of the factors controlling nonlinear noise generation. Details are given of various nonlinear effects found in acoustic performance data taken from the IAR Spacecraft Acoustic Chamber. This type of data has enabled the IAR to test large spacecraft to relatively tight acoustic tolerances over a wide frequency range using manually set controls. An analog random noise automatic control system was available and modified to provide automatic selection of the chamber's spectral sound pressure levels. The automatic control system when used to complete a typical qualification test appeared to equal the accuracy of the manual system and had the added advantage that parallel spectra could be easily achieved during preset tests.
Author

N91-19150*# Chicago Bridge and Iron Co., Oak Brook, IL.
SPACE SIMULATION FACILITIES PROVIDING A STABLE THERMAL VACUUM FACILITY
MARTIN L. TELLALIAN *In* NASA, Goddard Space Flight Center, 16th Space Simulation Conference Confirming Spaceworthiness Into the Next Millennium p 289-313 Nov. 1990
Avail: NTIS HC/MF A20 CSCL 14/2

CBI has recently constructed the Intermediate Thermal Vacuum Facility. Built as a corporate facility, the installation will first be used on the Boost Surveillance and Tracking System (BSTS) program. It will also be used to develop and test other sensor systems. The horizontal chamber has a horseshoe shaped cross section and is supported on pneumatic isolators for vibration isolation. The chamber structure was designed to meet stability and stiffness requirements. The design process included measurement of the ambient ground vibrations, analysis of various foundation test article support configurations, design and analysis of the chamber shell and modal testing of the chamber shell. A detailed 3-D finite element analysis was made in the design stage to predict the lowest three natural frequencies and mode shapes and to identify local vibrating components. The design process is described and the results are compared of the finite element analysis to the results of the field modal testing and analysis for the 3 lowest natural frequencies and mode shapes. Concepts are also presented for stiffening large steel structures along with methods to improve test article stability in large space simulation facilities.
Author

N91-19151*# Liege Univ. (Belgium). Centre de Recherches IAL SPACE.
THE SPACE SIMULATION FACILITIES AT IAL SPACE
M. HENRIST, A. CUCCHIARO, I. DOMKEN, and J. P. MACAU *In* NASA, Goddard Space Flight Center, 16th Space Simulation Conference Confirming Spaceworthiness Into the Next Millennium p 314-322 Nov. 1990
Avail: NTIS HC/MF A20 CSCL 14/2

The thermal vacuum facilities of IAL SPACE were tailored for testing of the ESA payloads. They were progressively upgraded for cryogenic payloads including 4 K (liquid helium temperature) experiments. A detailed review of the three vacuum chambers, ranging from 1.5 to 5 m diameter, is presented including the corresponding capabilities in the vacuum, thermal, and optical fields. The various aspects of cleanliness, product assurance, and quality control are also presented.
Author

N91-20672*# Ford Aerospace Corp., Sunnyvale, CA. Artificial Intelligence Group.
CHALLENGES IN BUILDING INTELLIGENT SYSTEMS FOR SPACE MISSION OPERATIONS
WAYNE HARTMAN *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 259-263 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 09/2

The purpose here is to provide a top-level look at the stewardship functions performed in space operations, and to identify the major issues and challenges that must be addressed to build intelligent systems that can realistically support operations functions. The focus is on decision support activities involving monitoring, state assessment, goal generation, plan generation, and plan execution. The bottom line is that problem solving in the space operations domain is a very complex process. A variety of knowledge constructs, representations, and reasoning processes are necessary to support effective human problem solving. Emulating these kinds of capabilities in intelligent systems offers major technical challenges that the artificial intelligence community is only beginning to address.
Author

N91-20690*# Boeing Computer Services Co., Huntsville, AL. Artificial Intelligence Center.
A KNOWLEDGE-BASED APPROACH TO CONFIGURATION LAYOUT, JUSTIFICATION, AND DOCUMENTATION
F. G. CRAIG, D. E. CUTTS, T. R. FENNEL, C. M. CASE, and J. R. PALMER (Boeing Aerospace and Electronics Co., Huntsville,

AL.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 393-396 Jan. 1991 Previously announced in IAA as A90-27286
Copyright Avail: NTIS HC/MF A21 CSCL 12/1

The design, development, and implementation of a prototype expert system which could aid designers and system engineers in the placement of racks aboard modules on the Space Station Freedom are described. This type of problem is relevant to any program with multiple constraints and requirements demanding solutions which minimize usage of limited resources. This process is generally performed by a single, highly experienced engineer who integrates all the diverse mission requirements and limitations, and develops an overall technical solution which meets program and system requirements with minimal cost, weight, volume, power, etc. This system architect performs an intellectual integration process in which the underlying design rationale is often not fully documented. This is a situation which lends itself to an expert system solution for enhanced consistency, thoroughness, documentation, and change assessment capabilities. Author

N91-20700*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PARALLEL PROCESSING AND EXPERT SYSTEMS
JERRY C. YAN (Sterling Federal Systems, Inc., Moffett Field, CA.) and SONIE LAU *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 469-476 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 09/2

Whether it be monitoring the thermal subsystem of Space Station Freedom, or controlling the navigation of the autonomous rover on Mars, NASA missions in the 90's cannot enjoy an increased level of autonomy without the efficient use of expert systems. Merely increasing the computational speed of uniprocessors may not be able to guarantee that real time demands are met for large expert systems. Speed-up via parallel processing must be pursued alongside the optimization of sequential implementations. Prototypes of parallel expert systems have been built at universities and industrial labs in the U.S. and Japan. The state-of-the-art research in progress related to parallel execution of expert systems was surveyed. The survey is divided into three major sections: (1) multiprocessors for parallel expert systems; (2) parallel languages for symbolic computations; and (3) measurements of parallelism of expert system. Results to date indicate that the parallelism achieved for these systems is small. In order to obtain greater speed-ups, data parallelism and application parallelism must be exploited. Author

04

SPACE ENVIRONMENTS

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

A91-10140#
SPACE DEBRIS - CAN POLICY AVOID DISASTER?
WILLIAM B. WIRIN (Colorado, University, Colorado Springs) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3774) Copyright

The contents of formal reports on space debris submitted to the ESA Director General and to the U.S. National Security Council are discussed. The ESA report was forceful in its call for policy solutions. The U.S. report found that the limitations on debris measurement and the consequent limitations in debris environment modeling create sufficiently uncertainty concerning the urgency of action and the effectiveness of any particular mitigation effort; it therefore called for enhanced measurement capabilities. The U.S. is prepared to enter into multilateral disssuioons with space faring nations. B.J.

A91-10142#
LEGAL IMPLEMENTATION OF ORBITAL DEBRIS MITIGATION PRACTICES - A SURVEY OF OPTIONS AND APPROACHES
PAMELA L. MEREDITH (Space Conform, Inc., Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3778) Copyright

An overview is presented of options for future legal input to resolution of the problem of earth orbital debris from civil sources. The roles of the FCC, the Office of Commercial Space Transportations, and of NOAA in formulating U.S. domestic law in the space debris area are addressed. The roles of the Committee on Peaceful Uses of Outer Space, the International Telecommunication Union, and the Conference of Spacefaring Nations in formulating relevant international law are examined. C.D.

A91-10203*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SUMMARY OF THE AIAA/NASA/DOD ORBITAL DEBRIS CONFERENCE - TECHNICAL ISSUES AND FUTURE DIRECTIONS
A. POTTER, D. KESSLER, R. NIEDER (NASA, Johnson Space Center, Houston, TX), and R. REYNOLDS (System Planning Corp., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 15 p.
(AIAA PAPER 90-3860)

An international conference on orbital debris was held on April 16-19, 1990, in Baltimore, Maryland. Topics of the conference included the implications of orbital debris for space flight, orbital debris measurements, modeling of the orbital debris environment, and methods to reduce the growth of the orbital debris population. Significant results from this meeting are summarized. Author

A91-10204#
THE GOVERNMENT'S RESPONSE TO THE INTERAGENCY REPORT ON ORBITAL DEBRIS
JAMES P. AHERN (DOD, Space Policy Directorate, Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 5 p.
(AIAA PAPER 90-3861)

This paper discusses the report on the implementation of the national policy regarding the creation of space debris, provided by the Interagency Group (Space), together with the results of the review of this report by the Orbital Debris Subcommittee of the AIAA's Space Operations and Support Technical Committee of the draft research plan. As a result of the review, 20 tasks were ear-marked for inclusion as orbital debris research objectives. The paper describes these objectives and the ultimate Orbital Debris Research Plan, which was submitted to the National Space Council Staff in May 1990, and approved in July the same year. I.S.

A91-10205#
DEFINING ORBITAL DEBRIS ENVIRONMENTAL CONDITIONS FOR SPACECRAFT VULNERABILITY ASSESSMENT
R. REYNOLDS, P. ANZ-MEADOR, and G. OJAKANGAS AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 25 p. refs
(AIAA PAPER 90-3862)

The major problem of orbital debris is not that of catastrophic collision, which fragments the space structure and which has been the focus of attention for orbital-debris environment evolution, but instead the threat of collisions with smaller debris objects that can damage the structure. In this paper, the debris environment is defined in a manner that supports the analysis of vulnerability of a particular space platform to the debris environment. Flux directionality functions related to surface penetrability, which are seen to be various velocity moments of the phase-space debris-density distribution, are derived for both the man-made debris environment and for a simple model of the meteoroid environment. A first-order model for the role of shielding of spacecraft surfaces by other spacecraft components, and the concomitant enhancement of secondaries from these same directions, is presented. Author

A91-10206#
ORBITAL DEBRIS ENVIRONMENT
G. W. OJAKANGAS, P. ANZ-MEADOR (Lockheed Engineering and Sciences Co., Houston, TX), and R. REYNOLDS (Systems Planning Corp., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 21 p. refs
(AIAA PAPER 90-3863) Copyright

A detailed computer model termed EVOLVE, developed at the NASA Johnson Space Center, is described. The EVOLVE program was designed to simulate the time-evolving debris environment in LEO and the threat posed by this debris. The program was run for the period from 1957 through 1989, with known historical space traffic and on-orbit fragmentations used as input. Orbits of intact objects are evolved in time using the routines of Mueller (1981) under the time-varying solar flux estimation of Hopson (1988). Debris clouds generated by on-orbit explosions and collisions are described by empirically-derived functions of altitude and time. Using a Monte Carlo method, a large number of possible future debris environments are generated for calculating means and standard deviations. I.S.

A91-10207*# Cincinnati Univ., OH.
A HIGH SEVERITY SPACE HAZARD - ORBITAL DEBRIS
G. K. BAHR and P. J. DISIMILE (NASA, Center for Health Monitoring Technology for Space Propulsion Systems; Cincinnati, University, OH) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 6 p. refs
(AIAA PAPER 90-3865) Copyright

This paper examines the orbital debris-meteoroid hazard that will be encountered by the Space Station Freedom. Recent reports on the orbital debris studies are discussed with special attention given to the procedures and techniques that can be used to minimize the impact damage, to avoid the collision, and to design shielding distribution so as to reduce the penetration damage. I.S.

A91-10208*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RADAR OBSERVATIONS OF ORBITAL DEBRIS AT NASA JOHNSON SPACE CENTER
E. G. STANSBERY and J. F. STANLEY (NASA, Johnson Space Center, Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 5 p.
(AIAA PAPER 90-3868) Copyright

This paper describes the original Debris Environment Characterization Radar concept and the design verification experiments developed and carried out with the purpose of establishing methods for assessing the hazards to the Space Station Freedom from radar measurements. Three design verification experiments, utilizing the Arecibo, the Goldstone, and the ALCOR radars were performed. Data obtained from RCS measurements of a representative sample of debris from ground-test hypervelocity impacts and from explosions of simulated satellites will be used to establish a relationship between the physical size of a randomly shaped debris object and its RCS. I.S.

A91-10209#
VERIFICATION AND VALIDATION OF ALGORITHMS FOR OBTAINING DEBRIS DATA USING HIGH FREQUENCY RADARS
NICHOLAS YOUNG and GEORGE BOHANNON (XonTech, Inc., San Bernardino, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3869) Copyright

This paper describes experiments conducted to support the development of algorithms for estimating the orbital debris size from data of high-frequency radars. The activities include data collection from the X-band Haystack radar, the analysis of hypervelocity impact ground test results, static RCS measurements on debris objects, and RCS calculations/simulations. The set of algorithms developed on the basis of these data will be used for calculating the orbital debris flux and the most probable debris size, and for making uncertainty estimates. I.S.

A91-10210*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
CCD OBSERVATIONS OF ORBITAL DEBRIS
KARL G. HENIZE, CHRISTINE A. O'NEILL (NASA, Johnson Space Center, Houston, TX), and MARK K. MULROONEY (Lockheed Engineering and Sciences Co., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p.
(AIAA PAPER 90-3870) Copyright

A portable 31 cm aperture f/1.3 Schmidt telescope with a CCD sensor at the prime focus has been designed and constructed to carry out photometric studies of earth-orbiting debris. When operated in the time delay integration mode in which the readout rate is matched to the predicted motion of the satellite, this system reaches a limiting diameter of about 10 cm for particles at 400 km height and albedo 0.1. It is used for statistical studies of phase angle effects and for swarm-to-swarm albedo differences between several selected debris groups which include the Cosmos 1275, Cosmos 1375, Landsat 1, Landsat 3, NOAA 3, Nimbus 4, Solwind, and Spot-1/Viking groups. Author

A91-10211*# Lockheed Engineering and Sciences Co., Houston, TX.
A SPACE-BASED CONCEPT FOR A COLLISION WARNING SENSOR
DAVID L. TALENT (Lockheed Engineering and Sciences Co., Houston, TX) and FAITH VILAS (NASA, Johnson Space Center, Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p. refs
(AIAA PAPER 90-3871) Copyright

This paper describes a concept for a space-based collision warning sensor experiment, the Debris Collision Warning Sensor (DCWS) experiment, in which the sensor will rely on passive sensing of debris in optical and IR passband. The DCWS experiment will be carried out under various conditions of solar phase angle and pass geometry; debris from 1.5 m to 1 mm diam will be observable. The mission characteristics include inclination in the 55-60 deg range and an altitude of about 500 km. The results of the DCWS experiment will be used to generate collision warning scenarios for the Space Station Freedom. I.S.

A91-10222#
TRACK TWO DIPLOMACY - AN INTERNATIONAL FRAMEWORK FOR CONTROLLING ORBITAL DEBRIS
DARREN S. MCKNIGHT (U.S. Air Force Academy, Colorado Springs, CO) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p. refs
(AIAA PAPER 90-3896)

Orbital debris is gaining increasing worldwide attention due to its potential for disrupting the international space infrastructure in the years to come. This paper proposes a framework for multinational cooperation that will help to control the growth of artificial space debris through Track Two Diplomacy. This style of diplomatic process emphasizes the use of citizen-to-citizen interaction. With discussions and negotiations being performed at the lowest level possible many of the liabilities of formal government-to-government interactions are avoided. The proposed Orbital Debris Action Committee (ODAC) would be the international group responsible for the development of action plans to be delivered to space faring countries representing consensus procedures and policies to control orbital debris. The time for talk is over - the international aerospace community must work together to act toward the preservation of our near earth space environment. Author

A91-10224#
HISTORICAL GROWTH OF QUANTITIES AFFECTING ON-ORBIT COLLISION HAZARD
DARREN S. MCKNIGHT (U.S. Air Force Academy, Colorado Springs, CO) and PHILLIP D. ANZ-MEADOR (Lockheed Engineering and Management Services Co., Inc., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p.
(AIAA PAPER 90-3902)

The probability of collision (PC) between an operational satellite in low earth orbit and the orbital debris environment is mainly a function of spatial density of the debris population, collision cross-section, relative impact velocity, and mission duration. Routinely only changes in spatial density and parent satellite size are used to account for changes in the PC as a function of altitude and time. This paper identifies historical changes to the on-orbit population that would affect the relative velocity and collision cross-section. Changes in the relative kinetic energy of an impact are also calculated. The analysis shows that the average relative velocity, collision cross-section, and relative energy of impact have increased over time due to alterations in the cataloged population. While changes in spatial density are found to have a dominating effect on PC values the other factors studied have a small effect on the PC but substantially influence the energy of representative impacts. Author

A91-10225#
DEBRIS CLOUDS IN ECCENTRIC ORBITS
ALAN B. JENKIN and MARLON E. SORGE (Aerospace Corp., El Segundo, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 15 p. refs
(AIAA PAPER 90-3903) Copyright

The short-term behavior of a debris cloud in an orbit with a semimajor axis of 7000 km and an eccentricity of 0.5 is investigated by estimating the effect of eccentricity on the cloud shape and computing the in-track particle density variations due to variable tangential velocity. A method was developed to calculate the cloud volume needed to compute collision probabilities. The results of these calculations showed that the behavior of debris clouds in eccentric orbits is considerably more complex than the behavior of clouds in circular orbits, described by Chobotov et al. (1988). I.S.

A91-10226#
AN ANALYTIC DESCRIPTION OF DEBRIS CLOUD EVOLUTION STARTING FROM THE EQUATIONS OF MOTION
G. W. OJAKANGAS (Lockheed Engineering and Sciences Co., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 15 p. refs
(AIAA PAPER 90-3904) Copyright

Results are presented of computations for a versatile model of the debris cloud evolution. The evolution of a debris cloud is described using an approach in which the equations of motion of particles in a cloud are solved collectively. The resulting system of time-varying orbital elements is transformed into an analytical expression of spatial density as a function of time and altitude. I.S.

A91-10227#
SPACE DEBRIS AND MICROMETEORITE EVENTS EXPERIENCED BY WL EXPERIMENT 701 IN PROLONGED LOW EARTH ORBIT
D. S. MCKNIGHT, R. E. DUEBER (U.S. Air Force Academy, Colorado Springs, CO), and E. W. TAYLOR (USAF, Weapons Laboratory, Kirtland AFB, NM) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 17 p. refs
(AIAA PAPER 90-3905) Copyright

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

A91-12336
AN EVALUATION OF THE MASS AND NUMBER OF SATELLITES IN LOW EARTH ORBIT
DARREN MCKNIGHT (U.S. Air Force Academy, Colorado Springs, CO) and NICHOLAS JOHNSON (Teledyne Brown Engineering, Huntsville, AL) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 943-948. refs
Copyright

The number and mass of objects in earth orbit provide two measures of hazard to satellites. Since 1972 the number of objects in the satellite catalog has tripled. Analysis shows that an increase in catalog population may not directly correlate to an increase in hazard. Since 1961 delayed cataloging of debris has masked the actual growth rate of 240 objects per year. The mass in low earth orbit is calculated to be between 1500 to 2000 metric tons. The status and growth of the number and mass of debris in orbit must be better understood before effective countermeasures to orbital debris may be formulated. Author

A91-12337
COLLISION RISK IN SPACE - DETAILED ANALYSIS AND BASIC CONSEQUENCES FOR DESIGN AND OPERATION OF LARGER STRUCTURES
P. EICHLER and D. REX (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 949-964. Research supported by BMFT.
Copyright

The detailed analysis of collision risks, possible reduction of risk, and cost of shielding are discussed. The number and origin of the objects and object density and collision risk in the near earth environment are considered and it is estimated that about 30,000 to 140,000 objects greater than 1 cm exist in this environment. A detailed collision analysis is presented with the help of a deterministic method of calculation. In order to investigate the angle, velocity, and mass distribution of the object flux, the orbital mechanics of each individual object in earth orbit is taken into consideration. The object flux in the near earth environment was found to depend strongly on the incidence angle. A strong accumulation inside the debris plane is also apparent, depending on the inclination of the target orbit. These features can be made use of by skillful selection of the structure or attitude orientation of larger structures in order to reduce the object flux and thus the shielding necessary. For this, the varying attitude orientations of a cylinder, which correspond to the Columbus in free flight, the MTFF or the Polar Platform, are investigated. L.K.S.

A91-12338
ORBITAL ANALYSES OF A DEBRIS POPULATION IN A SUN-SYNCHRONOUS ORBIT [ANALYSES ORBITALES DE L'ENSEMBLE DES DEBRIS SUR UNE ORBITE HELIOSYNCHRONE]
F. NOUEL (CNES, Toulouse, France) and J. Y. BURGAUD (Ecole Nationale Superieure d'Electrotechnique, d'Electronique, d'Informatique et d'Hydraulique, Toulouse, France) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 965-980. In French. refs
Copyright

On Feb. 22, 1986, Ariane 1 launched two satellites into LEO: Spot 1 and Viking. On Nov. 13, 1986, the third stage of the rocket, which had been in orbit near Spot 1, exploded, creating more than 450 bits of debris, detected by NORAD. This paper presents the results of an analysis of this debris population over the course of a year. An effort was made to reconstruct the spatial distribution of momenta imparted to the debris in the explosion. The analyses are performed on the basis of standard celestial mechanics techniques, e.g., the Gabbard diagram and the Meirovitch equations. B.J.

A91-13400
THE JUNKYARD IN THE SKY
BARBARA WOOD-KACZMAR New Scientist (ISSN 0262-4079), vol. 128, Oct. 13, 1990, p. 36-40.
Copyright
An account is given of the nature and current and prospective severity of the orbital space debris problem, from LEO to GEO. It has been hypothesized that so much debris will accumulate in the next few years that random collisions will set off an avalanche of secondary collisions in a runaway cascade; the resulting belt of small debris particles would render spaceflight impossible for several centuries. While NASA has postulated that such a critical mass will be reached before the middle of the next century, other researchers have calculated the critical mass to lie only a factor of 2 or 3 beyond the current population of 70,000 fragments 1 cm across or larger. This could make spaceflight impossible in as little as 20-30 years O.C.

A91-14080#
DISPERSION OF DEBRIS CLOUDS FROM ON-ORBIT FRAGMENTATION EVENTS
RUEDIGER JEHN (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-565) Copyright
The fragmentation of a satellite creates numerous debris. A new approach is chosen to model in four phases the dispersion of an ensemble of particles which originates from a common breakup point. During the first revolutions the ensemble is represented as a pulsating ellipsoid in an orbiting reference system (phase A). Within a few hours, the cloud spreads out to the shape of a torus (phase B). Due to the nonsphericity of the earth, different drift rates in ascending node and argument of perigee cause the torus to open to a band limited in latitude by the inclination of the parent satellite (phase C). In the last phase (D), starting after complete nodal and apsidal dispersion, only the cleaning effect of air drag has to be considered. Consequences for the LEO environment of fragmentations like that of the Ariane V-16 third stage in 1986 are investigated. Spatial density and collisional risk diminish quickly in the direct vicinity of the breakup point, but remain significant for years in a broad environment. Author

A91-14081#
AN ASSESSMENT OF ACTIVE REMOVAL AS AN OPTION FOR MITIGATING THE SPACE DEBRIS ENVIRONMENT
THOMAS E. ALBERT and WILLIAM B. MARGOPOULOS (Science Applications International Corp., Clearwater, FL) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p. refs
(IAF PAPER 90-568) Copyright
Future space activities in Low Earth Orbit (LEO) are threatened by the expected growth of the artificial space debris environment. If actions to minimize the generation of debris are not globally implemented, portions of the LEO region may become unacceptably hazardous for some missions within a few decades. A model has been developed to predict the effects of active removal as a management option on the future catastrophic collision hazard to spacecraft. The model incorporates all the dominant sources and sinks for debris large enough to cause catastrophic failures. The primary results are summarized in terms of the probability of a satellite surviving one year without a collision with a 1 cm or larger object. Methods are shown to calculate the probability of survival for other lifetimes from the one year data. Author

A91-14082#
ORBITAL DEBRIS REMOVAL BY LASER RADIATION
WOLFGANG O. SCHALL (DLR, Institut fuer Technische Physik, Stuttgart, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-569) Copyright
The use of high-power lasers is suggested for removing small dangerous orbital debris up to about 10 cm in diameter. Assuming data for a most probable collision orbit and for realistic ejection speeds of debris vapor under laser irradiation, calculations show the feasibility of treating a debris object like a laser propelled rocket. The acceleration of the debris during irradiation allows to change its orbit for a direct re-entry into the atmosphere of the earth or for escape from earth's gravitational field. Only a fraction of the laser power would be needed compared to that for complete vaporization of the debris. An autonomous orbital vehicle equiped with a moderately sized laser, proper optics and the instrumentation for the acquisition and tracking of debris objects could eventually clear the whole low earth orbital environment from small debris. In a modification of this method a laser could be used on short note to divert the flight path of a piece of debris to avoid a collision. The principal of the underlying mechanism is shown in a simple experiment. Author

A91-14083#
THE SPACE DEBRIS ISSUE - PROBLEMS AND RECOMMENDATIONS
D. FELSKE (Institut fuer Kosmosforschung, Neustrelitz, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p. refs
(IAF PAPER 90-570) Copyright
The near earth space is characterized by a proliferation of artificial objects as a result of launch activities, explosions and collisions. The number of trackable objects increases by a rate of about 300 per year. The population of smaller pieces can only be estimated. It is time to stop the contamination of space with debris and preserve this environment as a common resource. The relevant provisions of the Outer Space Treaty or the Environmental Modification Convention are insufficient and need be complemented by more stringent regulations. Much more attention should be given to the adoption of new launch and construction criteria aimed at reducing operational space debris to an absolute minimum. Particular emphasis is given to notification on launch activities and maneuvers in orbit. Requirements of a management system for orbiting objects of size larger than 1 mm are discussed. Author

A91-14100#
TECHNICAL ASPECTS OF THE CONTROL OF SPACE DEBRIS
LUBOS PEREK (Ceskoslovenska Akademie Ved, Astronomicky Ustav, Prague, Czechoslovakia) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-645) Copyright
An evaluation is made of preventive, active, and passive methods for space debris hazard minimization. Preventive measures for reducing any further debris production encompass avoidance of unintentional spacecraft explosions, the prohibition of intentional ones, and general restraint in the population of orbital space with additional spacecraft. Active measures envisioned include the removal of inactive spacecraft from orbital space, and the removal of smaller debris by such means as laser vaporization. Passive measures extend both to the devising of additional shielding for spacecraft and the institution of evasive maneuvers against the larger pieces of debris. O.C.

A91-14101*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
UNITED STATES STUDIES IN ORBITAL DEBRIS - PREVENTION AND MITIGATION
JOSEPH P. LOFTUS, JR. and ANDREW E. POTTER (NASA,

Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-646) Copyright

Debris in space has become an issue that has commanded considerable interest in recent years as society has become both more dependent upon space based systems, and more aware of its dependence. After many years of study the United States Space Policy of February 1988 directed that all sectors of the U.S. community minimize space debris. Other space organizations have adopted similar policies. Among the study activities leading to the policy and to subsequent implementing directives were discussions with the ESA, NASDA, and other space operating agencies. The policy derived from technical consensus on the nature of the issues and upon the courses of action available to mitigate the problem, but there remains the concern as to the adequacy of the data to define cost effective strategies. There are now in place mechanisms to continue technical discussions in more formal terms. Author

A91-14102*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

U.S. STUDIES IN ORBITAL DEBRIS

JOSEPH P. LOFTUS, JR. and ANDREW E. POTTER (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-564) Copyright

The combined effect of the natural meteoroid flux and the man-made debris on future space operations is discussed. The radar and optical systems used to study orbital debris are examined with special attention given to the Haystack Debris Observation Project and the Haystack radar at Millstone Hill, which is being modified to enable it to observe the regions of interest to the Space Station. Consideration is also given to techniques designed to remove objects from space. I.S.

A91-14103#

STRATEGY FOR THE ECONOMIC REMOVAL OF NUMEROUS LARGER DEBRIS OBJECTS FROM EARTH ORBITS

PETER EICHLER and ANETTE BADE (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-567) Copyright

A strategy for debris removal is presented using techniques expected to be available in the near future. The proposed concept, TERESA or tethered remover satellite, consists of a cycle of energy transfer and conversion by means of a conductive space tether. It is projected that such a strategy will dramatically reduce the propellant consumption for the removal of objects from earth orbits. Instead of consuming energy to force the debris to re-enter the earth's atmosphere, this part of the orbital energy of the debris will be transferred to the remover and converted into electrical energy. This energy can be stored in batteries and used later on for the next rendezvous maneuver. The effective removal of larger objects from higher altitudes could thus be realized. An alternative strategy which would replace the missing parts with conventional technology is also considered. L.K.S.

A91-14104#

CLASSIFICATION OF DEBRIS ORBITS WITH REGARD TO COLLISION HAZARD IN GEOSTATIONARY REGION

TETSUO YASAKA and SHUN'ICHI ODA (NTT, Radio Communication Systems Laboratory Yokosuka, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-571) Copyright

Neither detailed understanding of collisional probabilities in GEO nor policies for the future prevention of collisions are widespread in the communications satellite community. Known orbital elements of existing bodies which reach the GEO altitude are presently used to estimate the object densities and collisional probabilities of GEO and its vicinity. It is projected that two objects will collide with a probability of 1 percent within 10 years, and 4.5 percent within 20 years. The removal of such objects as dead satellites and upper stages from both GEO and the GEO-orbit transfer altitudes is deemed essential for collisional probability minimization. O.C.

A91-14399

INFLUENCE OF SIMULATED SPACE ENVIRONMENT ON THE PERFORMANCE OF OPTICAL SOLAR REFLECTOR (OSR)

BINGSEN HU, JIAWEN QIU, BIN WANG, and TIANHAI CHANG (Lanzhou Institute of Physics, People's Republic of China) IN: Hard materials in optics; Proceedings of the European Congress on Optics, The Hague, Netherlands, Mar. 14, 15, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 1275), 1990, p. 142-147. refs
Copyright

The influence of simulated space environment on the properties of the satellite temperature-control coating, Optical Solar Reflector (OSR) is discussed. Two kinds of OSR samples are tested in the simulated space environment. The simulation items include vacuum UV irradiation, electron and proton irradiation. The surface charge/discharge test is carried out too. After the electron, proton and UV accelerative irradiation of total dosage equivalent to 7 years at the south or north pole of geosynchronous satellite, the solar absorptance increases from 0.068 to 0.078 for conductive OSR, and from 0.066 to 0.085 for nonconductive OSR; the normal emittance decreases from 0.83 to 0.72 for conductive OSR, and from 0.82 to 0.76 for nonconductive OSR. Also, it is shown from the charge/discharge test that the surface charge potential is only 15-40 V for conductive OSR, and about 1-10 kV for nonconductive OSR. Author

A91-14531* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

COMMENTS ON 'PULSED ELECTRON BEAM EMISSION IN SPACE' BY NEUBERT ET AL. (1988)

W. M. FARRELL (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Geomagnetism and Geoelectricity (ISSN 0022-1392), vol. 42, no. 1, 1990, p. 57-62. refs
(Contract NGT-50034)
Copyright

Using the potentials measured by the Spacelab's Charge and Current Probe during beam ejections and the signature of the harmonic emissions generated by pulsed electron beams, Neubert et al. (1988) presented evidence that overdense electron beams (with electron density above 150,000/cu cm) can escape the near vicinity of the Shuttle. This paper supplements these results by presenting a further indication of the beam escape and propagation out to at least 200 m, using the whistler-mode wave signature obtained during the SL-12 electron beam ejection which occurred on DOY 213 of 1985 from 03:30 to 03:37 UT. The combined results support the hypothesis that overdense electron beams can and will escape from a spacecraft, contrary to predictions based upon idealized simulations of the injection process. I.S.

A91-15331

MODELING THE DYNAMICS OF ELECTRON FLUXES WITH ENERGIES OF 30-300 KEV IN GEOSTATIONARY ORBIT [MODELIROVANIE DINAMIKI POTOKOV ELEKTRONOV S ENERGIIAMI 30-300 KEV NA GEOSTATSIONARNOI ORBITE]

V. I. DEGTIAREV, G. V. POPOV, and S. S. SHESHUKOV (Sibirskii IZMIRAN, Irkutsk, USSR) Geomagnetizm i Aeronomiia (ISSN 0016-7940), vol. 30, Sept.-Oct. 1990, p. 866-868. In Russian. refs
Copyright

Based on data from the Promis experiment, a model is proposed for the distribution of electron fluxes with energies of 30-300 keV in geostationary orbit in connection with geomagnetic activity. The possibility of using this model for predicting mean hourly electron fluxes in geostationary orbit according to the Kp, Dst, and AE indices is assessed. B.J.

A91-16897
THE ESA AND US REPORTS ON SPACE DEBRIS - PLATFORM FOR FUTURE POLICY INITIATIVES
HOWARD A. BAKER (McGill University, Montreal, Canada) Space Policy (ISSN 0265-9646), vol. 6, Nov. 1990, p. 332-340. refs
Copyright

This article examines the development of policy on space debris in the European Space Agency and the USA, comments on its regulatory effectiveness, and proposes further recommendations for consideration when developing future space debris policy. The author argues that the international community must work towards a policy which incorporates an environmental perspective, and discusses the principles which should inform such a perspective.
Author

A91-18900
ORBITAL SCIENCE'S 'BERMUDA TRIANGLE'
THOMAS J. SHERRILL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Sky and Telescope (ISSN 0037-6604), vol. 81, Feb. 1991, p. 134-139.
Copyright

The effects of a part of the inner Van Allen belt lying closest to the earth, known as the South Atlantic Anomaly (SAA) upon spacecraft including the Hubble Space Telescope (HST), are discussed. The area consists of positively charged ions and electrons from the Van Allen Belt which become trapped in the earth's dipole field. Contor maps representing the number of protons per square centimeter per second having energies greater than 10 million electron volts are presented. It is noted that the HST orbit causes it to spend about 15 percent of its time in the SAA, but that, unlike the experience with earlier spacecraft, the satellite's skin, internal structure, and normal electronic's packaging provides sufficient protection against eletrons, although some higher energy protons still get through. Various charged particle effects which can arise within scientific instruments including fluorescence, Cerenkov radiation, and induced radioactivity are described.
B.P.

A91-19004* Princeton Univ., NJ.
INJECTION OF AN OVERDENSE ELECTRON BEAM IN SPACE
HIDEO OKUDA (Princeton University, NJ) and MAHA ASHOUR-ABDALLA (California, University, Los Angeles) Journal of Geophysical Research (ISSN 0148-0227), vol. 95, Dec. 1, 1990, p. 21307-21311. refs
(Contract NAGW-1606; NAGW-78; DE-AC02-76CH-03073; F19628-88-K-0011; F19628-88-K-0022)
Copyright

A three-dimensional particle simulation model is used to study the injection and propagation of an overdense electron beam in the vicinity of a conductor in space. Beam electrons with a density of more than 100 times the ambient electron density are modeled using large-scale plasma simulations; in these simulations the surface area of the conductor is several thousands times that of the beam cross section at the injection point. The parameters of the simulations are chosen to allow the realistic simulation of active space experiments such as the Space Shuttle's Spacelab 2 electron beam mission. These simulations confirm space observations that an overdense electron beam can at least partially escape the near vicinity of the spacecraft, even in a fully ionized plasma. Once they have escaped from the vicinity of the spacecraft, these beam electrons should be able to propagate away freely until their energy is dissipated. It is suggested that such large-scale simulations could be useful in interpreting data from space experiments.
Author

A91-19133*# Maryland Univ., College Park.
A RAPID METHOD OF CALCULATING THE ORBITAL RADIATION ENVIRONMENT
MICHELE M. GATES and MARK J. LEWIS (Maryland, University, College Park) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. Research supported by NASA. refs
(AIAA PAPER 91-0098) Copyright

This paper describes the process of integrating available environment models into a single package that calculates the radiation environment for any earth orbit quickly and accurately with the only input being initial orbit parameters, launch date and length of mission, and units of output. The radiation dose is calculated for particles penetrating varying aluminum shielding thicknesses and incident upon several materials inside. Included also are modifications that have been made to the codes that account for the decrease of the magnetic field with time, which allows the use of data taken in the past to accurately predict a future environment. The complete package has relatively short run times, 20 minutes per mission on a Micro VAX II, allowing multiple iterations for application to mission design and planning.
Author

A91-19143*# Massachusetts Inst. of Tech., Cambridge.
A GLOBAL ANALYSIS OF THE ELECTRODYNAMIC INTERACTIONS BETWEEN A SPACE STATION AND THE IONOSPHERIC PLASMA ENVIRONMENT
J. WANG and D. E. HASTINGS (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(Contract NAG3-695)
(AIAA PAPER 91-0114) Copyright

A general analysis of the electrodynamic interactions between a space station with two biased platforms and the ionospheric plasma is presented. This problem can be separated into a far-field problem, concerned with the electromagnetic interference surrounding the entire space station, and a near-field problem, concentrated on the interactions in the vicinity of the biased platforms. The far-field problem is solved by application of plasma fluid theory. The space station will generate a radiation field composed mainly of the Alfven waves. This far-field radiation depends on the details of the near-field current collection. Computer particle simulations were performed in the near-field of the biased platform to study the plasma flow field, the sheath structure and the current collection. Approximate analytical solutions to the near-field are also obtained. The far-field and near-field solutions are coupled to provide a global description of the electrodynamic interactions.
Author

A91-19145#
3-D GEOMETRICAL ANALYSIS TOOL FOR METEOROIDS/DEBRIS IMPACT RISK ASSESSMENT
J. BORDE (Matra Espace, Toulouse, France) and G. DROLSHAGEN (ESTEC, Noordwijk, Netherlands) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0117) Copyright

It is widely appreciated that meteoroids and space debris are critical factors in the safety and reliability of future missions, especially long-term mission such as the Space Station Freedom. In this paper, enhanced a 3-D numerical analysis tool for meteoroids/debris risk evaluation is presented. It is based on presently available environment and particle/wall interaction models together with spacecraft shielding design. This provides impact probabilities and resulting damaging effects using realistic geometrical treatments. The shielding by other parts of the spacecraft is considered. It accounts for directional and geometrical effects both in the environment and in the damage evaluation. It includes the latest environment and design models and allows an easy updating of these data as they are improved upon. This tool is a new application of the ESABASE framework, a geometrical system level analysis and engineering tool developed by MATRA ESPACE for ESA/ESTEC.
Author

A91-19224#
PRACTICAL CONSIDERATIONS OF IMPACT OF ORBITAL DEBRIS ON SPACE OPERATIONS
THOMAS J. ELLER and KENNETH D. KOPKE (Kaman Sciences Corp., Colorado Springs, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p.
(Contract F05603-88-D-0011)
(AIAA PAPER 91-0300) Copyright

This paper summarizes early work characterizing the near-term nature of space debris created by a kinetic energy antisatellite ('ASAT') engagement. Emphasis was twofold: reflect reality through accurate computations, and present easily understood data. The debris pieces of an assumed uniform breakup model were propagated using a special perturbations algorithm equivalent to that of the Space Surveillance Center. Breakup scenario ephemerides were generated, stored, and then displayed using a high speed graphics workstation. The screen showed orbit tracks of one-minute or continuous contrails or debris piece density concentrations in inertially fixed boxes in space (in order to display a moving debris 'cloud' rather than individual debris pieces). The simulation could run in real or accelerated time. New scalar indicators of dispersion were developed, and existing indicators were reexamined in an effort to provide meaningful debris-related information to operational commanders. Author

A91-19380*# Colby Coll., Waterville, ME.
PARTICLE FLOWS TO SHAPE AND VOLTAGE SURFACE DISCONTINUITIES IN THE ELECTRON SHEATH SURROUNDING A HIGH VOLTAGE SOLAR ARRAY IN LEO
ROGER N. METZ (Colby College, Waterville, ME) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(Contract NAG3-576)
(AIAA PAPER 91-0603) Copyright

This paper discusses the numerical modeling of electron flows from the sheath surrounding high positively biased objects in LEO (Low Earth Orbit) to regions of voltage or shape discontinuity on the biased surfaces. The sheath equations are derived from the Two-fluid, Warm Plasma Model. An equipotential corner and a plane containing strips of alternating voltage bias are treated in two dimensions. A self-consistent field solution of the sheath equations is outlined and is pursued through one cycle. The electron density field is determined by numerical solution of Poisson's equation for the electrostatic potential in the sheath using the NASCAP-LEO relation between electrostatic potential and charge density. Electron flows are calculated numerically from the electron continuity equation. Magnetic field effects are not treated. Author

A91-19381#
DIELECTRIC CHARGING PROCESSES AND ARCING RATES OF HIGH VOLTAGE SOLAR ARRAY
MENGU CHO and DANIEL E. HASTINGS (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(Contract AF-AFOSR-87-0340)
(AIAA PAPER 91-0605) Copyright

When high voltage solar arrays are used in the LEO environment, serious interactions are known to occur between the solar cell material and the surrounding plasmas. Arcing is known to be the most severe interaction. The charging process of the dielectric coverglass by charged particles is studied numerically. If there is a field emission site with a high electric field enhancement factor beta on the interconnector, charging process due to enhanced field electron emission can be initiated and leads to the Townsend breakdown in the neutral gas desorbed from the coverglass. Based on this arcing onset model, the arcing rate is calculated taking the reciprocal of the charging time and the threshold voltage is found to be a few hundred volts negative independent of the ambient ion density. Author

A91-20243
MONTE CARLO SIMULATION OF CONTAMINANT TRANSPORT TO AND DEPOSITION ON COMPLEX SPACECRAFT SURFACES
J. R. PHILLIPS, M. C. FONG, and T. D. PANCZAK (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Scatter from optical components; Proceedings of the Meeting, San Diego, CA, Aug. 8-10, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1989, p. 370-380. refs
Copyright

A test molecule Monte Carlo simulation algorithm was devised and tested to compute near equilibrium transitional flow and resulting mass flux on complex surface geometries. The results agreed, within the calculated statistical error of the simulation, with known analytical solutions at the free molecular limit, and gave satisfactory agreement near the continuum limit, when compared to a diffusion model with slip boundary conditions. The effects of the Knudsen number on dimensionless mass exchange factors are considered for slip flow in an aperture geometry. A variety of surface outgassing and surface adsorption-migration kinetics models can be mated with the test molecule simulation to compute surface deposition values. A multimolecular layer model with two-neighbor migration is considered as one such alternative for surface adsorption-migration kinetics. Calculations of surface deposition for heavy chain oil molecules, known as DC-704, are compared to experimental data, showing good agreement. This kinetic model can serve as a boundary condition when computing the exchange of mass among various surfaces. Author

A91-21370#
CHARACTERIZATION OF THE SPACE STATION FREEDOM EXTERNAL ENVIRONMENT
I. KATZ, G. JONGEWARD (Maxwell Laboratories, Inc., La Jolla, CA), and R. RANTANEN (ROR Enterprises, Castle Rock, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0113) Copyright

The interactions between Space Station Freedom and its environment are more complex and important than for previous space missions. Space Station Freedom (SSF) is larger, its mission is longer, and it will have more diverse payloads than any other spacecraft. In order to address the environment issues, a program is being instituted that will give SSF designers, operators, and users unprecedented access to integrated environment data and models. This program will have far-reaching importance not only for Space Station and future manned missions but will also provide comprehensive environment interactions analysis capabilities for all spacecraft of all sizes from Space Stations to light satellites. Author

A91-21448#
ORBITAL DEBRIS DAMAGE ESTIMATES USING COUPLED PRE- AND POST-IMPACT CALCULATIONS
GERALD J. DITTBERNER (Kaman Sciences Corp., Alexandria, VA), JEFF ELDER (Kaman Sciences Corp., Huntsville, AL), and DUNCAN STEEL (Spaceguard Pty., Ltd.; Adelaide, University, Australia) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0302) Copyright

This paper describes results of a joint effort to couple an orbital-debris collision probability model with an impact damage model. Collision probabilities are produced as a function of velocity and angle of impact on a sample satellite. Damage produced by such an incoming projectile is estimated with semiempirical software called KNAPP (Kaman New Analytic Penetration Program) originally developed for SDI. For purposes of illustration, the orbit of the Long Duration Exposure Facility is used for collision probability calculations, and a generic satellite structure is used for impact damage computations. Results indicate that the two methodologies can be successfully coupled together to provide likely damage as a function of impact velocity and orientation of specific surfaces of a satellite. Author

A91-21450#
EXAMPLES OF TECHNOLOGY TRANSFER FROM THE SDIO KINETIC ENERGY WEAPON LETHALITY PROGRAM TO ORBITAL DEBRIS MODELING
JOHN C. CONNELL, JR., WILLIAM J. TEDESCHI (DNA, Alexandria, VA), and DENNIS JONES (Kaman Sciences Corp., Alexandria, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0304)

The Defense Nuclear Agency (DNA) Kinetic Energy Weapon

Lethality and Target Hardening Program (LTH-5) has studied hypervelocity impacts on simple and complex targets for a number of years on behalf of the Strategic Defense Initiative Organization (SDIO). The test parameter space includes projectile masses from 0.1 - 93 grams and velocities ranging from 1-9 km/s. The work to date includes experimentation and modeling and the resulting data and codes can be made available to the Orbital Debris Spacecraft Breakup Modeling Program through technology transfer. This will reduce duplication, conserve scarce R&D funds, and provide a head start to orbital debris breakup modeling efforts. This paper highlights results from those LTH-5 activities which will be of most interest to those involved with orbital debris generation and the effects of debris on spacecraft. The attached bibliography documents some LTH-5 efforts which are directly applicable to orbital debris breakup modeling. Author

A91-21553#
GUIDELINES, MILITARY STANDARD, AND HANDBOOK ON SPACECRAFT SURFACE CHARGING
V. A. DAVIS (Maxwell Laboratories, Inc., La Jolla, CA), W. L. LOCKHART, J. K. KOGA, J. N. BARFIELD (Southwest Research Institute, San Antonio, TX), and A. G. RUBIN (USAF, Geophysics Laboratory, Hanscom AFB, MA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 6 p. Research supported by USAF. refs
(AIAA PAPER 91-0604) Copyright

Documentation of design, analysis, and experimental techniques to minimize the effects of spacecraft surface charging and verify that the effects will not interfere with the mission objectives is under development. The new documentation will update present guidelines and extend them to the auroral environment. The documentation will include calculational and experimental techniques to determine the risk to the mission of a given configuration. Generic examples will be included. The involvement of the spacecraft community through interviews and reviews of the documents will maximize the usefulness of the documents. Author

A91-23010* Sandia National Labs., Albuquerque, NM.
1990 IEEE ANNUAL CONFERENCE ON NUCLEAR AND SPACE RADIATION EFFECTS, 27TH, RENO, NV, JULY 16-20, 1990, PROCEEDINGS
DANIEL M. FLEETWOOD, ED. (Sandia National Laboratories, Albuquerque, NM) Conference sponsored by IEEE, DNA, Sandia National Laboratories, and JPL. IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 37, pts. 1 & 2, Dec. 1990, p. Pt. 1, 540 p.; pt. 2, 172 p. For individual items see A91-23011 to A91-23083.
Copyright

Various papers on nuclear and space radiation effects are presented. The general topics addressed include: basic mechanisms of radiation effects, dosimetry and energy-dependent effects, hardness assurance and testing techniques, single-event upset and latchup, isolation technologies, device and integrated circuit effects and hardening, spacecraft charging and electromagnetic effects. C.D.

A91-23053
ESTIMATION OF PROTON UPSET RATES FROM HEAVY ION TEST DATA
J. GREGORY ROLLINS (Technology Modeling Associates, Palo Alto, CA) (IEEE, DNA, JPL, et al., Annual Conference on Nuclear and Space Radiation Effects, 27th, Reno, NV, July 16-20, 1990) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 37, pt. 1, Dec. 1990, p. 1961-1965. refs
Copyright

A simple method of calculating the proton upset rates from heavy ion test data is presented. Given the approximations made, particularly in fitting a curve to the experimental data, the error made in determining the upset rate can be as large as four or six. It is clear from this model that ICs with heavy ion thresholds over 10 MeV/(mg/sq cm) will probably not upset with protons. In critical applications ICs with LET thresholds less than 10 MeV/(mg/sq cm) should be tested with protons, or at the minimum careful heavy ion test data should be taken in the low LET regions (for heavy ion upset considerations as well as proton upset). I.E.

A91-23223* Victoria Univ. (British Columbia).
DESIGN OF A SHUTTLE-BASED SPACE DEBRIS TELESCOPE
E. H. RICHARDSON (Victoria, University, Canada), D. L. TALENT, C. L. TRITSCH (Lockheed Engineering and Sciences Co., Houston, TX), and F. VILAS (NASA, Johnson Space Center, Houston, TX) IN: Advanced technology optical telescopes IV; Proceedings of the Meeting, Tucson, AZ, Feb. 12-16, 1990. Part 1. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 237-242. refs
Copyright

A 1.6-meter diameter f/0.95 all-reflecting telescope was designed to observe orbital debris particles as small as 1 mm from the shuttle payload bay. The telescope was specified to have a flat focal surface without the imposition of refractive elements. Two design configurations involving three mirrors were evaluated - a reflective Schmidt-Cassegrain and a modified Paul corrector. The Paul system was found to be more compact and appropriate for this application. Author

A91-27446
ENERGETIC PARTICLES IN THE ENVIRONMENT OF THE EARTH'S MAGNETOSPHERE
E. MOEBIUS (Max-Planck-Institut fuer Physik und Astrophysik, Garching, Federal Republic of Germany) Journal of Atmospheric and Terrestrial Physics (ISSN 0021-9169), vol. 52, Dec. 1990, p. 1169-1184. refs
Copyright

This review summarizes the work in the field of magnetospheric energetic particles during the years 1987-1989. First, it follows the path of ions extracted out of the polar ionosphere and their acceleration parallel and perpendicular to the magnetic field, as well as their subsequent transport into the equatorial magnetosphere and tail region. Then it focuses on acceleration of ions in the magnetotail and the related characteristics in the boundary layers including consequences for current substorm modeling. Finally, leading beyond the boundaries of the magnetosphere, attention is drawn to the still ongoing debate on the source of energetic particles upstream of the earth's bow shock and the respective importance of particle leakage and/or acceleration at the magnetospheric boundaries. Author

A91-27564
SPACE DEBRIS AND THE WORLD COMMUNITY
LUBOS PEREK (Czechoslovak Academy of Sciences, Astronomical Institute, Prague, Czechoslovakia) Space Policy (ISSN 0265-9646), vol. 7, Feb. 1991, p. 9-12. refs
Copyright

A survey is presented of literature, committees, and legislation dealing with the problem of space debris. Both past and current contributions of the Committee on the Peaceful Uses of Outer Space (COPUOS), created in 1959, to the creation of international policy concerning space debris are cited. It is suggested that there are two main reasons for the reluctance of international committees such as COPUOS to address the matter of space debris: either it is believed that the problem of space debris has been exaggerated and does not deserve serious attention or there is a certain aversion to taking up a problem which might lead to considerable expense or to regulations restricting member states' freedom of action. It is noted that the cost of removing space debris appears prohibitive, but it is stressed that this cost is entirely necessary. Various sources of information on the number, size, location, and motion of space debris are reviewed. Emphasis is placed on the necessity for COPUOS to immediately begin discussions on the problem of space debris. L.K.S.

A91-27565
TRACK TWO DIPLOMACY - AN INTERNATIONAL FRAMEWORK FOR CONTROLLING ORBITAL DEBRIS

DARREN S. MCKNIGHT (Kaman Sciences, Alexandria, VA) Space Policy (ISSN 0265-9646), vol. 7, Feb. 1991, p. 13-22. refs
Copyright

Due to apprehension concerning the immediate creation of a space debris policy, an alternative method, Track Two diplomacy, has been suggested as a means of approaching this problem on a citizen-to-citizen basis to encourage an international effort to control this environmental problem. Track Two diplomacy is defined as the interaction between private citizens or groups of people within a country or from different countries who are outside the formal governmental power structure. Typologies are provided of various Track Two diplomatic efforts and examples of their operation and effectiveness of this type of diplomacy are given. The problem of orbital debris and its growth is outlined, and the criticality of the situation is stressed. It is proposed that an Orbital Debris Action Committee be formed in order to investigate means to reduce the growth of orbital debris in a cooperative international framework. The organization would emphasize the need for more research in the areas of debris environment definition and break-up phenomenology. The matters of membership and funding are discussed and a proposed plan of action for the committee is presented. L.K.S.

A91-27569
REVIEW AND ANALYSIS OF THE REGISTER OF SPACE OBJECTS
R. WICKRAMATUNGA (UN, Outer Space Affairs Div., New York) Space Policy (ISSN 0265-9646), vol. 7, Feb. 1991, p. 77-81.
Copyright

The categories of information with which parties to the Registration Convention are committed to providing the United Nations concerning objects they launch into space are described. The inadequacies of the present Register of Objects Launched into Outer Space are outlined and suggestions for modifications presented. Categories of information required include whether it is UN registered, the year of launch, the name of the object, the launching site, the launching state, and the designator. Some suggestions made in an effort to enable the Register to be more effective include the specification of geostationary position where applicable, the inclusion of additional information such as updated orbital elements or experiments carried out, and the reduction of time scale for states to register objects. L.K.S.

A91-27658
INCIDENT SOLAR FLUX AT FIXED ORIENTATIONS
STEPHEN BILANOW (General Sciences Corp., Laurel, MD) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 842-851.
Copyright

Optimal orientations are computed to maximize or minimize the incident solar flux onto surfaces on spacecraft at fixed attitudes. This analysis was motivated by a potential need to optimize the power and thermal environment during the early assembly flights of Space Station Freedom. The time history of the incident solar flux is described using close analytical approximations. Author

A91-27660
MAN-MADE DEBRIS ENVIRONMENT CHARACTERIZATION FOR SPACECRAFT VULNERABILITY ASSESSMENT
ROBERT C. REYNOLDS (Lockheed Engineering and Sciences Co., Houston, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 863-873.
Copyright

An issue of growing importance in the study of orbital debris is the need to understand the consequence of impact on a space structure. In this paper, a technique is developed to analyze the flux directionality of debris for spacecraft surfaces having different orientations, using catalog element set data. Author

A91-27661
CLEARING SPACE DEBRIS USING ENERGETIC MATERIALS
LADDIE MARIN, JR., CHARLES A. MULLIGAN, and JOSEPH J. SECARY (USAF, Weapons Laboratory, Kirtland AFB, NM) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 874-883. refs
Copyright

Space debris is growing at an alarming rate. It consists not only of old, unusable payloads but also aluminum oxide combustion products of various space delivery systems and small fragments from payload breakups. Although the thousands of large, trackable objects pose a collision hazard for future U.S. space vehicles, the smaller, untrackable particles are an even larger threat due to their high velocities and nondetectability prior to impact. Even though efforts are under way to reduce the growth of this pollution problem, an effective debris clearing method is needed to ensure safe launch and deployment of expensive national space assets. This paper discusses the space solutions, and presents a new possible solution involving use of energetic material charges to cause reentry or escape of debris objects. Author

A91-27990* Massachusetts Inst. of Tech., Cambridge.
A DYNAMIC ANALYSIS OF THE RADIATION EXCITATION FROM THE ACTIVATION OF A CURRENT COLLECTING SYSTEM IN SPACE
J. WANG and D. E. HASTINGS (MIT, Cambridge, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 96, March 1, 1991, p. 3611-3620. refs
(Contract NAG3-695)
Copyright

Current collecting systems moving in the ionosphere will induce electromagnetic wave radiation. The commonly used static analysis is incapable of studying the situation when such systems undergo transient processes. A dynamic analysis has been developed, and the radiation excitation processes are studied. This dynamic analysis is applied to study the temporal wave radiation from the activation of current collecting systems in space. The global scale electrodynamic interactions between a space-station-like structure and the ionospheric plasma are studied. The temporal evolution and spatial propagation of the electric wave field after the activation are described. The wave excitations by tethered systems are also studied. The dependencies of the temporal Alfven wave and lower hybrid wave radiation on the activation time and the space system structure are discussed. It is shown that the characteristics of wave radiation are determined by the matching of two sets of characteristic frequencies, and a rapid change in the current collection can give rise to substantial transient radiation interference. The limitations of the static and linear analysis are examined, and the condition under which the static assumption is valid is obtained. Author

A91-28432
CLEANING UP LOW EARTH ORBIT
DOROTHY DIEHL Journal of Practical Applications in Space (ISSN 1046-8757), vol. 1, Spring 1990, p. 67-72.
Copyright

A91-29714*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ENVIRONMENTAL INTERACTIONS ON SPACE STATION
HENRY B. GARRETT, STEPHEN B. GABRIEL, and GERALD B. MURPHY (JPL, Pasadena, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 163-179. refs

This paper describes the key environment/system interactions associated with the Space Station and its companion polar platform and defines the range of test environments that will need to be simulated. These environments include the neutral atmosphere, the ionospheric plasma, natural and man-made particulates, the ambient magnetic field, the South Atlantic Anomaly, and the ram/wake environment. The system/environment interactions include glow, oxygen erosion, drag, radiation effects, induced electric fields, high-voltage solar-array effects, and EMC/EMI associated with plasma/neutral gas operations. The Space Station and its associated systems pose unique demands on the ability to simulate these effects; synergistic effects require multiple environments to be simulated simultaneously, and the long life requirements require proper scaling of the exposure time. The analysis of specific effects and the calibration or improvement of ground test techniques will likely require in situ evaluation. Qualification and acceptance testing, because of cost and the impractically of extensive on-orbit analysis/modification, will likely remain ground test objectives except in very rare cases. Author

A91-29790#
NONLINEAR DYNAMICAL MODEL OF RELATIVE MOTION FOR THE ORBITING DEBRIS PROBLEM
RICHARD S. HUJSAK (Applied Technology Associates, Inc., Lionville, PA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 460-465. USAF-supported research. Previously cited in issue 21, p. 3319, Accession no. A90-46778. refs
Copyright

A91-30297
SUMMARY OF INTERNATIONAL ASTRONOMICAL UNION COLLOQUIUM NO. 112 'LIGHT POLLUTION, RADIO INTERFERENCE, AND SPACE DEBRIS'
TOMAS E. GERGELY (NSF, Div. of Astronomical Sciences, Washington, DC) IN: Space safety and rescue 1988-1989. San Diego, CA, Univelt, Inc., 1990, p. 171-180.
(IAF PAPER 88-524) Copyright

The IAU colloquium was held in August 1988 in Washington DC. Most of the papers dealt with the deteriorating observing conditions that astronomers face today. Light pollution has increased over the last few decades, to the point of causing the closure of some observatories. Mankind is in danger of losing its view of the night sky and, consequently, of the universe. RF interference has also intensified enormously due to the pressures that new services, many of them space-based, exert on the radio spectrum, a quintessentially finite resource. Finally, space debris poses a danger not only for astronomers but for all space activities. Author

A91-30298
ARTIFICIAL SPACE DEBRIS - EFFECTS AND PREVENTION: A REVIEW
ANEY THOMAS KADAVIL (ISRO, Quality Assurance Div., Bangalore, India) IN: Space safety and rescue 1988-1989. San Diego, CA, Univelt, Inc., 1990, p. 309-320. ISRO-supported research. refs
(IAF PAPER 89-626) Copyright

The many collisions and explosions which have resulted from various space activities have led to the littering of space with man-made debris. Recent studies show that man-made orbital flux exceeds the natural meteoroid flux in most size ranges, except in the 0.1-1-mm size range. The hazards/effects of these fragments are reviewed in this paper. Damage/loss of active satellites through collisions, debris proliferation by secondary collision, risks involved in manned space flights, contamination by nuclear material in space, accidental/uncontrolled reentry of space hardware, crowding in GEO, and influence on ground-based and space astronomy are some of the major problems. Author

A91-30654* Cincinnati Univ., OH.
ENVIRONMENTAL SPACE HAZARDS - AN OVERVIEW
G. K. BAHR and PETER J. DISIMILE (NASA, Health Monitoring Technology Center for Space Propulsion Systems; Cincinnati, University, OH) IN: Annual Health Monitoring Conference for Space Propulsion Systems, 2nd, Cincinnati, OH, Nov. 14, 15, 1990, Proceedings. Cincinnati, OH, University of Cincinnati, 1990, p. 541-561. refs
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An overview of space hazards that exist in the geo-lunar environment is given along with specific examples of deleterious effects that can be visited upon a long-term mission-oriented spacecraft system in LEO, GEO, the intervening space, LLO, and the lunar surface. Hazards discussed are categorized as pervasive (radiation), incident specific (meteoroids, monatomic oxygen, thermal gradient and shock, and low earth orbital debris), and chemically corrosive (monatomic oxygen). It is pointed out that, while some of the difficulties encountered are common to all types of propulsion systems, in the interplanetary domain the emphasis shifts from incident specific hazards to the pervasive upsets caused by ionizing and nonionizing radiation. L.K.S.

A91-31669
THE DETERMINATION OF THE GAS-SURFACE INTERACTION FROM SATELLITE ORBIT ANALYSIS AS APPLIED TO ANS-1 (1975-70A)
R. CROWTHER and J. STARK (Southampton, University, England) Planetary and Space Science (ISSN 0032-0633), vol. 39, May 1991, p. 729-736. SERC-supported research. refs
Copyright

This paper considers the technique of orbital analysis as a means of determining the ill-defined gas-surface interaction between spacecraft and atmospheric molecules in Low-Earth Orbit (LEO). The problem of representing the aerodynamics of complex vehicles in LEO is considered. The theory required to represent the relationship between the changes in the spacecraft trajectory and the gas-surface interaction is developed. This theory is then applied to the orbital data of ANS-1 (1975-70A) and the results of the analysis compared with those of previous investigators. Author

A91-32369
EFFECT OF THE NONUNIFORM DENSITY OF CHARGE FORMED ON A SPACECRAFT SURFACE [VLIIANIE NERAVNOMERNOI PLOTNOSTI ZARIADOV, OBRAZUIUSHCHIKHSIA NA POVERKHNOSTI KOSMICHESKOGO APPARATA]
R. M. ZAIDEL' Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 29, Jan.-Feb. 1991, p. 149, 150. In Russian.
Copyright

The work of Rich and Stringer (1980) concerning the accumulation of charge on a spacecraft surface is extended. It is considered that the spacecraft is charged due to charged particles from the surrounding space as well as due to the emission of photoelectrons from the spacecraft surface under the effect of solar UV radiation. The present work shows that the nonuniform (over the spacecraft surface) emission of charged particles can lead to the generation of a much stronger electric field parallel to the surface than in the case of uniform emission. L.M.

N91-11646# Los Alamos National Lab., NM.
DISCUSSION PAPER ON ENVIRONMENTAL HAZARDS ON THE MOON, IN LOW EARTH ORBIT, AND IN LOW MARS ORBIT
GRANT HEIKEN, comp. Sep. 1990 9 p
(Contract W-7405-ENG-36)
(DE90-017854; LA-11882-MS; UC-900) Avail: NTIS HC/MF A02

In a lunar base era, potential problems with dust will be serious. Lunar soils, which make up most of the regolith that covers the Moon's surface, are similar to silty sands on Earth, with mean grain sizes of 45 to 100 microns. Lunar dust has very low electrical conductivity and dielectric losses, permitting accumulation of electric charge under ultraviolet irradiation. Dust coatings cover thermally-sensitive surfaces, windows and visors, clog moving parts, and create continual abrasion hazards. Reduced gravity on the Moon favors the stability of aerosolized lunar soil and thereby will prolong its availability for inhalation if it is not removed from habitat atmosphere by filtration systems. Some other hazards must be considered. On the lunar surface it is difficult to judge topographic details and distances. New materials are needed to protect astronauts and equipment at a lunar base from micrometeoroid impacts. Spacecraft in low orbits around Earth and Mars experience strong chemical interactions where O2 and CO2 are photodissociated by sunlight. A ground-based facility at Los Alamos can be used to test these chemical interactions with materials proposed for use in spacecraft and satellites. Another component of the space exploration initiative is the environmental effects posed by man on the tenuous lunar and Martian atmospheres. Before significant development occurs on these planets, these atmospheres must be measured. Orbiting sensors designed to measure these atmospheres can also be used to search for water. DOE

N91-12344*# California Univ., Los Angeles. Dept. of Physics.
CURRENTS BETWEEN TETHERED ELECTRODES IN A MAGNETIZED LABORATORY PLASMA
R. L. STENZEL and J. M. URRUTIA 1989 70 p
(Contract NAGW-1570)
(NASA-CR-186128; NAS 1.26:186128) Avail: NTIS HC/MF A04 CSCL 20/9

Laboratory experiments on important plasma physics issues of electrodynamic tethers were performed. These included current propagation, formation of wave wings, limits of current collection, nonlinear effects and instabilities, charging phenomena, and characteristics of transmission lines in plasmas. The experiments were conducted in a large afterglow plasma. The current system was established with a small electron-emitting hot cathode tethered to an electron-collecting anode, both movable across the magnetic field and energized by potential difference up to V approx.=100 T(sub e). The total current density in space and time was obtained from complete measurements of the perturbed magnetic field. The fast spacecraft motion was reproduced in the laboratory by moving the tethered electrodes in small increments, applying delayed current pulses, and reconstructing the net field by a linear superposition of locally emitted wavelets. With this technique, the small-amplitude dc current pattern is shown to form whistler wings at each electrode instead of the generally accepted Alfven wings. For the beam electrode, the whistler wing separates from the field-aligned beam which carries no net current. Large amplitude return currents to a stationary anode generate current-driven microinstabilities, parallel electric fields, ion depletions, current disruptions and time-varying electrode charging. At appropriately high potentials and neutral densities, excess neutrals are ionized near the anode. The anode sheath emits high-frequency electron transit-time oscillations at the sheath-plasma resonance. The beam generates Langmuir turbulence, ion sound turbulence, electron heating, space charge fields, and Hall currents. An insulated, perfectly conducting transmission line embedded in the plasma becomes lossy due to excitation of whistler waves and magnetic field diffusion effects. The implications of the laboratory observations on electrodynamic tethers in space are discussed. Author

N91-12739# Aerospace Corp., El Segundo, CA. Chemistry and Physics Lab.
PHOTOCHEMICAL SPACECRAFT SELF-CONTAMINATION: LABORATORY RESULTS AND SYSTEMS IMPACTS
THOMAS B. STEWART, GRAHAM S. ARNOLD, DAVID F. HALL, DEAN C. MARVIN, WARREN C. HWANG, ROLAINE C. YOUNGOWL, and H. DANIEL MARTEN 25 Jul. 1990 42 p
(Contract F04701-88-C-0089)
(AD-A226488; TR-0090(5470-01)-3) Avail: NTIS HC/MF A03 CSCL 03/2

It has become clear that photochemical reactions induced by solar vacuum ultraviolet (VUV) radiation play a substantial role in contaminant accretion and effects. A series of laboratory measurements of the absolute rates of adsorption, desorption, and VUV-induced deposition of contaminants have been made under simulated spacecraft conditions. The results of these experiments, together with analyses of operational and experimental flight data, show conclusively that the role of sunlight is not merely to darken or fix previously condensed contaminant films, but also to promote the irreversible deposition of contaminant films under conditions in which condensation would not occur. A simple model of the kinetics of photochemical deposition, based on a competition between desorption and photolysis of a transiently adsorbed contaminant molecule, using experimentally measured parameters, is reasonably successful in describing the deposition process. These laboratory experiments and analyses of space-flight experience reveal that photochemical deposition is significant mechanism whereby contaminant films accrete on orbit and must be considered in the design of future vehicles. GRA

N91-13807*# Southwest Research Inst., San Antonio, TX.
SEPAC DATA ANALYSIS IN SUPPORT OF THE ENVIRONMENTAL INTERACTION PROGRAM Interim Report
CHIN S. LIN 22 May 1990 51 p
(Contract NAS8-32488; NAGW-1231; SWRI PROJ. 15-4865-009)
(NASA-CR-184028; NAS 1.26:184028) Avail: NTIS HC/MF A04 CSCL 13/2

Injections of nonrelativistic electron beams from an isolated equipotential conductor into a uniform background of plasma and neutral gas were simulated using a two dimensional electrostatic particle code. The ionization effects of spacecraft charging are examined by including interactions of electrons with neutral gas. The simulations show that the conductor charging potential decreases with increasing neutral background density due to the production of secondary electrons near the conductor surface. In the spacecraft wake, the background electrons accelerated towards the charged space craft produced an enhancement of secondary electrons and ions. Simulations run for longer times indicate that the spacecraft potential is further reduced and short wavelength beam-plasma oscillations appear. The results are applied to explain the space craft charging potential measured during the SEPAC experiments from Spacelab 1. A second paper is presented in which a two dimensional electrostatic particle code was used to study the beam radial expansion of a nonrelativistic electron beam injected from an isolated equipotential conductor into a background plasma. The simulations indicate that the beam radius is generally proportional to the beam electron gyroradius when the conductor is charged to a large potential. The simulations also suggest that the charge buildup at the beam stagnation point causes the beam radial expansion. From a survey of the simulation results, it is found that the ratio of the beam radius to the beam electron gyroradius increases with the square root of beam density and decreases inversely with beam injection velocity. This dependence is explained in terms of the ratio of the beam electron Debye length to the ambient electron Debye length. These results are most applicable to the SEPAC electron beam injection experiments from Spacelab 1, where high charging potential was observed. Author

N91-15265# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.).
THE DLR PLUME SIMULATION FACILITY
G. DETTLEFF and J.-T. MEYER *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 381-383 Sep. 1990
Copyright Avail: NTIS HC/MF A23

A vacuum chamber under construction with sufficient pumping capability to allow the formation of thruster plumes into the highly rarefied flow region is described. The expansion chamber has a length of about 4.5 m and a diameter of about 1.5 m and is completely surrounded by cold walls. They act as a cryopump kept at about 4K by means of liquid helium. It is expected that thrusters with a thrust level up to 2 N can be fixed continuously. The first goal of the experimental work is the measurement of the mass flux distribution in the flow field, which is the basic quantity for the determination of undesired impingement effects (force, heat load, and contamination). ESA

N91-15266# Ernst-Mach-Inst., Freiburg (Germany, F.R.).
ACCELERATION OF PARTICLES IN LIGHT GAS GUNS FOR MICROMETEROID/SPACE DEBRIS SIMULATION
E. SCHNEIDER and A. STILP *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 385-388 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Light gas gun acceleration techniques and respective facilities are described. Concerning the effective mass range of particles, light gas guns are considered appropriate tools for experimental micrometeroid and space debris simulation. For example, aluminum spheres in the diameter range of millimeters can be accelerated to velocities in the order of 10 km/s. ESA

N91-15271# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
RESIDUAL GAS ANALYSIS AND LEAK RATE MEASUREMENTS DURING THERMAL VACUUM TESTS
H. E. NUSS and C. WUERSCHING *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 413-419 Sep. 1990
Copyright Avail: NTIS HC/MF A23

During thermal vacuum tests for the spacecraft mass spectrometer, measurements were performed to identify cleanliness conditions in the test facility in addition to other measuring methods. By comparison of the results of facility dry runs and thermal vacuum and space simulation tests, the outgassing rate of the test article can be estimated. The hydrocarbon partial pressures are presented as a function of thermal shroud temperature and thermal vacuum exposure time. Typical results of the hydrocarbon partial pressures in the atomic mass unit range 13 to 512 are 0.5 percent of the total pressure for thermal shroud temperatures of T sub sh = 100K and 4 percent for t sub sh = 300K. ESA

N91-15272# Intespace, Toulouse (France). Metrology Section.
SOLAR SIMULATED FLUXES SPECTRAL ANALYSIS AUTOMATION
R. HONIAT *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 421-428 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The replacement of the solar simulated fluxes spectral analysis system was addressed. General specifications are given and the system is described. The optical path of the monochromators is based on the Czerny-Turner configuration. The measurement is described, detailing the standard irradiance lamp data, calibration, analysis of the unknown source, data reduction and results editing. Validation of the method is described. With the new system, installation requires only 2 or 3 hours and data reduction needs only half an hour. ESA

N91-15284# Centre National d'Etudes Spatiales, Toulouse (France).
SATELLITE QUALIFICATION TESTS FOR ELECTROSTATIC DISCHARGES
J.-P. CATANI *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 507-510 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Satellite resistance to charging phenomena in geostationary orbits (between plasmasphere and magnetopause where there are intense fluxes or medium energy electrons) was addressed. The environment was reproduced in the laboratory by electron accelators applied to the satellite components so as to cause electrostatic discharge. Electric and electromagnetic measurements made during the discharges are used to define susceptibility tests to be applied to satellites or their electronic equipment. ESA

N91-15291# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Mathematical Software Div.
SPACE ENVIRONMENT ANALYSIS TOOLS
E. J. DALY, G. DROLSHAGEN, C. TRANQUILLE, and J. DEKRUYF *In its* International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 551-558 Sep. 1990
Copyright Avail: NTIS HC/MF A23

An important element in verifying the hardness of a spacecraft against the hostile space environment is analysis of the environment and its interaction with spacecraft. These environments, their effects, environments models and the various computerized tools employed for analyses are discussed, including radiation belt energetic particles, cosmic rays and solar flares particles, plasma environments, residual neutral atmosphere (including atomic oxygen), space debris and micrometeroid particles, and contamination. Available environment models and analysis tools, and the ways in which they are used in combination with test data are discussed. Analysis tools notably include elements of the ESABASE framework and the space environment information system. ESA

N91-15294# Naval Postgraduate School, Monterey, CA. Dept. of Physics.
DIELECTRIC CHARGING AS A CATALYST TO THE FORMATION OF POTENTIAL BARRIERS ON SYNCHRONOUS ORBIT SATELLITES M.S. Thesis
MAUDE E. YOUNG Mar. 1990 87 p
(AD-A225796) Avail: NTIS HC/MF A05 CSCL 20/3

A deep dielectric charging of exterior spacecraft dielectrics is postulated as a mechanism responsible for the sunlit charging even observed on the ISEE1 spacecraft. Deep dielectric charging can cause a negative potential to develop on the insulating surfaces of the spacecraft, resulting in the information of a potential barrier capable of suppressing photo and secondary emission. These events can lead to overall negative charging of the spacecraft. Calculations were made using in situ measurements from onboard the ISEE1 and the SCATHA spacecraft. The results indicate, within the range of the data used, that this mechanism is a viable explanation for the ISEE1 charging event. This mechanism can be generalized to most synchronous orbit spacecraft. GRA

N91-15953*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
CHARACTERISTICS OF TRAPPED PROTON ANISOTROPY AT SPACE STATION FREEDOM ALTITUDES
T. W. ARMSTRONG, B. L. COLBORN (Science Applications International Corp., Huntsville, AL.), and J. W. WATTS Oct. 1990 31 p
(Contract NAS8-37916)
(NASA-CR-184061; NAS 1.26:184061; SAIC-90/1474) Avail: NTIS HC/MF A03 CSCL 03/2

The ionizing radiation dose for spacecraft in low-Earth orbit (LEO) is produced mainly by protons trapped in the Earth's magnetic field. Current data bases describing this trapped radiation environment assume the protons to have an isotropic angular distribution, although the fluxes are actually highly anisotropic in LEO. The general nature of this directionality is understood theoretically and has been observed by several satellites. The anisotropy of the trapped proton exposure has not been an important practical consideration for most previous LEO missions because the random spacecraft orientation during passage through the radiation belt 'averages out' the anisotropy. Thus, in spite of the actual exposure anisotropy, cumulative radiation effects over many orbits can be predicted as if the environment were isotropic when the spacecraft orientation is variable during exposure. However, Space Station Freedom will be gravity gradient stabilized to reduce drag, and, due to this fixed orientation, the cumulative incident proton flux will remain anisotropic. The anisotropy could potentially influence several aspects of Space Station design and operation, such as the appropriate location for radiation sensitive components and experiments, location of workstations and sleeping quarters, and the design and placement of radiation monitors. Also, on-board mass could possible be utilized to counteract the anisotropy effects and reduce the dose exposure. Until recently only omnidirectional data bases for the trapped proton environment were available. However, a method to predict orbit-average, angular dependent ('vector') trapped proton flux spectra has been developed from the standard omnidirectional trapped proton data bases. This method was used to characterize the trapped proton anisotropy for the Space Station orbit (28.5 degree inclination, circular) in terms of its dependence on altitude, solar cycle modulation (solar minimum vs. solar maximum), shielding thickness, and radiation effect (silicon rad and rem dose). Author

N91-15972# Aerospace Corp., El Segundo, CA. Space Sciences Lab.

SOLAR CYCLE EFFECTS ON THE NEAR-EARTH SPACE SYSTEMS

DAVID J. GORNEY 6 Aug. 1990 74 p
(Contract F04701-88-C-0089)
(AD-A228037; TR-0090(5940-06)-3; SSD-TR-90-25) Avail: NTIS HC/MF A04 CSCL 03/2

Forecasts of the magnitude of solar activity in the 1990s (solar cycle 22) imply that the expected levels of activity might be some of the most extreme ever recorded, and almost certainly the levels of activity will be some of the most experienced during the space age. Even as early as one year before the expected maximum of solar cycle 22 in 1990, unprecedented levels of solar activity (for example, the solar flares and solar particle events of August to October 1989) and geomagnetic activity (for example, the auroral events and geomagnetic storms of March 1989) have been observed. The solar and geophysical events have stirred scientific interest in both the long-term behavior of solar activity and in the physics which couples the energy of solar events to the near-Earth environment. Furthermore, the operational community (including those involved in satellite operations, telephone and radio communication, electric power distribution, aviation, and others) have experienced many adverse effects of these solar and geophysical events. Many more episodes of activity are expected throughout the upcoming 4 to 5 years. The purpose of this report is to review the direct and indirect influences of solar activity on the near-Earth environment and to describe some of the implications of the high levels of solar activity which are expected to occur in the 1990 to 1994 time period. GRA

N91-17121# Office of Technology Assessment, Washington, DC.

ORBITING DEBRIS: A SPACE ENVIRONMENTAL PROBLEM. BACKGROUND PAPER

Oct. 1990 64 p
(PB91-114272; OTA-BP-ISC-72) Avail: NTIS HC/MF A04

Artificial debris, deposited in a multitude of orbits about the Earth as the result of the exploration and use of the space environment, poses a growing hazard to future space operations. Unless nations sharply reduce the amount of orbital debris they produce, future space activites could suffer loss of capability, loss of income, and even loss of life as a result of collisions between spacecraft and debris. This background paper discusses the sources of debris and how they can be greatly reduced. Author

N91-17713*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

CURRENT COLLECTION FROM SPACE PLASMAS

NAGENDRA SINGH, ed., K. H. WRIGHT, JR., ed. (Alabama Univ., Huntsville.), and NOBIE H. STONE, ed. Washington Dec. 1990 368 p Workshop held in Huntsville, AL, 24-25 Apr. 1989; sponsored by NASA. Marshall Space Flight Center and Alabama Univ.
(NASA-CP-3089; M-644; NAS 1.55:3089) Avail: NTIS HC/MF A16 CSCL 20/9

The First Workshop on Current Collection from Space Plasmas was held at the Tom Bevil Center on the campus of The University of Alabama in Huntsville on April 24 to 25, 1989. The intent of the workshop was to assemble experts on various topics related to the problem of current collection for deliberations that would elucidate the present understanding of the overall current collection problem. Papers presented at the workshop are presented.

N91-17721*# Massachusetts Inst. of Tech., Cambridge. Plasma Fusion Center.

THEORY OF PLASMA CONTACTORS IN GROUND-BASED EXPERIMENTS AND LOW EARTH ORBIT

M. J. GERVER, DANIEL E. HASTINGS, and M. R. OBERHARDT (Air Force Geophysics Lab., Hanscom AFB, MA.) *In* NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 150-189 Dec. 1990
Avail: NTIS HC/MF A16 CSCL 20/9

Previous theoretical work on plasma contactors as current collectors has fallen into two categories: collisionless double layer theory (describing space charge limited contactor clouds) and collisional quasineutral theory. Ground based experiments at low current are well explained by double layer theory, but this theory does not scale well to power generation by electrodynamic tethers in space, since very high anode potentials are needed to draw a substantial ambient electron current across the magnetic field in the absence of collisions (or effective collisions due to turbulence). Isotropic quasineutral models of contactor clouds, extending over a region where the effective collision frequency upsilon sub e exceeds the electron cyclotron frequency omega sub ce, have low anode potentials, but would collect very little ambient electron current, much less than the emitted ion current. A new model is presented, for an anisotropic contactor cloud oriented along the magnetic field, with upsilon sub e less than omega sub ce. The electron motion along the magnetic field is nearly collisionless, forming double layers in that direction, while across the magnetic field the electrons diffuse collisionally and the potential profile is determined by quasineutrality. Using a simplified expression for upsilon sub e due to ion acoustic turbulence, an analytic solution has been found for this model, which should be applicable to current collection in space. The anode potential is low and the collected ambient electron current can be several times the emitted ion current. Author

N91-17731*# Colorado Univ., Boulder. Dept. of Astrophysical, Planetary, and Atmospheric Sciences.

EFFECTS OF NEUTRAL GAS RELEASES ON ELECTRON BEAM INJECTION FROM ELECTRICALLY TETHERED SPACECRAFT

R. M. WINGLEE *In* NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 308-319 Dec. 1990
(Contract NAGW-1587; NAGW-91; NSG-7827; NSF ATM-87-19371)
Avail: NTIS HC/MF A16 CSCL 20/9

The presence of high neutral densities at low altitudes and/or during thruster firings is known to modify the spacecraft potential during active electron beam injection. Two-dimensional (three velocity) particle simulations are used to investigate the ionization processes including the neutral density required, the modification of the spacecraft potential, beam profile and spatial distribution of the return current into the spacecraft. Three processes are identified: (1) beam-induced ionization, (2) vehicle-induced ionization, and (3) beam plasma discharge. Only in the first two cases does the beam propagate away with little distortion. Author

N91-17732*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.

PRESSURE AND CURRENT BALANCE CONDITIONS DURING ELECTRON BEAM INJECTIONS FROM SPACECRAFT

K. S. HWANG and NAGENDRA SINGH *In* NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 320-333 Dec. 1990
(Contract NAS8-37107)
Avail: NTIS HC/MF A16 CSCL 20/9

Electrostatic charging level of a conducting surface in response to injections of electron beams into space plasma is investigated by means of one-dimensional Vlasov code. Injections of Maxwellian beams into a vacuum shows that the surface can charge up to an electric potential phi sub s greater than W sub b, where W sub b is the average electron beam energy. Since Maxwellian beams have extended trails with electrons having energies greater than W sub b, it is difficult to quantify the charging level in terms of the energies of the injected electrons. In order to quantitatively understand the charging in excess of W sub b, simulations were carried out for water-bag types of beam with velocity distribution functions described by f(V) = A for V sub min approx. less than V approx. less than V sub max and f(V) = O otherwise, where A is a constant making the normalized beam density unity. It is found that V sub max does not directly determine the charging level. The pressure distribution in the electron sheath determines the electric field distribution near the surface. The electric field in turn determines the electrostatic potential of the vehicle. The pressure distribution is determined by the beam parameters such as the average beam velocity and the velocity spread of the beam. Author

N91-17733*# Systems Science and Software, La Jolla, CA.
NASCAP/LEO CALCULATIONS OF CURRENT COLLECTION
MYRON J. MANDELL, IRA KATZ, VICTORIA A. DAVIS, and ROBERT A. KUHARSKI *In* NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 334-351 Dec. 1990
(Contract NAS3-23881)
Avail: NTIS HC/MF A16 CSCL 20/9

NASCAP/LEO is a 3-dimensional computer code for calculating the interaction of a high-voltage spacecraft with the cold dense plasma found in Low Earth Orbit. Although based on a cubic grid structure, NASCAP/LEO accepts object definition input from standard computer aided design (CAD) programs so that a model may be correctly proportioned and important features resolved. The potential around the model is calculated by solving the finite element formulation of Poisson's equation with an analytic space charge function. Five previously published NASCAP/LEO calculations for three ground test experiments and two space flight experiments are presented. The three ground test experiments are a large simulated panel, a simulated pinhole, and a 2-slit experiment with overlapping sheaths. The two space flight experiments are a solar panel biased up to 1000 volts, and a rocket-mounted sphere biased up to 46 kilovolts. In all cases, the authors find good agreement between calculation and measurement. Author

N91-18123*# Arizona Univ., Tucson.
AUTONOMOUS SPACE PROCESSOR FOR ORBITAL DEBRIS
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 11-21 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

This work continues to develop advanced designs toward the ultimate goal of a Get Away Special to demonstrate economical removal of orbital debris using local resources in orbit. The fundamental technical feasibility was demonstrated in 1988 through theoretical calculations, quantitative computer animation, a solar focal point cutter, a robotic arm design, and a subscale model. Last year improvements were made to the solar cutter and the robotic arm. Also performed last year was a mission analysis that showed the feasibility of retrieving at least four large (greater than 1500-kg) pieces of debris. Advances made during this reporting period are the incorporation of digital control with the existing placement arm, the development of a new robotic manipulator arm, and the study of debris spin attenuation. These advances are discussed here. Author

N91-18171*# Texas A&M Univ., College Station.
ORBITAL DEBRIS REMOVAL AND SALVAGE SYSTEM
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 329-331 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

Four Texas A&M University projects are discussed. The first project is a design to eliminate a majority of orbital debris. The Orbital Debris and Salvage System will push the smaller particles into lower orbits where their orbits will decay at a higher rate. This will be done by momentum transfer via laser. The salvageable satellites will be delivered to the Space Station by an Orbital Transfer Vehicle. The rest of the debris will be collected by Salvage I. The second project is the design of a space based satellite system to prevent the depletion of atmospheric ozone. The focus is on ozone depletion in the Antarctic. The plan is to use an orbiting solar array system designed to transmit microwaves at a frequency of 22 GHz over the region in order to dissipate polar stratospheric clouds that form during the months beginning in August and ending in October. The third project, Project Poseidon, involves a conceptual design of a space based hurricane control system consisting of a network of 21 low-orbiting laser platforms arranged in three rings designed to heat the upper atmosphere of a developing tropical depression. Fusion power plants are proposed to provide power for the lasers. The fourth project, Project Donatello, involves a proposed Mars exploration initiative for the year 2050. The project is a conceptual design for a futuristic superfreighter that will transport large numbers of people and supplies to Mars for the construction of a full scale scientific and manufacturing complex. Author

N91-18203# European Space Agency, Paris (France).
THE SPACE ENVIRONMENT: CHARACTERISTICS AND EFFECTS
In its Manned Space Stations: Their Construction, Operation and Potential Applications p 11-26 Nov. 1990 Original contains color illustrations
Copyright Avail: NTIS HC/MF A06; EPD, ESTEC, Noordwijk, Netherlands, HC 40 Dutch guilders

The space environment in low Earth orbit is an unfriendly place for both spacecraft and life forms. To exploit it properly, it is necessary to understand both its characteristics and corresponding effects on living organisms. Some of these characteristics offer advantages or involve only minor problems that can be resolved, while others are very hazardous and unpredictable. In space, there are not only the phenomena of microgravity, vacuum, and extreme temperature, but also lethal radiations and high speed junk that can severely damage or even destroy a space station. Each of these phenomena and the effects they have on the space station and the crew are discussed. Means of overcoming the possible disadvantageous effects are discussed and ways of exploiting space conditions are presented. ESA

N91-18531*# Stanford Univ., CA. Space, Telecommunications, and Radioscience Lab.
PLASMA DENSITY ENHANCEMENTS CREATED BY THE IONIZATION OF THE EARTH'S UPPER ATMOSPHERE BY ARTIFICIAL ELECTRON BEAMS
TORSTEN NEUBERT and PETER M. BANKS *In* AGARD, Ionospheric Modification and its Potential to Enhance or Degrade the Performance of Military Systems 6 p Oct. 1990
(Contract NAS8-35350; NAGW-1566; NAG5-607; F19628-89-K-0040)
Copyright Avail: NTIS HC/MF A21; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive CSCL 04/1

Analytical calculations and experimental observations relating to the interaction with the Earth's upper atmosphere of electron beams emitted from low altitude spacecraft are presented. The problem is described by two coupled nonlinear differential equations in the up-going (along a magnetic field line) and down-going differential energy flux. The equations are solved numerically, using the MSIS atmospheric model and the IRI ionospheric model. The results form the model compare well with recent observations from the CHARGE 2 sounding rocket experiment. Two aspects of the beam-neutral atmosphere interaction are discussed. First, the limits on the electron beam current that can be emitted from a spacecraft without substantial spacecraft charging are investigated. This is important because the charging of the spacecraft to positive potentials limits the current and the escape energy of the beam electrons and thereby limits the ionization of the neutral atmosphere. As an example, we find from CHARGE 2 observations and from the model calculations that below about 180 km, secondary electrons generated through the ionization of the neutral atmosphere by 1 to 10 keV electron beams from sounding rockets, completely balance the beam current, thereby allowing the emission of very high beam currents. Second, the amount of plasma production in the beam-streak is discussed. Results are shown for selected values of the beam energy, spacecraft velocity, and spacecraft altitude. Author

N91-18534# Norwegian Defence Research Establishment, Kjeller.
VEHICLE CHARGING IN LOW DENSITY PLASMAS

B. N. MAEHLUM and J. TROIM *In* AGARD, Ionospheric Modification and its Potential to Enhance or Degrade the Performance of Military Systems 11 p Oct. 1990
Copyright Avail: NTIS HC/MF A21; Non-NATO Nationals requests available only from AGARD/Scientific Publications Executive

Studies of electrical charging of space vehicles have been reported in a number of papers in the last ten years. These studies are based on charging due to onboard electron and ion accelerators as well as charging due to thermal and energetic electrically charge particles impinging on the surface of the vehicle. In spite of this significant effort made in the field, both theoretically and experimentally, the vehicle charging problem is far from being completely understood. Part of the problem relates to the effects of the plasma disturbances created by the beam. Several attempts have been made with a varying degree of success to simulate space plasma processes in large plasma chambers. The celebrated studies in the large chamber at Johnson Space Center show that the plasma may be very disturbed in the presence of a beam of fast electrons by a beam plasma discharge (BDP) process. This process was expected also to explain phenomena observed in the upper atmosphere and possible various aspects of the vehicle charging. However, there are still some doubts as to whether the BDP really occurs in space, and the significance of the laboratory simulation experiments conducted in the past remains obscure. A number of high vehicle chargings generated by electron beams is presented, and how this charging depends on the characteristics of the plasma environment is discussed. Also, some results from a simulation study of these problems conducted in the NDRE plasma chamber are reviewed. Author

N91-19126*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SIXTEENTH SPACE SIMULATION CONFERENCE CONFIRMING SPACEWORTHINESS INTO THE NEXT MILLENNIUM
JOSEPH L. STECHER, III, ed. Washington Nov. 1990 464 p
Symposium held in Albuquerque, NM, 5-8 Nov. 1990; sponsored by NASA, Inst. of Environmental Sciences, AIAA, and the American Society for Testing and Materials
(NASA-CP-3096; REPT-90B00146; NAS 1.55:3096) Avail: NTIS HC/MF A20 CSCL 22/2

The conference provided participants with a forum to acquire and exchange information on the state of the art in space simulation, test technology, thermal simulation and protection, contamination, and techniques of test measurements.

N91-19159*# Rockwell International Corp., Downey, CA.
A FLIGHT EXPERIMENT TO DETERMINE GPS PHOTOCHEMICAL CONTAMINATION ACCUMULATION RATES
A. C. TRIBBLE and J. W. HAFFNER *In* NASA, Goddard Space Flight Center, 16th Space Simulation Conference Confirming Spaceworthiness Into the Next Millennium p 435-446 Nov. 1990
Avail: NTIS HC/MF A20 CSCL 22/2

It was recently suggested that photochemically deposited contamination, originating from volatiles outgassed by a spacecraft, may be responsible for the anomalous degradation in power seen on the GPS Block 1 vehicles. In an attempt to confirm, or deny, the photochemical deposition rates predicted, a study was undertaken to design a flight experiment to be incorporated on the GPS vehicles currently in production. The objective was to develop an inexpensive, light weight instrument package that would give information on the contamination levels within a few months of launch. Three types of apparatus were studied, Quartz Crystal Microbalances, (QCM's), modified solar cells, and calorimeters. A calorimeter was selected due primarily to its impact on the production schedule of the GPS vehicles. An analysis of the sensitivity of the final design is compared to the predicted contamination accumulation rates in order to determine how long after launch it will take the experiment to show the effects of photochemical contamination. Author

N91-19164*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
HYPERVELOCITY IMPACT PHYSICS Final Report
WILLIAM P. SCHONBERG, ALAN J. BEAN, and KENT DARZI Washington NASA Jan. 1991 336 p
(Contract NAS8-36955)
(NASA-CR-4343; NAS 1.26:4343) Avail: NTIS HC/MF A15 CSCL 22/2

All large spacecraft are susceptible to impacts by meteoroids and orbiting space debris. These impacts occur at extremely high speed and can damage flight-critical systems, which can in turn lead to a catastrophic failure of the spacecraft. Therefore, the design of a spacecraft for a long-duration mission must take into account the possibility of such impacts and their effects on the spacecraft structure and on all of its exposed subsystems components. The work performed under the contract consisted of applied research on the effects of meteoroid/space debris impacts on candidate materials, design configurations, and support mechanisms of long term space vehicles. Hypervelocity impact mechanics was used to analyze the damage that occurs when a space vehicle is impacted by a micrometeoroid or a space debris particle. An impact analysis of over 500 test specimens was performed to generate by a hypervelocity impact damage database. Author

N91-19165*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECT OF THE LOW EARTH ORBIT ENVIRONMENT ON SPACE SOLAR CELLS
DAVID J. BRINKER, JOHN R. HICKEY (Eppley Lab., Inc., Newport, RI.), and DONALD K. BRASTED Nov. 1990 8 p Presented at the 5th International Photovoltaic Science and Engineering Conference, Kyoto, Japan, 26-30 Nov. 1990; sponsored in part by Japan Society of Applied Physics, Inst. of Electrical Engineers of Japan and Foundation for Adv. of Intern. Science, Kyoto, Japan
(NASA-TM-103735; E-5973; NAS 1.15:103735) Avail: NTIS HC/MF A02 CSCL 22/2

The results of a space flight experiment designed to provide reference cell standards for photovoltaic measurements as well as to investigate the solar spectrum and the effect of long-term exposure of solar cells to the space environment are presented. This experiment, the Advanced Photovoltaic Experiment (APEX), was launched into low Earth orbit as part of the Long Duration Exposure Facility in 1984 and retrieved 69 months later. APEX contained over 150 solar cells of a wide variety of materials, designs and coverglasses. Data on cell performance was recorded for the first year-on-orbit. Author

N91-20186# Systems Science and Software, La Jolla, CA.
POLAR CODE VALIDATION Final Report, 6 May 1986 - 6 Sep. 1989
I. KATZ, J. R. LILLEY, JR., GARY A. JONGEWARD, M. J. MANDELL, and T. T. LUU 30 Sep. 1989 56 p
(Contract F19628-86-C-0056)
(AD-A230138; SSS-DFR-89-10708/R1; GL-TR-89-0276) Avail: NTIS HC/MF A04 CSCL 22/2

The POLAR code was written to model charging by large spacecraft in low, polar orbit. This report documents comparisons of POLAR code calculations with flight experiments. Calculations of the plasma wake behind the Shuttle Orbiter are compared with the situ measurements of Murphy et al., 1989. Calculation of the charging of DMSP-7 are compared with the flight measurements of Gussenhoven et al., 1985. Calculations of current and potential on the SPEAR 1 rocket are compared with the flight measurements. Calculation of electron collection by the CHARGE 2 mother rocket payload are compared with flight observations. In all cases, the POLAR calculations agreed with the essential features of the observations. GRA

N91-20187# Arnold Engineering Development Center, Arnold Air Force Station, TN.
CONTAMINATION EFFECTS OF SATELLITE MATERIAL OUTGASSING PRODUCTS ON THERMAL SURFACES AND SOLAR CELLS Final Report, 1 Oct. 1988 - 30 Sep. 1990
B. L. SEIBER, W. T. BERTRAND, and B. E. WOOD Dec. 1990 57 p
(AD-A230199; AEDC-TR-90-27) Avail: NTIS HC/MF A04 CSCL 10/3

The Wright Research and Development Center (WRDC) and the Arnold Engineering Development Center (AEDC) have initiated a program for measuring optical and radiative effects of satellite material outgassing products on thermal control and cryo-optic surfaces. A solar absorptance chamber for making reflectance/absorptance measurements on thermal control materials has been established. This report describes the operation of the solar absorptance chamber used to measure the degradation of reflective surfaces and solar cells caused by deposition of outgassing contaminants. The effects of solar irradiation (UV) were also studied, and results are presented. Data are presented for Dow Corning 93-500 Space-grade encapsulant (DC93-500), Furane Products Uralane 5753-A/B(LV) encapsulant, and Polyclad FR-4 Epoxy laminate. GRA

N91-20431# RADEX, Inc., Bedford, MA.
ONE-DIMENSIONAL ANALYSIS OF A RADIAL SOURCE FLOW OF WATER PARTICLES INTO A VACUUM Technical Report, Jan. - Aug. 1990
A. SETAYESH 31 Aug. 1990 45 p
(Contract F19628-89-C-0068)
(AD-A230729; RX-R-90081; GL-TR-90-0246; SR-4) Avail: NTIS HC/MF A03 CSCL 20/4

An analytical investigation is made of a one-dimensional radial source flow of water into a vacuum. The equations that describe this model are a sixth-order, nonlinear, two-point boundary value problem. The problem is solved by the shooting/splitting technique. The results of this investigation are compared with the other works in the literature and the comparisons generally are in good agreement. Engineering parameters for the release of water into space are used to give some indication of waterflow characteristics into a vacuum environment; these parameters were chosen to resemble those of a recent water release experiment from the space shuttle. GRA

N91-20723*# Toronto Univ. (Ontario). Dept. of Electrical Engineering.
MAGNETOPLASMA SHEATH WAVES ON A CONDUCTING TETHER IN THE IONOSPHERE WITH APPLICATIONS TO EMI PROPAGATION ON LARGE SPACE STRUCTURES
K. G. BALMAIN, H. G. JAMES (Communications Research Centre, Ottawa, Ontario), and C. C. BANTIN *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 646-654 Jan. 1991
Sponsored in part by National Research Council of Canada; Natural Sciences and Engineering Research Council of Canada; and Institute for Space and Terrestrial Science, Ontario
Avail: NTIS HC/MF A14 CSCL 17/2

A recent space experiment confirmed sheath-wave propagation of a kilometer-long insulated wire in the ionosphere, oriented parallel to the Earth's magnetic field. This space tether experiment, Oedipus-A, showed a sheath-wave passband up to about 2 MHz and a phase velocity somewhat slower than the velocity of light in a vacuum, and also demonstrated both ease of wave excitation and low attenuation. The evidence suggests that, on any large structure in low Earth orbit, transient or continuous wave electromagnetic interference, once generated, could propagate over the structure via sheath waves, producing unwanted signal levels much higher than in the absence of the ambient plasma medium. Consequently, there is a need for a review of both electromagnetic interference/electromagnetic compatibility standards and ground test procedures as they apply to large structures in low Earth orbit. Author

N91-20725*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
ENVIRONET: AN ONLINE ENVIRONMENTAL INTERACTIONS RESOURCE
MICHAEL LAURIENTE *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 668-673 Jan. 1991 Sponsored by NASA, Washington; AFGL; and AFSC
Avail: NTIS HC/MF A14 CSCL 12/2

EnviroNET is a centralized depository for technical information on environmentally induced interactions likely to be encountered by spacecraft in both low-altitude and high-altitude orbits. It provides a user-friendly, menu-driven format on networks that are connected globally and is available 24 hours a day - every day. The service pools space data collected over the years by NASA, USAF, other government research facilities, industry, universities, and the European Space Agency. This information contains text, tables and over one hundred high resolution figures and graphs based on empirical data. These graphics can be accessed while still in the chapters, making it easy to flip from text to graphics and back. Interactive graphics programs are also available on space debris, the neutral atmosphere, magnetic field, and ionosphere. EnviroNET can help designers meet tough environmental flight criteria before committing to flight hardware built for experiments, instrumentation, or payloads. Author

N91-20727*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE ENVIRONMENT WORKBENCH: A DESIGN TOOL FOR SPACE STATION FREEDOM
GARY A. JONGEWARD, ROBERT A. KUHARSKI, THOMAS V. RANKIN, KATHERINE G. WILCOX (Systems Science and Software, La Jolla, CA.), and JAMES C. ROCHE *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 684-687 Jan. 1991
(Contract NAS3-25347)
Avail: NTIS HC/MF A14 CSCL 22/2

The environment workbench (EWB) is being developed for NASA by S-CUBED to provide a standard tool that can be used by the Space Station Freedom (SSF) design and user community for requirements verification. The desktop tool will predict and analyze the interactions of SSF with its natural and self-generated environments. A brief review of the EWB design and capabilities is presented. Calculations using a prototype EWB of the on-orbit floating potentials and contaminant environment of SSF are also presented. Both the positive and negative grounding configurations for the solar arrays are examined to demonstrate the capability of the EWB to provide quick estimates of environments, interactions, and system effects. Author

N91-20729*# Space Command, Peterson AFB, CO.
SMALL SATELLITE DEBRIS CATALOG MAINTENANCE ISSUES
PHOEBE A. JACKSON *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 696-704 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 22/1

The United States Space Command (USSPACECOM) is a unified command of the Department of Defense, and one of its tasks is to detect, track, identify, and maintain a catalog of all man-made objects in Earth orbit. This task is called space surveillance, and the most important tool for space surveillance is the satellite catalog. The command's reasons for performing satellite catalog maintenance is presented. A satellite catalog is described, and small satellite-debris catalog-maintenance issues are identified. The underlying rationale is to describe the catalog maintenance services so that the members of the community can use them with assurance. Author

N91-20730*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE IMPORTANCE OF MOMENTUM TRANSFER IN COLLISION-INDUCED BREAKUPS IN LOW EARTH ORBIT
ROBERT C. REYNOLDS and BRIAN J. LILLIE *In its* Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 706-717 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 22/1

Although there is adequate information on larger objects in low Earth orbit, specifically those objects larger than about 10 cm in diameter, there is little direct information on objects from this size down to 1 mm. Yet, this is the sized regime where objects acting as projectiles represent the ability to seriously damage or destroy a functioning spacecraft if they collide with it. The observed consequences of known collisional breakups in orbit indicates no significant momentum transfer in the resulting debris cloud. The position taken in this paper is that this is an observational selection effect: what is seen in these events is an explosion-like breakup of the target structure arising from shock waves introduced into the structure by the collision, but one that occurs significantly after the collision processes are completed; the collision cloud, in which there is momentum transfer, consists of small, unobserved fragments. Preliminary computations of the contribution of one known collisional breakup, Solwind at 500 km in 1985, and Cosmos 1275 in 1981, assume no momentum transfer on breakup and indicate that these two events are the dominant contributors to the current millimeter and centimeter population. A different story would emerge if momentum transfer was taken into account. The topics covered include: (1) observation of on-orbit collisional breakups; (2) a model for momentum transfer; and (3) velocity space representation of breakup clouds. Author

N91-20731*# Naval Space Surveillance System, Dahlgren, VA. Dept. of Analysis and Software.
NAVSPASUR ORBITAL PROCESSING FOR SATELLITE BREAK-UP EVENTS
PAUL W. SCHUMACHER, JR. *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 718-723 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 22/1

Satellite breakups via explosion or collision can instantly increase the trackable orbiting population by up to several hundred objects, temporarily perturbing the routine space surveillance operations at U.S. Space Command (USSPACWCOM) and the Naval Space Surveillance Center (NAVSPASUR). This paper is a survey of some of the procedures and techniques used by NAVSPASUR to respond to such events. First, the overall data flow at NAVSPASUR is described highlighting the places at which human analysts may intervene with special processing. So-called manual intervention is required in a variety of non-nominal situations, including breakups. Second, a description is given of some of the orbital analysis and other software tools available to NAVSPASUR analysts. These tools were developed in-house over the past thirty years and can be employed in a highly flexible manner. The basic design philosophy for these tools was to implement simple concepts as efficiently as possible and to allow the analyst maximum use of his personal expertise. Finally, several historical breakup scenarios are discussed briefly. These scenarios provide examples of the types of questions that are fairly easy to answer in the present operational environment, as well as examples of questions that are very difficult to answer. Author

N91-20733*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ATOMIC OXYGEN BEAM SOURCE FOR EROSION SIMULATION
J. W. CUTHBERTSON, W. D. LANGER, R. W. MOTLEY (Princeton Univ., NJ.), and J. A. VAUGHN *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 734-741 Jan. 1991
(Contract NASA ORDER H-83097-B)
Avail: NTIS HC/MF A14 CSCL 20/8

A device for the production of low energy (3 to 10 eV) neutral atomic beams for surface modification studies is described that reproduces the flux of atomic oxygen in low Earth orbit. The beam is produced by the acceleration of plasma ions onto a negatively biased plate of high-Z metal; the ions are neutralized and reflected by the surface, retaining some fraction of their incident kinetic energy, forming a beam of atoms. The plasma is generated by a coaxial RF exciter which produces a magnetically-confined (4 kG) plasma column. At the end of the column, ions fall through the sheath to the plate, whose bias relative to the plasma can be varied to adjust the beam energy. The source provides a neutral flux approximately equal to 5 x 10(exp 16)/sq cm at a distance of 9 cm and a fluence approximately equal to 10(exp 20)/sq cm in five hours. The composition and energy of inert gas beams was diagnosed using a mass spectometer/energy analyzer. The energy spectra of the beams demonstrate energies in the range 5 to 15 eV, and qualitatively show expected dependences upon incident and reflecting atom species and potential drop. Samples of carbon film, carbon-based paint, Kapton, mylar, and teflon exposed to atomic O beams show erosion quite similar to that observed in orbit on the space shuttle. Author

N91-20736*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
CHARACTERIZATION OF A 5-EV NEUTRAL ATOMIC OXYGEN BEAM FACILITY
J. A. VAUGHN, R. C. LINTON, M. R. CARRUTH, JR., A. F. WHITAKER, J. W. CUTHBERTSON, W. D. LANGER, and R. W. MOTLEY (Princeton Univ., NJ.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 764-771 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 20/8

An experimental effort to characterize an existing 5-eV neutral atomic oxygen beam facility being developed at Princeton Plasma Physics Laboratory is described. This characterization effort includes atomic oxygen flux and flux distribution measurements using a catalytic probe, energy determination using a commercially designed quadrupole mass spectrometer (QMS), and the exposure of oxygen-sensitive materials in this beam facility. Also, comparisons were drawn between the reaction efficiencies of materials exposed in plasma ashers, and the reaction efficiencies previously estimated from space flight experiments. The results of this study show that the beam facility is capable of producing a directional beam of neutral atomic oxygen atoms with the needed flux and energy to simulate low Earth orbit (LEO) conditions for real time accelerated testing. The flux distribution in this facility is uniform to +/- 6 percent of the peak flux over a beam diameter of 6 cm. Author

05

MATERIALS

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

A91-10141*# McDonnell-Douglas Space Systems Co., Houston, TX.
SPACE STATION METEOROID AND DEBRIS DESIGN REQUIREMENTS
JAMES T. GEHAN (McDonnell Douglas Space Systems Co., Houston, TX) and RAYMOND L. NIEDER (NASA, Johnson Space Center, Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3776)

General concepts and design requirements for the protection of Space Station Freedom against damage from meteoroids and orbital debris are reviewed. In particular, attention is given to the current approach to spacecraft protection from the meteoroid environment, derived from probability-based requirements. Alternative approaches are considered, which include a refined probability approach, an area ratio approach, and a particle matrix approach. The original approach and the new approaches are then compared in terms of design flexibility and programmatic maintenance considerations. V.L.

A91-13730#
SPACECRAFT MATERIALS IN THEIR ACTUAL FLIGHT ENVIRONMENT
J. C. GUILLAUMON, M. SUBIAS (CNES, Toulouse, France), J. C. MANDEVILLE, and A. PAILLOUS (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-005) Copyright

The effects of synergistic action of oxygen atoms and UV radiation on specimens of spacecraft materials are compared with the effects of solar UV radiation acting alone. The advantages and drawbacks of in-flight experiments are discussed. Preliminary experimental results are reviewed which show that very uniform ITO and silicone layers are very effective in decreasing oxidative surface degradation. Findings are also reported on Teflon specimens and paints. C.D.

A91-13786*# NASA Space Station Program Office, Reston, VA.
THE ROLE OF THE LONG DURATION EXPOSURE FACILITY IN THE DESIGN OF THE SPACE STATION FREEDOM
S. A. LITTLE (NASA, Space Station Freedom Program Office, Reston, VA), W. H. KINARD (NASA, Langley Research Center, Hampton, VA), and J. B. WHITESIDE (Grumman Corporate Research Center, Bethpage, NY) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-080)

The Long Duration Exposure Facility (LDEF) satellite retrieved this year by the U.S. Space Shuttle offers spacecraft designers an unprecedented opportunity to examine synergistic, long-term space environmental effects on systems and materials. This paper discusses the strategy for data development and the role its implementation will play in the design of the Space Station Freedom. Examples are provided from three key areas (environments definition, protection of external surfaces, and verification of system components) to illustrate LDEF's potential contribution. Author

A91-13921#
ADVANCED MATERIALS FOR SPACE STRUCTURES
JOHN R. WILLIAMSON (USAF, Materials Laboratory, Wright-Patterson AFB, OH) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-276) Copyright

The materials that are being used to meet the operational requirements of evolving space systems and applications are briefly discussed. The materials considered include tribomaterials, structural materials, and vibration suppression materials. Various demonstration results are presented. C.D.

A91-13922#
SPACECRAFT SHIELDING AGAINST ORBITAL DEBRIS - A REVIEW OF THE TECHNOLOGICAL WORK UNDERTAKEN IN EUROPE
M. LAMBERT and E. SLACHMUYLDERS (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER 90-277) Copyright

Technological work done by ESA to improve the state of the art in the design and implementation of meteoroid and debris protection is described. Hypervelocity impact physics is briefly reviewed, and the effects of impacts is examined along with the thermal protection measures that can be taken against impacts. Ongoing ESA research on engineering modeling, material selection, configurations, test facilities, computer simulation, and impact damage detection is reviewed, especially as it applies to Columbus. C.D.

A91-13923#
MATERIAL CONSIDERATIONS FOR SPACE STATION FREEDOM
H. W. BABEL, K. E. SIMPSON, and C. A. JONES (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. refs
(IAF PAPER 90-278) Copyright

An approach to materials selection for Space Station Freedom is described. The approach takes into consideration the effects of the environments and loads that will be encountered during launch, assembly, and in service. Thermal control coatings and materials for composites are addressed, and nonenvironmental issues such as pressure vessel materials conpatability are discussed. The status of multilayer insulation development, lubrication selection, and finishes to prevent cold-welding is reviewed. C.D.

A91-13924#
COLUMBUS MATERIALS SELECTION AND QUALIFICATION IN RELATION TO 30 YEARS LIFE TIME AND IN ORBIT MAINTENANCE/REPAIR
H.-J. STEPHAN (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p.
(IAF PAPER 90-279) Copyright

Materials selection for the Columbus program is discussed in the light of maintainability requirements. The long-term behavior of materials under the conditions which will be encountered by Columbus is addressed, and outgassing tests are reviewed as a determinant of the thermovacuum stability of materials. The tests described include the Volatile Condensible Material test, the Vacuum Balance Quartz Crystal tests, and thermogravimetric analysis. Sample results are presented. C.D.

A91-13925#
RESEARCH OF MATERIALS AND COATING OF SPACECRAFT EXTERNAL SURFACES USING RECOVERABLE CASSETTES ABOARD THE 'SALYUT-MIR'-TYPE STATIONS
S. F. NAUMOV, S. A. DEMIDOV, A. A. GORODETSKII, and N. I. KARPOV (Nauchno-Proizvodstvennoe Ob'edinenie Energiia, Kaliningrad, USSR) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-280) Copyright

Recoverable cassettes containing spacecraft thermal coating samples were used to study changes in the material characteristics of the coatings caused by long-term orbital flight conditions. The cassette configuration and the way that sample materials were installed, housed, and released for exposure are described. Sample results are presented for various thermal materials. C.D.

A91-16747#
EFFECTS OF A SURFACE DISCHARGE ON THE SPACE CHARGE DISTRIBUTIONS IN E-IRRADIATED TEFLON AND KAPTON FILMS
M. P. CALS, J. P. MARQUE (ONERA, Chatillon, France), and C. ALQUIE (Paris, Ecole Superieure de Physique et Chimie Industrielles, France) (Conference on Electrical and Dielectric Phenomena, Pocono, PA, Oct. 28-Nov. 1, 1990) ONERA, TP no. 1990-170, 1990, 9 p. Research supported by DRET. refs
(ONERA, TP NO. 1990-170)

An experimental simulation of charging and discharging of polymer films subjected to e-irradiation is presented. The charge profiles in the irradiated films are measured using a laser-induced pressure-wave propagation method. The method is reproducible and nondestructive, and the evolution of the charge density is recorded at various steps of the irradiation process until a discharge occurs. The method is used for in situ measurements of space charge distributions in a vacuum environment and at high charging levels. B.P.

A91-16974
TOWARDS UNOBTAINIUM
MOHAN MISRA (Martin Marietta Space Systems Co., Denver, CO) Aerospace Composites and Materials (ISSN 0954-5832), vol. 2, Nov.-Dec. 1990, p. 29-32.
Copyright
The space conditions to be endured by such prospective orbiting systems as the Space Station Freedom and various on-orbit components of SDI entail space structures with unprecedented dimensional stability throughout temperature changes and maneuver loadings, in order to secure high sensor-pointing accuracies. These requirements have prompted the study of advanced composites for light/stiff, highly damped and dimensionally stable structures; shape-memory alloy matrices for 'smart structure' composites; light alloys for propellant tanks; and such surface modifications as diamond films for tribological and other protective purposes. Attention is given to the development status of discontinuously-reinforced metal-matrix composites, carbon-carbon composites, and beryllide intermetallics. O.C.

A91-17376
COMPOSITE STRUCTURES 5; PROCEEDINGS OF THE FIFTH INTERNATIONAL CONFERENCE, PAISLEY COLLEGE OF TECHNOLOGY, SCOTLAND, JULY 24-26, 1989
I. H. MARSHALL, ED. (Paisley College of Technology, Scotland) Conference organized by the Paisley College of Technology; Sponsored by Scottish Development Agency, USAF, U.S. Army, et al. London, England and New York, Elsevier Applied Science, 1989, 895 p. For individual items see A91-17377 to A91-17414.
Copyright
The conference addresses the progress of composites as structure materials and includes such topics as shells and pressure vessels, failure studies, environmental effects, plate and shell vibration, and damage tolerance. Transport and aerospace applications are also among the issues, along with finite-element studies, and analyses of structural stability, platework structures, pipeworks, fatigue and creep, and laminates. Cementitious structures are reviewed, and focus is placed on matrix considerations and complementary studies. Attention is given to composite-intensive automobiles, failure modes of laminated axisymmetric shells of revolution subject to external pressure, moisture management and artificial aging of fiber-reinforced epoxy resins, and nonlinear forced vibrations of anisotropic composite unsymmetrically laminated plates. Free vibration characteristics of materially monolithic circular cylinders are discussed, along with a finite-element formulation for three-dimensional laminated composite plates, stress analysis of a composite plate based on a new plate theory, the outgassing of spacecraft composites, and vibrational analysis of large antennas for space applications. V.T.

A91-17400
SENSITIVITY STUDIES IN THE OUTGASSING OF SPACECRAFT COMPOSITES
ROBERT D. KARAM (Fairchild Space Co., Germantown, MD) IN: Composite structures 5; Proceedings of the Fifth International Conference, Paisley, Scotland, July 24-26, 1989. London, England and New York, Elsevier Applied Science, 1989, p. 547-559. refs
Copyright
A systematic approach is described for analyzing outgassing in spacecraft composites. Simplifications that apply to practical cases are listed then used to derive tractable mathematical expressions. The boundary condition in the model is related to temperature and surface treatment. Outgassing of a platform subjected to sinusoidal heating is discussed in a numerical example. Sensitivity to small temperature fluctuations does not appear significant, but variations in mean temperature, energy levels, and surface parameters produce very different estimates of outgasasing rates. It is recommended that thermal/diffusion tests be performed on samples fabricated simultaneously with flight hardware. Author

A91-21207*
U.S.-JAPAN WORKSHOP ON SMART/INTELLIGENT MATERIALS AND SYSTEMS, HONOLULU, HI, MAR. 19-23, 1990, PROCEEDINGS
IQBAL AHMAD, ED., ANDREWS CROWSON, ED., CRAIG A. ROGERS, ED., and MASUO AIZAWA, ED. Conference organized by the University of Hawaii; Sponsored by the U.S. Army, USAF, U.S. Navy, NASA, and DARPA. Lancaster, PA, Technomic Publishing Co., Inc., 1990, 353 p. For individual items see A91-21208 to A91-21217.
Copyright
Topics presented include the concept of intelligent materials, the molecular engineering of channel proteins, the prospects, limitations, and requirements of intelligent micro motion systems, the modeling of a shape memory integrated actuator for vibration control of large space structures, and intelligent materials for future electronics. Also presented are the slewing of an active structure, the health monitoring of control system components, the numerical modeling of the microstructure of crystals with symmetry-related variants, and the intelligent material system concept. R.E.P.

A91-21367*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LONG DURATION EXPOSURE FACILITY (LDEF) RESULTS
WILLIAM H. KINARD (NASA, Langley Research Center, Hampton, VA) and ROBERT L. O'NEAL (Lockheed Engineering and Sciences Co., Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p.
(AIAA PAPER 91-0096) Copyright
This paper presents an overview of the initial observations of the Long Duration Exposure Facility and the 57 onboard experiments which were retrieved from space on January 12, 1990, during the Space Shuttle STS Mission 32. The facility and the 57 science, technology, and applications experiments had remained in space for almost 6 years. The initial and the continuing observations of this retrieved hardware have provided, and will continue to provide for a number of years in the future, a wealth of basic science data on the environments of near-earth space and a unique opportunity to observe and study long duration synergistic effects of these space environments on a large array of typical spacecraft materials and systems. Author

A91-24427*# Alabama Univ., Huntsville.
HYPERVELOCITY IMPACT TESTING OF NON-METALLIC MATERIALS
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1225-1235. refs
(Contract NAS8-36955)
Copyright
A comparative analysis of impact damage in composite and ceramic specimens and in geometrically similar aluminum specimens is performed to determine the advantages and disadvantages of employing certain composite and ceramic materials in the design of structural wall systems for long-duration spacecraft. A similar analysis of the damage in single panel lexan and multi-plane glass windows shows that glass window systems are rather resilent under hypervelocity impact loadings. It is concluded that thin Kevlar 49, IM6/3501-6 graphite/epoxy, and alumina panels offer no advantage over equivalent aluminum 6061-T6 panels in reducing the penetration threat of hypervelocity projectiles. L.K.S.

A91-25326#
ATOMIC OXYGEN INTERACTION WITH SPACECRAFT MATERIALS
MASAAKI ITO, MASAMI WATANABE, MASAHIRO ISHII, and

KYOICHI KURIKI Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, Sept. 1990, p. 335-339. In Japanese, with abstract in English. refs

Atomospheric interaction with spacecraft materials in low earth orbits was demonstrated using an atomic oxygen flow facility. Resistance against atomic oxygen was assessed on some candidate materials. Polymide films, which are used for thermal control and structural materials, were tested to show surface degradation and substantial mass loss. The reaction mechanism was studied with XPS and FTIR methods. It is found that the imide ring is oxidized, opened, and evaporated, and that a higher glass transition temperature is effective in slowing the reaction. Other materials such as TFE-coated belt glass cloth, silicone rubber, MoS2, and CFRP were also tested. While TFE and CFRP are susceptible to atomic oxygen, glass cloth and silicone rubber are unaffected. The stability of MoS2 is also determined by its fixation method. Author

A91-26086#

SURFACE DISCHARGE ON E-IRRADIATED POLYMERS

J. P. MARQUE (ONERA, Chatillon, France) (Cours International de Technologie Spatiale, Toulouse, France, Nov. 26-30, 1990) ONERA, TP no. 1990-185, 1990, 12 p. refs

(ONERA, TP NO. 1990-185)

Deep charge trapping in thermal blankets at the surface of geostationary spacecrafts gave rise to interest in surface discharge occurring in a vacuum. Experiments on triggered surface discharges and bulk charge distribution in dielectrics present the physical processes which rules this type of discharges. The flashover propagation is mainly a surface process, for which a model based on the ionization of a thin layer of desorbed gas at the surface of the polymer is developed. Blowoff electrons are released under the effect of the expansion into vacuum of the plasma of the discharge channel. The part of the main parameters as they can act in orbit when a charging event leads to a radioelectric perturbation and the electrical consequences of such a discharge are described. Author

A91-27678

UNUSUAL SPACECRAFT MATERIALS

JONATHAN V. POST (Rockwell International Corp., Downey, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1055-1064. refs

Copyright

A speculative evaluation is made of exotic materials that might be conveniently and advantageously employed by future spacecraft of solar sail-powered, sungrazing, and nuclear fusion-powered 'iceship' types. Attention is given to the last of these concepts, envisioned as a spacecraft constructed from structure-forming clusters of hydrogen ice spheres that can be robotically detached as required for propulsion-system consumption. The hydrogen spheres act as cryogen, structure, propellant, radiation shielding, radiation absorber, radiation window, and electrical power source. The concept is subjected to thermal analyses and computer simulations. O.C.

A91-27933

ON THE INFLUENCE OF PLY-ANGLE ON DAMPING AND MODULUS OF ELASTICITY OF A METAL-MATRIX COMPOSITE

VIKRAM K. KINRA (Texas A & M University, College Station), GRAEME G. WREN (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia), SURAJ P. RAWAL, and MOHAN S. MISRA (Martin Marietta Aerospace Corp., Denver, CO) Metallurgical Transactions A - Physical Metallurgy and Materials Science (ISSN 0360-2133), vol. 22A, March 1991, p. 641-651. refs

(Contract N00014-84-C-0413)

Copyright

The central objective of the classical laminate theory is to predict the properties of a laminate having an arbitrary lay-up, taking as its input the measured properties of an individual lamina. Whereas a fair amount of work has been done concerning the prediction of the laminate stiffness, relatively little attention has been paid to the prediction of laminate damping. A recent model by Ni and Adams (1984) fills this gap. The objective of this paper is to compare the predictions of their model with the results of a careful and detailed experimental investigation of the problem as it concerns metal-matrix composites. Flexural modulus and flexural damping of a continuous graphite/aluminum composite of (+/-theta)s lay-up were measured for theta = 0, 15, 30, 45, 60, 75, and 90 deg. These were compared with the predictions of a slightly modified form of the Ni and Adams model; the model was modified to include the epsilon(y), sigma(y), and tau(xy) terms which were ignored in the earlier work, where (x,y,z) is the laminate coordinate system. Excellent agreement between the theory and experimental results was observed. Author

A91-28183* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

ATOMIC-OXYGEN INDUCED STRUCTURAL CHANGES IN POLYPHOSPHAZENE FILMS AND COATINGS

LARRY L. FEWELL (NASA, Ames Research Center, Moffett Field, CA) Journal of Applied Polymer Science (ISSN 0021-8995), vol. 41, 1990, p. 391-406. refs

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Various polymers were exposed to atomic oxygen O(3P) and comparisons made of their stability. The rates of reaction and mass removal for polyphosphazenes exposed to atomic oxygen were found to be significantly lower than for other polymers evaluated in this study. Surface analysis of polyphosphazene films indicated that O(3P) induces rearrangements in the phosphorus-nitrogen backbone of the polymer, resulting in cross-linking and cleavage of some pendant groups that are then replaced by oxygen. Author

A91-29701*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

EMI TESTING ADEQUACY AND FLIGHT ANOMALY HISTORY

RICHARD W. KUBERRY (JPL, Pasadena, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 51-58. refs

The effects of electromagnetic interference (EMI) and the space environment on the performance of long-duration spacecraft hardware are surveyed, and the implications for prelaunch test procedures are indicated. Topics addressed include the need for onboard environmental monitoring devices to aid in the identification of environmentally induced anomalies, environmental modeling methods, the existing spacecraft-anomaly data bases, electrostatic discharges, radiation effects, magnetic-field effects, and terrestrial sources of EMI. Statistical data on EMI-induced anomalies are presented in graphs and discussed in detail. It is recommended that testing beyond the current MIL-STD levels be performed on equipment for long-term missions such as the Space Station. T.K.

A91-29712#

EVALUATION OF RESIDUAL CONTAMINATION ON SILVERED-TEFLON AFTER REMOVAL OF COVERLAY

LOURDES MENES and MAX K. BARSH (Aerojet ElectroSystems, Azusa, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 151-156.

Recognition that contamination of silvered-Teflon surfaces could result in warming of temperature-sensitive spececraft hardware led to an evaluation of two coverlay materials. Coverlay materials, which are used to protect these surfaces, are removed just prior to launch. Investigations revealed that one of the coverlay candidates left only trace contaminant residues on the Teflon surface. It was also found that any adhesive residues remaining could be effectively removed without damaging the surface. Further studies are under consideration to quantify the impact of on-orbit radiation effects on the very small residue from the best coverlay candidate. Author

A91-32134* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
COATINGS COULD PROTECT COMPOSITES FROM HOSTILE SPACE ENVIRONMENT
ANN F. WHITAKER (NASA, Marshall Space Flight Center, Huntsville, AL) Advanced Materials and Processes (ISSN 0882-7958), vol. 139, April 1991, p. 30-32.
Copyright

An experiment has been conducted on about 100 different material/process combinations, most of which were candidates for use in solar arrays having high power-to-weight ratios. These substances were exposed to the LEO environment during Long-Duration Exposure Facility Experiment A0171 in order to evaluate the synergistic effects of the LEO environment on the materials' mechanical, electrical, and optical properties. Materials evaluated include solar cells, cover slips having antireflectance coatings, adhesives, encapsulants, reflective materials, mast and harness materials, structural composites, and thermal control thin films. About one-sixth of the experiment tray was devoted to composite-material tensile specimens, which were specifically to be studied for changes in their mechanical properties. Preliminary results of the surface-damage evaluation are presented. These surface effects are dominated by atomic-oxygen erosion and micrometeoroid/space debris impacts. L.K.S.

N91-11058*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PRELIMINARY RESULTS FROM THE ADVANCED PHOTOVOLTAIC EXPERIMENT FLIGHT TEST
DAVID J. BRINKER, RUSSELL E. HART, JR., and JOHN R. HICKEY (Eppley Lab., Inc., Newport, RI.) May 1990 12 p Presented at the 21st Photovoltaic Specialists Conference, Kissimmee, FL, 21-25 May 1990; sponsored in part by IEEE
(NASA-TM-103269; E-5709; NAS 1.15:103269) Avail: NTIS HC/MF A03 CSCL 21H

The Advanced Photovoltaic Experiment is a space flight test designed to provide reference cell standards for photovoltaic measurement as well as to investigate the solar spectrum and the effect of the space environment on solar cells. After a flight of 69 months in low earth orbit as part of the Long Duration Exposure Facility set of experiments, it was retrieved in January, 1990. The electronic data acquisition system functioned as designed, measuring and recording cell performance data over the first 358 days of flight; limited by battery lifetime. Significant physical changes are also readily apparent, including erosion of front surface paint, micrometeoroid and debris catering and contamination. Author

N91-11069# Oak Ridge National Lab., TN. Applied Technology Div.
POTENTIAL FOR ADVANCED THERMOPLASTIC COMPOSITES IN SPACE SYSTEMS
R. E. GARVEY 1990 15 p Presented at the 22nd International Technical Conference of the Society for the Advancement of Material and Process Engineering, Boston, MA, 6-8 Nov. 1990
(Contract DE-AC05-84OR-21400)
(DE90-014447; CONF-901104-1) Avail: NTIS HC/MF A03

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

N91-11118*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STUDIES OF MOLECULAR PROPERTIES OF POLYMERIC MATERIALS Final Report, period ending 31 Aug. 1990
W. L. HARRIES (Old Dominion Univ., Norfolk, VA.), SHEILA ANN T. LONG, and EDWARD R. LONG, JR. May 1990 169 p
(Contract NCC1-90)
(NASA-TM-101854; NAS 1.15:101854; PTR-90-3) Avail: NTIS HC/MF A08 CSCL 11B

Aerospace environment effects (high energy electrons, thermal cycling, atomic oxygen, and aircraft fluids) on polymeric and composite materials considered for structural use in spacecraft and advanced aircraft are examined. These materials include Mylar, Ultem, and Kapton. In addition to providing information on the behavior of the materials, attempts are made to relate the measurements to the molecular processes occurring in the material. A summary and overview of the technical aspects are given along with a list of the papers that resulted from the studies. The actual papers are included in the appendices and a glossary of technical terms and definitions is included in the front matter. M.G.

N91-11811# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.).
BASIC MATERIAL DATA AND STRUCTURAL ANALYSIS OF FIBER COMPOSITE COMPONENTS FOR SPACE APPLICATION
H. BANSEMIR and O. HAIDER 1990 25 p Presented at ICMC International Cryogenic Materials Conference on Nonmetallic Materials and Composites at Low Temperatures, Heidelberg, Fed. Republic of Germany, 17-18 May 1990
(MBB-UD-582-90-PUB; ETN-90-97887) Avail: NTIS HC/MF A03

Fiber composites are widely used for space applications such as antennas, solar arrays, and support structures for cryogenic tanks. For the calculation of the mechanical behavior of composite structures basic material data is presented. Main mechanical properties are thermal conductivity, thermal expansion, stiffness, and strength for the unidirectional material. Special fiber orientations and lay ups are used in order to optimize the laminates, taking special requirements into account. The optimized design for some composite parts for different space applications are shown, especially pointing out the aspects of the structural analysis and the tests performed to check the calculations. ESA

N91-11812# European Space Agency, Paris (France).
SPACE APPLICATIONS OF ADVANCED STRUCTURAL MATERIALS
W. R. BURKE, comp. Jun. 1990 433 p In ENGLISH and FRENCH Symposium held in Noordwijk, Netherlands, 21-23 Mar. 1990
(ESA-SP-303; ISBN-92-9092-054-8; ISSN-0379-6566; ETN-90-97990) Copyright Avail: NTIS HC/MF A19

The use of new structural materials and technology in spacecraft construction and development is discussed. Mirrors and reflectors, hot materials, joining and welding techniques and nondestructive testing of materials are described. Composite fiber reinforced plastics are discussed. Multiwall thermal protection and hot structures are outlined. New materials and techniques for pressure vessel and nozzle construction are described. Metals, metallic composites and functionally gradient materials are discussed. Design allowables and cost parameters are reviewed. Material testing and intelligent structures are discussed.

N91-11828# Aerospatiale Aquitaine, Saint-Medard en Jalles (France). Strategic and Space Div.
FIBER-REINFORCED GLASS-CERAMIC MATRIX COMPOSITES: NEW CLASS MATERIALS FOR SPACE APPLICATIONS

J. F. JAMET *In* ESA, Space Applications of Advanced Structural Materials p 109-113 Jun. 1990
Copyright Avail: NTIS HC/MF A19

A new type of glass and glass/ceramic matrix material is discussed. Potential uses of these fiber reinforced glasses and glass-ceramic matrix composites are reviewed. Their processing, interfaces and characterization are studied. Relationships between the behavior of the material and their microstructure are given special attention. Use of the material in high temperature conditions in space planes, and hot missiles is discussed. The high dimensional stability of the material makes it useful for applications in optical devices and space stations. ESA

N91-11845# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
STATUS OF ESA'S COMPOSITES DESIGN HANDBOOK FOR SPACE STRUCTURE APPLICATIONS
J. BOLZ *In* ESA, Space Applications of Advanced Structural Materials p 217-220 Jun. 1990 Prepared in cooperation with ERNO Raumfahrttechnik G.m.b.H.
Copyright Avail: NTIS HC/MF A19

The status of the Composites Design Handbook (CDH) in 1986 is discussed. General revisions and modifications based on the comments received from ESA's Advanced Structural Materials Exchange Group are outlined. New information on various topics which were considered relevant for the design of composite structures is described. A short survey of the updates and extensions of the CDH contents is presented. Future activities are expected to concentrate on reinforced ceramics and carbon-carbon materials. ESA

N91-11850# Aerospatiale Aquitaine, Saint-Medard en Jalles (France). Strategic and Space Div.
NEW DEVELOPMENTS IN COMPOSITES FOR SPACE APPLICATIONS
J. F. JAMET and D. CABANEL *In* ESA, Space Applications of Advanced Structural Materials p 247-253 Jun. 1990
Copyright Avail: NTIS HC/MF A19

Experience and capabilities in the area of nonmetallic composites for strategic and space applications are described. Special technologies developed for resin formulation and tow impregnation are outlined. High capacity winding machines, expert systems for the optimization of structural joining and radio-curing of large structures is described. Work carried out in the areas of carbon-carbon composites and ceramic composites is summarized. Characterization procedures, nondestructive testing and manufacturing control are discussed. ESA

N91-11874# United Kingdom Atomic Energy Authority, Harwell (England). Dept. of Advanced Engineering Materials.
THE CURRENT STATUS AND FUTURE PROSPECTS OF SMART COMPOSITES
R. DAVIDSON *In* ESA, Space Applications of Advanced Structural Materials p 429-436 Jun. 1990
Copyright Avail: NTIS HC/MF A19

Smart or intelligent materials, modeled on biological systems with sensors acting as a nervous system are discussed. Actuators act as muscles in these materials and real time computers act as a brain to interpret signals and control the system. Smart materials concepts are most easily applied in structural composite materials where appropriate sensors and actuators can be embedded into the structure during manufacture. The concepts involved in this area are reviewed. What is currently possible and will be possible in the future through emerging technology is discussed. ESA

N91-11875# Dornier System G.m.b.H., Friedrichshafen (Germany, F.R.).
MULTIFUNCTIONAL STRUCTURES FOR AEROSPACE APPLICATIONS
KAY W. DITTRICH *In* ESA, Space Applications of Advanced Structural Materials p 437-441 Jun. 1990
Copyright Avail: NTIS HC/MF A19

Multifunction or smart structures are discussed. Such structures are defined as structures incorporating additional functions besides the function of load carrying. The additional functions may be sensing, communication data processing or shape changing. To achieve this multifunctionality, additional elements must be embedded into the structure. Ways in which smart structures may enhance the performance and reduce the weight of space structures are discussed. Incorporation of antennas, sensors, electronics, processors, etc., into spacecraft construction materials is discussed. ESA

N91-12151*# George Mason Univ., Fairfax, VA. Dept. of Electrical and Computer Engineering.
LASER ANNEALING OF AMORPHOUS/POLY: SILICON SOLAR CELL MATERIAL FLIGHT EXPERIMENT Final Report, Oct. 1989 - Jun. 1990
ERIC E. COLE Jun. 1990 31 p
(Contract NAG5-1294)
(NASA-CR-187370; NAS 1.26:187370) Avail: NTIS HC/MF A03 CSCL 10/1

The preliminary design proposed for the microelectronics materials processing equipment is presented. An overall mission profile, description of all processing steps, analysis methods and measurement techniques, data acquisition and storage, and a preview of the experimental hardware are included. The goal of the project is to investigate the viability of material processing of semiconductor microelectronics materials in a micro-gravity environment. The two key processes are examined: (1) Rapid Thermal Annealing (RTA) of semiconductor thin films and damaged solar cells, and (2) thin film deposition using a filament evaporator. The RTA process will be used to obtain higher quality crystalline properties from amorphous/poly-silicon films. RTA methods can also be used to repair radiation-damaged solar cells. On earth this technique is commonly used to anneal semiconductor films after ion-implantation. The damage to the crystal lattice is similar to the defects found in solar cells which have been exposed to high-energy particle bombardment. Author

N91-12155# Naval Postgraduate School, Monterey, CA.
POWER RECOVERY OF RADIATION-DAMAGED GALLIUM ARSENIDE AND INDIUM PHOSPHIDE SOLAR CELLS M.S. Thesis
CORINNE CYPRANOWSKI Dec. 1989 155 p
(AD-A225307) Avail: NTIS HC/MF A08 CSCL 10/2

Radiation damaging to on-orbit solar arrays was found to significantly decrease power output and efficiency. By a process of annealing, these cells can recover some of the initial performance parameters. Gallium Arsenide (GaAs) and Indium Phosphide (InP) solar cells were subjected to 1 MeV electron radiation by a Dynamitron linear accelerator at two fluence levels of 1E14 and 1E15 electrons/sq cm. The annealing process was varied by temperature, amount of forward biased current, light conditions and time. Both types of cells were found to be hardened to radiation; however, the InP cells were superior over the two. Multiple cycles of irradiating and annealing were performed to observe the amount of degradation and recovery. The results prove that substantial recovery will occur, particularly with the InP cells. Applying this process to on-orbit spacecraft utilizing solar arrays as the main source of power will significantly increase mission life and potentially decrease cost of the on-board power system. GRA

N91-13324*# College of William and Mary, Williamsburg, VA. Dept. of Chemistry.
THE EFFECTS OF THE SPACE ENVIRONMENT ON TWO ARAMID MATERIALS
RICHARD L. KIEFER *In* Hampton Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1990 p 71-72 Sep. 1990
Avail: NTIS HC/MF A07 CSCL 11/3

Two aramid fibers having closely related chemical structures were chosen for important roles in the first tether to be used to connect pairs of orbiting vehicles. The protective outer jackets of the tethers will consist of woven fibers of poly(m-phenylene isophthalamide), commercially available from du Pont as Nomex. A cylindrical sheath of woven Kevlar 29, whose principal constituent is poly(p-phenylene terephthalamide), will be the load-bearing component for the tethers. Orbiting tethers will be in a hostile environment in which short wavelength electromagnetic radiation and energetic charged particles degrade exposed organic materials. At lower orbiting altitudes atomic oxygen is an especially serious hazard. Studies on the effects of ultraviolet radiation and atomic oxygen on fibers and films of Kevlar and Nomex are in progress. In an experiment to simulate the effects of atomic oxygen in space, small tows of Kevlar and Nomex were mounted in a commercial ashing device filled with oxygen at low pressure. An RF discharge in the instrument dissociated the molecular oxygen producing a strongly oxidizing atmosphere containing O(3P)(sup 4). Erosion was measured in terms of mass loss. Kevlar films were exposed to UV radiation in an apparatus consisting of a small vacuum chamber, 23 cm in diameter, into which a mass spectrometer and a quartz window were incorporated. Samples were exposed under vacuum with a 1000 watt xenon-arc lamp. Volatile products could be monitored with the mass spectrometer during the exposures. Transmission infrared spectra were taken before and after exposure to monitor chemical changes in the films. Author

N91-14437*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
OUTGASSING DATA FOR SELECTING SPACECRAFT MATERIALS, REVISION 2
WILLIAM A. CAMPBELL, JR. and JOHN J. SCIALDONE Washington Nov. 1990 398 p
(NASA-RP-1124-REV-2; REPT-90B00138-REV-2; NAS 1.61:1124-REV-2; NASA-RP-1014; NASA-TN-D-7362; NASA-TN-D-8008) Avail: NTIS HC/MF A17 CSCL 11/4

Outgassing data, derived from tests at 398 K (125 C) for 24 hours in vacuum as per ASTM E 595-77, were compiled for numerous materials for spacecraft use. The data presented are the total mass loss (TML) and the collected volatile condensable materials (CVCM). The various materials are listed by likely usage and alphabetically. Author

N91-14478 Department of the Navy, Washington, DC.
FABRICATIOI' BY FILAMENT WINDING WITH AN ELASTOMERIC MATERIAL Patent
WAYNE H. NAKAMURA, inventor (to Navy) 1 May 1990 8 p Filed 13 Jul. 1988
(AD-D014570; US-PATENT-4,921,557; US-PATENT-APPL-SN-209143; US-PATENT-CLASS-156-169) Avail: US Patent and Trademark Office CSCL 11/4

This patent discloses an invention that relates in general to fabricating fiber-reinforced membranes using elastometric materials and, in particular, to a filament winding process suitable for fabricating flexible fiber-reinforced membranes for inflatable deployable or expandable structures capable of sustaining high structural loads or providing thermal insulation to the structure. The invention relates especially to a filament winding process for fabricating a flexible membrane which may be inflated to provide a flexible membrane which may be inflated to provide a conically shaped deployable nose fairing for a missile. GRA

N91-15330# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Dept. of Product Assurance and Safety.
DATA FOR SELECTION OF SPACE MATERIALS
Jun. 1990 128 p Revised
(ESA-PSS-01-701-ISSUE-1-REV-2; ESA-PSS-01-701-ISSUE-1; ISSN-0379-4059; ETN-91-98399) Copyright Avail: NTIS HC/MF A07

The intention is to assist the designers and members of project groups in the selection of space materials. Also enclosed are data sheets of space proven material for general space applications, i.e., materials that have been successfully used for some applications in ESA space systems and associated equipment. Concern lies mainly with the constraints specific to space use such as vacuum or radiation. Classes of materials are: adhesives, adhesive tapes, coatings and varnishes, glasses, lubricants, metals, paints, plastic films, potting compounds, reinforced and thermosetting resins, rubbers, and thermoplastics. ESA

N91-15332*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFECTS OF CURE TEMPERATURE, ELECTRON RADIATION, AND THERMAL CYCLING ON P75/930 COMPOSITES
JOAN G. FUNK Dec. 1990 17 p
(NASA-TM-102712; NAS 1.15:102712) Avail: NTIS HC/MF A03 CSCL 11/4

Graphite/epoxy composites are candidates for future space structures due to high stiffness and dimensional stability requirements of these structures. Typical graphite/epoxy composites are brittle and have high residual stresses which often result in microcracking during the thermal cycling typical of the space environment. Composite materials used in geosynchronous orbit applications will also be exposed to high levels of radiation. The purpose of the present study was to determine the effects of cure temperature and radiation exposure on the shear strength and thermal cycling-induced microcrack density of a high modulus, 275 F cure epoxy, P75/930. The results from the P75/930 are compared to previously reported data on P75/934 and T300/934 where 934 is a standard 350 F cure epoxy. The results of this study reveal that P75/930 is significantly degraded by total doses of electron radiation greater than 10(exp 8) rads and by thermally cycling between -250 F and 150 F. The P75/930 did not have improved microcrack resistance over the P75/934, and the 930 resin system appears to be more sensitive to electron radiation-induced degradation than the 934 resin system. Author

N91-18550*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A COMPARISON OF GROUND-BASED AND SPACE FLIGHT DATA: ATOMIC OXYGEN REACTIONS WITH BORON NITRIDE AND SILICON NITRIDE
J. B. CROSS, E. H. LAN, C. A. SMITH, W. J. WHATLEY (Sparta, Inc., Huntsville, AL.), and S. L. KOONTZ 1990 7 p Presented at the Air Force Workshop on Surface Reactions in the Space Environment, Evanston, IL, 24-25 Sep. 1990
(Contract W-7405-ENG-36)
(NASA-TM-103385; NAS 1.15:103385; DE91-004856; LA-UR-90-3968; CONF-9009307-1) Avail: NTIS HC/MF A02 CSCL 04/1

The effects of atomic oxygen on boron nitride (BN) and silicon nitride (Si3N4) have been studied in low Earth orbit (LEO) flight experiments and in a ground-based simulation facility at Los Alamos National Laboratory. Both the in-flight and ground-based experiments employed the materials coated over thin (approx 250 Angstrom) silver films whose electrical resistance was measured in situ to detect penetration of atomic oxygen through the BN and Si3N4 materials. In the presence of atomic oxygen, silver oxidizes to form silver oxide, which has a much higher electrical resistance than pure silver. Permeation of atomic oxygen through BN, as indicated by an increase in the electrical resistance of the silver underneath, was observed in both the in-flight and ground-based experiments. In contrast, no permeation of atomic oxygen through Si3N4 was observed in either the in-flight or ground-based experiments. The ground-based results show good qualitative correlation with the LEO flight results, thus validating the simulation fidelity of the ground-based facility in terms of reproducing LEO flight results. DOE

N91-19149*# TRW Defense and Space Systems Group, Redondo Beach, CA.
SPACE SIMULATION TEST FOR THERMAL CONTROL MATERIALS
W. R. HARDGROVE *In* NASA, Goddard Space Flight Center, 16th Space Simulation Conference Confirming Spaceworthiness Into the Next Millennium p 267-285 Nov. 1990
Avail: NTIS HC/MF A20 CSCL 11/3

Tests were run in TRW's Combined Environment Facility to examine the degradation of thermal control materials in a simulated space environment. Thermal control materials selected for the test were those presently being used on spacecraft or predicted to be used within the next few years. The geosynchronous orbit environment was selected as the most interesting. One of the goals was to match degradation of those materials with available flight data. Another aim was to determine if degradation can adequately be determined with accelerated or short term ground tests. Author

N91-19294*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LOW EARTH ORBITAL ATOMIC OXYGEN AND ULTRAVIOLET RADIATION EFFECTS ON POLYMERS
JOYCE A. DEVER Feb. 1991 15 p
(NASA-TM-103711; E-5943; NAS 1.15:103711) Avail: NTIS HC/MF A03 CSCL 11/3

Because atomic oxygen and solar ultraviolet radiation present in the low earth orbital (LEO) environment can alter the chemistry of polymers resulting in degradation, their effects and mechanisms of degradation must be determined in order to determine the long term durability of polymeric surfaces to be exposed on missions such as Space Station Freedom. The effects of atomic oxygen on polymers which contain protective coatings must also be explored, since unique damage mechanisms can occur in areas where the protective coatings has failed. Mechanisms can be determined by utilizing results from previous LEO missions, by performing ground based LEO simulation tests and analysis, and by carrying out focussed space experiments. A survey is presented of the interactions and possible damage mechanisms for environmental atomic oxygen and UV radiation exposure of polymers commonly used in LEO. Author

N91-20732*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC OXYGEN INTERACTION WITH SOLAR ARRAY BLANKETS AT PROTECTIVE COATING DEFECT SITES
BRUCE A. BANKS, BRUCE M. AUER, SHARON K. RUTLEDGE, and CAROL M. HILL (Case Western Reserve Univ., Cleveland, OH.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 726-732 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 10/1

Atomic oxygen in the low-Earth-orbital environment oxidizes SiOx protected polyimide Kapton solar array blankets at sites which are not protected such as pin windows or scratches in the protective coatings. The magnitude and shape of the atomic oxygen undercutting which occurs at these sites is dependent upon the exposure environment details such as arrival direction and reaction probability. The geometry of atomic oxygen undercutting at defect sites exposed to atomic oxygen in plasma asher was used to develop a Monte Carlo model to simulate atomic oxygen erosion processes at defect sites in protected Kapton. Comparisons of Monte Carlo predictions and experimental results are presented for plasma asher atomic oxygen exposures for large and small defects as well as for protective coatings on one or both sides of Kapton. The model is used to predict in-space exposure results at defect sites for both directed and sweeping atomic oxygen exposure. A comparison of surface textures predicted by the Monte Carlo model and those experimentally observed from both directed space ram and laboratory plasma asher atomic oxygen exposure indicate substantial agreement. Author

N91-20735*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE EFFECT OF ATOMIC OXYGEN ON POLYSILOXANE-POLYIMIDE FOR SPACECRAFT APPLICATIONS IN LOW EARTH ORBIT
SHARON K. RUTLEDGE, JILL M. COOPER, and RAYMOND M. OLLE (Cleveland State Univ., OH.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 755-762 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 20/8

Polysiloxane-polyimide films are of interest as a replacement for polyimide Kapton in the Space Station Freedom solar array blanket. The blanket provides the structural support for the solar cells as well as providing transport of heat away from the back of the cells. Polyimide Kapton would be an ideal material to use; however, its high rate of degradation due to attack by atomic oxygen in low Earth orbit, at the altitudes Space Station Freedom will fly, is of such magnitude that if left unprotected, the blanket will undergo structural failure in much less than the desired 15 year operating life. Polysiloxane-polyimide is of interest as a replacement material because it should from its own protective silicon dioxide coating upon exposure to atomic oxygen. Mass, optical, and photomicrographic data obtained in the evaluation of the durability of polysiloxane-polyimide to an atomic oxygen environment are presented. Author

N91-20737*# Nebraska Univ., Lincoln. Center for Microelectronic and Optical Materials Research.
GROUND AND SPACE BASED OPTICAL ANALYSIS OF MATERIALS DEGRADATION IN LOW-EARTH-ORBIT
JOHN A. WOOLLAM, RON SYNOWICKI, JEFFREY S. HALE, JANE PETERKIN, HASSANAYN MACHLAB, BHOLA N. DE, and BLAINE JOHS *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 772-777 Jan. 1991
(Contract NAG3-95)
Avail: NTIS HC/MF A14 CSCL 07/4

There is strong interest in being able to accurately and sensitively monitor materials degradation in both ground-based and space-based environments. Two optical techniques for sensitive degradation monitoring are reviewed: spectroscopic ellipsometry and photothermal spectroscopy. These techniques complement each other in that ellipsometry is sensitive to atomically thin surface and subsurface changes, and photothermal spectroscopy is sensitive to local defects, pin-holes, subsurface defects, and delamination. Progress in applying these spectroscopies (both ex situ and in situ) to atomic oxygen degradation of space materials is reviewed. Author

N91-20738*# Case Western Reserve Univ., Cleveland, OH. Center for the Commercial Development of Space.
THE TRANSITION OF GROUND-BASED SPACE ENVIRONMENTAL EFFECTS TESTING TO THE SPACE ENVIRONMENT
STEPHEN V. ZAAT, GLEN A. SCHAEFER, and JOHN F. WALLACE *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 778-784 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 07/4

The goal of the space flight program at the Center for Commercial Development of Space (CCDS)--Materials for Space Structures is to provide environmentally stable structural materials to support the continued humanization and commercialization of the space frontier. Information on environmental stability will be obtained through space exposure, evaluation, documentation, and subsequent return to the supplier of the candidate material for internal investigation. This program provides engineering and scientific service to space systems development firms and also exposes CCDS development candidate materials to space environments representative of in-flight conditions. The maintenance of a technological edge in space for NASA suggests the immediate search for space materials that maintain their structural integrity and remain environmentally stable. The materials being considered for long-lived space structures are complex, high strength/weight ratio composites. In order for these new candidate materials to qualify for use in space structures, they must undergo strenuous testing to determine their reliability and stability when subjected to the space environment. Ultraviolet radiation, atomic oxygen, debris/micrometeoroids, charged particles radiation, and thermal fatigue all influence the design of space structural materials. The investigation of these environmental interactions is the key purpose of this center. Some of the topics discussed with respect to the above information include: the Space Transportation System, mission planning, spaceborne experiments, and space flight payloads. Author

N91-20958# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
ANALYSIS OF SPACE RADIATION EFFECTS IN GALLIUM ARSENIDE AND CADMIUM SELENIDE SEMICONDUCTOR SAMPLES USING LUMINESCENCE SPECTROSCOPIC TECHNIQUES M.S. Thesis
BRAD L. SHAFFER Dec. 1990 120 p
(AD-A230684; AFIT/GSO/ENP/90D-02) Avail: NTIS HC/MF A06 CSCL 07/4

Analysis of space radiation effects in gallium arsenide and cadmium selenide semiconductor samples using luminescence spectroscopic techniques. The M0006 semiconductor samples were placed into a 28.5 degree inclination, 480 km altitude, near-circular orbit aboard the Long Duration Exposure Facility satellite and exposed to direct space environment for a period of 11 months, and were shielded by 0.313 inches of aluminum for another 58 months. The samples were examined for changes using cathodoluminescence and photoluminescence in various wavelength regions from 0.5 to 1.8 microns. Samples were cooled to approximately 10 K in a vacuum of 10-8. GRA

06

STRUCTURAL MEMBERS & MECHANISMS

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

A91-10078*# Science Applications International Corp., Huntsville, AL.
GEOMETRIC PROGRAMMING DESIGN OF SPACECRAFT PROTECTIVE STRUCTURES TO DEFEAT EARTH-ORBITAL SPACE DEBRIS
ROBERT A. MOG and D. MARVIN PRICE (Science Applications International Corp., Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p. refs
(Contract NAS8-37378)
(AIAA PAPER 90-3662) Copyright

A unique methodology providing global optimization of spacecraft protective structures is presented. The Geometric Programming optimization technique, which has a long history of application to structural design problems, is employed to minimize spacecraft weight of protective structural systems exposed to meteoroid and space debris hypervelocity impacts. The space debris and meteoroid environment are defined followed by the formulation of the general weight objective function. The Wilkinson, Burch, and Nysmith hypervelocity impact predictor models are then used in example cases to display Geometric Programming capabilities. Results show that global nonlinear design optimization can be performed for hypervelocity impact models that follow the Geometric Programming form. Author

A91-10079*# Alabama Univ., Huntsville.
SPACECRAFT WALL DESIGN FOR INCREASED PROTECTION AGAINST PENETRATION BY SPACE DEBRIS IMPACTS
WILLIAM P. SCHONBERG (Alabama, University, Huntsville) and RANDY J. TULLOS (Southwest Research Institute, San Antonio, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 11 p. refs
(Contract NAS8-26955)
(AIAA PAPER 90-3663) Copyright

All orbiting spacecraft are susceptible to impacts by meteoroids and pieces of orbital space debris. These impacts occur at extremely high speeds and can damage flight-critical systems, which can in turn lead to catastrophic failure of the spacecraft. The design of a spacecraft for a long-duration mission into the meteoroid and space debris environment must include adequate protection against perforation of pressurized components by such impacts. This paper presents the results of an investigation into the perforation resistance of dual-wall structural systems fabricated with monolithic bumper plates and with corrugated bumper plates of equal weight. A comparative analysis of the impact damage in dual-wall systems with corrugated bumper specimens and that in dual-wall specimens with monolithic bumpers of similar weight is performed to determine the advantages and disadvantages of employing corrugated bumpers in structural wall systems for long-duration spacecraft. The analysis indicates that a significant increase in perforation protection can be achieved if a monolithic bumper is replaced by a corrugated bumper of equal weight. The parameters of the corrugations in the corrugated bumper plates are optimized in a manner that minimizes the potential for the creation of ricochet debris in the event of an oblique hypervelocity impact. Several design examples using the optimization scheme are presented and discussed. Author

A91-10080*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
FREEDOM STATION WALL DESIGN USING HYDRODYNAMIC MODELLING
JOEL E. WILLIAMSEN (NASA, Marshall Space Flight Center, Hunstville, AL) and JOHN P. TIPTON (U.S. Army, Corps of Engineers, Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 13 p.
(AIAA PAPER 90-3664) Copyright

The paper outlines selected outputs from an ongoing Marshall Space Flight Center/US Army Corps of Engineers parametric study of the effects of meteoroid/space debris impacts on Space Station Freedom module wall protection structures. The advantages and limitations of HULL hydrocode computer simulation are discussed, and examples of meteoroid/ debris impacts on various wall structural designs are presented. Trends in the terminal effects of particle sizes, velocities, shapes, and impact angles upon structural design parameters (wall and bumper thickness and spacing) are summarized and depicted through selected simulation runs. Throughout the paper, proposed structural modifications to the baseline module protection structure will be examined which are capable of mitigating damage from particle impacts. Author

A91-10081*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
AUGMENTATION OF ORBITAL DEBRIS SHIELDING FOR SPACE STATION FREEDOM
ERIC L. CHRISTIANSEN, JEANNE LEE CREWS (NASA, Johnson Space Center, Houston, TX), and JENNIFER R. HORN (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p.
(AIAA PAPER 90-3665) Copyright

Augmentation concepts for the Space Station Freedom (SSF) are described in detail and advantages and disadvantages of various proposals are evaluated. It is pointed out that early augmentation of SSF debris shielding, which would take place 6-9 years after the First Element Launch, could provide the greatest advantages to the program in terms of weight, cost, and safety benefits. Potential augmentation concepts include an attached, rigid aluminum second bumper; the multi-shock shield concept; a mesh double bumper concept; a debris shield augmentation element; a multi-shock airbag protection concept for 2-10 cm debris; and a debris sweeper. Requirements for and operation and deployment of these concepts are described in detail and an example of the augmentation effect on cumulative SSF probability of no-failure from debris and meteoroid impacts is given. An estimate of predicted encounter rates between debris and a 100 m radius sphere around SSF is presented. L.K.S.

A91-13729#
COLLAPSIBLE TUBE MAST - TECHNOLOGY DEMONSTRATION PROGRAM
F. DEL CAMPO and J. I. RUIZ URIEN (Sener Ingenieria y Sistemas, S.A., Las Arenas, Spain) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-004)

A specific design of the Collapsible Tube Mast (CTM) to be flown aboard the NASA STS is being prepared. The work is done under ESA contract, as part of the Technology Demonstration Program (TDP). The CTM is intended to deploy and retract a 15-kg in Flight Contamination Experiment at distances up to 15 m from the Orbiter Cargo Bay. Objectives of the mission are to measure the contamination in the vicinity of the Orbiter, as well as to demonstrate the CTM performance in orbit (this is the first flight of a retractable CTM). Author

A91-13733#
SPACE EXPERIMENTS OF DEPLOYABLE BOOM AND UMBRELLA TEST SATELLITE (DEBUT)
ATSUSHI NAKAJIMA (National Aerospace Laboratory, Chofu, Japan), MITSURU ABE (NEC Corp., Yokohama, Japan), YOKO NISHIO (Nissan Motor Co., Tokyo, Japan), and HISAO YAHAGI (Japan Aircraft Manufacturing Co., Yokohama) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-008) Copyright

This paper describes the results of the in-orbit performance testing of deployable and retractable umbrella and boom systems, which will be used as important subsystems of Boomerang/Tether satellites. The umbrella is one of the possible candidates of aerodynamic brake (ADB) system for boomerang satellite and the Boom is also one of the possible candidates of relative position adjusting mechanism between center of mass and aerodynamic force center of the boomerang satellite and initial release/final recovery mechanism of the tethered satellite. For this technology verifications, a small and inexpensive satellite, named DEBUT(Deployable Boom and Umbrella Test Satellite), was developed in a short period of 1.5 years elapsing from the start of the detailed design until the launch of the mission. The lithium dry cell batteries were used as the primary power and functioned normally during 10 days mission lifetime. Author

A91-13765*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
MISSION TO PLANET EARTH TECHNOLOGY ASSESSMENT AND DEVELOPMENT FOR LARGE DEPLOYABLE ANTENNAS
C. A. ROGERS, W. L. STUTZMAN (Virginia Polytechnic Institute and State University, Blacksburg), T. G. CAMPBELL (NASA, Langley Research Center, Hampton, VA), and J. M. HEDGEPETH (Astro Aerospace Corp., Carpinteria, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 16 p. refs
(Contract NAS1-18471)
(IAF PAPER 90-051) Copyright

A NASA R&D program, the Large Deployable Antenna program, was initiated to investigate and demonstrate the availability of critical technologies for passive microwave imagers. The science objectives, current state-of-the-art, a number of electromagnetic configurations under consideration, and the mechanical systems development effort are presented. The program team conducted a detailed technology review, evaluated the feasibility and technology readiness for a large dual-reflector radiometer, and developed a system concept for a 25-meter deployable radiometer. The study approach involved determining basic operational parameters and configurations for a geosynchronous wide-scanning radiometer from which specific structural requirements were utilized as goals (rather than specifications) with which specific technologies could be evaluated. R.E.P.

A91-13917#
DAMAGE TOLERANCE AND FRACTURE CONTROL FOR COLUMBUS STRUCTURES UNDER CONSIDERATION OF THEIR LONG DESIGN LIFE ON ORBIT
WERNER H. PAUL (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 14 p.
(IAF PAPER 90-270) Copyright

Aspects of fracture control for Columbus structures are discussed. The advantages and limitations of built-in maintenance and maintenance on-orbit are outlined, and the Columbus design philosophy with regard to structural safety is summarized. Primary sources of local damage are reviewed along with monitoring methods and failure modes and mechanisms. The effects of residual stresses are depicted and impact damage tolerance is discussed. Inspection in orbit is briefly examined. C.D.

A91-13918#
DEPLOYABLE STRUCTURE FOR THE ENTRY AERODYNAMIC BRAKING DECELERATOR SYSTEM OF PLANETARY PROBES
C. BONNET, J. PUECH, and M. RIGAULT (Dassault Aviation, Saint-Cloud, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-271) Copyright

A deployable decelerator concept applicable to the Cassini mission is described. In stowed position, the decelerator occupies a limited volume but is still stiff enough to offer good resistance to launch-induced vibration. The kinematics allow sufficient clearance for probe/orbiter attachment mechanisms to be deployed. The optimization of the structure and its static equilibrium are discussed. C.D.

A91-15170* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ACTIVE STRUCTURES FOR USE IN PRECISION CONTROL OF LARGE OPTICAL SYSTEMS
JAMES L. FANSON, ERIC H. ANDERSON, and DONALD RAPP (JPL, Pasadena, CA) Optical Engineering (ISSN 0091-3286), vol. 29, Nov. 1990, p. 1320-1327. refs
Copyright

This paper discusses the application of active structures technology to the control of precision structures for future space-based astrophysics observatories. The state of the art in active structures is reviewed and technology developments applicable to large optical systems are discussed. Author

A91-15172* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DEVELOPMENT OF AN ACTIVE TRUSS ELEMENT FOR CONTROL OF PRECISION STRUCTURES
ERIC H. ANDERSON, DONALD M. MOORE, JAMES L. FANSON (JPL, Pasadena, CA), and MARK A. EALEY (Itek Optical Systems, Lexington, MA) Optical Engineering (ISSN 0091-3286), vol. 29, Nov. 1990, p. 1333-1341. refs
Copyright

An active structural element for use in precision control of large space structures is described. The active member is intended to replace a passive strut in a truss-like structure. It incorporates an eddy current displacement sensor and an actuator that is either piezoelectric (PZT) or electrostrictive (PMN). The design of the device is summarized. Performance of separate PZT and PMN actuators is compared for several properties relevant to submicrometer control of precision structures. Author

A91-15173
LASER RADAR BEAM STEERING MIRRORS
STEVEN E. FORMAN, JOHN A. SULTANA, and RAYMOND A. LECLAIR (MIT, Lexington, MA) Optical Engineering (ISSN 0091-3286), vol. 29, Nov. 1990, p. 1342-1350. Research sponsored by the U.S. Navy and DARPA. refs
Copyright

The concept of a laser-beam steering mirror for space-based applications is considered with particular attention given to the structural aspects of developing a flat steering mirror for an optical discrimination of an array of spaceborne targets at 10.6 microns. Several steering mirror designs are discussed, and results are presented of computer simulations and of the structural performance of three principal structures: a thin glass sandwich coupled to a deep backup structure, a full-depth beryllium sandwich, and a depth graphite epoxy sandwich. I.S.

A91-16786 Virginia Polytechnic Inst. and State Univ., Blacksburg.
SMART SKINS AND STRUCTURES OVERVIEW
R. O. CLAUS, K. A. MURPHY, and K. D. BENNETT (Virginia Polytechnic Institute and State University, Blacksburg) IN: 1989 SEM Spring Conference on Experimental Mechanics, Cambridge, MA, May 29-June 1, 1989, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1989, p. 528-533. Research supported by Litton Industries, General Dynamics Corp., NASA, and Virginia Center for Innovative Technology. refs
Copyright
Optical fiber sensors have been applied to the measurement of a wide range of physical observables during the last ten years. A large portion of this work has been directed at the extension of such sensors to the internal characterization of materials; in particular, fiber sensor systems have been developed to determine distributed strain, temperature and chemical concentrations along the embedded length of fibers, as well as structural vibration mode shape amplitudes, surface acoustic wave displacement field amplitudes, bulk stress wave amplitudes and damage. Information obtained from these systems is intended to provide in situ material characterization during cure or fabrication, normal in-service lifetime, and gradual material degradation. The fundamental physical interaction between the material phenomenon to be measured and the optical fiber observable, and the limiting performance is described for each system. Specific applications in the testing of advanced aerospace materials are cited. Author

A91-17609
COMPUTATIONAL TRENDS IN LARGE SCALE ENGINEERING OPTIMIZATION
GARRET N. VANDERPLAATS and HIROKAZU MIURA (Engineering Design Optimization, Inc., Santa Barbara, CA) IN: Applications of supercomputers in engineering: Fluid flow and stress analysis applications; Proceedings of the First International Conference, Southampton, England, Sept. 5-7, 1989. Volume 2. Amsterdam and New York/Southampton, England, Elsevier/Computational Mechanics Publications, 1989, p. 269-283. refs
Copyright
Optimization methods are discussed with particular emphasis on features related to supercomputing. Basic concepts are first outlined to indicate the algorithmic features of optimization. Several features are identified which can benefit from parallel computations in order to maximize computational efficiency. Three particular topics are discussed that gain particular benefit from parallel computation. It is concluded that advances in computer architecture can dramatically change the approach to design optimization of large and complex systems. Author

A91-19401*# North Carolina State Univ., Raleigh.
DESIGN AND FABRICATION OF AN AEROBRAKE MOCK-UP
GORDON K. F. LEE (North Carolina State University, Raleigh), JURI FILATOVS (North Carolina Agricultural and Technical State University, Greensboro), JOHN GARVEY, DAVE ANDERSON, and LISA ROCKOFF (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. Research supported by McDonnell Douglas Space Systems Co. refs
(Contract NAGW-1331)
(AIAA PAPER 91-0658) Copyright
The paper reports on the design and fabrication of a Mars aerobrake mockup that has been used in a series of underwater neutral buoyancy tests designed to address this on-orbit assembly issue. Particular attention is given to the aerobrake shell, truss components, and fastener issues. It is noted that soft docking alignment fasteners, fasteners between petals, and fasteners to connect the petal-to-petal truss members are all needed for this mockup. K.K.

A91-19662*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SENSOR TECHNOLOGY FOR SMART STRUCTURES
R. S. ROGOWSKI, J. S. HEYMAN, M. S. HOLBEN, JR. (NASA, Langley Research Center, Hampton, VA), D. W. DEHART, and T. DOEDERLEIN (USAF, Astronautics Laboratory, Edwards AFB, CA) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 177-181. refs
Advanced aerospace structures are discussed that will very likely be fabricated with integral sensors, actuators, and microprocessors for monitoring and dynamic control of configuration. The concept of 'smart structures' integrates fiber-optic sensor technology with advanced composite materials, whereby the optical fibers are embedded in a composite material and provide internal sensing capability for monitoring parameters which are important for the safety, performance, and reliability of the material and the structure. Along with other research facilities, NASA has initiated a cooperative program to design, fabricate, and test composite trusses, tubes, and flat panels with embedded optical fibers for testing and developing prototype smart structures. It is shown that fiber-optic sensor technology can be combined with advanced material and structure concepts to produce a new class of materials with internal sensors for health monitoring of structures. R.E.P.

A91-21212
MODELING OF A SHAPE MEMORY INTEGRATED ACTUATOR FOR VIBRATION CONTROL OF LARGE SPACE STRUCTURES
B. J. MACLEAN, G. J. PATTERSON, and M. S. MISRA (Martin Marietta Space Systems, Denver, CO) IN: U.S.-Japan Workshop on Smart/Intelligent Materials and Systems, Honolulu, HI, Mar. 19-23, 1990, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1990, p. 124-144; Discussion, p. 145. refs
(Contract F04611-88-C-0063)
Copyright
A shape memory material actuator to provide active vibration and shape control for large, adaptive space structures is being developed. One aspect of this work is the development of analytic modeling capabilities for shape memory material behavior. In this project, Cory and McNichol's theory of nonequilibrium thermostatics was altered to account for the multiple quadrant (tension and compression) hysteretic behavior of shape memory alloys. This analytic development will provide critical insight into the design and analysis of smart, adaptive shape memory space truss tubes and actuators for vibration and shape control, as well as the vehicle by which future shape memory actuator control algorithms and methodologies can be assessed. R.E.P.

A91-24586#
CONTACT DYNAMICS OF A SPHERICAL JOINT AND A JOINTED TRUSS-CELL SYSTEM
H. S. TZOU and Y. RONG (Kentucky, University, Lexington) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 81-88. Research supported by the University of Kentucky. Previously cited in issue 11, p. 1702, Accession no. A90-29416. refs
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A91-26808* Ohio Univ., Athens.
PRACTICAL MODEL REDUCTION FOR FLEXIBLE STRUCTURES
JERREL R. MITCHELL, R. DENNIS IRWIN, and GENEVIEVE A. HUSTON (Ohio University, Athens) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 121-142. refs

(Contract NGT-50525)
(AAS PAPER 90-016) Copyright
The most accepted methods for developing models of flexible structures for the analysis, design and simulation of control systems are finite element methods and extraction from experimental data. Using either of these methods, models are often produced with modes that do not significantly add to the fidelity of the model. This paper presents techniques for eliminating these modes. Particular attention is paid to multiple-input, multiple-output systems. First, control system models developed for flexible structures, using finite element methods and experimental data, are briefly discussed. the shortcomings of using models with unnecessary and/or residual modes are delineated. Then, two techniques for reducing the order of models are presented; the first is applicable to single-input, single-output systems and the second for multiple-input, multiple-output systems. Finally, both are illustrated using model data from the proposed NASA Shuttle-C. Author

A91-27659
SPACE DEBRIS - A DESIGN CONSIDERATION
L. R. UTREJA (BDM International, Inc., Huntsville, AL) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 852-862. refs
Copyright
With the increased use of space by manned or unmanned missions, it has become necessary to include yet another parameter in the design of spacecraft, namely, the effect of a probable impact by the man-made space debris. Information about the number and size of small debris at the Space Station altitude is extremely limited and is mostly predicted by models. Protection of the Space Station against space debris is vital for its safe operation. The paper presents a review and discussion of the current space debris environment at the Space Station altitude, Space Station protection design analysis methods, and hypervelocity impact testing and analysis approaches. Author

A91-27685
DYNAMICS OF COMPOSITE TUBES
S. K. DATTA, T. KOHL (Cooperative Institute for Research in Environmental Sciences, Boulder, CO), A. H. SHAH, and R. RATTANAWANGCHAROEN (Manitoba, University, Winnipeg, Canada) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1122-1131. refs
Copyright
A displacement-based stiffness method is used to study the characteristics of dispersive wave propagation in laminate composite cylindrical tubes. It is assumed that the tube is composed of several bonded, uniaxial, or angle-ply composite laminates. The objective is to model modes of propagation in composite tubular struts that are to be used for truss elements or space structures. Numerical results are presented showing the dependence of dispersion characteristics on the fiber orientations in the laminae. Author

A91-27687
EFFECT OF GRAVITY ON DYNAMIC BEHAVIOR OF BEAMS
RALPH J. DORNSIFE (U.S. Army, Construction Engineering Research Laboratory, Champaign, IL) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1142-1148.
Copyright
Large space structures will be needed to provide structural framework for maintaining relative positions of individual components of systems in low earth orbit. Particularly because of the high cost of transporting payload into low earth orbit, large space structures must first be dynamically analyzed and tested on earth. The resulting ground based test behavior must be correlated to behavior in a microgravity environment. Past laboratory testing has, largely, examined dynamic behavior only in directions perpendicular to the gravity vector. This study examines the correlation between earth based natural frequencies in vibration directions parallel to the gravity vector and the theoretical natural frequencies encountered in a microgravity environment. The structure considered is a prismatic beam. Author

A91-29716#
TESTING THE SPACE STATION FREEDOM METEOROID/DEBRIS SHIELDING
ROY L. RICH and MICHAEL D. BJORKMAN (Boeing Co., Seattle, WA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 197-200. refs
The Space Station Freedom habitable modules are being designed to protect the crew from impact by meteoroids and man-made orbital debris. Due to the increasing amount of man-made debris in earth orbit, Space Station Freedom is the first spacecraft whose shielding design is driven by the man-made environment and not the natural environment. Since the characteristics of the orbital debris environment differ from the meteoroid, the test philosophy must differ from that used on prior missions such as Skylab. The points at which the impact testing for Space Station Freedom differ from prior manned spacecraft impact testing are discussed, followed by a brief discussion of the test techniques which are used to perform the tests. Author

A91-30128* Cincinnati Univ., OH.
PRACTICAL EXPERIENCE WITH MULTIVARIABLE POSITIVITY CONTROLLERS
GARY L. SLATER, A. BOSSE, and Q. ZHANG (Cincinnati, University, OH) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1445-1448. NASA-supported research. refs
Copyright
Experience with the application of positivity designed multivariable controllers for the NASA ACES flexible beam experiment is discussed. Multivariable controllers were designed using sets of rotational sensors/actuators (rate gyros/torque actuators) and linear sensors/actuators (accelerometers/LMEDs). Experience with this set of controllers demonstrated the difficulty of designing controllers with significant modal uncertainty and significant phase uncertainty. With the aid of multivariable scaling techniques these designs were ultimately able to achieve a high level of closed-loop damping. I.E.

A91-30141
ENERGY EQUIVALENT EXPANSION
NARESH PATEL (General Electric Co., Astro-Space Div., Valley Forge, PA) and AJMAL YOUSUFF (Drexel University, Philadelphia, PA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1596-1598. refs
Copyright
The authors deal with the overlapping decomposition and expansion of a mechanical system, such as a flexible space structure, to simplify decentralized control design. The approach suggested is to develop an expanded model which preserves the kinetic and potential energy of the original system. The resulting expanded system also maintains the symmetry in the model. Such an expanded system being nonunique, a constructive procedure is provided to produce an expanded system to yield subsystems with least interaction by means of a 2-norm minimization problem. Hence, the local control designs based upon the subsystems would be more justifiable. I.E.

A91-30169* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DISSIPATIVE COMPENSATORS FOR FLEXIBLE SPACECRAFT CONTROL
S. M. JOSHI and P. G. MAGHAMI (NASA, Langley Research

Center, Hampton, VA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1955-1961. refs
Copyright

The problem of controller design for flexible spacecraft is addressed. Model-based compensators, which rely on the knowledge of the system parameters to tune the state estimator, are considered. The instability mechanisms resulting from high sensitivity to parameter uncertainties are investigated. Dissipative controllers, which use collocated actuators and sensors, are also considered, and the robustness properties of constant-gain dissipative controllers in the presence of unmodeled elastic-mode dynamics, sensor/actuator nonlinearities, and actuator dynamics are summarized. In order to improve the performance without sacrificing robustness, a class of dissipative dynamic compensators is proposed and is shown to retain robust stability in the presence of second-order actuator dynamics if acceleration feedback is employed. A class of dissipative dynamic controllers is proposed which consists of a low-authority, constant-gain controller and a high-authority dynamic compensator. A procedure for designing an optimal dissipative dynamic compensator is given which minimizes a quadratic performance criterion. Such compensators offer the promise of better performance while still retaining robust stability. I.E.

A91-30231

ACTIVE AND PASSIVE JOINTS FOR DAMPING AUGMENTATION OF LARGE SPACE STRUCTURES

ALDO A. FERRI and BONNIE S. HECK (Georgia Institute of Technology, Atlanta) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2978-2983. refs
(Contract NSF MSM-87-07846)
Copyright

The development and analysis of improved joints for large space structures (LSSs) are discussed. The joints are designed so that the normal force to a frictional interface is varied, yielding a connecting joint with increased damping performance without significantly increasing the structure's weight or complexity. A single-degree-of-freedom joint and a system consisting of two elastic beams connected by a single active/passive joint are considered. It is shown that these joint designs are able to enhance the energy dissipation from an LSS in a relatively simple and robust way. Numerical simulation results are presented and discussed. I.E.

A91-30414

AN IMPROVED MULTILEVEL OPTIMIZATION APPROACH

Y. DING (Nanjing Aeronautical Institute, People's Republic of China) and B. J. D. ESPING (Royal Institute of Technology, Stockholm, Sweden) Computers and Structures (ISSN 0045-7949), vol. 38, no. 5-6, 1991, p. 557-567. refs
Copyright

An improved multilevel optimization approach is proposed. It is also used in the multilevel optimization of frames with beams including buckling constraints. Two types of the improved multilevel approach are treated at the component level. Hybrid approximation technique is adapted at two levels, however, the method of moving asymptotes is used at the component level. A new relationship between system variables and component variables is derived. Four numerical examples show that the improved multilevel approach has generalized applicability and availability. Author

A91-31846*# General Motors Corp., Saginaw, MI.

DESIGN OF A SHAPE MEMORY ALLOY DEPLOYMENT HINGE FOR REFLECTOR FACETS

W. S. ANDERS (General Motors Corp., Saginaw, MI) and C. A. ROGERS (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 148-158. refs
(Contract NAS1-18471)
(AIAA PAPER 91-1162) Copyright

A design concept for a Shape Memory Alloy (SMA) actuated hinge mechanism for deploying segmented facet-type reflector surfaces on antenna truss structures is presented. The mechanism uses nitinol, a nickel-titanium shape memory alloy, as a displacement-force micro-actuator. An electrical current is used to resistively heat a 'plastically' elongated SMA actuator wire, causing it to contract in response to a thermally-induced phase transformation. The resulting tension creates a moment, imparting rotary motion between two adjacent panels. Mechanical stops are designed into the device to limit its range of motion and to establish positioning accuracy at the termination of deployment. The concept and its operation are discussed in detail, and an analytical dynamic simulation model is presented. The model has been used to perform nondimensionalized parametric design studies. Author

A91-31893#

A KNOWLEDGE-BASED APPROACH TO THE STRUCTURAL ANALYSIS OF LARGE SPACE STRUCTURES

SHOICHI NAKAI, NOBUO FUKUWA, KEIICHI HIROSE, HIROSHI KATUKURA, and MANABU EBIHARA (Shimizu Corp., Tokyo, Japan) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 627-635. refs
(AIAA PAPER 91-1209) Copyright

An attempt is made to implement a knowledge-based approach to structural analysis based on the idea that numerical analysis programming can be thought of as a particular type of engineering design. A system is proposed which first accepts the user's description of a problem, then generates a program, along with input data, and finally gives results to the user. In order to test this approach, a problem-solving model is introduced and implemented based on the object-oriented program development. Author

A91-31964# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

A MICRODYNAMIC VERSION OF THE TENSILE TEST MACHINE

R. J. GLASER (JPL, Pasadena, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1305-1313. NASA-sponsored research.
(AIAA PAPER 91-1082) Copyright

Very large space structures require structural reactions to control forces associated with nanometer-level displacements; JPL has accordingly built a tensile test machine capable of mN-level force measurements and nm-level displacement measurements, with a view to the study of structural linear joining technology at the lower limit of its resolution. The tester is composed of a moving table that is supported by six flexured legs and a test specimen cantilevered off the table to ground. Three vertical legs contain piezoactuators allowing changes in length up to 200 microns while generating axial load and bending moments. Displacements between ground and table are measured by means of three laser-interferometric channels. O.C.

A91-31992*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DESIGN CONSIDERATIONS OF PSR MODERATE FOCUS-MISSION STRUCTURE

CHOON-FOO SHIH and MICHAEL C. LOU (JPL, Pasadena, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1578-1585. refs
(AIAA PAPER 91-1192)

A supporting space-frame has been designed for the segmented panels, secondary reflector, control system, and interface hardware of a near-term Precision Segmented Reflector (PSR) telescope. In addition to meeting areal mass density, vibration frequency, thermal expansion, positioning accuracy, and interface attachment design goals, the PSR structure must withstand Atlas launch loads. Analyses have been conducted of the optical pointing-related structural performance of the Moderate Focus Mission Structure (MFMS), with a view to both mechanical and thermal disturbance analyses; the results indicate that the dynamic responses of the MFMS optical mirrors, due to the chopping disturbance of the secondary reflector about its center-of-mass, are within maintenance sensor requirements. O.C.

A91-31993*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

GENERATION AND ANALYSIS OF REDUCED-PART-COUNT TRUSS GEOMETRIES FOR SPACE-BASED APPLICATIONS

TIMOTHY J. COLLINS (NASA, Langley Research Center, Hampton, VA) and HARESH LALVANI (Pratt Institute, Brooklyn, NY) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1586-1596. refs

(AIAA PAPER 91-1193) Copyright

A technique for deriving truss structures with reduced part count from the octahedral-tetrahedral (octet) truss by removal of struts and nodes is described. The technique is based on an understanding of the geometry and symmetry of the octet truss. Six example reduced-part-count structures are analyzed and compared with the parent octet truss with regard to part count, redundancy, mass, and free-free fundamental frequency. Part count reductions of 12 to 37 percent, mass reductions of 7 to 33 percent, and fundamental frequency reductions of 18 to 30 percent are demonstrated. Increases in strut cross-sectional area and truss depth are considered for the purpose of increasing the stiffness of the reduced structures. Author

A91-32087*# SDRC, Inc., San Diego, CA.

SIMULATION OF THE SPACE STATION STRUT-OUT CONDITION

PAUL A. BLELLOCH, NADINE M. MACK (SDRC, Inc., Engineering Services Div., San Diego, CA), and KELLY S. CARNEY (NASA, Lewis Research Center, Cleveland, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2570-2575.

(AIAA PAPER 91-1248) Copyright

A method is presented for reanalyzing a truss structure when one of the truss elements (struts) has failed. The method uses a modal model of the nominal structure coupled with a residual flexibility term to predict the effect of the failed strut without resolving the finite element model. By implementing the method as part of the transient simulation, it is feasible to consider a large number of potential strut failures with a minimum amount of extra effort. Preliminary application of the method to the Space Station indicates excellent agreement with results based on modifying and resolving the finite element model. Author

A91-32108*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

TESTING AND APPLICATION OF A VISCOUS PASSIVE DAMPER FOR USE IN PRECISION TRUSS STRUCTURES

M. TRUBERT, J. FANSON (JPL, Pasadena, CA), P. DAVIS (Honeywell, Inc., Minneapolis, MN), and E. ANDERSON IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2796-2808. refs

(AIAA PAPER 91-0996) Copyright

A passive damping device intended to replace individual struts in precision truss structures for space applications is described. The theory of operation of the D-Strut device is detailed, and simple five- and three-parameter models are derived. Results from tests conducted to characterize the D-Strut at submicron displacement levels are reporeted. The incorporation of a strut in a precision truss testbed is described. Parameters determined from the component-level tests are used in a finite element model of the truss, and damping augmentation is predicted. Using the simple three-parameter model, a damper is selected for multiple placement in a separate optical interferometer truss testbed. The effect of the addition of the damper struts is illustrated analytically in a model of the structure. Finally, an improved Arched Flexure D-Strut that is expected to provide higher loss factors, and is currently under development, is described. Author

A91-32116#

STRAIN RATE SENSING FOR VIBRATION CONTROL OF FLEXIBLE STRUCTURES

JOHN M. JUSTON and DAVID P. BAUER (IAP Research, Inc., Dayton, OH) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2888-2899. SDIO-supported research. refs

(Contract DACA88-90-C-0009)

(AIAA PAPER 91-1118) Copyright

Low mass, high performance strain rate sensing technology for the active control of vibrating structures is presented. The sensor is based on electromagnetic technology and has an output directly proportional to strain rate. Sensor physics are discussed and the sensitivity equation is derived, and strain rate sensing performance requirements are given. Proof-of-principle experiments demonstrate favorable strain rate resolution while measuring 80 microstrain, 0.1 Hz structural oscillations. Superior resolution is demonstrated while measuring larger strain rate magnitudes occurring during 16 microstrain, 20 Hz oscillations. Sizing estimates indicate that sensor mass can be made very small. Author

A91-32197#

DEVELOPMENT AND USE OF INFLATABLE PAYLOAD RECOVERY VEHICLES

ROBERT T. KENDALL, JR., R. T. KENDALL, SR. (Aerospace Recovery Systems, Inc., Grants Pass, OR), and ARTHUR M. MADDOX (Northrop University, Los Angeles, CA) IN: AIAA Aerodynamic Decelerator Systems Technology Conference, 11th, San Diego, CA, Apr. 9-11, 1991, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 421-435. refs

(AIAA PAPER 91-0888) Copyright

This paper presents concepts, development and application of uniquely designed positively pressurized, stowable, conically shaped coated tubular fabric structures for various manned and unmanned payload recovery systems for space and atmospheric usage. How the inflatable structure is inflated to envelop and protect the payload, then stabilize, decelerate and safely impact the vehicle on water or land without injury or damage to the personnel or payload is decribed. Also presented are delivery and recovery of manned and unmanned payloads in lower atmosphere applications for civil and/or military usage, disaster relief, and fire fighting efforts. Consideration is also given to various payload types including satellites, microgravity experiments, space debris or Space Station waste, individual/multiple Space Station or transport personnel emergency escape and return vehicles. R.E.P.

N91-11041*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

THERMAL-DISTORTION ANALYSIS OF A SPACECRAFT BOX TRUSS IN GEOSTATIONARY ORBIT

PATRICK A. COSGROVE (Lockheed Engineering and Sciences Co., Hampton, VA.), JEFFERY T. FARMER, and LAWRENCE F. ROWELL Washington Nov. 1990 26 p

(NASA-TP-3054; L-16828; NAS 1.60:3054) Avail: NTIS HC/MF A03 CSCL 22B

The Mission to Planet Earth enlists the use of a geostationary platform to support Earth science monitoring instruments. The strongback for a proposed geostationary platform is a deployable box truss that supports two large diameter passive microwave radiometer (PMR) and several other science instruments. A study was performed to estimate the north-south and east-west pointing errors at the mounting locations of the two PMRs due to on-orbit thermal distortions of the main truss. The baseline configuration indicated that the east-west pointing error greatly exceeded the required limits. Primary origins of the pointing errors were identified, and methods for their reduction were discussed. Thermal performance enhancements to the truss structure were modeled and analyzed, including state-of-the-art surface coatings and insulation techniques. Comparisons of the thermal enhancements to the baseline were performed. Results demonstrated that using a thermal enclosure insulating technique reduced external heat fluxes, and distributed those heat fluxes more evenly throughout the structure, sufficiently reducing the pointing error to satisfy pointing accuracy requirements for the PMR's. Author

N91-11819# Contraves Corp., Zurich (Switzerland). Space Div.
OPTICAL INTERFEROMETER SYSTEMS IN SPACE: CONFIGURATION AND STRUCTURE CONCEPTS USING SPACE RIGIDIZED ELEMENTS
M. C. BERNASCONI, S. KOESE, and W. J. RITS (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, Space Applications of Advanced Structural Materials p 47-56 Jun. 1990 Previously announced in IAA as A90-13554
(Contract ESA-6975/86/NL/PH)
Copyright Avail: NTIS HC/MF A19

The use of inflatable space-rigidized structures for use in orbital optical interferometry systems is discussed. Their ability to provide 100 m long supporting elements for such interferometers is analyzed. It is found that such systems can be built and packaged for launch to geostationary orbit by Ariane 5 with specific masses of 0.8 to 1.8 kg/m. They can be stiff enough to be controllable, and provide interfaces for observing telescopes sufficiently free of vibration for sensor scanning frequencies. The use of such optical interferometric methods is discussed. ESA

N91-11829# British Aerospace Dynamics Group, Bristol (England).
SLIP COEFFICIENTS FOR SHEAR JOINTS: THE EFFECTS OF DYNAMIC LOADING AND SURFACE TREATMENT
R. J. BAYLIS *In* ESA, Space Applications of Advanced Structural Materials p 117-122 Jun. 1990
Copyright Avail: NTIS HC/MF A19

An experimental program of work undertaken to generate data for slip coefficients for shear joints is described. The data is intended for inclusion in the guidelines for threaded fasteners with particular application to space structures. The effects of dynamic loading and surface treatments on aluminum and plastic composites in the shear joint are investigated. Statistical analysis is carried out to provide data for the initial design of shear loaded bolted joints typical of those used in space structures. Alochromed and anodized aluminum show better slip resistance than untreated aluminum. ESA

N91-11843# Surrey Univ., Guildford (England). Dept. of Civil Engineering.
HIGH-TECHNOLOGY CARBON-FIBRE/POLYETHERSULPHONE COMPOSITE FOR SPACE APPLICATIONS
A. THORNE and L. HOLLAWAY *In* ESA, Space Applications of Advanced Structural Materials p 207-211 Jun. 1990
Copyright Avail: NTIS HC/MF A19

A large skeletal structure to be used in making antenna reflectors for land mobile communications systems is described. The structure could also be used in making space platforms up to 300 m in diameter. The land based antenna reflectors would be limited to 50 m in diameter. The skeletal system in the form of a tetrahedral truss is described. Results of solar simulation tests in which polyethersulphone composite samples were tested between minus 150 and 40 C under high vacuum are described. ESA

N91-11861# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SHIELDING AGAINST ORBITAL DEBRIS: A CHALLENGING PROBLEM
MICHEL LAMBERT *In its* Space Applications of Advanced Structural Materials p 319-328 Jun. 1990
Copyright Avail: NTIS HC/MF A19

The physics of hypervelocity impacts is reviewed with special application to impact of space debris on orbiting spacecraft. The potential effects on different spacecraft structures are described. The status of experimental and theoretical work for the Columbus Space Station is reported in detail. A strategy for continued investigation of shielding performance is outlined. Ways in which the weight of shielding elements can be decreased are investigated. The use of composite materials for shielding is discussed. ESA

N91-11868# Fokker B.V., Amsterdam (Netherlands).
THE INFLUENCE OF MATERIAL PROPERTIES ON DESIGN VALIDITY AND MARGINS
M. P. NIEUWENHUIZEN *In* ESA, Space Applications of Advanced Structural Materials p 381-391 Jun. 1990
Copyright Avail: NTIS HC/MF A19

Ways to optimize design validity are outlined. Uncoupling of research on materials technology and product design activities are called for. The advantages of having handbooks applicable to standardized materials made readily available to users is stressed. Applied safety factors for a project are based on experience and the ratio of ultimate versus yield stress of the material. The factors influencing the safety of ductile and brittle materials are discussed. The importance of improving the knowledge of such safety behavior in nonhomogeneous polymer materials is stressed. ESA

N91-11870# British Aerospace Public Ltd. Co., Stevenage (England).
COST OPTIMISATION OF LOAD CARRYING STRUCTURES
B. A. REID and A. PRADIER (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, Space Applications of Advanced Structural Materials p 397-402 Jun. 1990
Copyright Avail: NTIS HC/MF A19

Research on identifying cost drivers and establishing guidelines for optimizing the cost of satellite structures is described. Specifications envelope, qualification philosophy, and standardization and methodology are identified as critical cost drivers. To assess the impact of material selection on achievement of the mass budget, alternative minimum mass and minimum cost design philosophies are applied to a range of materials. It is found that applying minimum mass philosophy to each material, up its performance limit is the most cost effective. ESA

N91-12114*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PROBABILISTIC STRUCTURAL ANALYSIS OF A TRUSS TYPICAL FOR SPACE STATION
SHANTARAM S. PAI Sep. 1990 11 p Presented at the 3rd Air Force/NASA Symposium on Recent Advances in Multidisciplinary Analysis and Optimization, San Francisco, CA, 24-26 Sep. 1990
(NASA-TM-103277; E-5725; NAS 1.15:103277) Avail: NTIS HC/MF A03 CSCL 20/11

A three-bay, space, cantilever truss is probabilistically evaluated using the computer code NESSUS (Numerical Evaluation of Stochastic Structures Under Stress) to identify and quantify the uncertainties and respective sensitivities associated with corresponding uncertainties in the primitive variables (structural, material, and loads parameters) that defines the truss. The distribution of each of these primitive variables is described in terms of one of several available distributions such as the Weibull, exponential, normal, log-normal, etc. The cumulative distribution function (CDF's) for the response functions considered and sensitivities associated with the primitive variables for given response are investigated. These sensitivities help in determining the dominating primitive variables for that response. Author

N91-12770# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Military Aircraft Div.

MBB-LAGRANGE: STRUCTURAL OPTIMIZATION SYSTEM FOR SPACE AND AIRCRAFT STRUCTURES

GUENTER KNEPPE 28 Jun. 1990 22 p Presented at COMMETT Seminar on Computer Aided Optimal Design, Bayreuth, Fed. Republic of Germany, 1990

(MBB/FW522/S/PUB/406; ETN-90-98156) Copyright Avail: NTIS HC/MF A03

The structural optimization system MBB-LAGRANGE allows the optimization of homogeneous isotropic, orthotropic or anisotropic structures as well as fiber reinforced materials with respect to weight, static, dynamic, aeroelastic, and manufacturing requirements. Design variables are sizing and geometric dimensions. The highlights are the treatment of large scale problems and especially the simultaneous optimization of different disciplines. Development is focused on three main topics: optimization models, structural analysis with sensitivity analysis, and optimization algorithms. Integration into the computer aided engineering environment is important for practical applications. ESA

N91-13473*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

ANALYTICAL AND PHOTOGRAMMETRIC CHARACTERIZATION OF A PLANAR TETRAHEDRAL TRUSS

K. CHAUNCEY WU, RICHARD R. ADAMS, and MARVIN D. RHODES Washington Dec. 1990 30 p

(NASA-TM-4231; L-16758; NAS 1.15:4231) Avail: NTIS HC/MF A03 CSCL 22/2

Future space science missions are likely to require near-optical quality reflectors which are supported by a stiff truss structure. This support truss should conform closely with its intended shape to minimize its contribution to the overall surface error of the reflector. The current investigation was conducted to evaluate the planar surface accuracy of a regular tetrahedral truss structure by comparing the results of predicted and measured node locations. The truss is a 2-ring hexagonal structure composed of 102 equal-length truss members. Each truss member is nominally 2 meters in length between node centers and is comprised of a graphite/epoxy tube with aluminum nodes and joints. The axial stiffness and the length variation of the truss components were determined experimentally and incorporated into a static finite element analysis of the truss. From this analysis, the root mean square (RMS) surface error of the truss was predicted to be 0.11 mm (0004 in). Photogrammetry tests were performed on the assembled truss to measure the normal displacements of the upper surface nodes and to determine if the truss would maintain its intended shape when subjected to repeated assembly. Considering the variation in the truss component lengths, the measures rms error of 0.14 mm (0.006 in) in the assembled truss is relatively small. The test results also indicate that a repeatable truss surface is achievable. Several potential sources of error were identified and discussed. Author

N91-14251*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SINGLE LAUNCH LUNAR HABITAT DERIVED FROM AN NSTS EXTERNAL TANK

CHARLES B. KING, ANSEL J. BUTTERFIELD, WARREN D. HYPES (Bionetics Corp., Hampton, VA.), JOHN E. NEALY, and LISA C. SIMONSEN Washington Dec. 1990 34 p

(NASA-TM-4212; L-16764; NAS 1.15:4212) Avail: NTIS HC/MF A03 CSCL 06/11

A concept for using the spent external tank from a National Space Transportation System (NSTS) to derive a lunar habitat is described. The external tank is carried into low Earth orbit where the oxygen tank-intertank subassembly is separated from the hydrogen tank, berthed to Space Station Freedom and the subassembly outfitted as a 12-person lunar habitat using extravehicular activity (EVA) and intravehicular activity (IVA). A single launch of the NSTS orbiter can place the external tank in LEO, provide orbiter astronauts for disassembly of the external tank, and transport the required subsystem hardware for outfitting the lunar habitat. An estimate of the astronauts' EVA and IVA is provided. The liquid oxygen intertank modifications utilize existing structures and openings for man access without compromising the structural integrity of the tank. The modifications include installation of living quarters, instrumentation, and an airlock. Feasibility studies of the following additional systems include micrometeoroid and radiation protection, thermal control, environmental control and life support, and propulsion. The converted lunar habitat is designed for unmanned transport and autonomous soft landing on the lunar surface without need for site preparation. Lunar regolith is used to fill the micrometeoroid shield volume for radiation protection using a conveyer. The lunar habitat concept is considered to be feasible by the year 2000 with the concurrent development of a space transfer vehicle and a lunar lander for crew changeover and resupply. Author

N91-14374* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

SMART TUNNEL: DOCKING MECHANISM Patent

JOHN A. SCHLIESING, inventor (to NASA) and KEVIN L. EDENBOROUGH, inventor (to NASA) 29 Aug. 1989 9 p Filed 30 Dec. 1988

(NASA-CASE-MSC-21360-1; US-PATENT-4,860,975; US-PATENT-APPL-SN-292131; US-PATENT-CLASS-244-161; US-PATENT-CLASS-405-188; US-PATENT-CLASS-14-71.5; US-PATENT-CLASS-244-137.2; INT-PATENT-CLASS-B64G-1/64) Avail: US Patent and Trademark Office CSCL 22/2

A docking mechanism is presented for the docking of a space vehicle to a space station comprising a flexible tunnel frame structure which is deployable from the space station. The tunnel structure comprises a plurality of series connected frame sections, one end section of which is attached to the space station and the other end attached to a docking module of a configuration adapted for docking in the payload bay of the space vehicle. The docking module is provided with trunnions, adapted for latching engagement with latches installed in the vehicle payload bay and with hatch means connectable to a hatch of the crew cabin of the space vehicle. Each frame section comprises a pair of spaced ring members, interconnected by actuator-attenuator devices which are individually controllable by an automatic control means to impart relative movement of one ring member to the other in six degrees of freedom of motion. The control means includes computer logic responsive to sensor signals of range and attitude information, capture latch condition, structural loads, and actuator stroke for generating commands to the onboard flight control system and the individual actuator-attenuators to deploy the tunnel to effect a coupling with the space vehicle and space station after coupling. A tubular fluid-impervious liner, preferably fabric, is disposed through the frame sections of a size sufficient to accommodate the passage of personnel and cargo.

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

N91-14614* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

MECHANICAL END JOINT SYSTEM FOR CONNECTING STRUCTURAL COLUMN ELEMENTS Patent

HAROLD G. BUSH, inventor (to NASA), MARTIN M. MIKULAS, JR., inventor (to NASA), and RICHARD E. WALLSOM, inventor (to NASA) 16 Oct. 1990 12 p Filed 30 Mar. 1990 Continuation-in-part of abandoned US-Patent-Appl-SN-388264, filed 1 Aug. 1989 which is a continuation-in-part of abandoned US-Patent-Appl-SN-223122, filed 22 Jul. 1988

(NASA-CASE-LAR-14465-1; US-PATENT-4,963,052; US-PATENT-APPL-SN-501910; US-PATENT-APPL-SN-388264; US-PATENT-APPL-SN-223122; US-PATENT-CLASS-403-322;

US-PATENT-CLASS-403-327; US-PATENT-CLASS-403-331; US-PATENT-CLASS-403-171; INT-PATENT-CLASS-B25G-3/18)
Avail: US Patent and Trademark Office CSCL 13/9

A mechanical end joint system is presented that eliminates the possibility of free movements between the joint halves during loading or vibration. Both node joint body (NJB) and column end joint body (CEJB) have cylindrical engaging ends. Each of these ends has an integral semicircular tongue and groove. The two joint halves are engaged transversely - the tongue of the NJB mating with the groove of the CEJB and vice versa. The joint system employs a spring loaded internal latch mechanism housed in the CEJB. During mating, this mechanism is pushed away from the NJB and enters the NJB when mating is completed. In order to lock the joint and add a preload across the tongue and groove faces, an operating ring collar is rotated through 45 deg causing an internal mechanism to compress a Belleville washer preload mechanism. This causes an equal and opposite force to be exerted on the latch bolt and the latch plunger. This force presses the two joint halves tightly together. In order to prevent inadvertent disassembly, a secondary lock is also engaged when the joint is closed. Plungers are carried in the operating ring collar. When the joint is closed, the plungers fall into tracks on the CEJB, which allows the joint to be opened only when the operating ring collar and plungers are pushed directly away from the joining end. One application of this invention is the rapid assembly and disassembly of diverse skeletal framework structures which is extremely important in many projects involving the exploration of space.

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

N91-15300*# Astro Aerospace Corp., Carpinteria, CA.
CONCEPTS AND ANALYSIS FOR PRECISION SEGMENTED REFLECTOR AND FEED SUPPORT STRUCTURES Final Report
RICHARD K. MILLER, MARK W. THOMSON, and JOHN M. HEDGEPETH Dec. 1990 90 p
(Contract NAS1-18567)
(NASA-CR-182064; NAS 1.26:182064; AAC-TN-1157) Avail: NTIS HC/MF A05 CSCL 22/2

Several issues surrounding the design of a large (20-meter diameter) Precision Segmented Reflector are investigated. The concerns include development of a reflector support truss geometry that will permit deployment into the required doubly-curved shape without significant member strains. For deployable and erectable reflector support trusses, the reduction of structural redundancy was analyzed to achieve reduced weight and complexity for the designs. The stiffness and accuracy of such reduced member trusses, however, were found to be affected to a degree that is unexpected. The Precision Segmented Reflector designs were developed with performance requirements that represent the Reflector application. A novel deployable sunshade concept was developed, and a detailed parametric study of various feed support structural concepts was performed. The results of the detailed study reveal what may be the most desirable feed support structure geometry for Precision Segmented Reflector/Large Deployable Reflector applications. Author

N91-15544* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CLEVIS JOINT FOR DEPLOYABLE SPACE STRUCTURES Patent
MARVIN D. RHODES, inventor (to NASA) 12 Jun. 1990 6 p
Filed 28 Jul. 1988
(NASA-CASE-LAR-13898-1; US-PATENT-4,932,807; US-PATENT-APPL-SN-225427; US-PATENT-CLASS-403-147; US-PATENT-CLASS-403-146; US-PATENT-CLASS-403-156; US-PATENT-CLASS-403-334; INT-PATENT-CLASS-F16C-11/00)
Avail: US Patent and Trademark Office CSCL 13/9

This invention relates generally to pin clevis joints, and more particularly, to zero play pin clevis joints for connecting structural members of a deployable space structure. A joint includes a pin, a tang, and a shackle. The pin is tapered at the same angle as the bores extending through the projections of the shackle and the tang. A spring washer biases the tang onto the tapered sidewall of the pin. The invention solves the free play problem associated with deployable space structures by using a tapered pin which is held in tapered holes by the spring washers.

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

N91-18456*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A VELOCITY COMMAND STEPPER MOTOR FOR CSI APPLICATION
JEFFREY L. SULLA (Lockheed Engineering and Sciences Co., Hampton, VA.), JER-NAN JUANG, and LUCAS G. HORTA Jan. 1991 19 p Presented at the 4th NASA/DOD CSI Conference, Orlando, FL, 5-7 Nov. 1990
(NASA-TM-102765; NAS 1.15:102765) Avail: NTIS HC/MF A03 CSCL 20/11

The application of linear force actuators for vibration suppression of flexible structures has received much attention in recent years. A linear force actuator consists of a movable mass that is restrained such that its motion is linear. By application of a force to the mass, an equal and opposite reaction force can be applied to a structure. The use of an industrial linear stepper motor as a reaction mass actuator is described. With the linear stepper motor mounted on a simple test beam and the NASA Mini-Mast, output feedback of acceleration or displacement are used to augment the structural damping of the test articles. Significant increases in damping were obtained for both the test beam and the Mini-Mast. Author

N91-18988*# New Orleans Univ., LA. Dept. of Mechanical Engineering.
THEORETICAL HYPERVELOCITY BALLISTIC LIMIT FOR SINGLE OR DOUBLE PLATES USING NONLINEAR MODAL ANALYSIS
DAVID HUI *In* Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 20/11

The original research on the use on nonlinear vibration technique to solve for the hypervelocity ballistic limit for double plates is examined. Such structure is commonly found in typical Space Station design where the incoming space or man-made debris would be fragmented upon hitting the outer plate (shield) and the subsequent impact on the main wall would result in a much reduced damge of the space station or spacecraft. The existing few theoretical impact equations do not agree well with each other. The existing computer code bumper used at NASA-Johnson Space Center appears to predict an unconservative ballistic limit when compared with experimental data where the velocity ranges from 3 km/s to 8 km/s. Such unconservative prediction is unacceptable from a practical safe design point of view. The bumper code is based on Wilkinson's (1968) paper and his equations have not been improved nor modified even though they are viewed with suspicion due to lack of agreement with experiments. To make matters worse, there is not another theory which is better than Wilkinson's equation and the designers are forced to use purely empirical Nysmith (1969) or semiempirical equations developed by Cour-Palais in 1969. The Cour-Palais equations were later modified empirically in 1989. The purpose of the present investigation is to examine the many assumptions of the Wilkinson equation. An attempt is made to present design charts based on the modified-Wilkinson equation so that the designer can get a feel of the ranges of the parameters which are of interest and discard a huge range of parameters, thus, significantly reducing the number of test shots required. The analysis is based on a solution of the governing nonlinear differential equations for a plate, assuming axisymmetric behavior using polar coordinates. Author

N91-19007*# Alabama Univ., Tuscaloosa. Dept. of Engineering Mechanics.
CHARACTERIZATION OF SPACE STATION MULTILAYER INSULATION DAMAGE DUE TO HYPERVELOCITY SPACE DEBRIS IMPACT
WILLIAM KEITH RULE *In its* Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 4 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 22/2

Four main tasks were accomplished. The first three tasks were related to the goal of measuring the degradation of the insulating capabilities of Space Station multilayer insulation (MLI) due to simulated space debris impacts at hypervelocities. The last task was associated with critically reviewing a Boeing document on the fracture characteristics of the Space Station pressure wall when subjected to a simulated hypervelocity space debris impact. In Task 1, a thermal test procedure for impact damaged MLI specimens was written. In Task 2, damaged MLI specimens were prepared. In Task 3, a computer program was written to simulate MLI thermal tests. In Task 4, the author reviewed a Boeing document describing hypervelocity impact testing on biaxially stressed plates. Author

N91-19157*# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
EXPERIMENTAL DETERMINATION OF SATELLITE BOLTED JOINTS THERMAL RESISTANCE
MARCIA BARBOSA HENRI MANTELLI and JOSE EDSON BASTO *In* NASA, Goddard Space Flight Center, 16th Space Simulation Conference Confirming Spaceworthiness Into the Next Millennium p 397-414 Nov. 1990
Avail: NTIS HC/MF A20 CSCL 22/2

The thermal resistance was experimentally determined of the bolted joints of the first Brazilian satellite (SCD 01). These joints, used to connect the satellite structural panels, are reproduced in an experimental apparatus, keeping, as much as possible, the actual dimensions and materials. A controlled amount of heat is forced to pass through the joint and the difference of temperature between the panels is measured. The tests are conducted in a vacuum chamber with liquid nitrogen cooled walls, that simulates the space environment. Experimental procedures are used to avoid much heat losses, which are carefully calculated. Important observations about the behavior of the joint thermal resistance with the variation of the mean temperature are made. Author

N91-20184*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DESIGNS FOR THE ATDRSS TRI-BAND REFLECTOR ANTENNA
SHUNG-WU LEE, MARTIN L. ZIMMERMAN (Illinois Univ., Urbana.), GENE FUJIKAWA, and G. RICHARD SHARP 1991 7 p
Proposed for presentation at the 1991 IEEE AP-S International Symposium and URSI Radio Science Meeting, London, Ontario, 24-28 Jun. 1991
(NASA-TM-103754; E-6008; NAS 1.15:103754) Avail: NTIS HC/MF A02 CSCL 20/14

Two approaches to design a tri-band reflector antenna for the Advanced TDRSS are examined. Two reflector antenna configurations utilizing frequency selective surfaces for operation in three frequency bands, S, Ku, and Ka, are proposed. Far-field patterns and the antenna feed losses were computed for each configuration. An offset-fed single reflector antenna configuration was adapted for conceptual spacecraft design. CADAM drawings were completed and a 1/13th scale model of the spacecraft was constructed. Author

N91-20194# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
INVESTIGATION OF DIRECT AND INDIRECT OPTIMIZATION ALGORITHMS FOR AEROSPACE STRUCTURES M.S. Thesis
HARRY HOPKINS Dec. 1990 93 p
(AD-A230549; AFIT/GA/ENY/90D-7) Avail: NTIS HC/MF A05 CSCL 22/1

This thesis investigated the performance of two direct and two indirect methods of structural optimization. A gradient calculator and overall design system was created with the finite element code FRAME. Three of the methods were employed using this system with the fourth being a commercial available code. The algorithms were applied to two different sized trusses using static constraints and were measured for accuracy, reliability, and efficiency. Results for the problems tested showed the Direct methods were sensitive to starting designs and their performance depended on the proper selection of internal parameters. They were also shown to have a high degree of accuracy and the flexibility to handle different problems. The indirect methods showed that they were very effective when applied to specific problems and were simpler to implement and manage than direct methods, but lacked the flexibility to handle a variety of problems. GRA

N91-20662*# New Mexico Univ., Albuquerque. Dept. of Mechanical Engineering.
DEPLOYABLE ROBOTIC WOVEN WIRE STRUCTURES AND JOINTS FOR SPACE APPLICATIONS
MO SHAHINPOOR and BRADFORD SMITH (Woven Wire Corp., Santa Fe, NM.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 159-166 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

Deployable robotic structures are basically expandable and contractable structures that may be transported or launched to space in a compact form. These structures may then be intelligently deployed by suitable actuators. The deployment may also be done by means of either airbag or spring-loaded typed mechanisms. The actuators may be pneumatic, hydraulic, ball-screw type, or electromagnetic. The means to trigger actuation may be on-board EPROMS, programmable logic controllers (PLCs) that trigger actuation based on some input caused by the placement of the structure in the space environment. The actuation may also be performed remotely by suitable remote triggering devices. Several deployable woven wire structures are examined. These woven wire structures possess a unique form of joint, the woven wire joint, which is capable of moving and changing its position and orientation with respect to the structure itself. Due to the highly dynamic and articulate nature of these joints the 3-D structures built using them are uniquely and highly expandable, deployable, and dynamic. The 3-D structure naturally gives rise to a new generation of deployable three-dimensional spatial structures. Author

07

VIBRATION & DYNAMIC CONTROLS

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

A91-11475
OPTIMAL DESIGN AND CONTROL OF A CROSS-PLY LAMINATE FOR MAXIMUM FREQUENCY AND MINIMUM DYNAMIC RESPONSE
J. C. BRUCH, JR., S. ADALI, J. M. SLOSS (California, University, Santa Barbara), and I. S. SADEK (North Carolina, University, Wilmington) Computers and Structures (ISSN 0045-7949), vol. 37, no. 1, 1990, p. 87-94. Research supported by the University of North Carolina. refs
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Optimal thickness design and optimal closed-loop and open-loop distributed control functions are determined for a symmetric, cross-ply laminate. The design/control problem is formulated as a multiobjective optimization problem by taking a performance index which comprises a weighted sum of the design and control objectives and a penalty functional of the control force. The design objective is the maximization of the fundamental frequency. The control objective is the minimization of the dynamic response of the plate, which is expressed in terms of the energy of the structure. The design/control problem is solved using two different approaches, namely closed-loop (feedback) control and the open-loop control. In the former approach, displacement and velocity feedback controls are employed. In the latter approach, the open-loop control involves an unknown control function which is determined optimally using a maximum principle. The design variables are determined by direct minimization of the design and control objectives. Numerical results are presented for a rectangular laminate made of an advanced composite material. Comparisons are given for controlled and uncontrolled laminates as well as for optimally designed and non-optimal laminates. Author

A91-11592
VARIABLE-STRUCTURE CONTROL APPROACH OF DECENTRALISED MODEL-REFERENCE ADAPTIVE SYSTEMS
XIAOHAO XU (Nanjing Aeronautical Institute, People's Republic of China), YAOHUA WU, and WENHU HUANG (Harbin Institute of Technology, People's Republic of China) IEE Proceedings, Part D - Control Theory and Applications (ISSN 0143-7054), vol. 137, pt. D, no. 5, Sept. 1990, p. 302-306. Research supported by the National Natural Science Foundation of the People's Republic of China. refs
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In the paper, the problem of decentralized model-reference adaptive control, for linear time-varying large-scale systems, is investigated by using a variable-structure control approach. The global reaching condition of the sliding mode of a composite system is derived and a new scheme of decentralized control is proposed. This scheme can guarantee the stability of a sliding manifold of the composite system. Furthermore, a modified scheme is given which makes the weighted sum of the sliding manifold motions converge to the prospective speed. Finally, a numerical example is calculated. Author

A91-11783#
MODAL FORMULATIONS FOR THE DYNAMICS OF FLEXIBLE MANIPULATORS AND LARGE SPACE STRUCTURES
E. WEHRLI (ONERA, Chatillon, France) and P. COIFFET (Paris VI, Universite, France) (International Workshop on Advances in Robot Kinematics, 2nd, Linz, Austria, Sept. 10-12, 1990) ONERA, TP no. 1990-120, 1990, 12 p. refs
(ONERA, TP NO. 1990-120)
The dynamic response of a serial link manipulator with flexibility in both its links and joints is presently calculated by a Lagrangian formulation of the equations of motion that is based on the modal decomposition of the link deformations. The robotic applications of this method encompass vibration control, cycle time reduction, and compliance control for assembly operations. Numerical results are presented for a one-link structure in order to deepen insight into the control problems and vibration damping of the arm's tip at the end of its trajectory. O.C.

A91-12339
ANALYSIS OF ORBITAL MANOEUVRES OF A LARGE SPACE STRUCTURE TO AVOID COLLISIONS WITH SPACE DEBRIS
J. BENDISCH and D. REX (Braunschweig, Technische Universitaet, Brunswick, Federal Republic of Germany) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 981-991. Research supported by BMFT.
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Means of identification and tracking of dangerous space debris and subsequent collision-avoiding maneuvers necessary to protect large space structures are discussed. It is estimated that, besides the active and spent satellites, there are more than 60,000 objects larger than 1 cm on low earth orbits between 200 and 2500 km, although only 10 percent of these objects can presently be tracked and cataloged. The operational aspects of avoiding maneuvers are outlined. It is pointed out that aspects which determine the efficiency and frequency of avoiding maneuvers such as the range of the buffer zone due to uncertainties during detection, the number of close encounters within this buffer zone, and the number of maneuvers necessary all directly influence scheduled Space Station operations by affecting fuel consumption, the microgravity level of the structure, and operation costs. Methods of identification of risk objects prior to a collision are discussed and a detailed analysis is given of an on-board detection system. Uncertainties in orbit prediction for the risk object and specific possible avoiding maneuvers are presented. L.K.S.

A91-12623
CONTROL OF LONGITUDINAL WAVES IN A ROD WITH VOIGT DAMPING
ANDREAS U. KUEHNLE and JAMES H. WILLIAMS, JR. (MIT, Cambridge, MA) Mechanics of Structures and Machines (ISSN 0890-5452), vol. 18, Sept. 1990, p. 335-351. refs
(Contract F49620-88-C-0036)
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The control of longitudinal waves in a rod constructed from material damping governed by the Voigt model is considered. Wave-mode coordinate methods are used to derive a relation between the force at a general point in the rod and the force applied to one end of the rod. The force relation includes the effects of a SISO controller that prevents the incoming waves from reaching the other end of the rod. Two methods, least-squares transfer function matching and direct-force reduction, are used for controller design. The force relation is used to assess wave-isolating effects of the controller. Wave isolations greater than 99 percent are obtained with low-order finite-dimensional controllers. Author

A91-12845
RATES OF CHANGE OF CLOSED-LOOP EIGENVALUES AND EIGENVECTORS OF ACTIVELY CONTROLLED STRUCTURES
T. S. PAN, S. S. RAO (Purdue University, West Lafayette, IN), and V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 30, Oct. 5, 1990, p. 1013-1028. refs
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The sensitivity of the closed-loop eigenvalues and eigenvectors of actively controlled flexible structures with distinct eigenvalues is considered. The sensitivity information is essential in the optimization of large space structures with stability/performance robustness, closed-loop eigenvalues or damping ratios treated as objective or constraint functions. The efficiency of the analytical expressions derived for the rates of change of the closed-loop eigenvalues with respect to structural design variables is demonstrated through two numerial examples. The utility of the sensitivity of the closed-loop eigenvalues and eigenvectors in evaluating the derivatives of the stability and performance robustness indices is also indicated and illustrated through numerical examples. Author

A91-12848* McDonnell-Douglas Space Systems Co., Houston, TX.
COMPUTATIONAL ENHANCEMENT OF AN UNSYMMETRIC BLOCK LANCZOS ALGORITHM
HYOUNG M. KIM (McDonnell Douglas Space Systems Co., Houston, TX) and ROY R. CRAIG, JR. (Texas, University, Austin) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 30, Oct. 5, 1990, p. 1083-1089. refs
(Contract NAS9-17254)
Copyright
An unsymmetric block Lanczos algorithm has been employed for the dynamic analysis of a large system which has arbitrary damping and/or repeated (or closely spaced) eigenvalues. In the algorithm development, the right and left Lanczos vectors are all theoretically biorthogonal to each other. However, these vectors may lose the biorthogonality owing to cancellation and roundoff

errors. For the unsymmetric case there can be a breakdown, even without numerical errors. This paper describes computational techniques which have led to a robust unsymmetric block Lanczos algorithm. Author

A91-13933#
NUMERICAL RESULTS OF SIMPLIFIED DYNAMIC ANALYSES ON LARGE IMPERFECT SPACE STRUCTURES
HUBA OERY, ANDREAS RITTWEGER (Aachen, Rheinisch-Westfaelische Technische Hochschule, Federal Republic of Germany), ERNST HORNUNG, and HERBERT LUDWIG (MBB-ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 39 p.
(IAF PAPER 90-289) Copyright

The calculated dynamic response of large space structures whose eigenfrequencies are of the order of 0.001-0.0001 Hz can substantially deviate from the predictions of linear analyses. The overall eigenfrequency of a trusslike structure can decrease by orders of magnitude, due to innevitable strut-component imperfections; for larger vibration amplitudes, a strong nonlinearity occurs. In addition, increasing strut lengths and slenderness ratios will exacerbate imperfection sensitivity while increasing strut eigenfrequency. It is noted, however, that if the strut eigenfrequency is much lower than that of the overall structural fundamental frequency, the deleterious influence of imperfections virtually disappears. O.C.

A91-13934*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE NASA CONTROLS-STRUCTURES INTERACTION TECHNOLOGY PROGRAM
JERRY R. NEWSOM (NASA, Langley Research Center, Hampton, VA), W. E. LAYMAN (JPL, Pasadena, CA), H. B. WAITES (NASA, Marshall Space Flight Center, Huntsville, AL), and R. J. HAYDUK (NASA, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 18 p. refs
(IAF PAPER 90-290) Copyright

The interaction between a flexible spacecraft structure and its control system is commonly referred to as controls-structures interaction (CSI). The CSI technology program is developing the capability and confidence to integrate the structure and control system, so as to avoid interactions that cause problems and to exploit interactions to increase spacecraft capability. A NASA program has been initiated to advance CSI technology to a point where it can be used in spacecraft design for future missions. The CSI technology program is a multicenter program utilizing the resources of the NASA Langley Research Center, the NASA Marshall Space Flight Center, and the NASA Jet Propulsion Laboratory. The purpose of this paper is to describe the current activities, results to date, and future activities of the NASA CSI technology program. Author

A91-13935#
THE INFLUENCE OF SAMPLING PERIOD IN DIGITAL CONTROL ON THE SPILLOVER IN VIBRATION SUPPRESSION OF FLEXIBLE STRUCTURES
SHIGEO KOBAYASHI (Tokyo Metropolitan Institute of Technology, Hino, Japan) and HIROSHI SASAKI (NASDA, Tsukuba, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 13 p. refs
(IAF PAPER 90-291) Copyright

The influence of sampling period in the digital control on the occurrence of the spillover instability was investigated by numerical simulations, theoretical analysis and experimental studies. Formulas of the spillover instability boundary are derived by approximate theoretical analysis and are confirmed by numerical simulations. It is concluded that the upper boundary of the sampling period under which stable control is achieved for vibration suppression is obtained for a single-degree-of-freedom system. In addition, formulas for the range of the sampling period in which the system becomes unstable are derived by an approximate theoretical analysis. R.E.P.

A91-13936*# Massachusetts Inst. of Tech., Cambridge.
DYNAMICS AND CONTROL OF MULTIPAYLOAD PLATFORMS - THE MIDDECK ACTIVE CONTROL EXPERIMENT (MACE)
DAVID W. MILLER, EDWARD F. CRAWLEY (MIT, Cambridge, MA), and JAVIER DE LUIS (Payload Systems, Inc., Cambridge, MA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. Research supported by NASA. refs
(IAF PAPER 90-292) Copyright

A flight experiment entitled the Middeck Active Control Experiment (MACE) proposed by the Space Engineering Research Center (SERC) at the Massachusetts Institute of Technology is described. The objective of this program is to investigate and validate the modeling of the dynamics of an actively controlled flexible, articulating, multibody platform free floating in zero gravity. A rationale and experimental approach for the program are presented. The rationale shows that on-orbit testing, coupled with ground testing and a strong analytical program, is necessary in order to fully understand both how flexibility of the platform affects the pointing problem, as well as how gravity perturbs this structural flexibility causing deviations between 1-and 0-gravity behavior. The experimental approach captures the essential physics of multibody platforms, by identifying the appropriate attributes, tests, and performance metrics of the test article, and defines the tests required to successfully validate the analytical framework. Author

A91-13937#
SIMULATION OF ON-ORBIT MODAL IDENTIFICATION
AXEL SCHENK (DLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 13 p. refs
(IAF PAPER 90-293) Copyright

Modularly designed large orbital systems cannot be tested as a total structure on earth. Size, zero-g design, and the existing atmosphere conflict with traditional structural dynamic qualification. In order to avoid the associated problems with terrestrial testing some form of on-orbit testing is likely to be used. This paper focuses on two objectives: (1) a brief discussion of hardware concerns, particularly under space conditions, and (2) the demonstration of one specific software tool for on-orbit modeling. Results extracted with the Ibrahim (1983) time-domain method from noisy responses of an analytical structure are presented. With an analytical structure, exact modal parameters can be used as a data base in order to illustrate the accuracy of identification. With a few exceptions, all results are within predefined 'assessment margins' of 2 percent for frequencies and 10 percent for damping and mode shapes. Author

A91-13982#
THE OPTIMAL LQR DIGITAL CONTROL OF A FREE-FREE ORBITING PLATFORM
APRILLE J. ERICSSON, PETER M. BAINUM, and GUANGQIAN XING (Howard University, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 13 p. refs
(Contract F33615-88-C-3208; F33615-89-C-3225)
(IAF PAPER 90-318) Copyright

Large, flexible space systems, approximated as thin square plates, are discussed in terms of their optimal LQR digital shape and orientation control. For a completely observable square plate, the inputs are assumed to be sampled data. Control of the attitude and shape of the plate is provided by six jet actuators, located perpendicularly to the main surface and to the edge of the plate. Mathematical models for the actuators are developed. Two sets of actuator locations were compared to find the optimal positioning. The design of the controller involves taking into account the influence of the sampling period and the state/control penalty matrices on the system's closed-loop eigenvalues and its transient performance. B.P.

A91-13983#
DYNAMIC ANALYSIS OF FLEXIBLE SPACECRAFT
GUANGJI QU (China Center for Advanced Science and Technology, Beijing, People's Republic of China) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER 90-321) Copyright

Dynamic analyses of spacecraft with flexible appendages (DASFA) is discussed with a view to the developing needs of three-axis-stabilized communication broadcast satellites, earth observation satellites, and other large spacecraft in China. This paper first gives the modeling principles and methods, then establishes models for dynamic analysis of flexible spacecraft suitable for engineering, and discusses problems of system reduction and modal truncation. The main functions and characteristics of DASFA program are introduced. Finally, an example is given. Author

A91-13984#
OPTIMAL DIGITAL SERVO-CONTROLLER FOR SEPS CLASS OF SATELLITES
A. G. SREENATHA, M. SEETHARAMA BHAT, and S. K. SHRIVASTAVA (Indian Institute of Science, Bangalore, India) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-325) Copyright

The design of a fixed, low-order dynamic output feedback controller along with a feedforward compensator for tracking command/reference input is presented. Design of the controller is performed for a flexible satellite of the Solar Electric Propulsion Spacecraft (SEPS) type. Controller performance is verified by designing and analyzing a third-order dynamic controller for an 18th-order system representing the SEPS. It is shown that first-order feedback and one integrator in the feedforward for each channel are sufficient. The concept of block-shift is employed for improving the performance. The improvement in the system response with block-shift is shown through numerical simulations. The simulation results show that perfect tracking can be achieved when the noise is absent. When consideration is given to the noise the mean trajectory followed by the desired output tracks the command input. R.E.P.

A91-13987#
NONLINEAR CONTROL STRATEGIES OF FLEXIBLE SPACECRAFT SLEWING MANEUVERS
LIANG JIN (Muenchen, Universitaet der Bundeswehr, Neubiberg, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. Research supported by the Alexander von Humboldt-Stiftung. refs
(IAF PAPER 90-332) Copyright

A nonlinear open-loop control approach is developed for the slewing maneuvers of a spacecraft with flexible appendages. The dynamics is modeled as the nonlinear hybrid coordinate equations and the reduced quaternion equations. The nonlinear system equations are transformed into the equivalent system equations which contain the three decoupled double integrators by using the partial linearizing coordinate transformations. It is thereby shown that the nonlinear control law determination for slewing maneuvers of the spacecraft can be carried out in the equivalent system by using the linear regulator technique together with a simple numerical integration for the modal coordinates. The simulation results of proposed approach are presented and discussed. Author

A91-13988#
AN APPROACH TO SYSTEM MODES AND DYNAMICS OF THE EVOLVING SPACE STATION FREEDOM
V. J. MODI, A. NG, and A. SULEMAN (British Columbia, University, Vancouver, Canada) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. refs
(Contract NSERC-STR-32682)
(IAF PAPER 90-319) Copyright

The value of flexibility with reference to large evolving space structures is discussed. General formulas applicable to a wide class of systems are considered, and it is noted that, while models vary significantly, the underlying objective is to obtain dynamic equations of motion for a system of arbitrarily connected flexible members in a branched or closed loop topological form. A relatively general formulation for studying the dynamics of an arbitrary spacecraft with interconnected flexible bodies is developed accounting for transient systems inertias and geometric nonlinearities. Computer implementation is carried out through symbolic manipulation of the equations of motion. The versatility of the formulation is illustrated through simulation of the dynamics of one of the evolving Space Station configurations. System response of the First Element Launch to initial liberational disturbance with respect to pitch, roll, and yaw disturbances are presented and discussed. L.K.S.

A91-13989#
HYBRID ADAPTIVE CONTROL OF SPACE STATION
P. A. BAO, Z. J. ZHANG, Z. J. JIN (Shanghai Jiao Tong University, People's Republic of China), and X. H. CHEN (Northwestern Polytechnical University, Xian, People's Republic of China) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-333) Copyright

From the equations of motion in modal coordinates, the left matrix fraction representation, which is of reduced order, for a two-panel Space Station has been established in this paper. Based on this representation, a new hybrid adaptive control scheme for continuous-time plant with recursive adaptive algorithm is developed and applied to the Space Station. Computer simulation results show the robustness and effectiveness of this scheme. Author

A91-16038* Texas A&M Univ., College Station.
DYNAMIC EFFECTS IN THERMOVISCOPLASTIC STRUCTURES
TED G. BYROM, DAVID H. ALLEN (Texas A & M University, College Station), EARL A. THORNTON, and J. D. KOLENSKI (Virginia, University, Charlottesville) IN: Thermal Structures Conference, 1st, Charlottesville, VA, Nov. 13-15, 1990, Proceedings. Charlottesville, VA, University of Virginia Light Thermal Structures Center, 1990, p. 259-269. Research supported by NASA. refs
Copyright

An algorithm for three-dimensional thermoviscoplasticity with inertial effects is presented. The algorithm utilizes a unified thermoviscoplastic constitutive model with directional hardening (Bodner-Partom). An example problem is shown in which thermally induced vibrations lead to material yielding at elevated temperatures. Significant dampening caused by inelastic strain is shown to take place in the structure. Author

A91-16065*# Massachusetts Inst. of Tech., Cambridge.
APPROXIMATE FREQUENCY DOMAIN ANALYSIS FOR LINEAR DAMPED SPACE STRUCTURES
NESBITT W. HAGOOD and EDWARD F. CRAWLEY (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 28, Nov. 1990, p. 1953-1961. Previously cited in issue 12, p. 1859, Accession no. A89-30854. refs
(Contract NAGW-21)
Copyright

A91-17004
EFFECT OF AN ONBOARD COMPUTER ON THE DYNAMICS OF A SPACECRAFT CONTROLLED BY TWO PAIRS OF POWERED GYROSCOPES [VLIIANIE BTSVM NA DINAMIKU NOSITELIA, UPRAVLIAEMOGO DVUMIA SPARKAMI SILOVYKH GIROSKOPOV]
N. I. KIRINA IN: Dynamics of control systems. Leningrad,

Izdatel'stvo Leningradskogo Universiteta, 1989, p. 41-45. In Russian. refs
Copyright
A particular problem of the stabilization of the principal central axes of a spacecraft in the direction of the axes of the orbital coordinate system is considered. The stabilization is effected via two powered-gyro complexes and an onboard computer in the control loop. Conditions on the signal quantization step which provide for the required spacecraft-stabilization accuracy are defined. B.J.

A91-17026
A PARTICULAR CASE OF THE MOTION OF A DYNAMICALLY SYMMETRICAL VISCOELASTIC BODY IN A CENTRAL NEWTONIAN GRAVITATIONAL FIELD [OB ODNOM CHASTNOM SLUCHAE DVIZHENIIA DINAMICHESKI SIMMETRICHNOGO UPRUGOVIAZKOGO TELA V TSENTRAL'NOM N'IUTONOVSKOM GRAVITATSIONNOM POLE]
A. P. MARKEEV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 28, Sept.-Oct. 1990, p. 643-654. In Russian. refs
Copyright
The motion of a large space structure in a Keplerian orbit in a central Newtonian gravitational field is examined. A viscoelastic body which is dynamically symmetrical when not in a state of strain is used as a mechanical model of the structure. Deformations of the body consist in longitudinal vibrations along the axis of symmetry and flexural vibrations of the axis of symmetry itself. Differential equations describing the deformation of the body and its motion relative to the center of mass are obtained. The existence of a motion in the case of which the axis of symmetry is perpendicular to the orbit of the center of mass is demonstrated. B.J.

A91-17027
DYNAMICS OF A SYSTEM COMPRISING A RIGID BODY AND FLEXIBLE EXTENDED RINGS MOVING IN A GRAVITATIONAL FIELD [DINAMIKA SISTEMY TVERDOGO TELA I GIBKIKH PROTIAZHENNYKH KOLETS, DVIZHUSHCHIKHSIA V POLE TIAGOTENIIA]
V. I. GULIAEV, A. G. CHERNIAVSKII, IU. D. KRAVCHENKO, V. V. GAIDAICHUK, V. L. KOSHKIN et al. Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 28, Sept.-Oct. 1990, p. 655-663. In Russian. refs
Copyright
The problem of the unsteady rotational and accelerated translational motion of a system consisting of a massive rigid body symmetrically connected to two extended flexible elastic rings. The motion of the system in circular orbit is examined. It is assumed that the rigid body can rotate in a specified manner around one of the three principal central axes of inertia of the system. Nonlinear relative vibrations of the rings induced by these motions are considered. B.J.

A91-17030
EXPERIMENTAL DETERMINATION OF THE COEFFICIENTS OF THE EQUATIONS OF THE PERTURBED MOTION OF A SPACECRAFT WITH ELASTIC ELEMENTS [OB EKSPERIMENTAL'NOM OPREDELENII KOEFFITSIENTOV URAVNENII VOZMUSHCHENNOGO DVIZHENIIA KOSMICHESKOGO APPARATA S UPRUGIMI ELEMENTAMI]
V. R. AMINOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 28, Sept.-Oct. 1990, p. 685-691. In Russian.
Copyright
Attention is given to experimental methods for determining the inertial-coupling coefficients and dissipative coefficients of equations describing the perturbed motion of a spacecraft consisting of a rigid body and elastic elements. These elements can be solar panels or instrumentation booms. B.J.

A91-17033
A NUMERICAL AND EXPERIMENTAL APPROACH FOR THE ANALYSIS OF THE DYNAMIC ACCURACY OF THE STABILIZATION OF FLEXIBLE SPACECRAFT UNDER THE EFFECT OF INTERNAL DISTURBANCES [RASCHETNO-EKSPERIMENTAL'NYI SPOSOB ANALIZA DINAMICHESKOI TOCHNOSTI STABILIZATSII GIBKIKH KA PRI DEISTVII VNUTRENNIKH ISTOCHNIKOV VOZMUSHCHENIIA]
N. N. SHEREMET'EVSKII, E. E. MALAKHOVSKII, E. L. POZNIAK, and A. A. EVMENOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 28, Sept.-Oct. 1990, p. 706-714. In Russian. refs
Copyright
The simulation of the motion of an uncontrolled geostationary satellite with flexible solar arrays in the case of disturbances from drive devices is examined. The approach used is based on finite-element modal analysis of the spacecraft structure and experimental data on the forces and moments from actual drive devices. B.J.

A91-17386
FREE-VIBRATION AND DAMPING CHARACTERIZATION OF COMPOSITES
PEARL CHU and OZDEN O. OCHOA (Texas A & M University, College Station) IN: Composite structures 5; Proceedings of the Fifth International Conference, Paisley, Scotland, July 24-26, 1989. London, England and New York, Elsevier Applied Science, 1989, p. 289-298. refs
Copyright
Many different applications have increased the demand for materials which can reduce fundamental frequencies and obtain high material damping. At present, composite materials offer the widest choice for designing lightweight space structures that can be effectively controlled. This study presents analytical/experimental results for natural frequencies of composite beams and plates. Finite element predictions for the fundamental frequency are checked against the experimental modal analysis results for all specimens. Optimum design parameters are sought for composites in terms of stacking sequence, fiber orientation, aspect ratio and boundary conditions. Effects of damage on damping and vibration is illustrated with the beam specimens. Author

A91-17401
VIBRATIONAL ANALYSIS OF LARGE ANTENNAE FOR SPACE APPLICATIONS
L. HOLLAWAY, M. O'NEILL, and M. GUNN (Surrey, University, Guildford, England) IN: Composite structures 5; Proceedings of the Fifth International Conference, Paisley, Scotland, July 24-26, 1989. London, England and New York, Elsevier Applied Science, 1989, p. 561-578. Research supported by SERC and Ministry of Defence.
Copyright
A large space structure with dishes modeled as continuum systems in order to reduce the storage requirements and running time during the modal analysis of a platform with mounted reflectors in position is considered. The experimental and analytical techniques used in obtaining the modal analysis of units of the structural system are discussed. A slab-analogy technique for the modal analyses of large reflector dishes is utilized, and its results are compared with those of the skeletal system it replaces. Focus is placed on a computer package used in obtaining the various resonant frequencies and corresponding modes for the structural system in a free/free condition. It is demonstrated that for structures based on the unit tetrahedral shape, satisfactory agreement exists between the two techniques. V.T.

A91-17629
ACTIVE VIBRATION DAMPING IN LARGE FLEXIBLE STRUCTURES
PETER HAGEDORN (Darmstadt, Technische Hochschule, Federal Republic of Germany) IN: Theoretical and applied mechanics;

Proceedings of the Seventeenth International Congress, Saint-Martin-d'Heres, France, Aug. 21-27, 1988. Amsterdam, Elsevier Science Publishers, 1989, p. 83-100. Research supported by the Stiftung Volkswagenwerk. refs
Copyright

A technique is proposed in which the structure is not discretized but split up into structural elements, such as beams and cables, each of these elements being a simple continuous system. The motion of the individual structural elements described by hyperbolic equations are represented by traveling waves and the controls are designed with the intent of absorbing locally as much as possible of the energy of these traveling waves. It is shown by numerical experiments that the decentralized character of the control makes it extremely robust. Also, this robustness holds for changes in the system's parameters, such as mass and stiffness. R.E.P.

A91-19013*# Arizona State Univ., Tempe.
PERIODIC-DISTURBANCE ACCOMMODATING CONTROL OF THE SPACE STATION FOR ASYMPTOTIC MOMENTUM MANAGEMENT
WAYNE WARREN, BONG WIE (Arizona State University, Tempe), and DAVID GELLER (NASA, Johnson Space Center, Houston, TX) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 984-992. Previously cited in issue 23, p. 3629, Accession no. A89-52570. refs
Copyright

A91-19014#
MULTIBODY INTERACTION EFFECTS ON SPACE STATION ATTITUDE CONTROL AND MOMENTUM MANAGEMENT
BONG WIE (Arizona State University, Tempe), ANREN HU, and RAMENDRA SINGH (Dynacs Engineering Co., Inc., Clearwater, FL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 993-999. Previously cited in issue 23, p. 3630, Accession no. A89-52606. refs
Copyright

A91-19015*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
SPILLOVER STABILIZATION OF LARGE SPACE STRUCTURES
EVA A. CZAJKOWSKI, RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg), and ANDRE PREUMONT (Brussel, Vrije Universiteit, Brussels, Belgium) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1000-1007. Previously cited in issue 12, p. 1934, Accession no. A88-31393. refs
(Contract NAG1-603)
Copyright

A91-19017*# Texas Univ., Austin.
PULSE-MODULATED CONTROL SYNTHESIS FOR A FLEXIBLE SPACECRAFT
TOBIN C. ANTHONY, BONG WIE (Texas, University, Austin), and STANLEY CARROLL (NASA, Marshall Space Flight Center, Huntsville, AL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1014-1022. Previously cited in issue 23, p. 3628, Accession no. A89-52533. refs
(Contract NAS8-36224)
Copyright

A91-19018*# Massachusetts Inst. of Tech., Cambridge.
HYBRID SCALED STRUCTURAL DYNAMIC MODELS AND THEIR USE IN DAMPING PREDICTION
EDWARD F. CRAWLEY, JONATHAN L. SIGLER, MARTHINUS C. VAN SCHOOR (MIT, Cambridge, MA), and MARC J. GRONET (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1023-1032. Research supported by McDonnell Douglas Corp. and NASA. refs
Copyright

Analytical and experimental techniques for the prediction and ground verification of the damped structural dynamics of space structures are developed. The options available for similarity-scaled model testing, including replica and multiple scale approaches, are reviewed. For the case when the distortion of potentially dissipative or nonlinear joints, which would be required in multiple-scale modeling, is impractical, a new type of modeling is introduced, which uses a hybrid of joints at replica scale and connecting elements at a modified multiple scale. The model design requirements for replica, multiple-scale, and hybrid models are developed, and the expected scaling of nonlinear dissipation in joints is derived. A damping prediction scheme is developed that relies on a finite element model of the undamped structure and measurements of the individual joint properties to predict the modal damping of the truss attributable to the joints. A hybrid-scaled model of a segment of the Space Station was built and dynamically tested. The predicted and measured truss damping compared favorably. Author

A91-19019*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
EFFICIENT EIGENVALUE ASSIGNMENT FOR LARGE SPACE STRUCTURES
PEIMAN G. MAGHAMI and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1033-1039. Previously cited in issue 12, p. 1860, Accession no. A89-30866. refs
Copyright

A91-19020#
FINITE ELEMENT MODELING OF FREQUENCY-DEPENDENT MATERIAL DAMPING USING AUGMENTING THERMODYNAMIC FIELDS
GEORGE A. LESIEUTRE (Sparta, Inc., Laguna Hills, CA) and D. LEWIS MINGORI (California, University, Los Angeles) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1040-1050. Previously cited in issue 12, p. 1859, Accession no. A89-30853. refs
Copyright

A91-19295*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON-ORBIT STRUCTURAL DYNAMIC PERFORMANCE OF A LOW-FREQUENCY MICROWAVE RADIOMETER FOR MISSION TO PLANET EARTH APPLICATIONS
DEBORAH M. WAHLS and JEFFERY T. FARMER (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p. refs
(AIAA PAPER 91-0428) Copyright

The present paper addresses the on-orbit dynamic performance of a low-frequency microwave radiometer for earth science applications. The radiometer is one of the earth-observing instruments aboard a geostationary platform proposed as part of the Mission to Planet Earth. The paper includes establishing the structural requirements of the antenna, developing the structural and disturbance models, performing modal and forced response analyses, and evaluating the resulting distortions in terms of the antenna's ability to meet stringent structural performance requirements. Two antenna configurations are discussed: free-flying and platform-mounted. These configurations are analyzed for a representative disturbance function which simulates rotation of the subreflector in order to perform a raster-type scan of the earth disk. Results show that the scanning maneuver modeled did not induce antenna performance errors which were outside their estimated limits. Author

A91-19517
DYNAMICS DURING SLEWING AND TRANSLATIONAL MANEUVERS OF THE SPACE STATION BASED MRMS
H. W. MAH, V. J. MODI (British Columbia, University, Vancouver, Canada), Y. MORITA, and H. YOKOTA (Institute of Space and Astronautical Science, Tokyo, Japan) Journal of the Astronautical

Sciences (ISSN 0021-9142), vol. 38, Oct.-Dec. 1990, p. 557-579. Research supported by the Network of Centers of Excellence. refs
(Contract NSERC-G-1547)
Copyright

The paper presents a relatively general formulation for studying librational dynamics of a flexible platform supporting a mobile base connected to a series of slewing, flexible appendages. It is applicable to missions requiring slew maneuvers of antennas, telescopes, scientific instruments, and in particular, the U.S. proposed Space Station's Mobile Remote Manipulator System (MRMS). Application of the formulation is illustrated through two simple examples: (1) a satellite consisting of a rigid platform with a slewing, rigid appendage; (2) a flexible beam-type platform representing the Space Station with a mobile, flexible, slewing arm. The analysis provides a useful insight into interactions between inertia parameters, orbit geometry, translational and slewing time histories, flexibility and initial conditions. Results suggest that under critical combinations of the parameters the system may become unstable. Application of the infinite time linear regulator is demonstrated to regain stability. Author

A91-19708
SENSOR/EFFECTOR INTERFACING AND CONTROL FOR THE SPACE STATION
ROBERT E. DAVIS (Honeywell, Inc., Satellite Systems Div., Glendale, AZ) IN: International Instrumentation Symposium, 35th, Orlando, FL, May 1-4, 1989, Proceedings. Research Triangle Park, NC, Instrument Society of America, 1989, p. 793-798.
Copyright

The Space Station multiplexer-demultiplexer (MDM), a flexible, cost-effective interface between sensors/effectors and digital processing/communications equipment is being developed for the International Space Station Freedom. This spaceborne system makes the transition from the classical time division multiplex telemetry system to a full packetized random access, computer compatible data system. Data management architecture, MDM input/output features, instrumentation and control, and physical configurations are studied in detail. Y.P.Q.

A91-19983
ACTIVE CONTROL OF LARGE SPACE STRUCTURES
EDUARDO MARIO NEBOT, THOMAS A. BRUBAKER (Colorado State University, Fort Collins), and GORDON K. F. LEE (North Carolina State University, Raleigh) Control and Computers (ISSN 0315-8934), vol. 17, no. 2, 1989, p. 42-47. refs
Copyright

A decouple pole-placement algorithm for adaptive control of large space structures is presented in order to facilitate the controller design. The algorithm, based on a block diagonal form of a flexible model, deals with mode vibration suppression. If one mode at a time is assigned, the algorithm is exact; if more than one mode is assigned, the algorithm is good enough if the location of the eigenvalues is properly selected. The algorithm is tested on the model, and the expected small displacement of the eigenvalues with respect to the ideal position is determined. Mode suppression is achieved with particular eigenvalue selection. The model can be updated based on physical parameters such as resonant frequencies and damping coefficients. B.P.

A91-21210* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADAPTIVE STRUCTURES IN SPACE
B. K. WADA, J. L. FANSON, G. S. CHEN, and C.-P. KUO (JPL, Pasadena, CA) IN: U.S.-Japan Workshop on Smart/Intelligent Materials and Systems, Honolulu, HI, Mar. 19-23, 1990, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1990, p. 59-81. refs
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Future NASA missions will need large (20 to 100m) structural systems with precision position (few microns to submicron) requirements. Data are presented which indicate the technology deficiencies of previous programs and analyses in current state-of-the-art structural design approaches, analytical prediction capabilities, control of structure capabilities, and ground test technologies to meet the performance requirements of future large precision structural systems. Test results on laboratory truss structures that demonstrate static displacement control, active damping, and on-orbit system identification are described. It is shown that for large precision structures, adaptive structures provide not only a means to achieve the precision and characteristics required in space, but can also significantly alleviate the ground test requirements for flight-validating the hardware. R.E.P.

A91-21211* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ADAPTIVE TRUSS STRUCTURE
C. G. HORNER (NASA, Langley Research Center, Hampton, VA) IN: U.S.-Japan Workshop on Smart/Intelligent Materials and Systems, Honolulu, HI, Mar. 19-23, 1990, Proceedings. Lancaster, PA, Technomic Publishing Co., Inc., 1990, p. 104-118.
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This paper discusses the research in adaptive structures conducted at NASA Langley Research Center. The objective in the research program on adaptive truss structures is to develop an integrated approach for the design, test, and evaluation of adaptive trusses. An adaptive structure must include sensors for measuring some of the states of the mechanism, a controller that processes the sensor information and generates command signals, and a device that will cause the struts in the mechanism to change length. Based on the results of the research program, it is concluded that alternative designs for future space applications are offered, and adaptive truss has been demonstrated to be effective for vibration suppression. R.E.P.

A91-21510#
MODELING AND ANALYSIS OF LINEARLY COUPLED ACOUSTIC AND STRUCTURAL SYSTEMS WITH THE GREEN'S ELEMENT METHOD (GEM)
JAMES P. WOOLLEY (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p.
(AIAA PAPER 91-0495) Copyright

A new approach for assembly of analytical models for the dynamic behavior of linear compound systems is utilized to couple an acoustic fluid and an elastic wall enclosing it. The concept employs the Green's Function for simple elements which are coupled together to form a compound system, hence the name, the Green's Element Method (GEM). The approach is applied to the coupling of a two-dimensional acoustic cavity, enclosed on one wall by a membrane. Exact natural frequencies of the combined system are obtained. System modal frequencies are obtained for both air and water as the acoustic fluid. Both volume displacing and non-volume displacing modal frequencies are calculated. The entire analysis, calculations, and graphics were carried out on a desk-top computer. It is anticipated that general algorithms will be developed to enable the method to be used as a production analysis tool for engineering systems, much as Finite Element methods are presently used. Author

A91-22113
MODELING OF UNCERTAIN DYNAMICS FOR ROBUST CONTROLLER DESIGN IN STATE SPACE
ALTUG IFTAR (Toronto, University, Canada) and UMIT OZGUNER (Ohio State University, Columbus) Automatica (ISSN 0005-1098), vol. 27, Jan. 1991, p. 141-146. refs
Copyright

Structured modeling of uncertain dynamics for robust controller design in state space is discussed. It is shown that, under mild conditions, it is possible to obtain a rational transfer function matrix (TFM), possibly dependent on a parameter vector which varies over a subset of a finite dimensional real vector space, to represent uncertain dynamics. Furthermore, in many practical cases, uncertain dynamics can be represented by a relatively low order TFM, even if the actual dynamics are of very high order. The procedure of determining such a TFM is discussed. It is shown that a controller which stabilizes the nominal system, including such a representation of uncertain dynamics, also stabilizes the actual system. Furthermore, desired performance or relative stability can also be guaranteed. The presented approach gives a unified framework for the solution to the robust controller design problem for systems with both parameter uncertainties and uncertain dynamics. An application to a robust controller design problem for a large flexible structure is also presented. Author

A91-22940#
LIBRATIONAL INSTABILITY OF RIGID SPACE STATION DUE TO TRANSLATION OF INTERNAL MASS
C. H. SPENNY and T. E. WILLIAMS (USAF, Institute of Technology, Wright-Patterson AFB, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 31-35. Previously cited in issue 23, p. 3630, Accession no. A89-52607. refs

A91-22941*# Colorado Univ., Boulder.
PASSIVE ATTITUDE DAMPING OF ALTERNATIVE ASSEMBLY CONFIGURATIONS OF SPACE STATION FREEDOM
JAMES W. WADE (Colorado, University, Boulder) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 36-43. Previously cited in issue 23, p. 3628, Accession no. A89-52535. refs
(Contract NAS9-17900)
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A91-22943#
GIBBS PHENOMENON IN STRUCTURAL CONTROL
H. BARUH and S. S. K. TADIKONDA (Rutgers University, New Brunswick, NJ) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 51-58. Previously cited in issue 23, p. 3703, Accession no. A89-52578. refs
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A91-22945*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODEL REDUCTION FOR FLEXIBLE SPACE STRUCTURES
WODEK GAWRONSKI (JPL, Pasadena, CA) and TREVOR WILLIAMS (Cincinnati, University, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 68-76. Previously cited in issue 12, p. 1797, Accession no. A89-30814. refs
Copyright

A91-22946*# DYNACS Engineering Co., Inc., Palm Harbor, FL.
SPECIAL CLASS OF NONLINEAR DAMPING MODELS IN FLEXIBLE SPACE STRUCTURES
ANREN HU, RAMENDRA P. SINGH (Dynacs Engineering Corp., Palm Harbor, FL), and LAWRENCE W. TAYLOR (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 77-83. refs
Copyright

A special class of nonlinear damping models is investigated in which the damping force is proportional to the product of positive integer or the fractional power of the absolute values of displacement and velocity. For a one-degree-of-freedom system, the classical Krylov-Bogoliubov 'averaging' method is used, whereas for a distributed system, both an ad hoc perturbation technique and the finite difference method are employed to study the effects of nonlinear damping. The results are compared with linear viscous damping models. The amplitude decrement of free vibration for a single mode system with nonlinear models depends not only on the damping ratio but also on the initial amplitude, the time to measure the response, the frequency of the system, and the powers of displacement and velocity. For the distributed system, the action of nonlinear damping is found to reduce the energy of the system and to pass energy to lower modes. Author

A91-22947*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
NONLINEAR BEHAVIOR OF A PASSIVE ZERO-SPRING-RATE SUSPENSION SYSTEM
STANLEY E. WOODARD and JERROLD M. HOUSNER (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988, Technical Papers. Part 2, p. 884-889) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 84-89. Previously cited in issue 12, p. 1906, Accession no. A88-32264.
Copyright

A91-22976* Tellabs Research Lab., Mishawaka, IN.
PARAMETER LEARNING FOR PERFORMANCE ADAPTATION
MARK D. PEEK (Tellabs Research Center, Mishawaka, IN) and PANOS J. ANTSAKLIS (Notre Dame, University, IN) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 10, Dec. 1990, p. 3-11. refs
(Contract JPL-957856)
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A parameter learning method is introduced and used to broaden the region of operability of the adaptive control system of a flexible space antenna. The learning system guides the selection of control parameters in a process leading to optimal system performance. A grid search procedure is used to estimate an initial set of parameter values. The optimization search procedure uses a variation of the Hooke and Jeeves multidimensional search algorithm. The method is applicable to any system where performance depends on a number of adjustable parameters. A mathematical model is not necessary, as the learning system can be used whenever the performance can be measured via simulation or experiment. The results of two experiments, the transient regulation and the command following experiment, are presented. I.E.

A91-23420
NON-LINEAR JOINT DYNAMICS AND CONTROLS OF JOINTED FLEXIBLE STRUCTURES WITH ACTIVE AND VISCOELASTIC JOINT ACTUATORS
H. S. TZOU (Kentucky, University, Lexington) Journal of Sound and Vibration (ISSN 0022-460X), vol. 143, Dec. 22, 1990, p. 407-422. Research supported by the University of Kentucky. refs
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Studies on joint dominated flexible space structures have attracted much interest recently due to the rapid developments in large deployable space systems. This paper describes a study of the nonlinear structural dynamics of jointed flexible structures with initial joint clearance and subjected to external excitations. Methods of using viscoelastic and active vibration control technologies, joint actuators, to reduce dynamic contact force and to stabilize the systems are proposed and evaluated. System dynamic equations of a discretized multi-degree-of-freedom flexible system with initial joint clearances and joint actuators (active and viscoelastic passive) are derived. Dynamic contacts in an elastic joint are simulated by a nonlinear joint model comprised of a nonlinear spring and damper. A pseudoforce approximation method is used in numerical time-domain integration. Dynamic responses of a jointed flexible structure with and without viscoelastic and active joint actuators are presented and compared. Effectiveness of active/passive joint actuators is demonstrated. Author

A91-23669#
VIBRATION ABSORBERS FOR HYSTERETICALLY DAMPED MASS-LOADED BEAMS
M. J. CROCKER (Auburn University, AL) and D. N. MANIKANAHALLY ASME, Transactions, Journal of Vibration and Acoustics (ISSN 0739-3717), vol. 113, Jan. 1991, p. 116-122. Research supported by Auburn University and SDIO. refs
(Contract DNA001-85-C-0183)
Copyright

A procedure is developed for designing dynamic vibration absorbers for a general mass-loaded beam system of variable cross-sectional area, subjected to an arbitrarily distributed harmonic force excitation. Equations of motion are derived for such a beam system, making it possible to optimize the number of absorbers depending on the number of significant modes to be suppressed. As an example, the analysis is used to synthesize two dynamic vibration absorbers to attenuate the response of a simplified mass-loaded uniform beam model of a space structure in the first two modes. I.S.

A91-23726
DYNAMICS AND CONTROL OF LARGE STRUCTURES; PROCEEDINGS OF THE SEVENTH VPI&SU SYMPOSIUM, BLACKSBURG, VA, MAY 8-10, 1989
L. MEIROVITCH, ED. (Virginia Polytechnic Institute and State University, Blacksburg) Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, 738 p. For individual items see A91-23727 to A91-23766.

Topics presented include the automated frequency domain system identification of a large space structure, a learning control for slewing of a flexible panel, the active boundary control of simple span bridges, and an algorithm for attitude identification for the spacecraft control laboratory experiment (SCOLE) using two IR cameras. Also presented are some methods for combined control-structure optimization, a disturbance rejection in large space structure control via eigenvalue realization, an integrated aeroelastic control optimization, and dynamical aspects in flexible rotating machinery. Also discussed are some efficient dynamic models for flexible robots, a formulation for studying dynamics of an orbiting flexible mobile manipulator, an independent modal space control with positive position feedback, and the on-off decentralized control of flexible structures. R.E.P.

A91-23727*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTOMATED FREQUENCY DOMAIN SYSTEM IDENTIFICATION OF A LARGE SPACE STRUCTURE
Y. YAM, D. S. BAYARD, F. Y. HADAEGH, E. METTLER, M. H. MILMAN (JPL, Pasadena, CA) et al. IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 1-19. refs

This paper presents the development and experimental results of an automated on-orbit system identification method for large flexible spacecraft that yields estimated quantities to support on-line design and tuning of robust high performance control systems. The procedure consists of applying an input to the plant, obtaining an output, and then conducting nonparametric identification to yield the spectral estimate of the system transfer function. A parametric model is determined by curve fitting the spectral estimate to a rational transfer function. The identification method has been demonstrated experimentally on the Large Spacecraft Control Laboratory in JPL. R.E.P.

A91-23728*# Columbia Univ., New York, NY.
LEARNING CONTROL FOR SLEWING OF A FLEXIBLE PANEL
M. PHAN, R. W. LONGMAN (Columbia University, New York), Y. WEI (Old Dominion University, Norfolk, VA), L. G. HORTA, and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 39-52. refs
(Contract NAG1-649)

This paper studies the applicability of a discrete-time learning control method to the slewing control of a large flexible panel. Among the issues discussed are feasibility of the desired trajectories and their specification schemes, learning control by linear feedback, limitation of the actuator device output, and robustness to parameter changes or modeling errors associated with the chosen learning control design. To demonstrate the effectiveness of learning control, the system is designed with a proportional controller of the base angle only. Then application of the learning control is shown to make the system learn quickly to achieve the desired slewing without residual vibration at the end of the maneuver. Simulation results are reported and discussed. Author

A91-23729#
A STATE-SPACE EIGENVALUE REALIZATION METHOD FOR MODAL PARAMETER IDENTIFICATION OF PERTURBED LARGE SPACE STRUCTURE MODELS
J. MARCZYK (Tecnomare S.p.A., Milan, Italy) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 53-66. refs

A realization algorithm is suggested for on-line identification of open-closed loop eigenvalues of dynamic matrices of perturbed LSS models. A linear time-invariant (LTI) model, subject to a generally nonlinear disturbance, is transformed, via a generalized similarity transformation, into an equivalent undisturbed linear-time-varying (LTV) model. The resulting linear process is simulated as a sequence of identifiable events. Successively, time dependent eigenvalue determination supports controller performance and stability evaluation. A minimum-order model is determined via singular value analysis of the realized dynamic matrices. Author

A91-23730#
LINEAR DYNAMIC BEHAVIOR OF SEMI-INFINITE TRUSSES
M. ETTOUNEY, J. WRIGHT (Weidlinger Associates, New York), and H. BENAROYA (Rutgers University, Piscataway, NJ) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 67-81. refs

A simple method is presented for analyzing large, semiinfinite large space structures which are built from a set of repeated panels. The methodology reduces the structural equations to a quadratic eigenvalue problem where the eigensolutions represent the wave numbers and the wave mode shapes. The dynamic stiffness matrix of the system may then be established. This approach offers a major savings in calculational efforts as well as a more accurate representation of the systems under consideration, particularly when compared to the continuum approach. The analytical method presented couples both structural acoustic and structural dynamic techniques, which result in an efficient, simple and accurate analysis tool for this type of engineering problem. R.E.P.

A91-23731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
APPLICATION OF OPTICAL DISTRIBUTED SENSING AND COMPUTATION TO CONTROL OF A LARGE FLEXIBLE SPACECRAFT
R. C. MONTGOMERY and S. S. WELCH (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 129-136. refs

Advances in real-time holography make possible the development of new distributed optical sensors and processors that may have application to the control of flexible structures. This paper presents the analytic evaluation of control system concepts utilizing this new technology on realistic spacecraft. The design of a distributed estimator based on this new optical sensing technique is targeted to vibration control of a complex spacecraft with multiple optical sensors, each of which views a portion of the spacecraft. A simulation of a complex truss structure that was flown in the Solar Array Flight Experiment is utilized to evaluate the performance of the estimator. It is shown that good performance can be obtained from a distributed estimator even in the presence of significant sensor noise. R.E.P.

A91-23733*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPTICAL DISTRIBUTED SENSING AND COMPUTATION FOR A PROPOSED FLEXIBLE BEAM EXPERIMENT
S. S. WELCH (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 153-164. refs

A new technology is being developed that supports distributed sensing and computation wherein crystal mediums are used with real-time holography to gather images that contain vibration and instantaneous geometry data for a spacecraft. Optical computation techniques are employed to process the image data and to compute commands to actuators located on the spacecraft. This paper presents an integrated sensor/processor design for an experiment to demonstrate this technology. A performance estimate for the design is presented in terms of the optical spatial bandwidth of the imaging system, as opposed to the temporal bandwidth. The advantages of an integrated optical sensor/processor relative to control of large spacecraft are addressed. Author

A91-23734*# Planning Research Corp., Hampton, VA.
LINEAR ESTIMATION AND CONTROL STUDIES OF VIBRATION SUPPRESSION OF SCOLE FLEXIBLE MAST
D. GHOSH (Planning Research Corp., Hampton, VA), R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA), M. A. NORRIS, and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 165-177.

A Kalman filter and a controller are presented for vibration suppression of the Spacecraft Control Laboratory Experiment flexible mast mounted in the cantilevered configuration. Mode shapes and frequencies of the structure obtained from a finite element analysis are used to compute the controller and filter gains. The paper presents results and discussion from simulation and experimental studies. Comparison of experimental results with those obtained by simulation show close agreement. Author

A91-23735*# State Univ. of New York, Buffalo.
DISTRIBUTED STRUCTURAL CONTROL USING MULTILAYERED PIEZOELECTRIC ACTUATORS. I - ANALYSIS
H. H. CUDNEY, D. J. INMAN (New York, State University, Buffalo), and Y. OSHMAN (Technion - Israel Institute of Technology, Haifa) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 179-190. refs
(Contract NGT-33-183-802; F49620-86-C-0111)

Timoshenko beam theory is applied to beams with multiple layers of piezoelectric material attached. The model is developed using a Hamiltonian approach, and includes a model of the external electrical circuits to which the piezoelectric layers are attached, as well as a complete set of boundary conditions. The resulting model is then formulated in state space, and compared to a state space model of the standard Timoshenko beam. Author

A91-23736*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
METHODS FOR COMBINED CONTROL-STRUCTURE OPTIMIZATION
M. MILMAN, R. E. SCHEID, M. SALAMA, and R. BRUNO (JPL, Pasadena, CA) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 191-206. refs

This paper outlines the development of methods for the combined control-structure optimization of physical systems encountered in the technology of large space structures. The objective of the approach taken in this paper is not to produce the 'best' optimized design, but rather to efficiently produce a family of design options so as to asist in early trade studies, typically before hard design constraints are imposed. The philosophy is that these are candidate designs to be passed on for further consideration, and their function is more to guide the development of the system design rather than to represent the ultimate product. A homotopy approach involving multi-objective functions is developed for this purpose, and a numerical example is presented. Author

A91-23739*# Columbia Univ., New York, NY.
ACTUATOR PLACEMENT BY DEGREE OF CONTROLLABILITY INCLUDING THE EFFECT OF ACTUATOR MASS
R. W. LONGMAN (Columbia University, New York) and L. G. HORTA (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 245-260. refs

Various concepts of the degree of controllability (DOC) have been previously developed for the purpose of choosing actuator locations in the control of large flexible spacecraft. A perturbation technique is presented to efficiently account for the actuator mass in the computation of the fuel-optimal, time-optimal, and energy-optimal DOC definitions. Methods are developed for computing each of the three DOCs, when the mass of the actuator is nonnegligible. The energy-optimal DOC is employed to find optimal actuator locations for a large spacecraft under study by the NASA Langley Research Center. The mass of the actuator is seen to have a significant effect on the optimal actuator locations and is shown to spread the actuator locations more evenly for large mass actuators. Results indicate that when the actuator mass is large when compared to the structural mass it should be included in selecting actuator locations. R.E.P.

A91-23741#
DISTURBANCE REJECTION IN LARGE SPACE STRUCTURE CONTROL VIA EIGENVALUE REALIZATION
J. MARCZYK and M. FOSSON (Tecnomare S.p.A., Milan, Italy) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 283-296. refs

The intention of this research effort is to adopt, for large space structure (LSS) control purposes, eigenvalue realization techniques. In particular, the problem of effective disturbance rejection is approached. A linear time-invariant plant, subject to a generally nonlinear disturbance, is transformed into an equivalent undisturbed time-dipendent plant. In this manner the external disturbance is 'merged' into the plant yielding time-dependent dynamics. Such a plant contains information on the disturbance acting upon it as part of its own dynamics. Control synthesis based on this plant requires continuous updating of its model. This is accomplished via eigenvalue realization which yields the closed-loop eigenvalues. These in turn drive the generation of the control synthesis reduced-order model. Subsequently, an LQG continuous regulator is obtained via the Riccati equation. Performance of this controller is compared with that of a classical asymptotic regulator via computer simulations. Author

A91-23745#
FLEXURAL-FLEXURAL-TORSIONAL PARAMETRIC VIBRATIONS OF A CANTILEVER BEAM
P. F. PAI and A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 395-409. refs
(Contract AF-AFOSR-86-0090; F49620-87-C-0088)

Three nonlinear integrodifferential equations that describe the motion of an inextensional beam are utilized to study the planar and nonplanar responses of a fixed-free beam to a principal parametric excitation. The method of multiple scales is employed to construct a first-order uniform expansion for the interaction of three resonant modes, giving six first-order nonlinear ordinary-differential equations governing the phases and amplitudes of the modes of vibration. Results indicate that the nonlinear inertia terms produce a softening effect and play a significant role in the planar responses of high-frequency modes. For some range of parameters, the response comprises chaotically or periodically modulated motions. The dynamic behavior of a slender, long beam is of interest in connection with manipulator arms, spacecraft antennas, helicopter rotor blades, flexible satellites, and other systems that perform complex and/or large motions. R.E.P.

A91-23746#
COMPUTATION OF FREQUENCY DOMAIN APPROXIMATION BOUNDS FOR LARGE SPACE STRUCTURES
Y. CHAIT (Massachusetts, University, Amherst) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 411-421. refs

In this paper, formula for the computation of useful approximation error bounds were developed for models of large space structures. The advantages of these bounds over the ones currently employed are: the assumption of uniform modal damping is relaxed to allow for arbitrary variations within a specified range, the vibration model can include uncertainties in both the natural frequencies and in the location of the actuators and sensors, and the bounds can be computed along any vertical axis in the closed left half complex plane. These bounds can be employed to obtain safe estimates of closed-loop responses corresponding to plants which have either infinite degrees of freedom or a high-order (finite-element) model. Author

A91-23752#
A FORMULATION FOR STUDYING DYNAMICS OF AN ORBITING FLEXIBLE MOBILE MANIPULATOR
J. K. CHAN and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 491-506. Research supported by NSERC.

This paper presents a Lagrangian formulation for studying dynamics of the proposed Space Station based Mobile Servicing System (MSS) for a particular case of pitch libration and inplane maneuvers. The simplified case is purposely considered to help focus on the effects of structural and joint flexibility parameters of the MSS on the complex interactions between the station and manipulator dynamics during slewing and translational maneuvers. The response results suggest that under critical combinations of parameters, the system can become unstable. The information is useful in planning of an appropriate control strategy. Author

A91-23756*# Catholic Univ. of America, Washington, DC.
INDEPENDENT MODAL SPACE CONTROL WITH POSITIVE POSITION FEEDBACK
A. BAZ, S. POH (Catholic University of America, Washington, DC), and J. FEDOR (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 553-567. refs
(Contract NAG5-749)

An independent modal space control (IMSC) algorithm is presented, whose modal control forces are generated from a positive position feedback (PPF) strategy. The proposed algorithm combines the attributes of both the IMSC and the PPF, and maintains the simplicity of the IMSC as it designs the controller of a complex structure at the uncoupled modal level. The effectiveness of the algorithm in damping out the vibration of flexible structures is validated experimentally. A simple cantilevered beam is employed as an example of a flexible structure whose multimodes of vibration are controlled by a single actuator. Performance of the active control system is determined in the frequency and the time domains. The experimental results indicate the potential of the proposed methodology as a viable method for controlling the vibration of large flexible structures. R.E.P.

A91-23758*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
LQG AND DIRECT RATE FEEDBACK CONTROL WITH MODEL REDUCTION ON A FLEXIBLE LABORATORY GRID STRUCTURE
G. C. SCHAMEL, II and R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 585-605. refs
(Contract NAG1-224)

This paper presents experimental and theoretical comparisons of three control laws applied to a complex laboratory structure. A reduced finite element model was generated for designing the control systems and then corrected based on measured mode shapes and frequencies. A standard time-invariant linear quadratic regulator with state estimation was investigated first. Two simple direct rate feedback control laws both guaranteeing stability were also designed using the reduced model. One minimizes the maximum control force and the other minimizes the same quadratic performance index as the linear quadratic regulator. The three control laws have comparable performance indices with the direct rate feedback designs having better spillover properties. Experimental results for all designs were obtained with digital implementation. It was shown that the performance of the control system designed on the basis of the corrected finite element model agreed better with experimental results than the performance of the control system designed on the basis of the uncorrected model. Author

A91-23759#
RECENT DEVELOPMENTS IN THE OSU FLEXIBLE STRUCTURE CONTROL LABORATORY
S. YURKOVICH and U. OZGUNER (Ohio State University, Columbus) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 607-622. Research supported by the Ohio State University and Digital Equipment Corp. refs
(Contract NSF DMC-85-06143)

The present status of the Flexible Structures Facility, is examined, with attention given to an entirely new set of experiments and new computing tools. Various experimental configurations have been developed that address generic problems in large flexible space structures and flexible robotic manipulators. The principal objectives of the experiments are that they be fairly simple to implement and instrument; that they tie in directly to current research in adaptive and decentralized control, modeling, and identification; and that they serve as building blocks to provide expertise for more complex configurations. R.E.P.

A91-23762#
LARGE ANGLE MANEUVERS WITH VIBRATION SUPPRESSION - ANALYTICAL AND EXPERIMENTAL RESULTS
Z. RAHMAN, J. JUNKINS, T. POLLOCK, and H. BANG (Texas A & M University, College Station) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 653-668. Research supported by the Texas Advanced Technology Program. refs
(Contract F49620-87-C-0078)

The implementation of control laws to perform large angle maneuvers with vibration suppression for a flexible space vehicle is described. A ground experiment is discussed with a hub-appendage configuration. Two control laws are considered, the first being a globally stable constant gain output law. The second law is a novel tracking law for near-minimum time maneuvers. For the case of large angle maneuvers, many advantages of the second law are demonstrated. Author

A91-23763#
DISCRETE-TIME MANEUVERING OF A FLEXIBLE SPACECRAFT
L. MEIROVITCH and M. E. B. FRANCE (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 669-690. refs

This paper considers the control of a spacecraft consisting of a rigid platform with retargetable flexible antennas. Each antenna undergoes an independent minimum-time maneuver causing it to align itself with a predetermined line of sight, while the platform is stabilized in an inertial space. During the same time, the elastic vibration of the antennas is suppressed. The system, which includes discrete, noisy actuators and sensors, is modeled by a set of linearized, time-varying equations of motion. A pseudo-decentralized control technique is then proposed, basing the control input on estimated state information obtained from a step-varying Kalman filter. A discrete-time approach permits consideration of the time-varying nature of the system in designing the digital control law. Both linear and nonlinear control laws were investigated and results from numerical examples involving a spacecraft with a maneuvering flexible antenna are presented. Author

A91-23765#
ON-OFF DECENTRALIZED CONTROL OF FLEXIBLE STRUCTURES
L. A. FOSTER and L. M. SILVERBERG (North Carolina State University, Raleigh) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 705-720. refs

A new minimum fuel method for on-off decentralized control of flexible structures is introduced. Fuel minimization is achieved by turning on actuators when local kinetic energy is in the neighborhood of a maximum and when local potential energy is in the neighborhood of a minimum. Maximum kinetic energy and minimum potential energy neighborhoods at each actuator location are determined by recursively computing standard deviations and averages of displacements and velocities over running intervals of time. The fuel consumed by the on-off control is shown to be 20 percent lower than by the linear optimal control for the same reductions in energy over the same periods of time. On-off control of a uniform beam illustrates the results. Author

A91-24590#
PROBE WAVEFORMS AND THE RECONSTRUCTION OF STRUCTURAL DYNAMIC GREEN'S FUNCTIONS
ALFRED S. CARASSO (NIST, Gaithersburg, MD) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 114-118. Research sponsored by USAF. refs
(Contract N00014-89-F-0013)

Experimental identification of dynamic behavior in linear structural systems can be achieved by exciting the structure with a specifically synthesized pulse, and reconstructing the relevant dynamic Green's function by deconvolution of the measured response. The reconstruction procedure involves the solution of an ill-posed integral equation in the presence of noise. This paper underlines the rich variety of infinitely divisible pulse shapes that may be used while still retaining a tractable deconvolution problem. Flexibility in pulse shape is necessary to allow for possible perturbations caused by interfacing devices that convert electrical voltages into mechanical forces. A numerical experiment, using synthetic noisy data, shows that the reconstruction procedure remains effective even when the probe waveform deviates strongly from the preferred unimodal shape. A dispersive structural network that may be representative of a large space structure is used as an illustrative example. Author

A91-24591#
SECANT-METHOD ADJUSTMENT FOR STRUCTURAL MODELS
SUZANNE WEAVER SMITH and CHRISTOPHER A. BEATTIE (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 29, Jan. 1991, p. 119-126. Previously cited in issue 12, p. 1854, Accession no. A89-30761. refs
(Contract NSF DMS-88-07483)
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A91-25080
UNIFORM ENERGY DECAY RATES FOR EULER-BERNOULLI EQUATIONS WITH FEEDBACK OPERATORS IN THE DIRICHLET/NEUMANN BOUNDARY CONDITIONS
J. BARTOLOMEO (Florida, University, Gainesville) and R. TRIGGIANI (Virginia, University, Charlottesville) SIAM Journal on Mathematical Analysis (ISSN 0036-1410), vol. 22, Jan. 1991, p. 46-71. refs
(Contract NSF DMS-87-96320; NSF DMS-89-02811; AF-AFOSR-87-0321)
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The boundary-feedback uniform-stabilization problem for the Euler-Bernoulli equations with Dirichlet/Neumann boundary conditions is investigated analytically, with a focus on explicit feedback operators. Proofs for several theorems and propositions are given in detail, and the results are shown to be fully consistent with the corresponding exact controllability results (Lasiecka and Triggiani, 1988 and 1989). The importance of the Euler-Bernoulli equations for studies of the dynamics, feasibility, and implementation of large flexible space structures is indicated. T.K.

A91-25235
A STUDY OF THE DYNAMICS OF ANNULAR FRAME STRUCTURES ON THE PROGRESS-40 CARGO SPACECRAFT [DOSLIDZHENNIA DINAMIKI KIL'TSEVIKH RAMKOVIKH KONSTRUKTSII NA VANTAZHNOMU KOSMICHNOMU KORABLI 'PROGRES-40']
B. E. PATON, IU. P. SEMENOV, P. M. BILOUSOV, V. D. BLAGOV, E. IU. BURMENKO (Kiivs'kii Inzhnerno-Budivnichnii Institut, Kiev, Ukrainian SSR) et al. Akademiia Nauk Ukrains'koi RSR, Dopovidi, Seriia A - Fiziko-Matematichni ta Tekhnichni Nauki (ISSN 0002-3531), Nov. 1990, p. 35-41. In Ukrainian. refs
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A method is proposed for solving the problem of the dynamics of the relative motions and free vibrations of annular frame structures of the type 'carrier body-rings'. The results based on the method proposed here are found to be in good agreement with experimental data obtained during the maneuvers of the Progress-40 cargo spacecraft. The results of the study can be useful in the development of methods for the optimal control of the dynamics of large structures. V.L.

A91-26606
AUTOMATIC CONTROL IN AEROSPACE; IFAC SYMPOSIUM, TSUKUBA, JAPAN, JULY 17-21, 1989, SELECTED PAPERS
T. NISHIMURA, ED. (Institute of Space and Astronautical Science, Sagamihara, Japan) Symposium sponsored by IFAC, Japan Society for Aeronautical and Space Sciences, Society of Instrument and Control Engineers of Japan, et al. Oxford, England and New York, Pergamon Press (IFAC Symposia Series, No. 6), 1990, 296 p. For individual items see A91-26607 to A91-26644.
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The present conference discusses topics in the fields of aerospace navigation, attitude-determination, and pointing systems, as well as satellite orbital control automation, space robotics and manipulators, spacecraft instrumentation and avionics, launch vehicles and interplanetary vehicles, and future highly automated space vehicles. Attention is given to the NASA telerobotics research program, Kalman filter-based range estimation for autonomous navigation using imaging sensors, the attitude and orbit control subsystem for ERS-1, a star pattern-recognition algorithm for autonomous attitude determination, and the simulation and control of space manipulators bearing complex payloads. Also discussed are spillover suppression in large space structures by a frequency-shaped optimal regulator, the Cassini Titan probe's adaptive descent control, guidance and control of miniature satellites, a continuous proportional low-thrust propulsion system, and the design of the Hermes orbital flight controller. O.C.

A91-26609
DYNAMIC EVALUATION FOR THE DRTS USER SPACECRAFT'S ANTENNA POINTING SYSTEM
H. HASHIMOTO (NASDA, Tokyo, Japan), S. MOTOHASHI, O. KAWAMOTO, and Y. SHIMAMOTO (Toshiba Corp., Komukai Works, Kawasaki, Japan) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 27-32.
Copyright
Spacecraft with antenna systems for tracking the Data Relay Tracking Satellite (DRTS) require antenna-pointing systems (APSs) with performance of the order of 0.055 deg accuracy, wide visual field, and high speed, as well as the ability to maintain fine jitter-stabilization levels. Attention is presently given to results obtained for such DRTS-using spacecraft APSs, with emphasis on the critical factors of the antenna pointing mechanism's dynamics and the interaction between the pointing mechanism and flexible spacecraft appendages. O.C.

A91-26628
ROBUST CONTROL FOR LARGE SPACE STRUCTURES - SPILLOVER SUPPRESSION BY FREQUENCY-SHAPED OPTIMAL REGULATOR
T. KIDA (National Aerospace Laboratory, Chofu, Japan) and M. IKEDA (Kobe University, Japan) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 165-170.
Copyright
This paper proposes to give the low-pass property to the LQ regulator in order to enhance the stability robustness against the high-frequency uncertainties. The controller design is formulated as a frequency-shaped regulator problem. Its algorithm and characteristics are studied. The controller is applied to a flexible spacecraft attitude control problem to demonstrate its capability to suppress the spillover instability. Some experimental results are shown. Author

A91-26629
ACTIVE STABILIZATION OF A LARGE FLEXIBLE ANTENNA FEED SUPPORT STRUCTURE
M. S. ELBUNI and M. HIGASHIGUCHI (Tokyo, University, Japan) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 171-176.
Copyright
The paper extends a design procedure that uses pole placement in a vertical strip and degenerate control. The control logic was synthesized using colocated actuators and sensors to obtain an output feedback gain matrix which results in a stable closed-loop system with desired performance qualities. Active stabilization to hold a feed at the focus of a large antenna dish is considered. Using the symmetry of the structure the model is decomposed into two subsystems and the algorithm is applied to both the coupled and decoupled systems. The controller performance given as a time history of a line of sight error is investigated for both systems. The effect of gradually shifting the vertical strip in the s-plane is investigated. In addition, the relation between the amount of damping introduced and the location of the vertical strip is studied. Author

A91-26690#
THE INFLUENCE OF SAMPLING PERIOD IN DIGITAL CONTROL ON THE SPILLOVER IN VIBRATION SUPPRESSION OF FLEXIBLE STRUCTURES. I - APPROXIMATE THEORETICAL ANALYSIS AND NUMERICAL SIMULATION 1. II - NUMERICAL SIMULATION 2 AND EXPERIMENT
SHIGEO KOBAYASHI and HIROSHI SASAKI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 443, 1990, p. 637-654. In Japanese, with abstract in English. refs

A91-27418#
AN INNOVATIVE APPROACH FOR VALIDATION OF LARGE SPACE STRUCTURE CONTROLS-STRUCTURES INTERACTION TECHNOLOGIES (CSI-SAT)
ROBERT R. STRUNCE, JR. (Star Technologies Corp., Great Falls, VA) IN: Annual AIAA/Utah State University Conference on Small Satellites, 4th, Logan, UT, Aug. 27-30, 1990, Proceedings. Vol. 2. Logan, UT, Utah State University, 1990, 14 p.
This paper describes an innovative approach for space flight experiments to demonstrate and validate control-structures interaction (CSI) technologies and methodologies based on emerging small satellite initiatives. The current trends in DOD/NASA missions, the existing CSI ground experiments, and the planned space experiments are presented. A concept is identified for a CSI satellite and compatible launching platform necessary for performing affordable on-orbit testing of CSI technologies which cannot be accommodated in ground tests. Selected technologies and technology suites for space testing are identified. Author

A91-27535
APPLICATION OF FORMEX ALGEBRA TO BANDWIDTH MINIMIZATION
C. M. ANEKWE (Port Harcourt, University, Nigeria) Computers and Structures (ISSN 0045-7949), vol. 38, no. 3, 1991, p. 283-288. refs
Copyright
Formex algebra is a mathematical system which is used for the efficient processing and organization of a collection of entities or configurations. The system, which can be applied universally to generate data for structural analysis, is especially suited for space structures. Band solvers require data to be presented in a form which produces a small bandwidth, leading to reduced number of arithmetical operations needed for problem solution. The use of formex algebra to produce efficient node numbering and renumbering schemes for certain classes of space structures is presented. It is shown how the principle can be applied to minimize the bandwidth of the stiffness matrix of such structures. Author

A91-27679
MOTION CONTROL OF SPACE STRUCTURES
LARRY SILVERBERG and WILLIAM DUNN (North Carolina State University, Raleigh) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1065-1074. refs
Copyright
A new area of civil engineering is emerging as the U.S. begins to establish a permanent presence in space. The new area of civil engineering is the motion control of space structures. This paper describes why the motion control of space structures problem is fundamentally a civil engineering problem. Author

A91-27680
EFFECTS OF INITIAL CONDITIONS ON LARGE SPACE STRUCTURES
RAMESH B. MALLA (Connecticut, University, Storrs) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1075-1084. Research supported by

University of Massachusetts. refs
(Contract AF-AFOSR-83-0025)
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Effects of initial conditions of axial deformation (length) and attitude (pitch) angle have been investigated on the subsequent orbital motion, attitude (librational) motion, and axial deformation (length) of a large space structure under the action of the earth's gravitational force. The space structure is assumed to be axially flexible and is considered to be executing a planar motion around the earth. It is observed that the initial values of the parameters can have appreciable effects on the structure's axial deformation and its attitude motion, whereas they have negligible effects on the structure's orbital motion (orbital radius and angular velocity). Author

A91-27681
ACTIVELY CONTROLLED OPTIMUM STRUCTURAL DESIGN
N. S. KHOT, D. E. VELEY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1085-1093. refs
Copyright

This paper deals with the investigation of the number and location of actuators and sensors on the optimum structure and control design of space structures. The optimization problem is posed with the objective of minimizing the weight of the structure and satisfying the constraints on the closed-loop eigenvalue distribution and damping parameters. The allocation of the actuators for a specific disturbance is based on the work done by the individual actuators. Author

A91-27682
WAVE PROPAGATION IN HYPER-STRUCTURES
M. ETTOUNEY, J. WRIGHT (Weidlinger Associates, New York), and H. BENAROYA (Rutgers University, Piscataway, NJ) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1094-1103. refs
Copyright

The concept of hyperelement was introduced by Kausel and Roesset (1977) in connection with the derivation of the dynamic stiffness matrix for layered continuum problems involving two widely separated boundaries. Their approach is extended here and the term hyperstructure is used in an analogous way for structural systems with a large number of periodically spaced, identical structures. For these structures, it is shown that the steady state responses can be calculated more accurately and with fewer operations when compared to more general methods. In order to demonstrate the method, two planar systems are analyzed. Author

A91-27683
SPACE CONSTRUCTION - A CSI PERSPECTIVE
JOHN R. SESAK and J. MEL WALDMAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1104-1111.
Copyright

Space construction control-structure interaction (CSI) problems are discussed in view of the configuration and capabilities of the Control Astrophysics and Structures Experiment in Space (CASES), which is to be conducted by the Space Shuttle Orbiter; CASES offers a unique opportunity to integrate slewing, pointing, vibration, and shape control in a single control subsystem. The CASES baseline design encompassed five modules, respectively concerned with astrophysics, propulsion, the boom structure, astrophysics electronics, and control and data-handling electronics. O.C.

A91-27684* North Carolina Agricultural and Technical State Univ., Greensboro.
THE TRUSS-BEAM AND SPACE TECHNOLOGY
ELIAS G. ABU-SABA, WILLIAM M. MCGINLEY (North Carolina Agricultural and Technical State University, Greensboro), and RAYMOND C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1112-1121. refs
Copyright

A method is presented herein to determine the dynamic characteristics of truss-beam systems for both planar and space structures. Results from this approach are compared with those of the finite element method and test results. The truss-beam model is based on the assumptions of negligible web contribution, i.e., very large flexible structures. Future experimental evaluation of the plane truss-system is planned at North Carolina Agricultural and Technical State University and this experimental program is described. Author

A91-28521
ADAPTIVE MODAL PARAMETERS IDENTIFICATION FOR COLLOCATED POSITION FEEDBACK VIBRATION CONTROL
C. J. GOH (Western Australia, University, Nedlands, Australia) and T. H. LEE (National University of Singapore, Singapore) International Journal of Control (ISSN 0020-7179), vol. 53, March 1991, p. 597-617. refs
Copyright

The concept of position feedback previously introduced in the vibration suppression of large space structures is reviewed and extended. New results detailing more effective damping specifications are presented. Since effective vibration control depends on the accuracy of the modal parameters used, the problem of accurate identification of the modal frequencies, damping and mode shapes of the control modes is investigated. An adaptive estimation procedure to identify the parameters required in the position feedback control is proposed which caters for both full and partial modal state estimation. Simulation results for a multiple-degree-of-freedom vibration system are presented to illustrate the applicability of the proposed technique. Author

A91-28612* Cleveland State Univ., OH.
DYNAMIC ANALYSIS OF SPACE-RELATED LINEAR AND NON-LINEAR STRUCTURES
PAUL A. BOSELA (Cleveland State University, OH), FRANCIS J. SHAKER (NASA, Lewis Research Center, Cleveland, OH), and DEMETER G. FERTIS (Akron, University, OH) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 590-597. Previously announced in STAR as N90-25174. refs
(Contract NAG3-1008)
Copyright

In order to be cost effective, space structures must be extremely light weight, and subsequently, very flexible structures. The power system for Space Station Freedom is such a structure. Each array consists of a deployable truss mast and a split blanket of photo-voltaic solar collectors. The solar arrays are deployed in orbit, and the blanket is stretched into position as the mast is extended. Geometric stiffness due to the preload make this an interesting non-linear problem. The space station will be subjected to various dynamic loads, during shuttle docking, solar tracking, attitude adjustment, etc. Accurate prediction of the natural frequencies and mode shapes of the space station components, including the solar arrays, is critical for determining the structural adequacy of the components, and for designing a dynamic control system. The process used in developing and verifying the finite element dynamic model of the photo-voltaic arrays is documented. Various problems were identified, such as grounding effects due to geometric stiffness, large displacement effects, and pseudo-stiffness (grounding) due to lack of required rigid body modes. Analysis techniques, such as development of rigorous solutions using continuum mechanics, finite element solution sequence altering, equivalent systems using a curvature basis, Craig-Bampton superelement approach, and modal ordering schemes were utilized. The grounding problems associated with the geometric stiffness are emphasized. Author

A91-28613

ACTIVE CONTROL OF STRUCTURAL VIBRATION USING A MULTI-FREQUENCY SPECTRAL OPTIMIZATION STRATEGY - WITH APPLICATIONS TO ROTATING MACHINERY

MAAMAR MAGHRAOUI and MAURICE L. ADAMS (Case Western Reserve University, Cleveland, OH) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 598-605. refs

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A new approach for actively minimizing structural vibration has been developed and tested using computer simulations on a rotor-bearing system. This new approach is based on the use of optimization techniques to determine the combination of applied actuator forces that minimize an objective function that contains multifrequency orbital vibration levels at selected stations on the rotor system. Simulations show the basic approach to be quite effective and robust in handling system uncertainties and nonlinearities. In fact, one main advantage of this approach is that it does not rely upon any 'modeling knowledge' of the system. The other main advantage is that the approach, being essentially an active open-loop technique, does not create the potential for any additional instabilities in the rotor dynamical system, that is, the inherent eigenvalues of the uncontrolled system are unaltered by this control methodology. Author

A91-28624* State Univ. of New York, Buffalo.

AN OPTIMAL ESTIMATION APPROACH FOR ENHANCED IDENTIFICATION OF LARGE SPACE STRUCTURES

D. JOSEPH MOOK (New York, State University, Buffalo) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 749-756. Research supported by USAF and NASA. refs

Copyright

A very robust technique for the realization/identification of structural dynamic systems is presented. This methodology combines the eigensystem realization algorithm (ERA) and minimum model error (MME) techniques to develop an extremely robust algorithm able to distinguish modes whose amplitudes are small fractions of the noise amplitude. As the amplitude of the noise grows, the enhanced robustness of the combined ERA/MME algorithm becomes more significant. This is a result of the MME being able to produce simulated measurements of much greater accuracy than the original measurements, for input to the ERA. The new method was able to determine correct model order at noise levels many times higher than the original ERA for the realization problem in which the model order must be derived. R.E.P.

A91-28632* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

CONTINUATION METHODS IN MULTIOBJECTIVE OPTIMIZATION FOR COMBINED STRUCTURE CONTROL DESIGN

M. MILMAN, M. SALAMA, R. SCHEID, R. BRUNO (JPL, Pasadena, CA), and J. S. GIBSON (California, University, Los Angeles) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 830-837. refs

Copyright

A homotopy approach involving multiobjective functions is developed to outline the methods that have evolved for the combined control-structure optimization of physical systems encountered in the technology of large space structures. A method to effect a timely consideration of the control performance prior to the finalization of the structural design involves integrating the control and structural design processes into a unified design methodology that combines the two optimization problems into a single formulation. This study uses the combined optimization problem as a family of weighted structural and control costs. Connections with vector optimizations are described; an analysis of the zero-set of required conditions is made, and a numerical example is given. R.E.P.

A91-28633* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

EXPERIMENTS IN ON-ORBIT IDENTIFICATION FOR CONTROL OF SPACE STRUCTURES

Y. YAM, F. Y. HADAEGH, and D. S. BAYARD (JPL, Pasadena, CA) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 838-845. refs

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Two extensions to an earlier work on system identification for large flexible structures are presented. The first extension applies an integrated frequency-domain ID approach to experiments utilizing rib root actuators for full system excitation of both 'boom-dish' and 'dish' modes of the structure; while the second extension employs a time-domain identification, utilizing frequency-domain results obtained for initialization of the parameter estimates. For the first extension, the results show that in the presence of closely packed modes, the curve-fit algorithm employed can distinguish modes with frequency separation as small as 0.04 Hz. The maximum likelihood estimation used in the second extension produce estimates close to the parametric modal values of frequencies and damping. V.T.

A91-28634

ON THE MANEUVERING OF FLEXIBLE MULTI-BODY SYSTEMS

LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) IN: Developments in theoretical and applied mechanics. Vol. 15 - Proceedings of the 15th Southeastern Conference on Theoretical and Applied Mechanics, Atlanta, GA, Mar. 22, 23, 1990. Atlanta, GA, Georgia Institute of Technology, 1990, p. 846-853. refs (Contract F49620-89-C-0049)

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This paper is concerned with the dynamics and control of flexible multi-body systems. The mathematical model consists of a central substructure and a given number of retargeting substructures. The control design represents a substructure decentralized control scheme, whereby the control gains are designed independently for each substructure. Assuming that the time-varying terms are relatively small, the controls are first computed in closed form by means of a perturbation technique and then implemented in discrete time. The actuator forces designed by substructure decentralized control are applied to the fully interacting structure. A numerical example demonstrates the approach. Author

A91-29704*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MOTION AND FORCE CONTROLLED VIBRATION TESTING

TERRY D. SCHARTON, DAVID J. BOATMAN, and DENNIS L. KERN (JPL, Pasadena, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 77-85. USAF-sponsored research. refs

A technique for controlling both the input acceleration and force in vibration tests is proposed to alleviate the overtesting risks and the problems associated with response limiting in conventional vibration tests of aerospace hardware. Previous research on impedance and force controlled vibration tests is reviewed and a simple equation governing the dual control of acceleration and force is derived. A practical method for implementing the dual control technique in random vibration tests has been demonstrated in JPL's environmental test facility using a conventional digital controller operating in the extremal mode. The dual control technique provides appropriate real-time notching of the input acceleration and a corresponding reduction of the test item response at resonances. Issues concerning the need for force and acceleration phase information, the adequacy of specifying the blocked force, and the derivation of the total force for multipoint supports are discussed. Author

A91-29764#
OPTIMAL PROJECTION CONTROL OF AN EXPERIMENTAL TRUSS STRUCTURE
LEE D. PETERSON (Purdue University, West Lafayette, IN) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 241-250. Previously cited in issue 23, p. 3628, Accession no. A89-52534. refs
(Contract DE-AC04-76DP-00789)
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A91-29765#
SENSOR PLACEMENT FOR ON-ORBIT MODAL IDENTIFICATION AND CORRELATION OF LARGE SPACE STRUCTURES
DANIEL C. KAMMER (Wisconsin, University, Madison) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 251-259. Structural Dynamics Research Corp.-supported research. refs
Copyright

A method is presented for the selection of a set of sensor locations from a larger candidate set for the purpose of on-orbit identification and correlation of large space structures. The method ranks the candidate sensor locations according to their contribution to the linear independence of the target modal partitions. In an iterative manner, locations that do not contribute significantly are removed. The final sensor configuration tends to maximize the trace and determinant and minimize the condition number of the Fisher information matrix corresponding to the target modal partitions. This leads to better estimates and improved correlation. Advantages of the method include its computationally nonintensive nature compared with exhaustive search techniques found in the literature and the benefit of physical insight into the ranking and ultimate selection of sensor locations. The method is successfully applied to the selection of sensor locations for identification and correlation of a set of target modes for the structural characterization of a proposed large space structure. The final sensor configuration provides superor Fisher information matrix trace, determinant, and condition number values compared to other methods of sensor selection. Author

A91-29766*# Texas Univ., Austin.
MODEL REDUCTION AND CONTROL OF FLEXIBLE STRUCTURES USING KRYLOV VECTORS
TZU-JENG SU and ROY R. CRAIG, JR. (Texas, University, Austin) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 260-267. Previously cited in issue 12, p. 1897, Accession no. A89-30722. refs
(Contract NAS9-17254)
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A91-29767#
ACCOMMODATION OF KINEMATIC DISTURBANCES DURING MINIMUM-TIME MANEUVERS OF FLEXIBLE SPACECRAFT
YAAKOV SHARONY and LEONARD MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 268-277. Previously cited in issue 21, p. 3512, Accession no. A88-50440. refs
(Contract F33615-86-C-3233)
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A91-29768*# California Inst. of Tech., Pasadena.
SELECTION OF COMPONENT MODES FOR FLEXIBLE MULTIBODY SIMULATION
JOHN T. SPANOS and WALTER S. TSUHA (California Institute of Technology, Pasadena) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 278-286. NASA-supported research. Previously cited in issue 21, p. 3328, Accession no. A90-46804. refs
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A91-29769#
APPROXIMATE SOLUTIONS FOR VIBRATIONS OF DEPLOYING APPENDAGES
A. K. MISRA (McGill University, Montreal, Canada) and S. KALAYCIOGLU Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 287-293. Previously cited in issue 21, p. 3510, Accession no. A88-50383. refs
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A91-29770#
MODAL IDENTITIES FOR MULTIBODY ELASTIC SPACECRAFT
HARI B. HABLANI (Rockwell International Corp., Seal Beach, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 294-303. refs
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This paper answers the question: which set of modes furnishes a higher fidelity math model of dynamics of a multibody, deformable spacecraft, hinges-free, or hinges-locked vehicle modes? Three sets of general, discretized, linear equations of motion of a spacecraft with an arbitrary number of deformable appendages, each articulated directly to the core body, are obtained using the above two families of modes and appendage modes. By a comparison of these equations, 11 sets of matrix and scalar modal identities are constructed that involve modal momenta coefficients and frequencies associated with the three classes of modes. Applying the above identities to a four-body spacecraft, the hinges-locked vehicle modes are found to yield a higher-fidelity model than hinges-free modes because the hinges-free modes have nondiminishing modal coefficients, whereas the hinges-locked modes have modal angular momentum coefficients diminishing rapidly with frequency. Author

A91-29771#
FRACTIONAL ORDER STATE EQUATIONS FOR THE CONTROL OF VISCOELASTICALLY DAMPED STRUCTURES
R. L. BAGLEY and R. A. CALICO (USAF, Institute of Technology, Wright-Patterson AFB, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 304-311. Previously cited in issue 12, p. 1851, Accession no. A89-30701. refs

A91-29776*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL RESULTS USING ACTIVE CONTROL OF TRAVELING WAVE POWER FLOW
DAVID W. MILLER and STEVEN R. HALL (MIT, Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 350-359. NASA-supported research. refs
Copyright

Active structural control experiments conducted on a 24-ft pinned-free beam derived feedback compensators on the basis of a traveling-wave approach. A compensator is thus obtained which eliminates resonant behavior by absorbing all impinging power. A causal solution is derived for this noncausal compensator which mimics its behavior in a given frequency range, using the Wiener-Hopf. This optimal Wiener-Hopf compensator's structure-damping performance is found to exceed any obtainable by means of rate feedback. Performance limitations encompassed the discovery of frequencies above which the sensor and actuator were no longer dual and an inadvertent coupling of the control hardware to unmodeled structure torsion modes. O.C.

A91-29791*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
DESIGN OF OPTIMAL SECOND-ORDER STATE ESTIMATORS
SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 466-468. refs
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The present consideration of the design of online computation-saving second-order state estimators for second-order vector-matrix differential systems proposes a class of such estimators which is proven to possess guaranteed convergence. A class of optimal second-order estimators is then obtained, and the conditions required for optimality are identified. The estimator proposed offers high performance in conjunction with online computation reductions sufficiently great to allow the estimation of the large number of state variables associated with control of large, flexible space structures represented by high-dimensional second-order systems. O.C.

A91-30026
1990 AMERICAN CONTROL CONFERENCE, 9TH, SAN DIEGO, CA, MAY 23-25, 1990, PROCEEDINGS. VOLS. 1-3
Conference sponsored by American Automatic Control Council. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. Vol. 1, 1067 p.; vol. 2, 1091 p.; vol. 3, 1124 p. For individual items see A91-30027 to A91-30033, A91-30035 to A91-30109, A91-30111 to A91-30231, A91-30233 to A91-30244.
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The present conference discusses discrete-event systems, control applications to military systems, adaptive control systems, modeling and control for microelectronics processing, pole-placement in linear control, nonlinear controls, control of lightweight robotic systems, analysis and control of redundant manipulators, aerospace vehicle guidance and trajectory optimization, intelligent vehicle highway systems, modeling and realization, experimental control of flexible structures, complexity and uncertainty in control system design, decentralized and large scale systems, robust control of complex systems, modeling and control of stochastic systems, automatic aids for ATC, and robust adaptive control. Also discussed are reactor control, linear and nonlinear robust control, control of flexible manipulator arms, robust robot control, aircraft and missile control, optimal control, robust feedback design, robust H2/H-infinity control design, manufacturing processes control, digital control, space systems control, control of active suspension systems, intelligent and fuzzy control, neural network control, large space structures, aerospace trajectory optimization, nonlinear process control, robot kinematics, flexible manipulators, and batch process control. O.C.

A91-30054
REDUCED ORDER ROBUST CONTROLLERS FOR AN EXPERIMENTAL FLEXIBLE GRID
S. VITTAL RAO, M. WESTERHEIDE (Missouri-Rolla, University, Rolla), and ALOK DAS (USAF, Astronautics Laboratory, Edwards AFB, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 356-361. refs
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A procedure for the design and implementation of reduced-order robust controllers for active vibration control on an experimental flexible grid structure is presented. The grid hangs vertically, being cantilevered at the top to a large T-beam anchored to a cinder block wall. The grid structure is represented by a 75-degree-of-freedom finite-element model, and the controller uses three piezoelectric accelerometer sensors to command three noncollocated DC motor torquers. The modified balance-truncation model-reduction method is used to derive a control synthesis model. A 10-mode mathematical representation of the experimental grid structure has nonminimum-phase zeros. The effects of non-minimum-phase zeros on the performance of a closed-loop LQG/LTR controller are investigated. The reduced-order controllers are implemented on the structure using an ISI Max 100 computer. Experimental closed-loop performance of the grid is obtained for various parameter variations. I.E.

A91-30056* Ohio State Univ., Columbus.
DECENTRALIZED CONTROL EXPERIMENTS ON THE JPL FLEXIBLE SPACECRAFT
U. OZGUNER, K. OSSMAN, J. DONNE, M. BOESCH (Ohio State University, Columbus), and A. AHMED (JPL, Pasadena, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 368-373. refs
(Contract JPL-958604)
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Decentralized control experiments were successfully demonstrated for the JPL/AFAL Flexible Structure. A simulation package using MATRIXx showed strong correlation between the simulations and experimental result, while providing a means for test and debug of the various control strategies. Implementation was simplified by a modular software design that was easily transported from the simulation environment to the experimental environment. Control designs worked well for suppression of the dominant modes of the structure. Static decentralized output feedback dampened the excited modes of the structure, but sometimes excited higher order modes upon startup of the controller. A second-order frequency shaping controller helped to eliminate excitation of the higher order modes by attenuating high frequencies in the control effort. However, it also resulted in slightly longer settling times. I.E.

A91-30057
A CONTROL SYSTEM DESIGN METHODOLOGY FOR LARGE-SCALE INTERCONNECTED SYSTEMS
KARL W. FLUECKIGER, JOHN R. DOWDLE, and TIMOTHY C. HENDERSON (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 428-434. Charles Stark Draper Laboratory, Inc.-supported research. refs
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The need to develop analysis approaches that may be applied to complex design problems to complement the experience of design engineers is addressed by the development of a large-scale interconnected control system design methodology. An overview of the methodology developed to date is presented. An application of modern multivariable techniques to a space-based laser jitter control system illustrates the development and utilization of the methodology. I.E.

A91-30084* Boeing Aerospace Co., Seattle, WA.
OPTIMIZATION OF LINEAR, CONTROLLED STRUCTURES
K. SCOTT HUNZIKER, RAYMOND H. KRAFT (Boeing Aerospace and Electronics, Seattle, WA), ROBERT T. KOSUT (Integrated Systems, Inc., Santa Clara, CA), and ERNEST S. ARMSTRONG (NASA, Langley Research Center, Hampton, VA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 854-859. refs
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An approach to the integrated design of linear controlled structures, which is being investigated as part of NASA's controlled structures interaction (CSI) methodology development program, is presented. The approach is integrated in the sense that the structure and its controller are simultaneously designed. The design methodology uses constrained nonlinear optimization procedures based on analytically obtained gradients of the structural responses. Design of the controller is based on the so-called Q-parameterization theory, which parameterizes all closed-loop input/output maps achievable with stabiizing linear controllers. Very general objective and constraint functions are possible, and structural shape can be included in the design variables. This method has been partially implemented and demonstrated; early findings are reported. I.E.

A91-30085* Integrated Systems, Inc., Santa Clara, CA.
SIMULTANEOUS CONTROL AND STRUCTURE DESIGN FOR LARGE SPACE STRUCTURES
ROBERT L. KOSUT, GUNTEKIN M. KABULI, SCOT MORRISON, and Y.-P. HARN (Integrated Systems, Inc., Santa Clara, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 860-865. refs
(Contract NAS1-18818)
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The problem of developing design guidelines for the simultaneous selection of control and structural parameters is addressed. One guideline is offered for the case of vibration suppression due to disturbances. The effect of structural design changes is examined by means of a parameterized LQG compensator. It is shown that using the LQG design provides a simple means to evaluate simultaneous control and design changes. I.E.

A91-30086
DEVELOPMENT AND VERIFICATION OF KEY TECHNOLOGIES FOR THE SUCCESS OF AGILE SPACE MISSIONS
V. A. SPECTOR, R. A. MANNING, M. L. NARIGON, D. W. WISE, and M. D. ROESLER (TRW Space and Technology Group, Redondo Beach, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 866-869.
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The status of several of the key technologies that address the needs of the upcoming agile spacecraft missions is examined. Simultaneous structural/control design, system identification, active/passive vibration suppression, and testbed definition are discussed. I.E.

A91-30087
MODEL ORDER EFFECTS ON THE TRANSMISSION ZEROS OF FLEXIBLE SPACE STRUCTURES
TREVOR WILLIAMS (Cincinnati, University, OH) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 876, 877. refs
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The question of the sensitivity of zeros to changes in model dimension is studied. It is proved that a result entirely analagous to the classical Rayleigh-Ritz convergence property for the poles of a flexible structure also applies for its zeros, so long as compatible sensor/actuator pairs are used. Thus, the zeros of a finite-dimensional model of such a structure always bound the true zeros from above, and converge monotonically to these values as model order is increased. Furthermore, the low-frequency fundamental zeros, i.e., those of the greatest physical significance, are the first to converge. One consequence of this result is that a pole/zero cancellation controller designed for a truncated model of a given FSS (flexible space structure) will cancel the fundamental zeros of the true system quite accurately. Thus, the low-frequency modes of the closed-loop system will hardly contribute to the measured system output. A simple cantilever example is used to illustrate the zeros convergence result. I.E.

A91-30124* Massachusetts Inst. of Tech., Cambridge.
FAILURE DETECTION AND ISOLATION EXPERIMENTS WITH THE LANGLEY MINI-MAST
WALLACE E. VANDER VELDE and CHRISTIAAN M. VAN SCHALKWYK (MIT, Cambridge, MA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1422-1427. refs
(Contract NAG1-968)
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A report is presented on experiments to demonstrate failure detection and isolation (FDI) using the flexible truss facility Mini-Mast at the NASA Langley Research Center. Two techniques are selected for study because they are applicable both to sensor and actuator failures and because they do not depend on hypotheses about the forms of possible failures. These two are the method of generalized parity relations and the failure detection filter. These methods utilize the concept of analytical redundancy and therefore their performance depends on the fidelity of the model of the dynamics of the system being monitored. Results are given for sensor FDI using generalized parity relations and input-output data collected during operation of the Mini-Mast. component failures are simulated in the data. The dependence of the performance of the methods on choices of the parameters in their implementation is explored. I.E.

A91-30125* Arizona State Univ., Tempe.
ACTIVE STRUCTURAL CONTROL DESIGN AND EXPERIMENT FOR THE MINI-MAST
BONG WIE (Arizona State University, Tempe), LUCAS HORTA, and JEFF SULLA (NASA, Langley Research Center, Hampton, VA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1428-1434. refs
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Control system design and closed-loop test results for the Mini-Mast truss structure located at the NASA Langley Research Center are presented. The simplicity and effectiveness of a classical control approach to the active structural control design are demonstrated by ground experiments. The concepts of robust nonminimum phase compensation and periodic disturbance rejection are also experimentally validated. The practicality of a sensor output decoupling approach is demonstrated for the inherent, multivariable control problem of the Mini-Mast. I.E.

A91-30126* Purdue Univ., West Lafayette, IN.
CLOSED LOOP LAB TESTS OF NASA'S MINI-MAST
C. HSIEH, J. H. KIM, and ROBERT E. SKELTON (Purdue University, West Lafayette, IN) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1435-1440. refs
(Contract NAG1-958)
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A design strategy which integrates model reduction by modal cost analysis and a multiobjective controller synthesis algorithm is used to design controllers for NASA's Mini-Mast system. The necessary modeling and control algorithms are easily programmed in Matlab standard software. Hence, this method is very practical for controller design for large space structures. The design algorithm also presents a solution for the important problem of tuning multiple-loop controllers. I.E.

A91-30127
PRACTICAL EXPERIENCE WITH IDENTIFICATION OF LARGE FLEXIBLE STRUCTURES
RANDALL J. ALLEMANG, S. J. SHELLEY, D. L. BROWN, and Q. ZHANG (Cincinnati, University, OH) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1441-1444. refs
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A summary is presented of work done to characterize the combined actuator-structure-sensor system and the control system hardware of the active control evaluation for spacecraft (ACES) facility at the NASA Marshall Space Flight Center. The input-output frequency response functions of the actuator-structure-sensor system were measured for all analog actuator inputs and sensor outputs. System nonlinearity and time variance, measurement delays, and control hardware sampling delays and alias protection were investigated. Modal models of the system were generated from frequency response function data. State-space models are formed from these modal parameters for use in controller design. I.E.

A91-30129* Harris Government Aerospace Systems Div., Melbourne, FL.
DESIGN AND IMPLEMENTATION OF ROBUST DECENTRALIZED CONTROL LAWS FOR THE ACES STRUCTURE AT MARSHALL SPACE FLIGHT CENTER
EMMANUEL G. COLLINS, JR., DOUGLAS PHILLIPS, and DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1449-1454. refs
(Contract NAS1-18872)
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An experiment was conducted to design controllers that would provide substantial reduction of line-of-sight control errors. The satisfaction of this objective required the controllers to attenuate the beam vibration significantly. Particular emphasis was placed on controller simplicity (i.e., reduced-order and decentralized controller architectures). Complexity reduction in control law implementation is of paramount interest due to stringent limitations on throughput of even state-of-the-art space qualified processors. The results of this experiment successfully demonstrate active vibrator control for a flexible structure. The testbed is the ACES structure at the NASA Marshall Space Flight Center. The ACES structure is dynamically traceable to future space systems and especially allows the study of line-of-sight control issues. I.E.

A91-30134
SHAPE CONTROL OF DISTRIBUTED PARAMETER SYSTEMS - MODELING AND PERFORMANCE ANALYSIS
SHAWN E. BURKE and JAMES E. HUBBARD, JR. (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1552-1557. Charles Stark Draper Laboratory, Inc.-supported research. refs
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A method of analyzing self-adjoint linear distributed parameter shape control systems is presented. It is based on their input-output representation in a spatially and temporally transformed frequency space. The analysis is specialized to the shape control problem by expanding the plant spatial response in orthogonal functions, e.g., a generalized Fourier spatial transform; for example, a Zernike polynomial basis can be introduced for deformable mirror optical wavefront correction tasks. The spatially transformed plant models are amenable to control analysis and design techniques and software. Design measures are presented over both temporal and spatial bandwidths. A modeling correction is introduced to accommodate modal truncation while maintaining static and bandlimited dynamic shape fidelity. I.E.

A91-30138* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN AVERAGING APPROACH TO OPTIMAL ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES
D. S. BAYARD (JPL, Pasadena, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1576-1582. refs
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Averaging methods are applied to analyzing the transient response associated with adaptive control of large space structures. Using a dominant mode approximation to the plant, an analytical bound is found on the envelope of the adaptive response, characterizing many of the features of the response useful for control design (e.g., peak values, quadratic costs, settling times, etc.). An optimal adaptive design problem is formulated based on minimizing the product of the settling time and peak torque requirement. The resulting nonlinear constrained optimization problem is solved in closed form, and several properties of the optimal adaptive design are discussed. I.E.

A91-30149* North Carolina State Univ., Raleigh.
A SINGLE-AXIS TESTBED FOR SLEWING CONTROL EXPERIMENTS
JONATHAN HAMILTON, GORDON K. F. LEE (North Carolina State University, Raleigh), and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1733-1737. refs
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A simple single-axis testbed is described, and initial experimental results are presented to illustrate collocated and noncollocated control for this structure. The testbed is made up of a pair of single-axis flexible beams attached to a DC servo motor. An optical encoder and strain gauges provide hub and beam position information, respectively. The system is driven by an IBM PC system; with a motor controller, a programmable digital filter processes position error information through user-selected gains and pole-zero configurations. A 25-kHz data acquisition system provides the necessary interface between processor and motor. The control approaches currently being investigated include collocated PD control and noncollocated phase compensation. I.E.

A91-30153
REDUCED-ORDER MODEL BASED CONTROL OF LARGE FLEXIBLE MANIPULATORS - THEORY AND EXPERIMENTS
BRIAN T. REISENAUER, MARK J. BALAS (Colorado, University, Boulder), and MADISON RAMEY (Martin Marietta Astronautics Group, Denver, CO) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1760-1765. Research supported by Martin Marietta Corp. and University of Colorado. refs
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Inherent in the application of reduced-order-model (ROM) control schemes is the problem of controller-structure interaction (CSI). The issue of CSI is addressed through residual mode filter compensation which is added onto the ROM controller. The design of the ROM-based control law takes into account only system performance, while the residual-mode-filter (RMF) design insures closed-loop system stability. This partitioned design method is examined in its discrete-time representation, focusing on its application to a flexible manipulator. It is found that the structure's performance is related only to a small number of modes that can be combined in a ROM and controlled. However, by itself, the ROM controller can cause problems with unmodeled structure dynamics. For large flexible systems, full-order control becomes impossible to implement. In order to guarantee stable, ROM-based control, RMF compensation for CSI is used. Design of the RMF is independent of the ROM controller, it focuses on some of the residual modes, called Q-modes, that are extremely susceptible to CSI. The RMF is simple to implement as a parallel bank of second-order filters added onto the ROM controller. Experiments with a robot arm demonstrate the effectiveness of RMF compensation on a flexible manipulator. I.E.

A91-30164
COLLOCATED VERSUS NON-COLLOCATED MULTIVARIABLE CONTROL FOR FLEXIBLE STRUCTURE
GARY J. BALAS (Minnesota, University, Minneapolis) and JOHN C. DOYLE (California Institute of Technology, Pasadena) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1923-1928. California Institute of Technology-supported research. refs
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The benefits and limitations associated with multivariable control design using noncollocated and collocated sensors and actuators are compared. The question of whether performance is restricted due to the noncollocation of the sensors and actuators or the uncertainty associated with the modeling of flexible structures is addressed. Control laws are formulated based on models of the system and evaluated analytically and experimentally. Results of implementation of these control laws on the Caltech flexible structure are presented. I.E.

A91-30165

POWER FLOW, ENERGY BALANCE, AND STATISTICAL ENERGY ANALYSIS FOR LARGE-SCALE INTERCONNECTED SYSTEMS

DAVID C. HYLAND and DENNIS S. BERNSTEIN (Harris Corp., Melbourne, FL) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1929-1934. refs

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Some of the basic ideas of SEA (statistical energy analysis) in rigorous system-theoretic language are elucidated, and generalizations of certain fundamental SEA results are provided. The problem is first formulated in terms of a Lyapunov equation. Motivated by the literature on large-scale systems theory, the authors then utilize Kronecker matrix algebra and M-matrix theory as their principal mathematical tools. I.E.

A91-30167* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SENSOR/ACTUATOR PLACEMENT FOR FLEXIBLE SPACE STRUCTURES

P. G. MAGHAMI and S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1941-1948. refs

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A new approach for the placement of sensors and actuators in the active control of flexible space structures is developed. The approach converts the discrete nature of the sensor and actuator positioning problem to a nonlinear programming optimization through approximation of the control forces and output measurements by spatially continuous functions. The locations of the sensors and actuators are optimized in order to move the transmission zeros of the system farther to the left of the imaginary axis. The criterion for sensor/actuator placement can be quite useful for optimal regulation and tracking problems, as well as for low-authority controller designs. Two performance metrics are considered for the optimization and are applied to the sensor/actuator positioning of a large-order flexible space structure. I.E.

A91-30168* North Carolina Univ., Charlotte.

SLEW MANEUVERS OF LARGE FLEXIBLE SPACECRAFTS

Y. P. KAKAD (North Carolina, University, Charlotte) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1949-1954. refs

(Contract NAG1-535)

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The dynamics and control of arbitrary slew maneuvers of a large flexible spacecraft are developed. The dynamics of slew maneuvers are nonlinear and include the coupling between the rigid orbiter and the flexible appendage. A decentralized control scheme is used to perform a large-angle slew maneuver about an arbitrary axis in space and to suppress the vibrations of the flexible appendage during and after the maneuver. I.E.

A91-30173

ROBUST MODAL CONTROL OF DISTRIBUTED-PARAMETER SYSTEMS WITH UNCERTAINTY

Y. H. CHEN (Georgia Institute of Technology, Atlanta) and E. D. PIONTEK (Syracuse University, NY) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2014-2019. refs

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Control is designed for decreasing vibratory motion of large flexible structures which possess unknown mass and stiffness distributions and have disturbance forces acting upon them. A postulated model of a self-adjoint positive definite distributed-parameter system is employed to obtain an orthonormal set of eigenfunctions used to convert the uncertain flexible structure into modal space. A class of robust controls that guarantee practical stability for dynamic systems which consist of interconnected subsystems with uncertainties is then employed to control each mode of the flexible structure. This control design is based on the possible bound of the uncertainty. Since it may be difficult to obtain the bound of uncertainty, an adaptive algorithm is employed to estimate the bound online. I.E.

A91-30179* Purdue Univ., West Lafayette, IN.

AN ITERATIVE ALGORITHM COMBINING MODEL REDUCTION AND CONTROL DESIGN

C. HSIEH, J. H. KIM, G. ZHU, K. LIU, and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2120-2125. refs

(Contract NAG1-958)

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A design strategy which integrates model reduction by modal cost analysis and a multiobjective controller design is proposed. The necessary modeling and control algorithms are easily programmed in Matlab standard software. Hence, this method is very practical for controller design for large space structures. The design algorithm also solves the very important problem of tuning multiple loop controllers (multi-input, multi-output, or MIMO). Instead of the single gain change that is used in standard root locus and gain and phase margin theories, this method tunes multiple loop controllers from low to high gain in a systematic way in the design procedure. This design strategy is applied to NASA's Mini-Mast system. I.E.

A91-30202* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

INTEGRATED IDENTIFICATION AND ROBUST CONTROL TUNING FOR LARGE SPACE STRUCTURES

Y. YAM, D. S. BAYARD, and R. E. SCHEID (JPL, Pasadena, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2424-2429. refs

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System identification is studied for the explicit purpose of supporting modern H-infinity robust control design objectives. In the analysis, the true plant is not assumed to be in the identification model set. An integrated identification/robust control problem is posed in which the optimal solution guarantees the best robust performance relative to the system information contained in a given experimental data set. A numerical example demonstrating an approximate solution to the problem indicates the usefulness of the approach. I.E.

A91-30203

ROBUST NONLINEAR CONTROL OF FLEXIBLE SPACE STRUCTURES

W. H. BENNETT, O. AKHRIF, and T. A. W. DWYER (Techno-Sciences, Inc., Greenbelt, MD) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2430-2436. SDIO-supported research. refs

(Contract F49620-87-C-0103)

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A description is given of results on the robust implementation of decoupling control for multibody systems with flexible interactions. Requirements for decoupling control arise in input-output linearization of certain principal system outputs with respect to available controls. In many applications, it is desired to decouple multibody dynamic interactions from critical system outputs using available controls. For decoupling control implementation to be robust, it should be insensitive to model perturbations. Consideration is given to parasitic dynamics arising from flexible interactions, the role of reduced-order modeling, and the implementation of partial (input-output) linearizing feedback control. The importance of model reduction based on time scaling of the decoupled or zero dynamics is highlighted. I.E.

A91-30205
MODELING AND STABILIZATION OF ROTATING FLEXIBLE STRUCTURES
T. A. POSBERGH (Minnesota, University, Minneapolis) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2452, 2453. refs
(Contract AF-AFOSR-87-0073)
Copyright
An outline is presented of a linear model which is obtained by linearizing about a steady-state, planar rotation of a rigid body with an attached flexible appendage modeled as a geometrically exact rod. The linearized model includes terms which arise from the uniform rotation of the assemblage and are consistent with the physics of the nonlinear model. For the problem of stabilizing the system by a control law, the effects which physically correspond to this model are crucial. I.E.

A91-30207* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ROBUST CONTROL OF AN ACTIVE PRECISION TRUSS STRUCTURE
C. C. CHU, R. S. SMITH, and J. L. FANSON (JPL, Pasadena, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2490-2495. refs
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A description is given of the efforts in control of an active precision truss structure experiment. The control objective is to provide vibration suppression to selected modes of the structure subject to a bandlimited disturbance and modeling errors. Based on performance requirements and an uncertainty description, several control laws using the H-infinity optimization method are synthesized. The controllers are implemented on the experimental facility. Preliminary experimental results are presented. I.E.

A91-30229
ON CONTROL OF LARGE SPACE STRUCTURES
T. S. TANG and G. M. HUANG (Texas A & M University, College Station) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2965-2970. Texas Advanced Research Program-supported research. refs
Copyright
The authors show that the spillover effect can be minimized by selecting actuator and sensor locations and choosing feedback and observer gain structures through a systematic process. The proposed procedure is named the target approximation method (TAM) since it imitates an idealized system as a desired target. The advantage of the TAM procedure over the H-infinity and classical methods is illustrated through a simple flexible beam example. I.E.

A91-30230* Texas A&M Univ., College Station.
ACTIVE DISTURBANCE REJECTION IN LARGE FLEXIBLE SPACE STRUCTURES
ALEXANDER G. PARLOS (Texas A & M University, College Station) and JOHN W. SUNKEL (NASA, Johnson Space Center, Houston, TX) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2971-2977. refs
(Contract NAG9-275)
Copyright
The design of an active control law for the rejection of persistent disturbances, in large space structures is presented. The control system design approach is based on a deterministic model of the disturbances and it optimizes the magnitude of the disturbance that the structure can tolerate without violating certain predetermined constraints. In addition to closed-loop stability, the explicit treatment of state, control, and control rate constraints, such as structural displacement and control actuator effort, guarantees that the final design will exhibit desired performance characteristics. The technique is applied to a simple two-bay truss structure, and its response is compared with that obtained using a linear-quadratic-Gaussian/loop-transfer-recovery (LQG/LTR) compensator. Preliminary results indicate that the proposed control system can reject persistent disturbances of greater magnitude by utilizing most of the available control, while limiting the structural displacements to within desired tolerances. I.E.

A91-30233
APPROXIMATE CIRCLE CONTROL DESIGN FOR LIGHTLY DAMPED PLANTS
DALE A. LAWRENCE and TIMOTHY J. WARDLOW (Cincinnati, University, OH) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2991-2996. refs
Copyright
A control design technique is introduced for plants having lightly damped parasitic or uncontrolled dynamics, such as large space structures. The circular Nyquist plots of these dynamics are used to construct simple yet accurate constraints on a reduced-order controller. Two techniques are presented for identifying these control design constraints, one using standard direct-form filters, and one using an approximate circle filter structure. Simulation results offer evidence that the direct form and the approximate circle form algorithms are viable methods for identifying the significant resonance modes of lightly damped dynamical systems. The direct form identifier is better at precisely matching the plant over all frequencies. However, the approximate circle identification form makes it possible to extract the key resonance mode parameters in a real-time setting. I.E.

A91-30672* Alabama Univ., Huntsville.
SLOSH WAVE EXCITATION AND STABILITY OF SPACECRAFT FLUID SYSTEMS
R. J. HUNG, C. C. LEE (Alabama, University, Huntsville), and F. W. LESLIE (NASA, Marshall Space Flight Center, Huntsville, AL) IN: TABES 90 - Annual Technical and Business Exhibition and Symposium, 6th, Huntsville, AL, May 15, 16, 1990, Submitted Papers. Huntsville, AL, Huntsville Association of Technical Societies, 1990, p. 237-244. refs
(Contract NAG8-035; NAG8-129)
(TABES PAPER 90-1810) Copyright
The instability of liquid and gas interface can be induced by the pressure of longitudinal and lateral accelerations, vehicle vibration, and rotational fields of spacecraft in a microgravity environment. Characteristics of slosh waves excited by the restoring force field of gravity jitters have been investigated. Results show that lower frequency gravity jitters excite slosh waves with higher ratio of maximum amplitude to wave length than that of the slosh waves generated by the higher frequency gravity jitters. Author

A91-30791
VARIABLE STRUCTURE SLEWING CONTROL AND VIBRATION DAMPING OF FLEXIBLE SPACECRAFT
ASHOK IYER and SAHJENDRA N. SINGH (Nevada, University, Las Vegas) Acta Astronautica (ISSN 0094-5765), vol. 25, Jan. 1991, p. 1-9. refs
(Contract DAAL03-87-G-0004)
Copyright
The question of attitude control and elastic mode stabilization of a spacecraft (orbiter) with 'beam-tip mass' type payload is considered. It is assumed that bounded but unknown disturbance torques are acting on the spacecraft. Based on variable structure system theory, a discontinuous three-axis moment control law is derived to control the attitude of the spacecraft. Although this control law accomplishes attitude trajectory tracking, it excites the elastic modes of the beam. A modal velocity feedback design is

presented to damp the elastic oscillations using additional actuators at the tip of the beam. Simulation results are presented to show that rotational maneuvers and vibration stabilization can be accomplished in the closed-loop system in spite of disturbance torques and uncertainty in the system. Author

A91-30894#
ROBUSTNESS OF A MOVING-BANK MULTIPLE MODEL ADAPTIVE ALGORITHM FOR CONTROL OF A FLEXIBLE SPACESTRUCTURE
PETER S. MAYBECK and MICHAEL R. SCHORE (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 368-374. refs

The robustness capabilities of moving-bank multiple model adaptive estimation and control algorithms are investigated for application to a flexible space-structure in which parameter uncertainties dictate a need for online adaptivity. For both estimation and control, the algorithms are sufficiently robust to allow a six-state dynamics design model to yield excellent performance against a 24-state truth model of the actual system. Particularly for control, where nonadaptive controllers were shown to lead readily to unstable closed-loop systems, the moving-bank MMAC (multiple model adaptive control) provided control that was essentially equivalent to what of an artificially informed benchmark controller. It is pointed out that the values of the measurement noise covariance play an important role in the performance potential of the moving-bank algorithms. A range of admissible measurement precisions exists beyond which the effective movement of the bank in parameter space is seriously impaired. I.E.

A91-31095
PARTIAL EIGENSTRUCTURE ASSIGNMENT AND ITS APPLICATION TO LARGE SCALE SYSTEMS
JIN LU, HSIAO-DONG CHIANG, and JAMES S. THORP (Cornell University, Ithaca, NY) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. 36, March 1991, p. 340-347. K.C. Wong Education Foundation-supported research. refs
(Contract F08671-88-O-0448)
Copyright

The notion of partial eigenstructure assignment (PEA) via linear state feedback control in linear multivariable systems is introduced. This notion is a natural extension of eigenstructure assignment and partial eigenvalue assignment. Some theoretical basis for PEA is provided, and a parametric expression for feedback gain matrices achieving PEA is derived. An effective numerical algorithm for PEA tailored to large-scale systems is presented. As an extension of the algorithm, a recursive algorithm for eigenstructure assignment is presented. These algorithms possess the following desired properties: (1) compared to existing methods, the presented algorithms significantly reduce the required computation time via transforming high-dimensional matrix computations into low-dimensional matrix computations; (2) they can be implemented in a parallel fashion. The proposed algorithm for PEA is applied to modal control of large flexible space structure systems. I.E.

A91-31226* Virginia Polytechnic Inst. and State Univ., Blacksburg.
ON THE ACCURACY OF SHAPE SENSITIVITY
R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) and B. BARTHELEMY (Ford Scientific Research Laboratory, Dearborn, MI) Structural Optimization (ISSN 0934-4373), vol. 3, March 1991, p. 1-6. refs
(Contract NAG1-224)
Copyright

The calculation of sensitivity of the response of a structure modeled by finite elements to shape variation is known to be subject to numerical difficulties. The accuracy of a given method is typically measured against the yard stick of finite-difference sensitivity calculation. The present paper demonstrates with a simple example that this approach may be flawed because of discretization errors associated with the finite element mesh. Seven methods for calculating sensitivity derivatives are compared for a two-material beam problem with a moving interface. It is found that as the mesh is refined, displacement sensitivity derivatives converge more slowly than the displacements. Six of the methods agree fairly well, but the adjoint variational surface method provides substantially different results. However, the difference is found to reflect convergence from another direction to the same answer rather than reduced accuracy. Additionally, it is observed that small derivatives are particularly prone to accuracy problems. Author

A91-31428
GROUND-BASED TESTING DYNAMICS FOR PRISMATIC BEAM IN MICROGRAVITY
RALPH J. DORNSIFE (U.S. Army, Construction Engineering Research Laboratory, Champaign, IL) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, April 1991, p. 165-183.
Copyright

Largely because of the high cost of transporting payloads into low earth orbit, large space structures must first be dynamically analyzed and tested prior to installation in space. The resulting ground-based test behavior must be correlated to actual behavior in a microgravity environment. This paper will first examine the dynamics of a simple beam on an elastic foundation with, and without, a gravity environment. The same beam is then examined with discrete spring supports in the presence of gravity. The mathematics and solution procedure are described. Resulting theoretical behavior in gravity is compared with the theoretical behavior expected in microgravity. Author

A91-31761
PARTICULAR ASPECTS OF THE FORCED RESPONSE OF FINITE-DIMENSIONAL MODULAR STRUCTURES
FRANCO BERNELLI-ZAZZERA and AMALIA ERCOLI-FINZI (Milano, Politecnico, Milan, Italy) (ESA, Workshop on Modal Representation of Flexible Structures by Continuum Methods, Noordwijk, Netherlands, June 1989) Meccanica (ISSN 0025-6455), vol. 25, Dec. 1990, p. 265-271. refs
Copyright

The problem of finite-dimensional modular structures, directly relevant to the dynamics of large space structures, is analyzed from the engineering standpoint. The relation between the propagation characteristics of an indefinite structure and the forced response of a finite-dimensional structure is established in closed form for a periodic beam in transverse vibration. It is concluded that, under certain conditions, the knowledge of the dispersion relations can be sufficient to predict the forced response of a finite-dimensional structure. The analytical results are found to be in good agreement with numerical simulations. V.L.

A91-31826
AIAA/ASME/ASCE/AHS/ASC STRUCTURES, STRUCTURAL DYNAMICS, AND MATERIALS CONFERENCE, 32ND, BALTIMORE, MD, APR. 8-10, 1991, TECHNICAL PAPERS. PTS. 1-4
Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. Pt. 1, 924 p.; pt. 2, 829 p.; pt. 3, 764 p.; pt. 4, 668 p. For individual items see A91-31827 to A91-32131.
Copyright

Various papers on structures, structural dynamics, and materials are presented. The general topics addressed include: material characterization and evaluation, modeling of materials and processes, shape memory alloys, structural optimization, composite materials design optimization, optimization methods, aircraft design optimization, integrated structures and controls optimization, design optimization tools, shape optimization, buckling of composites, analysis techniques for composites, analysis of composite beams, impact damage of composites, damage and fracture of composites, probabilistic analysis of structures, reliability method, structural analysis and testing, thermal mechanical analysis. Also discussed are: advanced analysis methods, finite element methods, advanced structural applications, structural design, aging aircraft, hypersonic structures and materials, aeroelasticity, aeroservoelasticity and active control, unsteady aerodynamics, panel flutter, rotor aeroelasticity and vibration, composite wings and active control, adaptive structures, system identification, damping, dynamics analysis, multibody dynamics, random and nonlinear dynamic analysis, spacecraft dynamics, control of space structure, space structure on orbit test, composite materials dynamics. C.D.

A91-31874#
MINIMIZING DISTORTION IN TRUSS STRUCTURES - A COMPARISON OF SIMULATED ANNEALING AND TABU SEARCH
REX K. KINCAID (College of William and Mary, Williamsburg, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 424-430. refs
(AIAA PAPER 91-1095) Copyright

Inaccuracies in the length of members and the diameters of joints of large space structures may produce unacceptable levels of surface distortion. Based on the influence matrices generated by a small deformation linear analysis, a discrete optimization problem to minimize surface distortion (DSQRMS) is formulated. A description of two general purpose discrete optimization solution techniques - simulated annealing and tabu search - is given and a comparison of their performances on DSQRMS is provided. Author

A91-31885#
OPTIMUM DESIGN OF INTELLIGENT TRUSS STRUCTURES
R. A. MANNING (TRW Space and Technology Group, Redondo Beach, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 528-533. refs
(AIAA PAPER 91-1158) Copyright

An integrated structures/active vibration suppression design optimization procedure for intelligent truss structures is presented. The intelligent truss structures consist of inert trusses augmented with active members. The active members contain piezoelectric sensors and actuators embedded within a composite layup and local vibration suppression loops. A two stage optimization procedure is described which breaks a complex implicit combinatoric optimization problem into a heuristic subproblem for active member placement and a formal subproblem for sizing the inert truss members and the active truss members. By designing the local loops around the active members simultaneously with the structural parameters of the inert and active members, damping in the lower modes can be obtained without destabilizing the higher modes. Solution to the optimum design problem is found in relatively few iterations by employing approximation concepts. Author

A91-31887*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
QUASI-STATIC SHAPE ESTIMATION AND CONTROL OF ADAPTIVE TRUSS STRUCTURES
FUMIHIRO KUWAO, GUN-SHING CHEN, and BEN K. WADA (JPL, Pasadena, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 544-552. refs
(AIAA PAPER 91-1160) Copyright

Methods for estimating the deformation of adaptive truss structures are proposed which employ internal displacement sensors to measure changes in the length of selected truss members. Based on the measured data from the instrumented truss member, the total truss deformation pattern can be estimated through direct interpolation. To verify the validity of the methods presented here, numerical simulations are carried out for simple plane trusses, a beam truss, and a tetrahedral truss. V.L.

A91-31888#
CONTROL-STRUCTURE INTEGRATED DESIGN - A COMPUTATIONAL APPROACH
ACHILLE MESSAC (Charles Stark Draper Laboratory, Inc., Cambridge, MA), RICHARD GUELER, and KAMAL MALEK IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 553-568. Charles Stark Draper Laboratory, Inc.-sponsored research. refs
(AIAA PAPER 91-1161) Copyright

This paper presents an optimization-based approach to the integrated control and structural design of space systems. The framework of a general formulation is developed, which directly lends itself to the design of structural plants which require control. Classical and modern control techniques can be employed in time domain or frequency domain. A new formalism for modeling plant uncertainties in physical or modal space is presented. A performance norm is developed which fully allows for the control and structural design characteristics. It explicitly addresses the disturbance-rejection and command-following performance of the system, in addition to the vibration level and the control effort. The design methodology is demonstrated by simultaneously performing the structural and control designs of a truss-like spacecraft undergoing a rotational maneuver. Author

A91-31896#
TOPOLOGICALLY-BASED ADAPTIVE MESH GENERATOR FOR SHAPE OPTIMAL DESIGN
S. D. RAJAN, J. BUDIMAN, and L. GANI (Arizona State University, Tempe) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 653-663. refs
(AIAA PAPER 91-1212) Copyright

An automated scheme to generate acceptable finite element meshes is presented. The mesh generator works on a geometric-model description in terms of n-sided polygons. Near-equilateral triangles are created in a smoothly varying mesh where the mesh density is controlled by a local parameter, the mesh density coefficient (MDC), and a global parameter, the standard element length (SEL). A stress invariant based error criterion is used to locally and globally refine the mesh and convergence check is carried out by computing the global strain energy of the system. The mesh generator is used to create the input data for the hybrid natural shape optimal design approach. Illustrative example problems are solved. Author

A91-31897#
A VARIATIONAL PRINCIPLE FOR SHAPE DESIGN SENSITIVITY ANALYSIS
JASBIR S. ARORA and J. B. CARDOSO (Iowa, University, Iowa City) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 664-674. refs
(Contract NSF MSM-89-13218)
(AIAA PAPER 91-1213) Copyright

The adjoint method of design sensitivity analysis is stated as a variational principle. The principle gives a very simple and straightforward method of obtaining the design sensitivity expression for a functional dependent on the state fields. The sensitivity expression involves certain adjoint fields and explicit design variations of the functional and the governing equations for the primary state fields. The principle is proved and applied to several classes of linear and nonlinear problems, such as field problems, structural problems, and dynamic response problems. It is shown that the design sensitivity expressions that are derived in the literature using long procedures, are obtained quite routinely by use of the principle. Author

A91-31898#
STRUCTURAL SHAPE DESIGN SENSITIVITY ANALYSIS - A UNIFIED VIEWPOINT
JASBIR S. ARORA, TAE HEE LEE, and J. B. CARDOSO (Iowa, University, Iowa City) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 675-683. refs
(Contract NSF MSM-89-13218)
(AIAA PAPER 91-1214) Copyright

Two major approaches for structural shape design sensitivity analysis - the material derivative and control volume approaches - are presented, analyzed, and compared. Starting with a continuum formulation and a general response functional needing sensitivity analysis, the two approaches are derived. It is shown that the final design sensitivity expression for one approach can be obtained from the final expression for the other. Thus the two approaches are theoretically the same. Discretizations of the continuum expressions are discussed, and it is shown that the two approaches can lead to different implementations for numerical calculations.
Author

A91-31906#
VIBRATION SUPPRESSION FOR PRECISION METAL MATRIX TRUSS STRUCTURES
R. A. MANNING and S. S. SIMONIAN (TRW Space and Technology Group, Redondo Beach, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 754-757. USAF-supported research. refs
(AIAA PAPER 91-1016) Copyright

The progress on incorporating damping in metal matrix composites for precision truss structures is presented. The design, analysis, and fabrication techniques will be applicable to future space missions where dimensional precision under a severe dynamic environment is required. A testbed is described which has performance requirements similar to those of many future space missions where purely structural solutions offer little potential for mission success. Methods of analysis and system tailoring for enhanced damping are discussed. Preliminary results indicating the payoff that can be expected using damping and metal matrix composites are presented.
Author

A91-31913#
SHAPE OPTIMIZATION USING FULLY-AUTOMATIC 3-D MESH GENERATION
M. E. BOTKIN (GM Research Laboratories, Warren, MI) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 815-823. refs
(AIAA PAPER 91-1132) Copyright

A novel shape-optimization approach is presented which uses fully automatic three-dimensional mesh generation for the large geometrical changes that can occur at the outset of each new optimization step; a local remeshing procedure is also implemented which operates only on the specific edges and faces associated with the design variable being perturbed. The importance of the mesh-generation system lies in the underlying data structures supplying the associativity between the design model and the mesh points. The geometric model also provides a convenient way of handling the problem posed by stress constraints, in which the same number of elements is not sustained throughout the design iteration history. Two realistic illustrative problems are presented.
O.C.

A91-31915*# Duke Univ., Durham, NC.
A MATHEMATICAL BASIS FOR THE DESIGN OPTIMIZATION OF ADAPTIVE TRUSSES IN PRECISION CONTROL
S. K. DAS, S. UTKU (Duke University, Durham, NC), G. S. CHEN, and B. K. WADA (JPL, Pasadena, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 829-839. refs
(AIAA PAPER 91-1134) Copyright

Optimal actuator placement schemes are presently studied for cases of adaptive truss precision control and prestressing control, with a view to the maximization of actuator efficiencies. In statically indeterminate truss structures, the optimal placement criteria and techniques differ, depending on whether the primary determinate structure is known. A suboptimal actuator-placement solution to the global optimization problem which combines displacement control and prestressing control is suggested, by combining the separate displacement control and prestressing control optimization results. Attention is given to the results obtained for the illustrative case of a two-bay, three-dimensional precision truss structure.
O.C.

A91-31917*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A MULTIOBJECTIVE APPROACH TO INTEGRATED CONTROL, STRUCTURE AND OPTICAL DESIGN
M. MILMAN, M. SALAMA, M. WETTE, and R. BRUNO (JPL, Pasadena, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 846-854. refs
(AIAA PAPER 91-1136) Copyright

The underlying mathematical formulation and issues associated with integrated control, structure, and optical design are discussed. Topics addressed include the development of cost functionals, optimization in the vector objective setting, and computational aspects of the optimization problem with special emphasis on model reduction strategies. Results on simple design problems are presented.
Author

A91-32000*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED CONTROL OF THERMALLY DISTORTED LARGE SPACE ANTENNAS
ROBERT H. TOLSON (NASA, Langley Research Center, Hampton, VA) and JEN-KUANG HUANG (Old Dominion University, Norfolk, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1644-1654. refs
(AIAA PAPER 91-0965) Copyright

The objective is to develop a control system design method that (1) recognizes the time dependence of the thermal distortion due to orbital motion and (2) controls variables that are directly related to far field performance for earth pointing space antennas. The first objective is accomplished by expanding the distortion into principal components that are orthogonal in space and time. The approach for the second objective is to expand the far zone electric field in a Zernike-Bessel series. The method accommodates tapered feeds and arbitrary polarizations. Simulations are performed for a geosynchronous radiometer to determine the effectiveness of the control system under variations in solar geometry, structure materials and thermal properties.
Author

A91-32020#
ACTIVE DAMPING BY A LOCAL FORCE FEEDBACK WITH PIEZOELECTRIC ACTUATORS
ANDRE PREUMONT, JEAN-PAUL DUFOUR, and CHRISTIAN MALEKIAN (Bruxelles, Universite Libre, Brussels, Belgium) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 1879-1887. refs
(AIAA PAPER 91-0989) Copyright

This paper summarizes a research in the field of active damping

of space structures. The test facility consists of a truss structure provided with two active elements that can be placed in various locations. Each of the active elements consists of a linear piezoelectric actuator collocated with a force transducer. Each active element is controlled in a decentralized manner, with an integral feedback of the force on the voltage applied to the piezo actuator. This control law is always stable and has been found very effective: the damping ratio of the first mode has been increased from 0.003 (open loop) to 0.09 with one actuator.
Author

A91-32043*# Engineering Mechanics Association, Inc., Torrance, CA.
A RECENT CASE STUDY IN SYSTEM IDENTIFICATION
T. K. HASSELMAN and J. D. CHROSTOWSKI (Engineering Mechanics Associates, Inc., Torrance, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2154-2168. refs
(Contract NAS7-1064)
(AIAA PAPER 91-1190) Copyright

Results of a recent study of a ten-bay truss structure at the NASA Langley Research Center are reported. First, the conditioning of complex eigenvectors derived by the ERA method is discussed. Results of parameter estimation using the SSID (Structural System Identification) code are then presented. Based on the results of the study, it is concluded that (1) parameter estimation based on modal data should include eigenvectors as well as eigenvalues; (2) the eigenvectors should be orthogonalized when orthogonality is poor due to closely spaced modes; and (3) the parameters used in the estimation should enable the model to match the data.
V.L.

A91-32054#
APPLICATION OF NEURAL NETWORKS TO SMART STRUCTURES
CHARLIE D. TURNER (Nichols Research Corp., Huntsville, AL) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2261-2268. refs
(AIAA PAPER 91-1235) Copyright

The paper discusses the integration of the sensor, actuator, control, (software), and structure utilizing a hybrid neural network architecture. This architecture which is the focus of the paper provides for the control of a distributed sensor/actuator system which includes the ability to monitor the health of both the network and the structure. The system is adaptive in that it can reconfigure itself if a neuron, data path, sensor, actuator, or structure fails or is damaged. Analytical techniques developed in order to support future modeling and analysis requirements are presented.
Author

A91-32057#
ADAPTIVE PIEZOELECTRIC SHELL STRUCTURES - THEORY AND EXPERIMENTS
H. S. TZOU and J. P. ZHONG (Kentucky, University, Lexington) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2290-2296. refs
(Contract NSF RII-86-10671)
(AIAA PAPER 91-1238) Copyright

Active 'smart' space and mechanical structures with adaptive dynamic characteristics have long been interested in a variety of high-performance systems, flexible space structures, flexible robots, 'smart' machines, etc. In this paper, an active adaptive structure made of piezoelectric materials is proposed and evaluated. Electromechanical equations of motion and generalized boundary conditions of a generic piezoelectric shell subjected to mechanical and electrical excitations are derived using Hamilton's principle and the linear piezoelectric theory. The structural adaptivity is achieved by a voltage feedback (open or closed loops) utilizing the converse piezoelectric effect. Applications of the theory is demonstrated in a bimorph beam case and a cylindrical shell case. Frequency manipulation of the bimorph beam is studied theoretically and experimentally. Damping control of the cylindrical shell via in-plane membrane forces is also investigated. Author

A91-32060*# Kentucky Univ., Lexington.
OPTIMAL IDENTIFICATION USING INCONSISTENT MODAL DATA
SUZANNE WEAVER SMITH (Kentucky, University, Lexington) and CHRISTOPHER A. BEATTIE (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2319-2324. refs
(Contract NAG1-960; NSF DMS-88-07483)
(AIAA PAPER 91-0948) Copyright

This work examines techniques under the general approach of optimal-update identification which produce optimally adjusted, or updated, property matrices (i.e., mass, stiffness and damping matrices) to more closely match the structure modal response. For practical applications, the techniques must perform when the modal response is inconsistent with other constraints on the desired model. An alternate view of the optimal-update problem is presented that leads to new techniques for addressing inconsistent data. Viewpoints used for previously published techniques are also examined to explore issues in optimal-update identification.
Author

A91-32065#
CHARACTERIZATION OF DAMPING OF MATERIALS AND STRUCTURES FROM NANOSTRAIN LEVELS TO ONE THOUSAND MICROSTRAIN
JOSEPH TING (Advanced Composites Laboratories, Waltham, MA) and E. F. CRAWLEY (MIT, Cambridge, MA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2371-2380. refs
(AIAA PAPER 91-1125) Copyright

Results are presented from an experimental study performed to characterize material and structural damping over a range of strain from 1 nanostrain to 1000 microstrain. Material damping was measured in aluminum rectangular bars and tubes and laminated, graphite/epoxy bars and tubes. Structural damping was measured in a precision, three-dimensional tetrahedral truss consisting of ball nodes and tubular bars. Damping ratios were obtained via a sine sweep approach using piezoceramic strain sensors and piezoceramic proof mass actuators. Results show that material damping is generally independent of strain below 10 microstrain. Experimental damping measured at small strain levels compare well with theoretical models where available. Material damping showed a dependence on strain at levels above 100 microstrain and could be modeled for metals by the movement of dislocations. Joint dominated structural damping is independent of strain below 1 microstrain and increased with strain above 1 microstrain.
Author

A91-32082#
AN INCLUSION PRINCIPLE FOR THE RAYLEIGH-RITZ BASED SUBSTRUCTURE SYNTHESIS
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2515-2522. refs
(Contract F49620-89-C-0045)
(AIAA PAPER 91-1058) Copyright

This paper is concerned with the convergence characteristics of a Rayleigh-Ritz based substructure synthesis developed earlier.

According to this substructure synthesis, the motion of every substructure is modeled in terms of quasi-comparison functions, which are linear combinations of admissible functions capable of satisfying all the boundary conditions. A consistent kinematical procedure permits the aggregation of the various substructures and ensures compatibility without the need of imposing constraints. The computed eigenvalues satisfy the inclusion principle, which in turn can be used to demonstrate uniform convergence of the approximate solution. A numerical example illustrates the inclusion principle. Author

A91-32091*# Texas A&M Univ., College Station.
A NONRECURSIVE 'ORDER N' PRECONDITIONED CONJUGATE GRADIENT/RANGE SPACE FORMULATION OF MDOF DYNAMICS
A. J. KURDILA, R. MENON (Texas A & M University, College Station), and JOHN SUNKEL (NASA, Johnson Space Center, Houston, TX) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2603-2617. refs
(AIAA PAPER 91-1112) Copyright

This paper addresses the requirements of present-day mechanical system simulations of algorithms that induce parallelism on a fine scale and of transient simulation methods which must be automatically load balancing for a wide collection of system topologies and hardware configurations. To this end, a combination range space/preconditioned conjugage gradient formulation of multidegree-of-freedon dynamics is developed, which, by employing regular ordering of the system connectivity graph, makes it possible to derive an extremely efficient preconditioner from the range space metric (as opposed to the system coefficient matrix). Because of the effectiveness of the preconditioner, the method can achieve performance rates that depend linearly on the number of substructures. The method, termed 'Order N' does not require the assembly of system mass or stiffness matrices, and is therefore amenable to implementation on work stations. Using this method, a 13-substructure model of the Space Station was constructed. I.S.

A91-32092# Colorado Univ., Boulder.
FORMULATION AND SOLUTION OF INVERSE SPAGHETTI PROBLEM - APPLICATION TO BEAM DEPLOYMENT DYNAMICS
J. D. DOWNER and K. C. PARK (Colorado, University, Boulder) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2618-2630. refs
(Contract NAG1-756; NGT-50254)
(AIAA PAPER 91-1113) Copyright

A methodology for the discrete modeling of spaghetti problems, viz., the dynamics of deploying and retrieving beam-like structures, is presented. A moving spatial grid corresponding to the configuration of a deployed rigid beam is employed as a reference for the dynamic variables. A transient integration scheme which accounts for the moving node formulation is derived from a space-time finite element discretization of a Hamiltonian variational statement. The computational results of this general deforming finite element beam formulation are compared to reported results for a planar inverse-spaghetti problem. Author

A91-32093#
FURTHER APPROXIMATIONS IN FLEXIBLE MULTIBODY DYNAMICS
CARLOS E. PADILLA and ANDREAS H. VON FLOTOW (MIT, Cambridge, MA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2631-2640. refs
(AIAA PAPER 91-1115) Copyright

A useful model for open chains of flexible bodies undergoing large rigid body motions, but small elastic deformations, is one in which the equations of motion are linearized in the small elastic deformations and deformation rates. For slow rigid body motions, the correctly linearized, or consistent, set of equations can be compared to prematurely linearized, or inconsistent, equations and to 'oversimplified', or ruthless, equations through the use of open loop dynamic simulations. This paper examines the conditions under which the ruthless model is valid. Further, it is shown how the ruthless model can be obtained directly, simplifying the dynamicist's task. An even simpler model (nicknamed the brutally linearized model) is a introduced in an attempt to get the simplest model that still captures the essential features of the dynamic systems under consideration when undergoing slow rigid body motions. Finally, a comparison of the different models for various test cases presented both analytically and through the use of numerical simulations. Author

A91-32103#
MODELLING BEAM-LIKE SPACE TRUSSES WITH NONLINEAR JOINTS
MARK WEBSTER and WALLACE VANDER VELDE (MIT, Cambridge, MA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2745-2754. refs
(AIAA PAPER 91-1225) Copyright

The paper discusses a method of modeling beam-like truss structures with nonlinear joints. The method commbines the describing function technique for modeling nonlinearies with an equivalent beam method for modeling trusses. The paper examines the accuracy of the describing function technique and the characteristics of the equivalent beam modeling procedure. The method is applied to simple two truss bay two-dimensional models. The method is then used to model the Mini-Mast truss. A response analysis is compared to experimental data from the Mini-Mast for sine sweeps in the vicinity of the first torsion mode. Results were inconclusive due to the lack of accurate data on the response characteristics of the joints of the Mini-Mast. Author

A91-32109#
JOINT CONTACT DYNAMICS AND CONTROLS USING PASSIVE VISCOELASTIC AND ACTIVE JOINT ACTUATORS
H. S. TZOU (Kentucky, University, Lexington) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2809-2816. University of Kentucky-supported research. refs
(AIAA PAPER 91-0997) Copyright

A nonlinear joint model with nonlinear noint stiffness and damping is proposed. In order to control/eliminate the joint contacts, two techniques are proposed and evaluated (1) the passive technique using a viscoelastic joint actuator and (2) the active technique using an active joint actuator. Equations of motion of a discretized multi-degree-of-freedom jointed system with initial joint clearances and passive viscoelastic and active joint actuators are derived. Nonlinear joint dynamics of various joint clearances or excitation frequencies are studied using a finite element technique. Numerical time-domain integration is carried out using a modified Wilson-theta method and a pseudoforce approximation technique. Dynamics of a jointed flexible structure with and without joint actuators are studied and evaluated. Author

A91-32110#
DYNAMICS OF ORBITING MULTIBODY SYSTEMS - A FORMULATION WITH APPLICATION
V. J. MODI, A. NG, A. SULEMAN, and Y. MORITA (British Columbia, University, Vancouver, Canada) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and

Astronautics, 1991, p. 2817-2830. Centers of Excellence Program-supported research. refs
(Contract NSERC-A-2181)
(AIAA PAPER 91-0998) Copyright

A relatively general formulation for investigating the dynamics of an orbiting multibody spacecraft with interconnected flexible bodies is developed. The formulation accounts for the transient system inertias, a shift in the center of mass, shear deformations, the rotary inertias, and geometric nonlinearities of such an aircraft. The versatility of the formulation is illustrated through an application to the proposed Space Station. I.S.

A91-32111*# California Univ., Los Angeles.
FREE AND FORCED RESPONSE OF NEARLY PERIODIC MULTI-SPAN BEAMS AND MULTI-BAY TRUSSES
S. D. LUST, P. P. FRIEDMANN, and O. O. BENDIKSEN (California, University, Los Angeles) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2831-2842. refs
(Contract JPL-958410)
(AIAA PAPER 91-0999) Copyright

The influence of several effects on mode localization in free-free multispan beams is investigated. Finite-element methods are used to study localization as a function of Timoshenko beam effects, imperfection strength, coupling strength, and imperfection type. The multispan beam study is conducted with random realizations of a forty-span free-free beam. In addition, free and forced response of free-free trusses and frames is investigated. Results indicate that, for the trusses and frames considered, the dynamic behavior can be approximated by continuum modeling approaches for only the lowest few global modes. Also, for reasonable values of modal damping, localized modes play a subtle role in the overall structural response. Author

A91-32112*# Purdue Univ., West Lafayette, IN.
NONLINEAR MODAL RESONANCES IN LOW-GRAVITY SLOSH-SPACECRAFT SYSTEMS
LEE D. PETERSON (Purdue University, West Lafayette, IN) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2843-2851. Boeing Aerospace Co.-supported research. refs
(Contract NAGW-21)
(AIAA PAPER 91-1000) Copyright

Nonlinear models of low gravity slosh, when coupled to spacecraft vibrations, predict intense nonlinear eigenfrequency shifts at zero gravity. These nonlinear frequency shifts are due to internal quadratic and cubic resonances between fluid slosh modes and spacecraft vibration modes. Their existence has been verified experimentally, and they cannot be correctly modeled by approximate, uncoupled nonlinear models, such as pendulum mechanical analogs. These predictions mean that linear slosh assumptions for spacecraft vibration models can be invalid, and may lead to degraded control system stability and performance. However, a complete nonlinear modal analysis will predict the correct dynamic behavior. This paper presents the analytical basis for these results, and discusses the effect of internal resonances on the nonlinear coupled response at zero gravity. Author

A91-32113#
ACTIVE DAMPING OF A LARGE LIGHTWEIGHT STRUCTURE USING PIEZOELECTRIC SENSORS AND ACTUATORS
RAYMOND F. FREYMANN (BMW AG, Munich, Federal Republic of Germany) and EDMOND STUEMPER (Institut Superieur de Technologie, Luxembourg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2852-2864. refs
(AIAA PAPER 91-1001) Copyright

The quasi-steady and dynamic behavior of piezoelectric transducers and the formulation of the related equations are discussed. It is shown that the properties of piezoelectric actuating systems must be carefully adjusted to the electromechanical structural system to be controlled in order to allow for an optimum transfer of damping energy. Equations of motion of actively controlled structural systems are formulated along with the control law for damping augmentation. Experimental investigations carried out on a cantilevered aluminum beam structure are reported which show the extent to which damping augmentation can be achieved in the two fundamental bending eigenmodes with eigenfrequencies of 1.44 and 8.60 Hz by using an overall number of 35 piezoceramic transducers as actuators and two piezopolymer elements as sensors. C.D.

A91-32117#
MINIMUM TIME PULSE RESPONSE BASED CONTROL OF FLEXIBLE STRUCTURES
JEFFREY K. BENNIGHOF and SHIH-HSIAO MARK CHANG (Texas, University, Austin) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2900-2910. refs
(Contract AF-AFOSR-90-0297)
(AIAA PAPER 91-1119) Copyright

This paper presents the Pulse Response Based Control (PRBC) method for minimum time control of structures. In this method, an explicit model of a structure is not required, as the structure's response is characterized entirely in terms of its measured response to pulses in control inputs and its inertial properties. There is no modal truncation in the pulse response representation of the response, because all modes contribute to the pulse response measurements. Although the minimum time control for a finite-order model of a structure must be bang-bang, the minimum time control history obtained using PRBC is not bang-bang, which is consistent with the minimum time control for the actual distributed system. Numerical examples are presented which demonstrate that PRBC is capable of finding the exact solution of a certain minimum time control problem whose exact solution is known, and is effective in the solution of other problems as well. Author

A91-32118#
WAVE MODE CONTROL OF LARGE TRUSS STRUCTURES
H. BENAROYA, S. MESTER (Rutgers University, Piscataway, NJ), and M. ETTOUNEY (Weidlinger Associates, New York) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2911-2919. refs
(AIAA PAPER 91-1120) Copyright

The transmitting boundary method is introduced for the dynamic modeling and control of structures which are constructed of repeated identical substructures. This dynamic model is derived within a direct output feedback control context. This paper presents the general formulation with numerical results for the uncontrolled system. Subsequently, numerical results will be presented for the controlled case as well as for structures of finite length. Author

A91-32119#
A NEW APPROACH TO THE EQUATIONS OF MOTION FOR THE MANEUVERING AND CONTROL OF FLEXIBLE MULTI-BODY SYSTEMS
MOON K. KWAK and LEONARD MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2920-2928. refs
(Contract F49620-89-C-0045)
(AIAA PAPER 91-1121) Copyright

In this paper, a mathematical foarmulation capable of treating the problem of maneuvering and control of flexible multibody

systems is developed. The formulation is based on equations of motion in terms of quasi-coordinates derived independently for the individual substructures and on a consistent kinematical synthesis causing the substructures to act as a single structure. A perturbation approach permits the separation of the nonlinear high-dimensional system of equations into a zero-order, low-dimensional problem for the rigid-body maneuvering and a first-order, high-dimensional, time-varying problem for the elastic motions and the perturbations from the rigid-body motions. The formulation lends itself to ready computer implementation.
Author

A91-32120*# Lockheed Engineering and Sciences Co., Hampton, VA.
ACTIVE VIBRATION ABSORBER FOR THE CSI EVOLUTIONARY MODEL - DESIGN AND EXPERIMENTAL RESULTS
ANNE M. BRUNER (Lockheed Engineering and Sciences Co., Hampton, VA), W. KEITH BELVIN, LUCAS G. HORTA, and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2929-2938. refs
(AIAA PAPER 91-1123) Copyright

The development of control of large flexible structures technology must include practical demonstrations to aid in the understanding and characterization of controlled structures in space. To support this effort, a testbed facility has been developed to study practical implementation of new control technologies under realistic conditions. The paper discusses the design of a second order, acceleration feedback controller which acts as an active vibration absorber. This controller provides guaranteed stability margins for collocated sensor/actuator pairs in the absence of sensor/actuator dynamics and computational time delay. Experimental results in the presence of these factors are presented and discussed. The robustness of this design under model uncertainty is demonstrated. Author

A91-32121#
EFFECT OF MODEL ERROR ON SENSOR PLACEMENT FOR ON-ORBIT MODAL IDENTIFICATION OF LARGE SPACE STRUCTURES
DANIEL C. KAMMER (Wisconsin, University, Madison) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2939-2946. refs
(AIAA PAPER 91-1180) Copyright

A theory is presented for the effect of errors in Large Space Structure prelaunch finite element models upon sensor placement for the on-orbit independent identification of a set of selected target modes. The idea of positive net information is introduced. If the net information matrix remains positive definite as sensor locations are deleted from an initial candidate set, the analytical model provides useful information for the identification of the real target modes. If the net information matrix becomes indefinite, the sensor placement analysis based upon the prelaunch analytical model will actually detract from the independent identification of the target modes. A bound is presented which can be easily checked after each iteration during which a sensor was deleted to determine positive definiteness of the net information matrix. Numerical examples are used to illustrate the ideas which are presented. Author

A91-32122*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON-ORBIT DAMAGE DETECTION AND HEALTH MONITORING OF LARGE SPACE TRUSSES - STATUS AND CRITICAL ISSUES
THOMAS A.-L. KASHANGAKI (NASA, Langley Research Center, Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2947-2958. refs
(AIAA PAPER 91-1181) Copyright

The literature in the fields of structural identification, mode shape expansion and orthogonalization, and on-orbit damage location of large space trusses is reviewed. The use of a Dynamic Scale Model Technology (DSMT) hybrid scale model for damage location research and as a universal test bed for other damage location methods is proposed as a means of comparing and evaluating existing and newly developed methods in the named areas. Issues concerning on-orbit data acquisition, data accuracy, and data quality relevant to structural dynamic system identification which require extensive research are identified. C.D.

A91-32123#
MODE REDUCTION OF FLEXIBLE APPENDAGES VIA TRANSFER FUNCTIONS AND CORRECTION VECTORS
Y. C. YIU, E. L. WESTON, and L. C. LOH (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2959-2967. refs
(AIAA PAPER 91-1182) Copyright

Finite element models of large flexible appendages are characterized by many DOFs and high modal density in the low frequency range. This poses a significant computational problem for system level dynamic analysis. The dynamic interactions of appendages with attached primary structure can be characterized by input-output transfer functions at the appendage attachment. The method presented in this paper aids in the systematic selection of a significantly reduced, but dynamically representative set of modes by enforcing a matching of the peaks (poles) and static response of the base interface transfer functions. Convergence of the 6 x 6 rigid body mass matrix and static strain energy are also employed to gain physical insight into the reduction method.
Author

A91-32124*# McDonnell-Douglas Space Systems Co., Houston, TX.
MODAL IDENTIFICATION EXPERIMENT DESIGN FOR LARGE SPACE STRUCTURES
HYOUNG M. KIM and HAROLD H. DOIRON (McDonnell Douglas Space Systems Co., Space Station Div., Houston, TX) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2968-2976. refs
(Contract NAS9-18200)
(AIAA PAPER 91-1183) Copyright

This paper describes an on-orbit modal identification experiment design for large space structures. Space Station Freedom (SSF) systems design definition and structural dynamic models were used as representative large space structures for optimizing experiment design. Important structural modes of study models were selected to provide a guide for experiment design and used to assess the design performance. A pulsed random excitation technique using propulsion jets was developed to identify closely-spaced modes. A measuremenat location selection approach was developed to estimate accurate mode shapes as well as frequencies and damping factors. The data acquisition system and operational scenarios were designed to have minimal impacts on the SSF. A comprehensive simulation was conducted to assess the overall performance of the experiment design. Author

A91-32125*# Lockheed Engineering and Sciences Co., Hampton, VA.
SENSOR PLACEMENT FOR ON-ORBIT MODAL TESTING
TAE W. LIM (Lockheed Engineering and Sciences Co., Hampton, VA) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr.

8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2977-2985. refs
(Contract NAS1-19000)
(AIAA PAPER 91-1184) Copyright

A systematic procedure of placing accelerometers for the on-orbit modal identification of large flexible space structures is addressed. Target modes for modal testing are selected by examining the modal cost of each mode. Assuming that a time-domain modal identification algorithm such as Eigensystem Realization Algorithm is employed to identify the modes from measured time response data, the sensors are placed to ensure the recovery of the target modes. As an application example of the procedure, an accelerometer placement study for the Space Station Freedom On-Orbit Modal Identification Experiment is presented. Author

N91-10301*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RESEARCH IN STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS, 1990
JEAN-FRANCOIS M. BARTHELEMY, comp. and AHMED K. NOOR, comp. (George Washington Univ., Hampton, VA.) Washington Mar. 1990 283 p The 31st conference was held in Long Beach, CA, 2-4 Apr. 1990; sponsored by AIAA, ASME, ASCE, AHS, and ASC
(NASA-CP-3064; L-16735; NAS 1.55:3064) Avail: NTIS HC/MF A13 CSCL 20K

The Structural Dynamics and Materials (SDM) Conference was held on April 2 to 4, 1990 in Long Beach, California. This publication is a compilation of presentations of the work-in-progress sessions and does not contain papers from the regular sessions since those papers are published by AIAA in the conference proceedings.

N91-10314*# Michigan Univ., Ann Arbor. Dept. of Aerospace Engineering.
COMBINED DESIGN OF STRUCTURES AND CONTROLLERS FOR OPTIMAL MANEUVERABILITY
JER LING, PIERRE KABAMBA, and JOHN TAYLOR *In* NASA, Langley Research Center, Research in Structures, Structural Dynamics and Materials, 1990 p 179-192 Mar. 1990
Avail: NTIS HC/MF A13 CSCL 20K

Approaches to the combined design of structures and controllers for achieving optimal maneuverability are presented. A maneuverability index which directly reflects the minimum time required to perform a given set of maneuvers is introduced. By designing the flexible appendages, the maneuver time of the spacecraft is minimized under the constraints of structural properties, and post maneuver spillover is kept within a specified bound. The spillover reduction is achieved by making use of an appropriate reduced order model. The distributed parameter design problem is approached using assumed shape functions, and finite element analysis with dynamic reduction. Solution procedures have been investigated. Approximate design methods have been developed to overcome the computational difficulties. Some new constraints on the modal frequencies of the spacecraft are introduced in the original optimization problem to facilitate the solution process. It is shown that the global optimal design may be obtained by tuning the natural frequencies to satisfy specific constraints. Researchers quantify the difference between a lower bound to the solution for maneuver time associated with the original problem and the estimate obtained from the modified problem, for a specified application requirement. Numerical examples are presented to demonstrate the capability of this approach. Author

N91-10604 National Aerospace Lab., Tokyo (Japan).
FUNCTION LIBRARY USING APL FOR TIME SERIES ANALYSIS AND SYSTEM IDENTIFICATION IN STRUCTURES [KOUZOUBUTSU NO JIKEIRETSU BUNSEKI TO SHISUTEMU DOUTEI NO TAMENOEI PI ERU NIYORU KANSUU RAIBURARI]
KEIJI KOMATSU Nov. 1987 31 p In JAPANESE
(NAL-TM-578; ISSN-0452-2982; JTN-90-80006) Avail: NTIS HC/MF A03

The influence of the digital signal processing technology on the theoretical and experimetal aspects of the study on dynamic characteristics is becoming stronger day by day.The National Aerospace Laboratory (NAL) in these circumstances has written down and completed a basic library which makes it possible to easily conduct a time series analysis of structures and a numerical simulation with a fixed system using the programming language APL. APL was adopted since it has for its proceeding basis an array of interpreting methods capable of interactively executing a simulation and using a subroutine structure with the help of a functional language, which is characterized by the possibility of a clarifying algorithm with the aid of a short program list adapted to a time series handling. The beta method of Newmark is explained for the preparation of time series data on a structure, the program for plate bending, and three-dimensional beam by finite element method which forms its basis for inputting, the occurrence of M-series as external forces and the program for generating a random wave by combining sinus curves as external force and noise. In addition, the power spectrum/frequency response function is explained with FFT as a basis. The low-pass, high-pass and bandpass digital filter; the autocorrelation function; the spectral analysis by maximum entrop method; and the program for free attenuation wave extraction from random data by random deck are explained. NASDA

N91-10922# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. fuer Aeroelastik.
STRUCTURAL DYNAMICS QUALIFICATION OF SPACECRAFT [STRUKTURDYNAMISCHE QUALIFIKATION VON RAUMFAHRZEUGEN]
H. HUENERS *In its* Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 39-54 Apr. 1990 In GERMAN; ENGLISH summary
Avail: NTIS HC/MF A13

The status of various feasibility studies on improved spacecraft dynamic qualification concepts using hydraulic multi-axial vibration simulators is presented. Dynamic mechanical loads in the low frequency range determine to a large extent the design of the primary and partially the secondary structures of most present day spacecraft. A dynamic qualification concept based on an experimental flight load simulation requires a multi-axis transient test approach, which cannot be offered current vibration test specifications. Vibration tests on single-axis electrodynamic shakers, flight load simulation on multi-axis hydraulic vibration simulators, and the further development of multi-axis hydraulic test stands are described. The possible prospects of the approach to dynamic structural verification are discussed. ESA

N91-10930# Messerschmitt-Boelkow-Blohm/Entwicklungspring Nord, Bremen (Germany, F.R.).
NON-LINEAR VIBRATION OF LARGE, IMPERFECT SPACE STRUCTURES
E. HORNUNG and H. OERY (Technische Hochschule, Aachen, Germany, F.R.) *In* DLR, Contributions in the Field of Aeroelastics on the Occasion of the 60th Anniversary of Professor Dr.-Ing. Habil. Hans Wilhelm Foersching p 203-222 Apr. 1990
Avail: NTIS HC/MF A13

The fundamental dynamic behavior of a large framework structure with imperfect struts was investigated under periodic excitations. It is shown that initial imperfections have an important influence on the effective stiffness of the struts and on their loading capacity. At low excitation levels, the stiffness can be considered with the linearized values, even if the struts introduce important frequency shifts. At higher excitation levels the mathematical model becomes strongly nonlinear, leading to very high dynamic factors in transient load cases and chaotic responses at harmonic excitations in the critical frequency range. It is concluded that an active shape control, ensuring also the straightness of the struts, seems to be mandatory for large space structures. ESA

N91-11387*# North Carolina State Univ., Raleigh. Mars Mission Research Center.
DISTRIBUTED DIGITAL SIGNAL PROCESSORS FOR MULTI-BODY STRUCTURES Interim Report
GORDON K. LEE 1990 16 p
(Contract NAG1-1136)
(NASA-CR-187375; NAS 1.26:187375) Avail: NTIS HC/MF A03 CSCL 09B

Several digital filter designs were investigated which may be used to process sensor data from large space structures and to design digital hardware to implement the distributed signal processing architecture. Several experimental tests articles are available at NASA Langley Research Center to evaluate these designs. A summary of some of the digital filter designs is presented, an evaluation of their characteristics relative to control design is discussed, and candidate hardware microcontroller/microcomputer components are given. Future activities include software evaluation of the digital filter designs and actual hardware inplementation of some of the signal processor algorithms on an experimental testbed at NASA Langley. Author

N91-11783*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
PERIODIC-DISTURBANCE ACCOMMODATING CONTROL OF THE SPACE STATION FOR ASYMPTOTIC MOMENTUM MANAGEMENT
WAYNE WARREN and BONG WIE (Texas Univ., Austin.) 2 Mar. 1989 31 p
(Contract NCC9-16)
(NASA-CR-187264; NAS 1.26:187264) Avail: NTIS HC/MF A03 CSCL 22B

Periodic maneuvering control is developed for asymptotic momentum management of control gyros used as primary actuating devices for the Space Station. The proposed controller utilizes the concepts of quaternion feedback control and periodic-disturbance accommodation to achieve oscillations about the constant torque equilibrium attitude, while minimizing the control effort required. Three-axis coupled equations of motion, written in terms of quaternions, are derived for roll/yaw controller design and stability analysis. It is shown that the quaternion feedback controller is very robust for a wide range of pitch angles. It is also shown that the proposed controller tunes the open-loop unstable vehicle to a stable oscillatory motion which minimizes the control effort needed for steady-state operations. Author

N91-11786 California Univ., Berkeley.
PROBLEMS IN THE CONTROL OF FLEXIBLE SPACECRAFTS Ph.D. Thesis
OMER MORGUL 1989 196 p
Avail: Univ. Microfilms Order No. DA9028964

The application of boundary control techniques to a rotating flexible spacecraft is investigated. More precisely, a rigid body, is considered whose center of mass is fixed in an inertial frame with a flexible beam clamped to the rigid body at one end and free at the other end. This configuration is investigated under the assumptions of whether the motion takes place on a plane, or in the three-dimensional space, as well as the model chosen for the beam. In each case, a stabilization problem is posed, a feedback law is proposed, and it is shown that under the proposed control law the stability of the configuration is obtained. Chapter 2 reviews some basic tools of Newtonian Dynamics and some recent developments in the nonlinear beam theories, namely the director theory of beams and the geometrically exact beam theory. Then, as an example, the equations of motion for the configuration mentioned above are derived. Chapter 3 studies the basic configuration under the planar motion assumption and the Euler-Bernoulli beam model is used. Two control laws are proposed, each consisting of a torque applied to the rigid body and a force and a torque applied to the free end of the beam. It is shown that under the proposed control law, exponential stabilization is obtained. Chapter 4 generalizes the results of Chapter 3 to the motion of the same configuration in three dimensions. Chapter 5 proves a stabilization result for the basic configuration using the geometrically exact beam model, without any linearization. Using this result, the results obtained in Chapter 2 are generalized to the case of planar motion of the basic configuration using the Timoshenko beam model. Dissert. Abstr.

N91-11788# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Dienstleistungsbereich.
NON-LINEAR VIBRATION OF LARGE, IMPERFECT SPACE STRUCTURES
H. OERY, A. RITTWEGER, E. HORNUNG, and E. ERBEN (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1990 24 p Presented at International Conference on Dynamics of Flexible Structures in Space, Cranfield, England, 15-19 May 1990
(MBB-UO-0080-90-PUB; ETN-90-97884) Avail: NTIS HC/MF A03

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. ESA

N91-11791# Maryland Univ., College Park. Dept. of Electrical Engineering.
CONTROL OF COMPLEX MULTIBODY SPACECRAFT Annual Technical Report, 1 Dec. 1988 - 31 Dec. 1989
P. S. KRISHNAPRASAD, EYAD ABED, STUART ANTMAN, JOHN BARAS, CARLOS BERENSTEIN, JOHN MADDOCKS, JERROLD MARSDEN, and JUAN SIMO 31 Dec. 1989 14 p
(Contract AF-AFOSR-0073-87; AF PROJ. 3484)
(AD-A224707; AFOSR-90-0807TR) Avail: NTIS HC/MF A03 CSCL 22/1

The Project C-MULTICS (Control of Complex Multibody Spacecraft) is a center of excellence at the University of Maryland. The modeling, analysis, control and simulation of large scale complex multibody spacecraft with rigid and flexible components is studied. GRA

N91-11876# Westland Aerostructures Ltd., East Cowes (England).
DEVELOPMENT OF INTELLIGENT STRUCTURES
JIM SCRAGG *In* ESA, Space Applications of Advanced Structural Materials p 443-444 Jun. 1990
Copyright Avail: NTIS HC/MF A19

The development of structures within composite materials used to provide a quiet vibration free mounting for sensitive equipment is described. Fiber optic sensors embedded in composite thermoset materials can measure vibration. Advanced thermoplastic composites offer better environmental characteristics. Ways to incorporate vibration free structures into a carbon fiber reinforced thermoplastic matrix are discussed. Development of an actuation system to counteract vibration is described. Difficulties involved in embedding fiber optic sensors into thermoplastic composites which are processed at much higher temperatures than thermosets are discussed. ESA

N91-12108 Cornell Univ., Ithaca, NY.
VIBRATION SUPPRESSION OF FLEXIBLE STRUCTURES USING COLOCATED VELOCITY FEEDBACK AND NONLOCAL ACTUATOR CONTROL Ph.D. Thesis
PEI-YEN CHEN 1990 222 p
Avail: Univ. Microfilms Order No. DA9027039

A generalized colocated velocity feedback control system is proposed as an active damper which never pumps energy into the structure, and is applied to suppress the vibration in large flexible structures. Some fundamental characteristics of this system are exploited, as well as locations of poles and zeros for the open loop, and root loci for the closed loop. By minimizing a quadratic objective function defined by structural states and control forces, a suitable optimization procedure is presented to determine the optimal feedback gains in the form of general, symmetric,

diagonal, and proportional matrices where the robustness property is preserved. A 6.5 m long experimental space truss with rigid joints was manufactured to implement the concept of generalized colocated velocity feedback control. The self-equilibrated internal control forces are generated through a new magnetic actuators with a high force-to-mass ratio. The corresponding velocity signals are picked up by magnetic sensors which were designed as an integral part of the actuators. In order to transmit these nonlocal torque-free control forces, an actuator mechanism was also invented. All of the results from theoretical analysis, numerical simulation, and experimental testing demonstrate that the transient vibration of the lowest modes in the experimental truss can be suppressed efficiently by using this control strategy with an optimal feedback gain. A comparison of the performance between colocated and noncolocated controls is examined. In addition, the effects on the robustness of this system due to non-ideal conditions are investigated, such as dynamic characteristics of control elements, unmodelled masses, nonlinear buckling behavior of structural members, and saturation limits on control forces.
Dissert. Abstr.

N91-12423*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE STATION DYNAMICS
REG BERKA *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 34 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Structural dynamic characteristics and responses of the Space Station due to the natural and induced environment are discussed. Problems that are peculiar to the Space Station are also discussed. These factors lead to an overall acceleration environment that users may expect. This acceleration environment can be considered as a loading, as well as a disturbance environment. Author

N91-12424*# Boeing Aerospace Co., Seattle, WA.
SPACE STATION STRUCTURAL PERFORMANCE EXPERIMENT
DICK GATES *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 11 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

A flight experiment that could be used to measure Space Station dynamics during and after its assembly is discussed. By integrating sensors into the structure to measure its ambient dynamic responses, it will provide some information as to how it behaves during its evolution. The objectives of the experiment are to define a series of experiments to measure the dynamic responses due to disturbances to establish the experiment scenarios, and to identify the locations of the instrumentation that can be integrated into the structure. Researchers have also defined the Space Station resources that are required so that they can be included in the Mission Requirements Data Base (MRDB). They used the 16-flight-assembly scenario that was recommended by Rockwell as the baseline. Author

N91-13325*# College of William and Mary, Williamsburg, VA. Dept. of Mathematics.
MINIMIZING DISTORTION IN TRUSS STRUCTURES VIA TABU SEARCH
REX K. KINCAID *In* Hampton Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1990 p 73-74 Sep. 1990
Avail: NTIS HC/MF A07 CSCL 22/2

The shape control of large flexible space structures is of great interest to structural designers. A related problem is to seek ways to minimize the need for active controls by careful design and construction of the space structure. A tetrahedral truss structure that is used to support a precision segmented reflector or antenna surface is considered. The structure has a hexagonal platform and is characterized by the number of rings of members in the truss. For simplicity it is assumed that a flat truss geometry exists. Hence, all structural members and ball joints are required to have the same nominal length and diameter, respectively. Inaccuracies in the length of member or diameters of joints may produce unacceptable levels of surface distortion and internal forces. In the case of a truss structure supporting an antenna, surface distortions may cause unacceptable gain loss or pointing errors. The focus is solely on surface distortion, however, internal forces may be treated in a similar manner. To test the Tabu search code for DSQRMS the appropriate influence matrices are used for a flat, two-ring tetrahedral reflector truss generated by Green and Haftka (1989). In this example there are 102 members (NMEMB) and 31 ball joints (NJOINT) of the same nominal length, respectively. Hence, all the members may be interchanged and all the joints may be interchanged. In addition, 19 positions on the surface of the truss (NNODES) were used to measure error influences. After a variety of experiments a set of good parameters was choosen for Tabu search. The sample size at each iteration is 10*NMEMB and the short term memory size is 40. In addition four pruning rules were used to accelerate the search.. Author

N91-13342*# West Virginia Univ., Morgantown. Dept. of Electrical and Computer Engineering.
REDUCED-ORDER FILTERING FOR FLEXIBLE SPACE STRUCTURES
CRAIG S. SIMS *In* Hampton Univ., NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1990 p 113-114 Sep. 1990
Avail: NTIS HC/MF A07 CSCL 22/2

There is a need for feedback control of the large flexible space structures which are going to be increasingly important in the future of the space program. These structures are very lightly damped, and vibrations may persist for a long time when the system is disturbed unless an active feedback control strategy is used to damp out the vibrations. The system is best described by a partial differential equation description, but the more common approach is to use a large set of second order differential equations, where a large number of modes must be retained if the mathematics is to provide an adequate description of the dynamical process. Sensors, such as accelerometers and rate gyros, may provide data to the feedback controller so that it may respond appropriately to control the system. The data from the sensors is not perfect, but is subject to noise, called measurement noise, and the dynamical process itself is subject to disturbances referred to as process noise. Filtering the sensor signals to remove the measurement noise, and using the resulting state estimates to control the system are investigated. Author

N91-13477# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
MULTIVARIABLE METHODS FOR THE DESIGN, IDENTIFICATION, AND CONTROL OF LARGE SPACE STRUCTURES. VOLUME 1: ESTIMATOR EIGENVALUE PLACEMENT IN POSITIVE REAL DESIGN Final Report, Jul. 1987 - Feb. 1989
G. L. SLATER and M. D. MCLAREN Jul. 1989 36 p
(Contract F33615-86-C-3216)
(AD-A226525; WRDC-TR-90-3037-VOL-1) Avail: NTIS HC/MF A03 CSCL 22/2

The objective of this contract was to develop mathematical algorithms for the integration of structural dynamics and controls with particular reference to the design of large space structures. A numerical technique is presented to place the eigenvalues of the estimator in a positive real control environment. The estimator is based on a reduced-order model of the full system. The technique involves posing the problem as a constrained optimization problem. Two formulations are presented for solving the optimization problem, which differ in their objective functions and in the way constraints are handled. Examples are given illustrating the pole placement for estimators based on arbitrary second order model and on fourth and sixth order models of the DRAPER I tetrahedral truss structure. GRA

N91-13478# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
MULTIVARIABLE METHODS FOR THE DESIGN, IDENTIFICATION, AND CONTROL OF LARGE SPACE STRUCTURES. VOLUME 3: A STUDY OF THE INTEGRATED CONTROL/STRUCTURE DESIGN OPTIMIZATION PROBLEM FOR LARGE FLEXIBLE STRUCTURES Final Report, Jul. 1987 - Feb. 1989
M. D. MCLAREN and G. L. SLATER Jul. 1989 101 p
(Contract F33615-86-C-3216)
(AD-A226526; WRDC-TR-90-3037-VOL-3) Avail: NTIS HC/MF A06 CSCL 22/2

A comparison of optimal and suboptimal estimation applied to large flexible structures under perfect and imperfect model information conditions is presented. The filters estimate the modal positions and velocities of a simple pinned-pinned beam. Among the types of estimators investigated are full and reduce-order centralized estimators, reduced-order decentralized estimators, and one-mode and two-mode sensitivity-shaped estimators. The suboptimal estimators are shown to have lower position rms error values than the optimal estimator when 20 percent errors in the structural frequencies are present. The sensitivity-shaped estimators produce more accurate position estimates when velocity sensors are used that any of the reduced-order linear quadratic centralized or decentralized estimators. A method for choosing the gains of the sensitivity-shaped estimators is given. Robustness of the system is discussed using a proposed phase-shaping method and the Lyapunov method. The closed-loop system with the one-mode sensitivity-shaped filter is proven to be marginally stable with the former method and asymptotically stable with the latter method, provided controller gains satisfy requirements. GRA

N91-13479# Texas A&M Univ., College Station.
ANALYTICAL AND EXPERIMENTAL RESEARCH ON LARGE ANGLE MANEUVERS OF FLEXIBLE STRUCTURES Final Report, 1 Oct. 1988 - 31 Mar. 1990
JOHN L. JUNKINS, THOMAS C. POLLOCK, and ZAHIDUL H. RAHMAN 4 May 1990 310 p
(Contract F49620-87-C-0078)
(AD-A226679; TAMURF-AERO-90-5-1; AFOSR-90-0919TR) Avail: NTIS HC/MF A14 CSCL 22/1

New methods are presented for structural system identification and control of large angle maneuvers. Both analytical and experimental results are presented. Globally stable control laws for flexible body maneuvers are derived and validated experimentally. Stereo triangulation methods are proposed and tested experimentally for structural identification. GRA

N91-13480*# Colorado Univ., Boulder. Center for Space Structures and Controls.
COMPUTATIONAL METHODS AND SOFTWARE SYSTEMS FOR DYNAMICS AND CONTROL OF LARGE SPACE STRUCTURES Final Report
K. C. PARK, C. A. FELIPPA, C. FARHAT, and E. PRAMONO Jul. 1990 265 p
(Contract NAG1-756)
(NASA-CR-187669; NAS 1.26:187669; CU-CSSC-90-17) Avail: NTIS HC/MF A12 CSCL 22/2

Two key areas of crucial importance to the computer-based simulation of large space structures are discussed. The first area involves multibody dynamics (MBD) of flexible space structures, with applications directed to deployment, construction, and maneuvering. The second area deals with advanced software systems, with emphasis on parallel processing. The latest research thrust in the second area involves massively parallel computers. Author

N91-14375# Cincinnati Univ., OH. Dept. of Aerospace Engineering and Engineering Mechanics.
MULTIVARIABLE METHODS FOR THE DESIGN, IDENTIFICATION, AND CONTROL OF LARGE SPACE STRUCTURES. VOLUME 2: OPTIMAL AND SUB-OPTIMAL ESTIMATION APPLIED TO LARGE FLEXIBLE STRUCTURES Final Report, Jul. 1987 - Feb. 1989
S. DUMBACHER Jul. 1989 114 p
(Contract F33615-86-C-3216; AF PROJ. 2302)
(AD-A226699; WRDC-TR-90-3037-VOL-2) Avail: NTIS HC/MF A06 CSCL 22/2

This report investigates the integrated control/structure design optimization problem for large flexible structures subject to stochastic disturbance forces. The full state feedback control of truss type structures is considered. The problem is formulated as a mathematical programming problem, and solved using a sequential approximations solution technique along with a scaling procedure. Due to the special nature of full state feedback control, it is shown that the controller can be assumed to be an LQR controller, where the control and state weightings are Lagrange multipliers from the mathematical programming optimality conditions. The design space is therefore effectively reduced to the truss element cross-sectional areas and these Lagrange multipliers, significantly reducing the computational effort required for solution. In this report, the solution algorithm is applied to the DRAPER I tetrahedral truss structure. GRA

N91-14377# Integrated Systems, Inc., Santa Clara, CA.
ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES Final Technical Report, 1 Feb. 1989 - 31 Mar. 1990
ROBERT L. KOSUT 15 Aug. 1990 39 p
(Contract F49620-89-C-0043; AF PROJ. 2302)
(AD-A227304; ISI-5877-01; AFOSR-90-0921TR) Avail: NTIS HC/MF A03 CSCL 12/4

Preliminary results are presented for set estimation of uncertain nonlinear systems. Set estimation is a process in an adaptive robust control system which produces a set of models from the measured data. The set is then used in an on-line robust control design to implement a controller which is guaranteed to achieve performance goals for all members on the set. The scheme works whenever the actual system which produced the data is a member of the estimated set. The results of this report extend some previous work in linear set estimation to nonlinear systems. This report also summarizes an analysis of an adaptive nonlinear system using the method of averaging. The aim of adaptive control is to implement in real-time and on-line as many as possible of the design functions now performed off-line by the control engineer. Although it is easy to configure an adaptive system by connecting an estimator and control design rule, research is essential to identify the performance limitations of adaptive strategies for LSS control. The long range goal of this research program is to establish guidelines for selecting the appropriate strategy, to evaluate performance improvements over fixed-gain mechanizations, and to examine the architecture necessary to produce a practical hardware realization. The initial and continuing thrust, however, is to build a strong theoretical foundation without losing sight of the practical implementation issues. GRA

N91-14499 State Univ. of New York, Buffalo.
ON THE MODELING AND CONTROL OF SLEWING FLEXIBLE STRUCTURES Ph.D. Thesis
EPHRAHIM GARCIA 1990 150 p
Avail: Univ. Microfilms Order No. DA9022156

The slewing control of a single link flexible structure is investigated. First a simple model of a slewing beam is examined. This structure is modeled as an Euler-Bernoulli beam which is pinned at one end with the other end free. A model summation procedure is applied to determine the response of the structure. A servo system acting at the pinned end is idealized as a spring. It is shown that the effects of the spring can be modeled through the boundary conditions for the flexible structure, or, the pin-free (open loop) modes of vibration can be assumed and the effects of the spring are included through the use of a position feedback

matrix. The slewing equations of motions are derived from Hamilton's principle. The feedback closed loop system matrices are derived for the angular position and velocity, and structural strain signal. The controllability norm of a system with various degree of actuator structure interaction is investigated to determine the degree of controllability of the higher modes of vibration. The nonlinear equations of motion are derived and a summary of nonlinear dynamics in slewing is given. A parameter for gauging the speed of response of slewing structures is proposed, and an example is given which shows the divergence of the linear and nonlinear models as this parameter is increased. The optimal control of the slewing system is discussed and an example using optimal output feedback is presented. The proposed model which accounts for the actuator structure interaction is used to model an experimental slewing structure in a direct drive configuration. It is shown that by taking advantage of the interaction between actuator and structure, vibration attenuation of the flexible modes can be achieved using only angular position and velocity sensors.
Dissert. Abstr.

N91-14630*# Engineering Mechanics Association, Inc., Torrance, CA.
METHODS FOR EVALUATING THE PREDICTIVE ACCURACY OF STRUCTURAL DYNAMIC MODELS Quarterly Report No. 6, 1 Sep. - 30 Nov. 1990
T. K. HASSELMAN and JON D. CHROSTOWSKI 9 Dec. 1990 60 p Sponsored by NASA
(NASA-CR-187649; NAS 1.26:187649; EMA-TR-89-1152-6)
Avail: NTIS HC/MF A04 CSCL 20/11
Uncertainty of frequency response using the fuzzy set method and on-orbit response prediction using laboratory test data to refine an analytical model are emphasized with respect to large space structures. Two aspects of the fuzzy set approach were investigated relative to its application to large structural dynamics problems: (1) minimizing the number of parameters involved in computing possible intervals; and (2) the treatment of extrema which may occur in the parameter space enclosed by all possible combinations of the important parameters of the model. Extensive printer graphics were added to the SSID code to help facilitate model verification, and an application of this code to the LaRC Ten Bay Truss is included in the appendix to illustrate this graphics capability.
K.S.

N91-15180*# Boeing Aerospace Co., Seattle, WA.
INTEGRATED CONTROL-STRUCTURE DESIGN Final Report
K. SCOTT HUNZIKER, RAYMOND H. KRAFT, and JOSEPH A. BOSSI 15 Jan. 1991 65 p
(Contract NAS1-18762)
(NASA-CR-182020; NAS 1.26:182020) Avail: NTIS HC/MF A04 CSCL 01/3
A new approach for the design and control of flexible space structures is described. The approach integrates the structure and controller design processes thereby providing extra opportunities for avoiding some of the disastrous effects of control-structures interaction and for discovering new, unexpected avenues of future structural design. A control formulation based on Boyd's implementation of Youla parameterization is employed. Control design parameters are coupled with structural design variables to produce a set of integrated-design variables which are selected through optimization-based methodology. A performance index reflecting spacecraft mission goals and constraints is formulated and optimized with respect to the integrated design variables. Initial studies have been concerned with achieving mission requirements with a lighter, more flexible space structure. Details of the formulation of the integrated-design approach are presented and results are given from a study involving the integrated redesign of a flexible geostationary platform.
Author

N91-15253# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
MULTI-AXIS VIBRATION SIMULATION IN SPACE STRUCTURES: EXPERIMENTS WITH DFS/STM
G. LACHENMAYR, W. RAASCH, and W. SAAD *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 291-297 Sep. 1990
(Contract BMFT-01-RS-8850)
Copyright Avail: NTIS HC/MF A23
The hydraulic multiaxis test facility was upgraded with a state variable feedback system for the actuators, which results in good dynamic behavior up to 200 Hz. Experiments were performed with the structure model of the satellite DFS using transients derived from Ariane flight signals. The results show a very good performance for the components of the transients even in the high frequency range; the problem of crosstalk between low level and high level degrees of freedom could be reduced but not eliminated, because of friction problems of the test facility. It was proven that it is state of the art in the reproduction of typical space transients on a multiaxis vibration test facility. All steps necessary for the full availability of this new test techniques are defined in detail.
ESA

N91-15257# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
COMBINING BASE-MOTION TESTING WITH TECHNIQUES DEVELOPED FOR POINT-FORCE EXCITATION FOR THE MODAL IDENTIFICATION OF MECHANICAL STRUCTURES
K. MUEHLBAUER, S. DILLINGER, and H. TROIDL *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 317-323 Sep. 1990
Copyright Avail: NTIS HC/MF A23
Base motion tests are usually carried out as loading tests, but also offer the possibility of determining the modal parameters of the structure tested under realistic loading conditions. This is of particular importance if the vibration test specification itself depends on the precise knowledge of these parameters, as is the case in the multi-axial transient test which is considered as a valuable extension of the conventional vibration test, especially for the dynamic qualification of spacecraft structures. Some possibilities of applying techniques originally developed for point-force modal testing to the modal identification of structures on the basis of vibration test data are considered. The practical performance of the procedures mentioned are illustrated by using test data from real spacecraft structures.
ESA

N91-15258# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
NEW CAPABILITIES IN MODAL TESTING ON LARGE-SCALE PROJECT LEVEL
S. DILLINGER, K. HERBOLD, and K. MUEHLBAUER *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 325-331 Sep. 1990
Copyright Avail: NTIS HC/MF A23
The improvements added to the previously described modal test system used for the Ariane 4 structural system tests are outlined. These additional capabilities include on the side of the test execution error compensating and amplitude monitoring features as well as the planned implementation of a new hardware generation. On the side of sine data evaluation improved and new procedures could be implemented for the combination and visualization of broadband sweeps and for the determination of a consistent set of modal parameters from narrowband sweeps. These new capabilities providing greater efficiency in large scale project testing are illustrated with data from real spacecraft tests.
ESA

N91-15259# Intespace, Toulouse (France).
A SURVEY OF FINITE ELEMENT MODEL UPDATING METHODS
N. A. ROY, A. GIRARD, L. P. BUGEAT, and J. N. BRICAUT (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 333-340 Sep. 1990
Sponsored by CNES
Copyright Avail: NTIS HC/MF A23
The representativity of finite element models used for dynamic structural analysis of complex structures may be improved by

updating the modal characteristics with respect to experimental data. A survey of the various methods found is presented with their advantages and drawbacks. Two general classes are identified: global methods and local methods based on residual forces, sensitivity or energy approaches. Conclusions concerning their possible use in an industrial context are given. ESA

N91-15268# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (Germany, F.R.).
HOLOGRAPHY: A SUCCESSFUL TOOL FOR DISTORTION MEASUREMENTS ON ANTENNAS UNDER SPACE SIMULATION CONDITIONS
H. U. FREY *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 395-402 Sep. 1990
Copyright Avail: NTIS HC/MF A23

So called double exposure holography for measuring the distortion of antennas under space simulation conditions is described. Fringe patterns over the whole antenna show the distortion like contour lines on a map. The wavelength of the laserlight is the scaling. The range of useful applications in comparison to other methods (photogrammetry) is shown. Advantages and disadvantages of the method are discussed. The high resolution of 0.2 microns and information about each point of the specimen gives an excellent interpretation of the behavior during the test. On the other hand the high sensitivity involves many problems in the performance of such a test. The solution of these problems by the test set up and the performing of distortion measurements is shown. The evaluation, that is the way from the fringe pattern to the distortion map, is presented. Manual digitizing or an automatic process, transformation, elimination of rigid body movements and the presentation of results are discussed. Test results for several antennas are shown. ESA

N91-15269# Construcciones Aeronauticas S.A., Madrid (Spain). Space Div.
THERMAL DISTORTION MEASUREMENT ON ANTENNA-REFLECTORS BY REAL-TIME HOLOGRAPHIC INTERFEROMETRY IN AMBIENT PRESSURE
I. CABEZA, N. BISBAL, G. GALIPIENSO, A. GAMONAL, A. FIMIA, R. FUENTES, and R. GARCIA-PRIETO (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 403-407 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Dimensional stability requirements for antenna-reflectors are becoming more restricted. This causes the use of highly stable materials and configurations for antenna-reflector manufacturing and, consequently, the necessity of high resolution systems in order to obtain the verification of dimensional stability requirements. Due to the in orbit environment, thermal distortions play an important role in dimensional stability performances. A feasibility study of the application of real time holographic interferometry at ambient pressure method for thermal stability testing of highly stable large antenna-reflectors is presented. The successful results indicate that the development of a high resolution and non expensive thermal stability test facility based on holographic interferometry is feasible. ESA

N91-15279# Dornier System G.m.b.H., Friedrichshafen (Germany, F.R.).
DEVELOPMENT AND APPLICATION OF THE TEST DATA ANALYSIS AND MONITORING SOFTWARE DIANA
W. SEYBOLDT and R. BISANZ *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 465-472 Sep. 1990
Copyright Avail: NTIS HC/MF A23

During the thermal vacumm tests of ROSAT (German X-ray satellite) and MAS (Millimeter Atmospheric Sounder), the data acquisition, monitoring and analysis software system DIANA was employed successfully. The software can be used for acquiring test and analysis data from various sources (different test facilities and analysis tools), monitoring measurement and analysis data (on line and mixed), fitting and trend extrapolating measurements versus time. All these data can be mixed, plotted and processed (vector operations, interpolation, extrapolation). The data processing facilities of DIANA may be used to calculate trends based on the measured data of some essential temperatures during the test. These trends may be the basis for actions, to get steady state temperatures of certain structure parts. Additionally, the comparison of measured and predicted values, which is important for the validation of a thermal mathematical model, can be performed in the post processing phase. ESA

N91-15281# Intespace, Toulouse (France).
A NEW NEED FOR MECHANICAL TEST DATA ANALYSIS: AN INTERACTIVE SOFTWARE FOR MANIPULATION AND COMPUTATION SPECIFICATION AND EXAMPLE OF IMPLEMENTATION
J. MERLET and J. P. GOUBE *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 477-479 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The new systems of test data acquisition give large amounts of results typically more than one hundred per test run, i.e., more than five hundred measurements per test. This gives rise to new needs. It is necessary to give to the project team, during and after the test, the following possibilities: a production of a data base from test results; a data base management system for sorting and retrieval of desired information; an interactive software for visualization of results with complete capabilities for comparison, zoom, etc.; and a command language for mathematical functions, identifications, statistical analysis, etc. All these capabilities are dictated by the need for new verification methods. The following deals with this new need for test data analysis: specification in terms of computational functions; specification in terms of operator interface; and specification in terms of communication via test data acquisition system, finite element analysis, common data base management system. A prototype of such new software is described and its possibilities are given. Some examples of applications are explained. ESA

N91-15299*# Lawrence Livermore National Lab., CA.
CONTROL-STRUCTURE-INTERACTION (CSI) TECHNOLOGIES AND TRENDS TO FUTURE NASA MISSIONS Final Report
Dec. 1990 109 p Prepared in cooperation with Photon Research Associates, Inc., Cambridge, MA
(NASA-CR-187471; L-44566C; NAS 1.26:187471) Avail: NTIS HC/MF A06 CSCL 22/2

Control-structure-interaction (CSI) issues which are relevant for future NASA missions are reviewed. This goal was achieved by: (1) reviewing large space structures (LSS) technologies to provide a background and survey of the current state of the art (SOA); (2) analytically studying a focus mission to identify opportunities where CSI technology may be applied to enhance or enable future NASA spacecraft; and (3) expanding a portion of the focus mission, the large antenna, to provide in-depth trade studies, scaling laws, and methodologies which may be applied to other NASA missions. Several sections are presented. Section 1 defines CSI issues and presents an overview of the relevant modeling and control issues for LLS. Section 2 presents the results of the three phases of the CSI study. Section 2.1 gives the results of a CSI study conducted with the Geostationary Platform (Geoplat) as the focus mission. Section 2.2 contains an overview of the CSI control design methodology available in the technical community. Included is a survey of the CSI ground-based experiments which were conducted to verify theoretical performance predictions. Section 2.3 presents and demonstrates a new CSI scaling law methodology for assessing potential CSI with large antenna systems. Author

N91-16057*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE NASA CONTROLS-STRUCTURES INTERACTION TECHNOLOGY PROGRAM

JERRY R. NEWSOM, W. E. LAYMAN, H. B. WAITES, and R. J. HAYDUK (National Aeronautics and Space Administration, Washington, DC.) Oct. 1990 19 p Presented at the 41st Congress of the International Astronautical Federation, Dresden, German Democratic Republic, 6-12 Oct. 1990 Previously announced in IAA as A91-13934 Submitted for publication
(NASA-TM-102752; NAS 1.15:102752; IAF-90-290) Avail: NTIS HC/MF A03 CSCL 22/2

The interaction between a flexible spacecraft structure and its control system is commonly referred to as controls-structures interaction (CSI). The CSI technology program is developing the capability and confidence to integrate the structure and control system, so as to avoid interactions that cause problems and to exploit interactions to increase spacecraft capability. A NASA program has been initiated to advance CSI technology to a point where it can be used in spacecraft design for future missions. The CSI technology program is a multicenter program utilizing the resources of the NASA Langley Research Center (LaRC), the NASA Marshall Space Flight Center (MSFC), and the NASA Jet Propulsion Laboratory (JPL). The purpose is to describe the current activities, results to date, and future activities of the NASA CSI technology program. Author

N91-16059*# Texas Univ., Austin. Center for Aeronautical Research.
A DECENTRALIZED LINEAR QUADRATIC CONTROL DESIGN METHOD FOR FLEXIBLE STRUCTURES Interim Report
TZU-JENG SU and ROY R. CRAIG, JR. May 1990 118 p
(Contract NAG9-357)
(NASA-CR-187860; NAS 1.26:187860; CAR-90-1) Avail: NTIS HC/MF A06 CSCL 22/2

A decentralized suboptimal linear quadratic control design procedure which combines substructural synthesis, model reduction, decentralized control design, subcontroller synthesis, and controller reduction is proposed for the design of reduced-order controllers for flexible structures. The procedure starts with a definition of the continuum structure to be controlled. An evaluation model of finite dimension is obtained by the finite element method. Then, the finite element model is decomposed into several substructures by using a natural decomposition called substructuring decomposition. Each substructure, at this point, still has too large a dimension and must be reduced to a size that is Riccati-solvable. Model reduction of each substructure can be performed by using any existing model reduction method, e.g., modal truncation, balanced reduction, Krylov model reduction, or mixed-mode method. Then, based on the reduced substructure model, a subcontroller is designed by an LQ optimal control method for each substructure independently. After all subcontrollers are designed, a controller synthesis method called substructural controller synthesis is employed to synthesize all subcontrollers into a global controller. The assembling scheme used is the same as that employed for the structure matrices. Finally, a controller reduction scheme, called the equivalent impulse response energy controller (EIREC) reduction algorithm, is used to reduce the global controller to a reasonable size for implementation. The EIREC reduced controller preserves the impulse response energy of the full-order controller and has the property of matching low-frequency moments and low-frequency power moments. An advantage of the substructural controller synthesis method is that it relieves the computational burden associated with dimensionality. Besides that, the SCS design scheme is also a highly adaptable controller synthesis method for structures with varying configuration, or varying mass and stiffness properties. Author

N91-16411*# Old Dominion Univ., Norfolk, VA. Dept. of Civil Engineering.
PASSIVE DAMPING CONCEPTS FOR TUBULAR BEAMS WITH PARTIAL ROTATIONAL AND TRANSLATIONAL END RESTRAINTS Final Report, period ending 20 Sep. 1989
ZIA RAZZAQ and DAVID K. MUYUNDO Feb. 1991 79 p
(Contract NAG1-336)
(NASA-CR-187833; NAS 1.26:187833) Avail: NTIS HC/MF A05 CSCL 20/11

The main objectives of the study are: (1) identification of potential passive damping concepts for slender tubular structural members with rotational and translational end springs under natural and forced-free vibrations; (2) evaluation of damping efficiencies of the various damping concepts; and (3) evaluation of the suitability of a theoretical finite difference analysis by comparison to the experimental results for the case of natural vibrations. Only member flexural an translation motion is considered. The natural vibration study is conducted on the seven damping concepts and for only one specific initial deflection. The most suitable of the seven dampers is further investigated under forced-free vibrations. In addition only one set of end springs is used for all of the experiments. The results show that passive damping provides a possible approach to structural vibration reduction. Y.S.

N91-17114*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON-ORBIT STRUCTURAL DYNAMIC PERFORMANCE OF A 15-METER MICROWAVE RADIOMETER ANTENNA
DEBORAH M. WAHLS, JEFFERY T. FARMER, and DAVID W. SLEIGHT (Illinois Univ., Urbana.) Washington Dec. 1990 44 p
(NASA-TP-3041; L-16795; NAS 1.60:3041) Avail: NTIS HC/MF A03 CSCL 22/2

The on-orbit structural dynamic performance of a microwave radiometer antenna for Earth science applications is addressed. The radiometer is one of the Earth-observing instruments aboard a proposed geostationary platform as part of the Mission to the Planet Earth. A sequential approach is presented for assessing the ability of an antenna structure to retain its geometric shape subject to a representative onboard disturbance. This approach includes establishing the structural requirements of the antenna, developing the structural and disturbance models, performing modal and forced response analyses, and evaluating the resulting distortions in terms of the antenna's ability to meet stringent structural performance requirements. Two antenna configurations are discussed: free-flying and platform-mounted. These configurations are analyzed for a representative disturbance function which simulates rotation of the subreflector in order to perform a raster-type scan of the Earth disk. Results show that the scanning maneuver modeled would not induce antenna structural errors outside the specified limits. Author

N91-17119 California Inst. of Tech., Pasadena.
ROBUST CONTROL OF FLEXIBLE STRUCTURES: THEORY AND EXPERIMENTS Ph.D. Thesis
GARY JOHN BALAS 1990 179 p
Avail: Univ. Microfilms Order No. DA9031431

Stringent requirements envisioned for the pointing and shape accuracy of future space missions necessitate advances in the control of large flexible structures. Due to their size and complexity, testing of these structures will lead to system models that are inaccurate for control purposes. Therefore, control design methods must be developed to account for model inaccuracies or uncertainties. Such methods should optimize the robustness and performance characteristics of control laws based on the accuracy of the design model. Incorporating the knowledge of the mismatch between the physical system and its mathematical models into the control design is emphasized. Control design models are developed to fit into the structured singular value framework that is used in the analysis and synthesis of control laws. To validate and verify theoretical developments, a flexible structure experiment is developed to investigate large flexible control problems in a laboratory environment. The Caltech experiment has a number of their attributes: closely spaced, lightly damped modes, collocated and noncollocated sensors, and actuators combined with numerous modes in the controller crossover region. The experimental structure is used to investigate several important issues related to control of flexible structures: (1) tradeoffs between robustness and performance associated with uncertainty modeling for flexible structures; (2) robust control of flexible modes in the controller crossover region; and (3) benefits and limitations of collocated versus noncollocated control design. A consistent trend in the results indicates that an accurate description of the flexible structure and model errors is required to synthesize high performance, robust control laws for flexible structures. Dissert. Abstr.

N91-17393 Texas Univ., Austin.
ROBUST CONTROL SYNTHESIS FOR UNCERTAIN DYNAMICAL SYSTEMS Ph.D. Thesis
KUK WHAN BYUN 1990 273 p
Avail: Univ. Microfilms Order No. DA9031530

Stability robustness and performance are opposing objectives in control systems design. Generic models of flexible space structures and the Space Station are employed as examples to investigate such important issues arising in robust control designs. A new generalized structural filtering concept is developed for active vibration control synthesis. This concept is a generalization of classical gain/phase stabilization. Non-minimum phase stabilization is shown to be a particularly effective means of active vibration control in the presence of plant uncertainty. The concept is combined with a quantitative feedback design method to develop a robust frequency-domain control synthesis technique, which yields a nonconservative design for a single-input single-output control system. A robust H(sub infinity) control synthesis technique is also developed in the state-space by utilizing the concept of input-output decomposition, which effectively handles parameter variations in robust control synthesis. A simplified method of H(sub infinity) controller parameterization is developed by modifying the available approaches. These synthesis techniques are then applied to flexible structure control, resulting in non-minimum phase compensation. The robust H(sub infinity) control design technique is applied to momentum/attitude control of the Space Station, which yields a remarkable result in stability robustness with respect to the inertia variations. Dissert. Abstr.

N91-17432*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STATION FREEDOM: DYNAMIC INSTRUMENTATION FOR A LARGE SPACE STRUCTURE
JOHN P. RANEY, PAUL A. COOPER, and JAMES W. JOHNSON Dec. 1990 44 p Presented at the 4th NASA/DoD CSI Conference, Orlando, FL, 5-7 Nov. 1990
(NASA-TM-102711; NAS 1.15:102711) Avail: NTIS HC/MF A03 CSCL 20/11

A proposed approach called Modal Identification Experiment (MIE) for obtaining on-orbit dynamic response measurements on Space Station Freedom, the first of a family of large, flexible space structures is discussed. The Phase 2 conceptual design study which provides a conceptual design of a proposed measurement system and an experimental protocol for inobstrusively collecting dynamic response data critical to characterizing important vibration modes of Space Station Freedom were recently concluded. The case for conducting such a measurement program is presented and the specific MIE objectives that were identified, are listed. The sequence of discrete Space Station Freedom assembly configurations is described, and the Phase 2 conceptual design of the experiment and instrumentation system are defined. In addition, a plan to utilize a space station hydrid scale model in laboratory simulations as part of the design process are discussed. Author

N91-18184*# Texas A&M Univ., College Station. Decision and Information Systems Lab.
ACTIVE VIBRATION CONTROL TECHNIQUES FOR FLEXIBLE SPACE STRUCTURES Final Report, 1 Apr. 1989 - 30 Sep. 1990
ALEXANDER G. PARLOS and SUHADA JAYASURIYA Oct. 1990 110 p
(Contract NAG9-347)
(NASA-CR-185643; NAS 1.26:185643; REPT-90-DISL-06) Avail: NTIS HC/MF A06 CSCL 22/2

Two proposed control system design techniques for active vibration control in flexible space structures are detailed. Control issues relevant only to flexible-body dynamics are addressed, whereas no attempt was made to integrate the flexible and rigid-body spacecraft dynamics. Both of the proposed approaches revealed encouraging results; however, further investigation of the interaction of the flexible and rigid-body dynamics is warranted. Author

N91-18185*# Texas A&M Univ., College Station. Decision and Information Systems Lab.
ATTITUDE CONTROL/MOMENTUM MANAGEMENT AND PAYLOAD POINTING IN ADVANCED SPACE VEHICLES Contractor Report, Jun. 1988 - May 1990
ALEXANDER G. PARLOS and SUHADA JAYASURIYA Aug. 1990 194 p
(Contract NAG9-275)
(NASA-CR-185644; NAS 1.26:185644; REPT-90-DISL-05) Avail: NTIS HC/MF A09 CSCL 22/2

The design and evaluation of an attitude control/momentum management system for highly asymmetric spacecraft configurations are presented. The preliminary development and application of a nonlinear control system design methodology for tracking control of uncertain systems, such as spacecraft payload pointing systems are also presented. Control issues relevant to both linear and nonlinear rigid-body spacecraft dynamics are addressed, whereas any structural flexibilities are not taken into consideration. Results from the first task indicate that certain commonly used simplifications in the equations of motions result in unstable attitude control systems, when used for highly asymmetric spacecraft configurations. An approach is suggested circumventing this problem. Additionally, even though preliminary results from the second task are encouraging, the proposed nonlinear control system design method requires further investigation prior to its application and use as an effective payload pointing system design technique. Author

N91-18186*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 5TH ANNUAL NASA SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) WORKSHOP, PART 1
LAWRENCE W. TAYLOR, JR., comp. Dec. 1990 383 p Workshop held in Lake Arrowhead, CA, 31 Oct. 1988
(NASA-CP-10057-PT-1; NAS 1.55:10057-PT-1) Avail: NTIS HC/MF A17 CSCL 22/2

The modeling, systems identification, and control synthesis for the Spacecraft Control Laboratory Experiment (SCOLE) configuration are examined. Author

N91-18188*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
INTEGRATION OF MECHANISM AND CONTROL FOR LARGE-ANGLE SLEW MANEUVERS OF FLEXIBLE STRUCTURES Final Report, period ended 31 Aug. 1990
MENG-SANG CHEW Feb. 1991 38 p
(Contract NAG1-952)
(NASA-CR-187876; NAS 1.26:187876) Avail: NTIS HC/MF A03 CSCL 22/2

A rolling contact noncircular gear system is applied to assist a desired controller in the slewing of a flexible space structure. The varying gear ratio in cooperation with the controller results in lower feedback gains at the controller, as well as considerably reducing flexural vibrations of the space structure. The noncircular gears consist of a pair of convex noncircular cylinders with specially designed profiles that are synthesized in conjunction with the optimal controller gains for minimizing the flexural vibrations of flexible structure during a slew maneuver. Convexity of the cylindrical profiles for this noncircular gear device must be ensured to maintain rolling contact between the two cylinders. Simulations of slewing control tasks for two kinds of flexible space structures, such as a planar flexible beam and the planar articulated flexible beams, are presented. Author

N91-18448 Purdue Univ., West Lafayette, IN.
CONTROL OF SECOND-ORDER INFORMATION FOR LINEAR SYSTEMS Ph.D. Thesis

CHEN HSIEH 1990 196 p
Avail: Univ. Microfilms Order No. DA9031339

Four controller design problems for linear systems are addressed that have several common features: (1) they are multi-objective designs; (2) performance specifications and system uncertainties, if any, are given a priori; and (3) they have equivalent deterministic and stochastic meaning. In the covariance assignment problem, the whole set of steady state covariance, X, that a closed-loop discrete system can possess is obtained. Furthermore, all controllers which assign this X to the system are parameterized in a closed form. In the output variances constrained (OVC) control problem, the minimum energy controller is designed to achieve prespecified output constraint. Necessary and sufficient conditions are derived for the optimal solution. A simple algorithm to solve this problem is also given. Instead of designing based on the nominal plant, the robust output variances constrained (ROVC) control problem considers the perturbations in the plant. The performance specifications required are the same as those in the OVC problem but should be satisfied for all admissible plants. A complete algorithm solving this problem is given. In this design, the admissible set, which is given a priori, is treated as a guide for this design algorithm. With the help of this guide, starting with a stability robust controller carefully tunes the performance robustness of the closed loop system while maintaining the stability robustness. By noting that an output weighting matrix is the main design parameter for both the OVC algorithm and model reduction by modal cost analysis (MCA), a design strategy is proposed which integrates both modeling and controller synthesis. This design strategy is applied to NASA's Mini-Mast system, a standard large space structure, and successful results are obtained.
Dissert. Abstr.

N91-18910 Stanford Univ., CA.
MODELING AND SHAPE CONTROL OF A SEGMENTED-MIRROR TELESCOPE Ph.D. Thesis
ALAIN CHARLES CARRIER 1990 389 p
Avail: Univ. Microfilms Order No. DA9024315

The Advanced Structure Control Integrated Experiment (ASCIE) is an optical telescope consisting of seven hexagonal segments mounted on a lightweight flexible truss. The position and the attitude of the six peripheral segments are actively controlled by 18 electromagnetic actuators to keep the segments optically aligned. Some 24 inductance sensors are used to measure the relative displacements between the segments. Disturbability, controllability and static fidelity analyses are used to eliminate modes from the finite element model while keeping enough of the dynamic and static characteristics of the system for evaluation and control design purposes. New optimal and aggregation based algorithms are introduced for matching impulse and step responses. A systematic norm preserving procedure is developed to take advantage of the six fold symmetry of the ASCIE and to decompose the control design model into input/output decoupled subsystems. Worst case control design methods that trade performance, parameter stability margins, and spillover margins are used to synthesize the control laws.
Dissert. Abstr.

N91-18989*# Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.
SYSTEM IDENTIFICATION AND CONTROLLER DESIGN USING EXPERIMENTAL FREQUENCY RESPONSE DATA
R. DENNIS IRWIN *In* Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 4 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 09/2

Recent findings from modeling and controller design for the NASA-Marshall Single Structure Control Facility have raised questions regarding the ability of modern control design techniques and modern modeling techniques to deal effectively with the stringent modeling and control design requirements of Large Space Structure Control. A brief and general discussion is presented of the results of studies into the modeling and control issues performed under sponsorship of the NASA/ASEE Summer Faculty Fellowship Program. Several issues are addressed. The first is a study of a modeling technique based on least squares identification of individual transfer functions from measured frequency response data. The second is a study of multiobjective optimization techniques applied to the modeling, or system identification, problem. The third issue is a study into the question of whether multiobjective optimization approaches can be effectively used for control system design using only frequency response data, thereby bypassing the difficult modeling problem. The last issue studied involves the resolution of seeming discrepancies between predicted and measured control computer time delays in the Single Structure Control Facility.
Author

N91-19122*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 5TH ANNUAL NASA SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) WORKSHOP, PART 2
LAWRENCE W. TAYLOR, JR., comp. Dec. 1990 369 p
Workshop held in Lake Arrowhead, CA, 31 Oct. 1988
(NASA-CP-10057-PT-2; NAS 1.55:10057-PT-2) Avail: NTIS HC/MF A16 CSCL 22/2

A collection of papers from the workshop are presented. The topics addressed include: the modeling, systems identification, and control synthesis for the Spacecraft Control Laboratory Experiment (SCOLE) configuration.
Author

N91-19125 Old Dominion Univ., Norfolk, VA.
CONTROL AND MECHANISM INTERACTION FOR GROUND-BASED TESTING OF SPACE STRUCTURES Ph.D. Thesis
LI-FARN YANG 1990 279 p
Avail: Univ. Microfilms Order No. DA9025219

In the ground-based validation testing, the adverse effect of terrestrial conditions such as a gravitational force interferes with the dynamic behavior of space structures. A suspension system is developed to assess the structural characteristics in a simulated zero-gravity environment. Using a mechanisms approach, the synthesis of a noncircular disk with a torsional spring at its rotational axis is designed to counteract the gravitational force of test structures during the testing. The multibody dynamics of a flexible steel beam carried on a rigid trolley was investigated. The system is constructed in such a way that the rapid and large angle slewing maneuver is performed by means of hybrid rotational/translational motions. A flexible one-beam structure and a flexible two-beam structure with such noncircular gears is investigated. One optimization technique based on the Generalized Reduced Gradient Method is employed to determine the optimal design of the controllers as well as the noncircular gears for vibrational suppression during the rapid slewing maneuvers. The numerical simulations are implemented to evaluate the effectiveness of the integrated design of control and mechanism for the slewing maneuvers of flexible space structures. Based on the Lyapunov stability criterion, the stability analysis of space structures leads to the design of a Lyapunov-based controller that yields a stable closed-loop system. Such a controller is developed by combining a linear part and a nonlinear part for the rotational/translational maneuver. The simulations of three kinds of nonlinear dynamic systems are performed to verify the usefulness of Lyapunov-based nonlinear feedback control. Two types of beam-like flexible space structure are simulated to implement maneuvering tasks of position control while suppressing the structural vibration simultaneously.
Dissert. Abstr.

N91-19471*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ACTIVE DAMPING APPLICATION TO THE SHUTTLE RMS
MICHAEL G. GILBERT, MICHAEL A. SCOTT, and SEAN P. KENNY Jan. 1991 19 p Presented at the 4th NASA/DOD CSI Conference, Orlando, FL, 5-7 Nov. 1990
(NASA-TM-102763; NAS 1.15:102763) Avail: NTIS HC/MF A03 CSCL 20/11

Control Structure Interaction (CSI) is a relatively new technology developed over the last 10 to 15 years for application to large

flexible space vehicles. The central issue is recognition that high performance control systems necessary for good spacecraft performance may adversely interact with the dynamics of the spacecraft structures, a problem increasingly aggravated by the large size and reduced stiffness of modern spacecraft structural designs. The CSI analysis and design methods were developed to avoid interactions while maintaining spacecraft performance without exceeding structural capabilities, but they remain largely unvalidated by hardware experiments or demonstrations, particularly in-space flight demonstrations. One recent proposal for a low cost flight validation of CSI technology is to demonstrate active damping augmentation of the Space Shuttle Remote Manipulator System (RMS). An analytical effort to define the potential for such an active damping augmentation demonstration to improve the structural dynamic response of the RMS following payload maneuvers is described. It is hoped that this study will lead to an actual inflight CSI test with the RMS using existing shuttle hardware to the maximum extent possible. By using the existing hardware, the flight demonstration results may eventually be of direct benefit to actual Space Shuttle RMS operations, especially during the construction of the Space Station Freedom.
Author

N91-19474*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MODAL IDENTIFICATION OF A DEPLOYABLE SPACE TRUSS
AXEL SCHENK (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, Germany, F.R.) and RICHARD S. PAPPA Sep. 1990 22 p Presented at the 15th International Seminar on Modal Analysis and Structural Dynamics, Leuven, Belgium, 17-21 Sep. 1990
(NASA-TM-102720; NAS 1.15:102720) Avail: NTIS HC/MF A03 CSCL 20/11

Work performed under a collaborative research effort between NASA and the German Aerospace Research Establishment (DLR) is summarized. The objective is to develop and demonstrate advanced technology for system identification of 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-meter-long deployable space truss used for structural dynamics and active-vibration control research at the NASA Langley Research Center. Due to nonlinearities and numerous local modes, modal identification of Mini-Mast proved to be surprisingly difficult. Methods available with ERA for obtaining detailed, high-confidence results are illustrated. Author

N91-20129*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
CONTROL SYSTEM FAILURE MONITORING USING GENERALIZED PARITY RELATIONS M.S. Thesis Interim Technical Report
CHRISTIAAN MAURITZ VANSCHALKWYK Feb. 1991 109 p
(Contract NAG1-968)
(NASA-CR-187945; NAS 1.26:187945) Copyright Avail: NTIS HC/MF A06 CSCL 01/3

Many applications require that a control system must be tolerant to the failure of its components. This is especially true for large space-based systems that must work unattended and with long periods between maintenance. Fault tolerance can be obtained by detecting the failure of the control system component, determining which component has failed, and reconfiguring the system so that the failed component is isolated from the controller. Component failure detection experiments that were conducted on an experimental space structure, the NASA Langley Mini-Mast are presented. Two methodologies for failure detection and isolation (FDI) exist that do not require the specification of failure modes and are applicable to both actuators and sensors. These methods are known as the Failure Detection Filter and the method of Generalized Parity Relations. The latter method was applied to three different sensor types on the Mini-Mast. Failures were simulated in input-output data that were recorded during operation of the Mini-Mast. Both single and double sensor parity relations were tested and the effect of several design parameters on the performance of these relations is discussed. The detection of actuator failures is also treated. It is shown that in all the cases it is possible to identify the parity relations directly from input-output data. Frequency domain analysis is used to explain the behavior of the parity relations.
Author

N91-20188# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
A THEORETICAL APPROACH TO ANALYSIS AND DESIGN OF EFFICIENT REDUCED CONTROL FOR SPACE STRUCTURES Final Report, Oct. 1986 - Oct. 1990
HAYRANI OZ Oct. 1990 270 p
(AD-A230223; WRDC-TR-90-3027) Avail: NTIS HC/MF A12 CSCL 12/9

The report develops concepts of efficiency for the control of structural dynamic systems. The efficiencies defined are unique nondimensional measures of structure control system performance forming a common basis of evaluation of such systems. Developments are presented both for distributed parameter systems and spatially discrete, typically finite element models of structural control systems are given by developing an efficiency modes analysis of controllers. The significance of relationship of controller efficiency modes to structural modes is studied. Based on these concepts, efficient model/controller reduction approaches are developed. The efficiencies of systems with dynamic compensators including reduced order efficiency-state estimators are also developed. Illustrative examples based on the ACOSS-4 tetrahedral structure and the CSDL-ACOSS-6 (Model 2) as typical large space structures, are given. The research establishes that efficiency of structural control systems is a fundamental concept that must be addressed in any structure control system design. The efficiency measures also establish the performance of infinity-dimensional systems on the basis of finite dimensional control design models. GRA

N91-20192# Air Force Inst. of Tech., Wright-Patterson AFB, OH.
MOVING-BANK MULTIPLE MODEL ADAPTIVE ESTIMATION AND CONTROL APPLIED TO A LARGE FLEXIBLE SPACE STRUCTURE M.S. Thesis
ROBERT B. MOYLE Dec. 1990 234 p
(AD-A230515; AFIT/GE/ENG/90D-45) Avail: NTIS HC/MF A11 CSCL 22/2

The performance of moving-bank multiple model adaptive estimation (MMAE) and control (MMAC) algorithms for large space structure control is analyzed in this thesis. The performance of a six-state filter model and associated controller are evaluated on the basis of estimation/control performance against a 24-estate truth model. A model developed using finite element analysis is used to approximate a large flexible space structure. The space structure is configured as a two-bay truss which is attached to a large central hub, where the mass of the hub is considered to be much more larger than the mass of the flexible structure. The model is developed in physical coordinates and then transformed into modal coordinates, where the method of singular perturbations is used to obtain a reduced order filter model. The actual positions and velocities of various physical points on the structure are used in the evaluation of the moving-bank algorithm performance. Results of the research indicate that appropriate determination of the filter model noise statistics as well as the LQG controller weighting matrices significantly improve performance of the bank throughout the parameter space. The results indicate that the performance of the moving-bank algorithms is seriously degraded by the inclusion of the filter-computed residual covariance in the conditional probability density function for computation of the hypothesis conditional probabilities within the multiple model algorithms. GRA

N91-20198# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
MULTIDISCIPLINARY MODELING AND DESIGN OF A SPACE STRUCTURE M.S. Thesis
BRIAN K. CASSIDAY, LAWRENCE L. GATSCHET, JOHN T.

TESTER, STEPHEN O. GAINES, II, and MARIO N. MOYA Dec. 1990 263 p
(AD-A230626; AFIT/GSE/ENY/90D-1) Avail: NTIS HC/MF A12 CSCL 05/1

A method is needed to simultaneously integrate several engineering disciplines into one complete model to determine the performance of the system as a whole during the design development. System engineering methodologies are particularly suited to this problem. These methods provide a structured approach to problem formulation and system parameter identification. Bond graphs are also well suited as bond graphs model power flow and energy relationships within subsystems, a characteristic inherent to all dynamic systems. The intent was to demonstrate the use of concurrent engineering theory to systematically model a large flexible space structure involving several engineering disciplines. The disciplines considered include: dynamics, controls, optics, structures, and heat transfer. A set of optimal solutions is presented and the results of this research are compared and contrasted with the results from classical design and modelling techniques. GRA

N91-20202*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
A ROBUST MOMENTUM MANAGEMENT AND ATTITUDE CONTROL SYSTEM FOR THE SPACE STATION
J. L. SPEYER and IHNSEOK RHEE (California Univ., Los Angeles.) 1991 41 p
(Contract NCC9-16)
(NASA-CR-188115; NAS 1.26:188115) Avail: NTIS HC/MF A03 CSCL 22/2

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 assurately 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

N91-20505*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
STATUS OF DSMT RESEARCH PROGRAM
PAUL E. MCGOWAN, MEHZAD JAVEED, and HAROLD H. EDIGHOFFER (Analytical Services and Materials, Inc., Newport News, VA.) Jan. 1991 31 p Presented at the 4th NASA/DoD CSI Conference, Orlando, FL, 5-7 Nov. 1990
(NASA-TM-102764; NAS 1.15:102764) Avail: NTIS HC/MF A03 CSCL 20/11

The status of the Dynamic Scale Model Technology (DSMT) research program is presented. DSMT is developing scale model technology for large space structures as part of the Control Structure Interaction (CSI) program at NASA Langley Research Center (LaRC). Under DSMT a hybrid-scale structural dynamics model of Space Station Freedom was developed. Space Station Freedom was selected as the focus structure for DSMT since the station represents the first opportunity to obtain flight data on a complex, three-dimensional space structure. Included is an overview of DSMT including the development of the space station scale model and the resulting hardware. Scaling technology was developed for this model to achieve a ground test article which existing test facilities can accommodate while employing realistically scaled hardware. The model was designed and fabricated by the Lockheed Missile and Space Co., and is assembled at LaRc for dynamic testing. Also, results from ground tests and analyses of the various model components are presented along with plans for future subassembly and matted model tests. Finally, utilization of the scale model for enhancing analysis verification of the full-scale space station is also considered. Author

N91-20696*# New Mexico Univ., Albuquerque. Dept. of Civil Engineering.
ASSESSING DAMPING UNCERTAINTY IN SPACE STRUCTURES WITH FUZZY SETS
TIMOTHY J. ROSS and TIMOTHY K. HASSELMAN (Engineering Mechanics Association, Inc., Torrance, CA.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 442-448 Jan. 1991
(Contract NAS7-1020)
Avail: NTIS HC/MF A21 CSCL 22/2

NASA has been interested in the development of methods for evaluating the predictive accuracy of structural dynamic models. This interest stems from the use of mathematical models in evaluating the structural integrity of all spacecraft prior to flight. Space structures are often too large and too weak to be tested fully assembled in a ground test lab. The predictive accuracy of a model depends on the nature and extent of its experimental verification. The further the test conditions depart from in-service conditions, the less accurate the model will be. Structural damping is known to be one source of uncertainty in models. The uncertainty in damping is explored in order to evaluate the accuracy of dynamic models. A simple mass-spring-dashpot system is used to illustrate a comparison among three methods for propagating uncertainty in structural dynamics models: the First Order Method, the Numerical Simulation Method, and the Fuzzy Set Method. The Fuzzy Set Method is shown to bound the range of possible responses and thus to provide a valuable limiting check on the First Order Method near resonant conditions. Fuzzy Methods are a relative inexpensive alternative to numerical simulation. 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.

A91-10028*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
INSIGHT TO HUMAN AND ROBOTIC PARALLELS IN SPACECRAFT AND SPACE TOOL DESIGN
RUTHAN LEWIS (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 6 p. refs
(AIAA PAPER 90-3570) Copyright

The parallels between human space activity and robotics and the role of their compatibility in the design of critical spacecraft elements are discussed with reference to current manned spacecraft programs, such as the Shuttle and Space Station Freedom. In particular, it is noted that the human variable may be the limiting factor with regards to repetition, fatigue, and possibly strength. This limiting factor serves as the natural constraint in the design of compatible interfaces. However, the mechanism or tool, not the capability of the robot, is constrained to human limits. Results of a limited test to study the robotic compatibility of the EVA-suitable connectors are reported. V.L.

A91-10088*# Rockwell International Corp., Downey, CA.
ADVANCED ENGINEERING SOFTWARE FOR IN-SPACE ASSEMBLY AND MANNED PLANETARY SPACECRAFT

DONALD DELAQUIL (Rockwell International Corp., Downey, CA) and ROBERT MAH (NASA, Ames Research Center, Moffett Field, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p. refs
(AIAA PAPER 90-3677) Copyright

Meeting the objectives of the Lunar/Mars initiative to establish safe and cost-effective extraterrestrial bases requires an integrated software/hardware approach to operational definitions and systems implementation. This paper begins this process by taking a 'software-first' approach to systems design, for implementing specific mission scenarios in the domains of in-space assembly and operations of the manned Mars spacecraft. The technological barriers facing implementation of robust operational systems within these two domains are discussed, and preliminary software requirements and architectures that resolve these barriers are provided. Author

A91-10089#
EVA/TELEROBOTIC COOPERATION FOR AEROBRAKE ASSEMBLY
DAVID E. ANDERSON and LISA M. ROCKOFF (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 11 p. refs
(AIAA PAPER 90-3678) Copyright

This paper describes the newly developed EVA/telerobotic cooperation aerobrake assembly techniques as well as neutral-buoyancy tests of an aerobrake concept combining EVA crew members and telerobots. The results of these tests indicate that such operations are feasible. The successful application of combined EVA and telerobotics to the aerobrake tasks will be applicable to other Space Station evolution tasks such as the large deployable reflector assembly, on-orbit engine refurbishment, and general maintenance of the station. Special attention is given to the safety issues for EVA crewmembers working near the telerobot when it is not under direct human control and to the interaction between the EVA crew members and the telerobot control computer. I.S.

A91-10090#
MARS AEROBRAKE ASSEMBLY DEMONSTRATION
JOHN M. GARVEY (McDonnell Douglas Space Systems Co., Huntington Beach, CA), GORDON K. LEE (North Carolina State University, Raleigh), and JURI FILATOVS (North Carolina Agricultural and Technical State University, Greensboro) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p. refs
(AIAA PAPER 90-3679) Copyright

A key concern for large aerobrake designs for Mars Transfer Vehicle is that they may exceed the capabilities of launch vehicles to fly them as single integrated units. This paper discusses design options where a large aerobrake can be assembled on orbit. The design and fabrication of a mock-up that is currently being tested at neutral buoyancy in an underwater test facility are described. The tests address the definition of the impacts of the assembly requirements on the aerobrake design and the Space Station Freedom facilities and operations, as well as some specific points, such as the fastener evaluation and the procedure time lines. I.S.

A91-10104#
AUTONOMOUS CONTROL FOR SPACE STATION FREEDOM IVA OPERATIONS
R. B. PURVES, W. S. DAVIS, and J. R. CARNES (Boeing Co., Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 5 p. refs
(AIAA PAPER 90-3705) Copyright

Research and development activities aimed at increasing the efficiency of Space Station Freedom intravehicular operations through the use of automation and robotics technologies are reviewed. The approaches considered include: (1) the development of the capability to autonomously generate and validate operations plans for an array of agents, including robots, crew members, and software simulations; and (2) evaluation of the performance of these plans in a testbed using intelligent simulation, sensor integration, and automated diagnostic techniques to ensure the safe and consistent execution of the program. V.L.

A91-10910*# North Carolina Agricultural and Technical State Univ., Greensboro.
EVA/ORU MODEL ARCHITECTURE USING RAMCOST
CELESTINE A. NTUEN, EUI H. PARK, Y. M. WANG (North Carolina Agricultural and Technical State University, Greensboro), and R. BRETOI (NASA, Ames Research Center, Moffett Field, CA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 4 p.

A parametrically driven simulation model is presented in order to provide a detailed insight into the effects of various input parameters in the life testing of a modular space suit. The RAMCOST model employed is a user-oriented simulation model for studying the life-cycle costs of designs under conditions of uncertainty. The results obtained from the EVA simulated model are used to assess various mission life testing parameters such as the number of joint motions per EVA cycle time, part availability, and number of inspection requirements. RAMCOST first simulates EVA completion for NASA application using a probabilistic like PERT network. With the mission time heuristically determined, RAMCOST then models different orbital replacement unit policies with special application to the astronaut's space suit functional designs. R.E.P.

A91-10918*# National Aeronautics and Space Administration, Washington, DC.
EVA CREWPERSON OVERBOARD - SIMPLIFIED RESCUE AID (SIRA)
H. T. FISHER (NASA, Office of Space Flight, Washington, DC; Lockheed Missiles and Space Co., Inc., Astronautics Div., Sunnyvale, CA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 5 p. Research supported by Lockheed Missiles and Space Co., Inc.

This paper discusses potential roles for extravehicular activity (EVA) in space logistics and the possibilities for a crewperson to become inadvertently detached from the work site. Factors which could cause the detachment will be presented and a rescue technique described. Finally, implications to the design and implementation of space logistics will be portrayed relative to minimizing or eliminating the adrift EVA crewperson possibility. Author

A91-13748#
HOW ARTIFICIAL INTELLIGENCE CAN IMPROVE MAN-MACHINE INTERFACE - PRACTICAL EXAMPLE WITH EXTRAVEHICULAR ACTIVITIES
P. DUPRAT, S. BERTHIER, P. NORY, J. P. GAUTIER, and J. R. CHEVALLIER (Dassault Aviation, Saint-Cloud, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-026) Copyright

The integration of artificial intelligence into the man-machine interface of an EVA spacesuit is demonstrated. This EVA suit matches demonstration requirements with a medium-complexity system and highly constrained operations involving reduced mobility and visibility in a harsh environment. The main functions involved in information and control, communication, and data management are outlined, and the functionalities explored in the study are summarized. The roles of the media and information managers are discussed, and the system architecture and implementation are briefly addressed. C.D.

A91-13775*# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
SPACE STATION INTEGRATED TRUSS STRUCTURE AND ASSEMBLY TECHNIQUES
DAVID C. WENSLEY, BRIAN D. VICKERS (McDonnell Douglas

Space Systems Co., Space Station Div., Huntington Beach, CA), and GARY P. GUTKOWSKI (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 15 p.
(IAF PAPER 90-066) Copyright

The current design and on-orbit assembly techniques are examined for several principal elements and distributed systems attached to the Work Package 2 Space Station Freedom integrated truss structure. The truss structure is examined, including its configuration, the materials used in its construction, and the erectable joints used in its assembly in space. The unpressurized elements and distributed systems attached to and integrated into the truss structure are discussed and the assembly techniques relevant to them are described. C.D.

A91-13783#
AUTONOMOUS EVA SUPPORT COMPLEX DESIGNED FOR USAGE DURING SPACE STATION ASSEMBLY AND MAINTENANCE - METHODS TO INCREASE THE COMPLEX EFFECTIVENESS
G. I. SEVERIN, V. I. SVERTSHEK, I. P. ABRAMOV, and V. A. FROLOV (Zvezda, Tomilino, USSR) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-075) Copyright

Results of flight development tests of the EVA unit and MMU during EVAs from the Mir orbiting station Kvant-2 module are presented. Needs which must be addressed in future development of the equipment are considered. The main characteristics of the EVA support facility are listed, and diagrams of the cosmonaut maneuvering unit are shown, along with a unit function diagram. C.D.

A91-13795*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ASSEMBLING A SPACE STATION IN ORBIT
VANCE D. BRAND, J. MICHAEL LOUNGE, and DAVID M. WALKER (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-092) Copyright

The factors affecting the degree of difficulty of assembling a Space Station in orbit and ways of arriving at the optimum construction solution are briefly reviewed and applied to the Space Station Freedom (SSF). The assembly of the SSF navigation and control systems and the relevant tools and methods are examined along with the characteristics of early assembly flights. The most significant challenges facing the construction of the SSF are discussed, and new technologies which will be incorporated into the SSF are briefly considered. C.D.

A91-13796
SPACE STATION BUILDING AND ASSEMBLY OPTIMIZATION
PIERRE ZGIRSKI and MAX GRIMARD (Aerospatiale, Division Systemes Strategiques et Spatiaux, Les Mureaux, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p.
(IAF PAPER 90-093)

The optimization of a future European space station aimed at creating European autonomy in manned space flight by the year 2000 is addressed. The mission scenarios considered include moon settlement and Mars exploration and the associated requirements are defined. The configuration of the station, its transportation needs, the relevant orbital activities and ground support needs are addressed. Criteria for initiating a sensitivity analysis are examined. Finally, a recommended building scenario is presented. C.D.

A91-13919*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AUTOMATED ASSEMBLY OF LARGE SPACE STRUCTURES
MARVIN D. RHODES and RALPH W. WILL (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 16 p. refs
(IAF PAPER 90-272) Copyright

A research program to evaluate telerobotic methods for inspace assembly of large truss structures has been initiated at the NASA Langley Research Center. A commercial robot is mounted on a carriage positioning system and a tetrahedral truss, which is composed of 102 members each 2 m long, is assembled on a rotating motion-base. The facility system is described including details of characterization tests on the truss structure. The current status of the assembly tests is discussed and observations from these tests indicate that no problems have been encountered that would prohibit automated telerobotic assembly from being a viable inspace construction method. Author

A91-13938#
USE OF SYMBOLIC COMPUTATION AND IN-ORBIT VALIDATION OF SOLAR ARRAY DEPLOYMENTS
P. RIDEAU (Aerospatiale, Cannes-la-Bocca, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-294) Copyright

A new deployment concept, Amede, is designed to increase simplicity and reliability by applying new hinges with low friction allowing low motorization. This concept is meant to obtain validation of the deployment by numerical simulation. The general capabilities of GEMMES and its use to simulate the deployment of specific mechanical systems and predict their in-orbit deployment is considered. The Amadeus experiment, which was designed to demonstrate the correlation between experimentation and simulation, is described in detail. The experiment took place aboard the Mir station in December 1988 and two-dimensional and three-dimensional deployments of a mockup were performed. Results of this experiment indicate that the difference between simulations and tests is less than 5 percent. L.K.S.

A91-19466#
AEROBRAKE ASSEMBLY USING EVA/TELEROBOTIC COOPERATION - RESULTS OF NEUTRAL BUOYANCY TESTING
DAVID E. ANDERSON, LISA M. ROCKOFF, and LISA K. EVELSIZER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0791) Copyright

EVA/telerobotic cooperation in aerobrake assembly including aerobrake assembly techniques currently under development are discussed. Neutral buoyancy testing of an aerobrake assembly concept is discussed. EVA crewmembers and telerobots are used in combination to complete the task. The telerobot used includes some autonomous capabilities. Results of aerobrake testing indicate that on-orbit assembly of large space structures is feasible for Space Station Freedom and the Space Exploration Initiative, but that the designs of these structures must incorporate EVA technologies compatibility for assembly and maintenance. L.K.S.

A91-21623*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
FLIGHT SYSTEMS TO FACILITATE DEPLOYMENT AND ON-ORBIT OPERATIONS OF THE UPPER ATMOSPHERE RESEARCH SATELLITE
THOMAS J. GRIFFIN and DAVID A. LORENZ (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p.
(AIAA PAPER 91-0802)

UARS flight systems are designed to ensure mission success during the NSTS Orbiter deployment of the UARS Observatory. The Orbiter and its crew capabilities allow the UARS project to take advantage of the on-orbit human presence. These capabilities include human intervention and correction of spacecraft anomalies. The UARS Observatory is based on the Multi-Mission Modular Spacecraft to allow for flexible monitoring and commanding of the observatory. The observatory's Solar Array and High Gain Antenna systems are designed to allow for manual release and/or deployment. The UARS Airborne Support Equipment are designed to support the observatory as an electrical and communication interface to the Orbiter; and as work platform to support Extra-Vehicular Activity (EVA). Tools and EVA equipment were designed and developed to assist the crewmember perform the required contingency tasks. Author

A91-23455
THE EUROPEAN SPACE SUIT - A DESIGN FOR PRODUCTIVITY AND CREW SAFETY
A. INGEMAR SKOOG (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) and BERTHIER S. OLLIVIER (Dassault Aviation, Saint-Cloud, France) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 207-216.
Copyright

The crew safety and productivity criteria that are essential to the design and construction of the European Space Suit System (ESSS) are discussed. A summary of major ESSS requirements is presented, including specifications for sortie duration (7 h), number of EVA crew (2), useful life (15 yrs), and emergency life support (30 min minimum). It is noted that the design of the ESSS is due to the Hermes/Columbus specific mission objectives and incorporates optimal solutions for individual features from both the U.S. and USSR space suit concepts. Also provided are almost 'hands-free' operations, zero prebreath, unassisted donning/doffing, and a high operational flexibility due to a multifunction LCD and voice processing. L.K.S.

A91-25408
RENDEZVOUS RADAR FOR THE ORBITAL MANEUVERING VEHICLE
JOHN W. LOCKE, KEITH A. OLDS, and THOMAS D. OHE (Motorola, Inc., Strategic Electronics Div., Chandler, AZ) IN: IEEE 1990 International Radar Conference, Arlington, VA, May 7-10, 1990, Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 38-43.
Copyright

The rendezvous radar set (RRS) under development will be a key subsystem aboard NASA's new orbital maneuvering vehicle (OMV). The RRS is an X-band all solid-state, monopulse tracking, frequency-hopping, pulse-Doppler radar system. Targets of 1m2 are detected at ranges greater than 4.5 nautical miles, and larger targets are detected at up to 10 nautical miles. The target is then tracked in angle, range, and range rate to a distance of 35 feet from the OMV. In addition to performance and cost, the design drivers for the RRS development have included the minimization of power consumption, size, and weight. I.E.

A91-26836
NEW DESIGN STRATEGIES AND TECHNOLOGIES FOR OPERATOR-MACHINE INTERFACE FOR SPACE PLATFORM DESIGN, OPERATIONS, AND PLANNING
J. L. NEVINS, D. E. WHITNEY, and R. W. METZINGER (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 625-633. refs
(AAS PAPER 90-006) Copyright

It is proposed that considerable gains in efficiency can be achieved in the areas of space platform design and construction as well as in the planning and execution of space operations by the application of recent advances in manufacturing technology. The advances which are considered applicable include the concurrent design or engineering strategy and new sensor capabilities which will perform wrist force sensing and target location determination. It is pointed out that these devices can augment the capabilities of conventional manipulator devices. L.M.

A91-26837* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MULTIPLE MANIPULATOR CONTROL FROM ORBITER FOR SPACE STATION ASSEMBLY
CHARLES R. PRICE and SUSAN H. BURNS (NASA, Johnson Space Center, Houston, TX) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 635-639.
(AAS PAPER 90-007) Copyright

This paper discusses the assembly process of the Space Station Freedom. It is shown that the assembly of the Space Station will require 29 flights of the Space Shuttle Orbiter: six shuttle flights during the initial assembly stage when the Space Station will not have sufficient life-support capability; seven more flights before the Station will support human occupation independent of the presence of the Space Shuttle; and 16 more flights for achieving full operational capability. The shuttle systems to be used in the Space Station assembly are described together with the results of simulation and analyses. Special attention is given to the Space Shuttle Remote Manipulator System which will be available on all Shuttle flights to support the Space Station assembly. I.S.

A91-27576* BDM International, Inc., Albuquerque, NM.
ENGINEERING, CONSTRUCTION, AND OPERATIONS IN SPACE II; PROCEEDINGS OF SPACE 90, THE SECOND INTERNATIONAL CONFERENCE, ALBUQUERQUE, NM, APR. 22-26, 1990. VOLS. 1 & 2
STEWART W. JOHNSON, ED. and JOHN P. WETZEL, ED. (BDM International, Inc., Albuquerque, NM) Conference sponsored by ASCE, AIAA, NASA, et al. New York, American Society of Civil Engineers, 1990, p. Vol. 1, 819 p.; vol. 2, 811 p. *For individual items see A91-27577 to A91-27727.*
Copyright

Attention is given to such topics as the processing of lunar soils, the automated processing of extraterrestrial materials, lunar excavation and mining, lunar oxygen, lunar base development, lunar surface structures, planetary surface transportation, and Mars missions. Papers are also presented on the Space Station, space debris, robotics and automated processing, structures and structural response, Mission to Planet Earth, life support systems, space power, human factors, artificial gravity, and education. B.J.

A91-27648* North Carolina State Univ., Raleigh.
AEROBRAKE CONSTRUCTION CONCEPTS FOR THE MARS MISSION
ERIC KLANG (North Carolina State University, Raleigh) and GREG WASHINGTON IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 738-747.
(Contract NAGW-1331)
Copyright

This paper describes a new aerobrake construction concept for the Mars mission, based on the NASA design, which utilizes a truss structure for supporting hexagonally shaped panels used for thermal protection system. Compared to previous designs, the aerobrake geometry in the new concept is modified to include a more accurate doubly-curved structure, and the analysis includes more realistic aerodynamic loads. The structural weight of the aerobrake is reduced by using variable truss and panel cross sections. I.S.

A91-27653* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
REQUIREMENTS AND CONCEPT FOR AN ON-ORBIT CONSTRUCTION FACILITY FOR PHASE 1 SPACE STATION FREEDOM
ROBERT W. BUCHAN, LAURA M. WATERS (NASA, Langley Research Center, Hampton, VA), and RICHARD M. GATES (Boeing Aerospace and Electronics, Seattle, WA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr.

22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 791-800. refs

A construction facility attached to NASA's Space Station Freedom (SSF) will be required for the accommodation of assembly activities for large payloads, as well as demonstration of the on-orbit construction of future spacecraft. This facility's capabilities must be sufficiently flexible to address the wide variety of future spacecraft needs without compromising the SSF's phase 1 configuration. The proposed construction facility concept will incorporate a storage module, a construction turntable, equipment-attachment platforms, a surrogate payload bay structure, and a portable workstation. Attention is given to this configuration's resulting mass properties and control characteristics. O.C.

A91-27654
AN ASTRONAUT POSITIONING SYSTEM FOR SPACE STATION ASSEMBLY AND MAINTENANCE SUPPORT
R. W. ADKISSON, D. R. BARRON, and R. P. VELGOS (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 801-810.

A method is presented for the positioning of astronauts during EVA assembly, maintenance, and servicing tasks for the Space Station Freedom (SSF). This Astronaut Positioning System (APS) will handle two astronauts at once on a given EVA worksite; during initial assembly of the SSF, the APS will be an integral part of the assembly work platform, thereby furnishing an efficient basis for truss-construction and hardware-module installation. The two APSs used are about 25 ft long and employ three primary positioning joints; of these, two are rotary and one is linear. Attention is given to the APS control architecture block diagram and Space Shuttle Orbiter construction interface. O.C.

A91-27656
FLUID LINE DEPLOYMENT AND REPAIR FOR SPACE STATION
RAYMOND H. ANDERSON, SHIRLEY J. PEARSON (McDonnell Douglas Space Systems Co., Huntington Beach, CA), and J. DOUGLAS DREWRY (McDonnell Douglas Space Systems Co., Houston, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 821-830. refs

The on-orbit deployment of the fluid and electrical power distribution systems for Space Station Freedom must be based on highly reliable procedures which minimize EVA crew time. The use of an automated spool, in conjunction with flexible hinged trays to deploy these power lines, is under consideration. The spool and metal tray concept for line deployment will save 10-min/tray, when compared to on-orbit joining of flat tray sections. A series of weightless simulation tests has shown the successful unwinding of flexible test sections from the spool, while attached to preassembles truss sections. An umbilical connection was made by quick-disconnect coupling. O.C.

A91-27708
A PROTOTYPE MODEL FOR HUMAN/AUTOMATION TRADE-OFFS
RICHARD JOHNSON (Colorado, University, Boulder) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1334-1343. refs

Future space construction missions will involve both human and machine constructors. Selection of the optimum constructor mix requires a model of constructor capabilities and requirements. The database for that model is developed via extrapolation from current literature. Optimization is done via minimization of total mission cost using a linear programming approach. This prototype is the first cut at producing a general tool for choosing a near-optimum constructor mix for any space construction mission. The linear programming optimization model illuminates several significant representational and data-gathering problems. Author

A91-27724
THE SELECTION OF CONSTRUCTORS FOR SPACE CONSTRUCTION
BRENT HELLECKSON, ELAINE HANSEN, JOHN BLANCO, and CHRIS ECHOHAWK (Colorado, University, Boulder) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1503-1512. refs

This paper outlines a high-level model of space construction and illustrates the relationship between constructor and task. The construction process model is then utilized to investigate the process of constructor selection. Author

A91-27725
A LANGUAGE MODEL FOR SPACE CONSTRUCTION CONTROL
BRENT HELLECKSON and JOHN BLANCO (Colorado, University, Boulder) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second Internatio. al Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1513-1522. refs

The optimal construction system for many space construction projects is a mixed construction ensemble. Such an ensemble consists of humans, robots with varying degrees of teleoperation and autonomy, and self-deploying structures. The methods of real-time management of such an ensemble have yet to be developed and proven. Musical theory is presented as a paradigm to facilitate the study of such a control methodology. A limited application of music theory and notation to telerobotic control is presented. Author

A91-29681* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
OPTICAL SURFACE REFURBISHMENT IN SPACE ENVIRONMENT
JAMES B. HEANEY, HOWARD HERZIG, JOHN F. OSANTOWSKI, and ALBERT R. TOFT (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Instrumentation in astronomy VII; Proceedings of the Meeting, Tucson, AZ, Feb. 13-17, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 858-866. refs

The potential use of the vacuum environment of space to clean contaminated mirror surfaces or generate Al mirror surfaces with high reflectance in the 80-200-nm region is discussed and illustrated with diagrams and graphs, reviewing previous studies and current experiment proposals. Consideration is given to (1) applying the atomic oxygen plasma environment of LEO to clean coated mirrors and (2) depositing freshly evaporated Al onto a mirror surface in vacuum, providing relatively long periods of high EUV reflectance before oxidation of the surface degrades performance: such a procedure could be performed as a maintenance measure or even incorporated into the design of a space observatory. A free-flying experiment is described which would produce and maintain an Al surface with controlled exposure to OH, H2O, and O2; demonstrate directed-beam Al deposition onto a simulated telescope/spectrometer surface; monitor instrument reflectance/sensitivity over time; and demonstrate in situ refurbishment of the degraded surface. D.G.

N91-10109# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Integration Orbital Systems.
OPTIMIZATION CRITERIA FOR THE DESIGN OF ORBITAL REPLACEMENT UNITS
MANFRED W. SCHULZE 1990 24 p Presented at the 17th International Symposium of Space Technology and Science, Tokyo, Japan, 21-25 May 1990 Prepared in cooperation with Erno Raumfahttechnik G.m.b.H.
(MBB-UO-0092-90-PUB; OTN-027668; ETN-90-97885) Avail: NTIS HC/MF A03

A reduction of life cycle costs of spacecraft or Space Station elements can be achieved by a modular build up which allows an in orbit replacement, maintenance, and service of functional units named Orbital Replacement Units (ORUs). The criteria for an optimal design for an ORU is presented. Requirements involving the user spacecraft configuration, the servicing vehicle, the handling by astronauts and remote manipulator system are considered. ESA

N91-11787 Dayton Univ., OH.
OPTIMAL SELECTION OF ORBITAL REPLACEMENT UNIT SPARES: A SPACE STATION SYSTEM AVAILABILITY MODEL Ph.D. Thesis
DOUGLAS GERARD SCHWAAB 1990 256 p
Avail: Univ. Microfilms Order No. DA9027422

A methodology is investigated for the logistics support analysis of the selection of orbital replacement unit (ORU) on-orbit spares for a space station. A mathematical model is developed to select the ORU spares combination that maximizes system availability and is constrained for both the weight and volume allocated from the pressurized logistics module (PLM) payload capacity for the system's ORU spares. The optimal solution of ORU spares will replenish the space station's on-orbit inventory. The model integrates the system design and logistics parameters to provide a decision support tool for both engineering analysis and logistics resupply planning. The impact of resupply mission scenario, center of gravity, and mechanical vibration restrictions on loading cargo in the PLM are also explored. The analyses consider the deviations from loading the PLM racks with a uniform mass distribution and the resulting loss of usable PLM payload capacity. The system availability model is formulated as a nonlinear integer programming problem and is transformed into a 0 to 1 linear integer programming problem. Conceptual data for the space station's environmental control and life support system (ECLSS) is used to exercise the model and conduct a sensitivity analysis on the model's logistics resupply and system design parameters. A preliminary investigation is conducted on the issue of selecting ORU on-orbit spares when there are multiple systems with different criticality levels. The system availability model solutions are used to approximate the availability response to payload allocations in a prototype, multiple-objective decision model to optimize the distribution of the PLM payload capacity between the multiple systems. To illustrate the methodology, the prototype model is exercised with the subsystems that compose the ECLSS. Dissert. Abstr.

N91-11789# Air Univ., Maxwell AFB, AL. Airpower Research Inst.
BUILDING BLOCKS IN SPACE
JAMES D. MARTENS Apr. 1990 71 p
(AD-A224614; AU-ARI-89-6) Avail: NTIS HC/MF A04 CSCL 22/1

The role of standardization and modularity in solving operational acquisition, and supportability concerns is examined. The advantages, disadvantages, and difficulties of standardizing military space systems are evaluated. Modular construction is examined as a method of applying standardization to future spacecraft development. The conclusions suggest new alternatives for space vehicle construction during the next decade. GRA

N91-11794# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Dienstleistungsbereich.
GUIDELINE FOR ORBITAL SERVICE TECHNOLOGY (LOS) [LEITKONZEPT FUER ORBITALE SERVICING TECHNOLOGIEN (LOS)]
L. KERSTEIN and U. BECKER 1990 21 p In GERMAN Presented at Statusseminar des BMFT Automatisierungstechnologien fuer die Raumfahrt, Bad Honnef, Fed. Republic of Germany, 13-14 Feb. 1990 Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H.
(MBB-UO-0083-90-PUB; ETN-90-97850) Avail: NTIS HC/MF A03

The aim of the LOS (German acronym) project is to create a guidance concept technology for unmanned servicing. The technological guiding concept that is used as a basis and reference for the coordinates, the requirement adapted development, and the correletion, of requisite service technology, takes the following aspects into account: applicability of service technology in future space travel system; development steps for orbital servicing; cross section technology for residual space travel technical ranges; lead themes for a technical program of orbital servicing. ESA

N91-11836# Norske Veritas, Oslo.
IN ORBIT IN-SERVICE INSPECTION
O. FORLI *In* ESA, Space Applications of Advanced Structural Materials p 157-161 Jun. 1990
Copyright Avail: NTIS HC/MF A19

In service inspection systems to reveal possible in orbit degradation or damage are discussed. A review of projected inspection needs and the inspection tools that need to be developed for the Columbus space laboratory is presented. Various projected nondestructive testing systems are described. Meteoroid and debris impact as well as overloads due to operation and human activities are identified as being the most significant sources of degradation. The Columbus in service inspection system is to be based on a global acoustic impact monitoring system and local eddy current or ultrasonic examination to further characterize impact damage and reveal possible cracks. ESA

N91-13876*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GENERIC EXTRAVEHICULAR (EVA) AND TELEROBOT TASK PRIMITIVES FOR ANALYSIS, DESIGN, AND INTEGRATION. VERSION 1.0: REFERENCE COMPILATION FOR THE EVA AND TELEROBOTICS COMMUNITIES
JEFFREY H. SMITH and MICHAEL DREWS 30 Mar. 1990 302 p
(Contract NAS7-918)
(NASA-CR-187429; JPL-PUBL-90-10; NAS 1.26:187429) Avail: NTIS HC/MF A14 CSCL 05/8

The results are described of an effort to establish commonality and standardization of generic crew extravehicular (crew-EVA) and telerobotic task analysis primitives used for the study of spaceborne operations. Although direct crew-EVA plans are the most visible output of spaceborne operations, significant ongoing efforts by a wide variety of projects and organizations also require tools for estimation of crew-EVA and telerobotic times. Task analysis tools provide estimates for input to technical and cost tradeoff studies. A workshop was convened to identify the issues and needs to establish a common language and syntax for task analysis primitives. In addition, the importance of such a syntax was shown to have precedence over the level to which such a syntax is applied. The syntax, lists of crew-EVA and telerobotic primitives, and the data base in diskette form are presented. Author

N91-15217# Messerschmitt-Boelkow-Blohm/Entwicklungspring Nord, Bremen (Germany, F.R.).
ORGANISATIONAL ASPECTS OF ASSEMBLY, INTEGRATION AND VERIFICATION FOR COLUMBUS
A. GRAEBNER and H. NIMMO *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 35-40 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The responsibility of the assembly integration and verification branch as an engineering control function of a project is explained on the example of Columbus. Special emphasis was put on the associated documentation aspects keeping in mind the fact the AIV (Assembly, Integration, Verification) responsibilities are spread over the complete life cycle of the program. The possibilities of a database support is especially considered. ESA

N91-18603*# National Aeronautics and Space Administration, Washington, DC.
SPACESUIT GUIDEBOOK
1991 24 p
(NASA-PED-117; NAS 1.84:117) Avail: NTIS HC/MF A03 CSCL 06/11

This guidebook is designed to supplement the Spacesuit wall chart (WAL-114) published by the Education Affairs Division, January 1990. The wall chart depicts Astronaut Bruce McCandless on his historic first untethered spacewalk using the manned maneuvering unit. He flew on Shuttle mission 41-B, and ventured 100 meters for the Shuttle's cargo bay and returned safely. This guidebook explains in depth the elements depicted on the wall chart in see-through and cut-away perspectives. Together the wall chart and guidebook show as well as explain the inside workings of the spacesuit and its various components. Forty separate elements are identified with an accompanying numerical legend. Those elements are further explained in this guidebook along with their functions and how they work in relation to other elements. Additional chapters discuss essential components of the spacesuit such as the primary life support system and the manned maneuvering unit, and the method for donning the spacesuit. Author

N91-20665*# National Aeronautics and Space Administration, Washington, DC.
GROUND CONTROLLED ROBOTIC ASSEMBLY OPERATIONS FOR SPACE STATION FREEDOM
JOSEPH C. PARRISH *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 184-191 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

A number of dextrous robotic systems and associated positioning and transportation devices are available on Space Station Freedom (SSF) to perform assembly tasks that would otherwise need to be performed by extravehicular activity (EVA) crewmembers. The currently planned operating mode for these robotic systems during the assembly phase is teleoperation by intravehicular activity (IVA) crewmembers. While this operating mode is less hazardous and expensive than manned EVA operations, and has insignificant control loop time delays, the amount of IVA time available to support telerobotic operations is much less than the anticipated requirements. Some alternative is needed to allow the robotic systems to perform useful tasks without exhausting the available IVA resources; ground control is one such alternative. The issues associated with ground control of SSF robotic systems to alleviate onboard crew time availability constraints are investigated. Key technical issues include the effect of communication time delays, the need for safe, reliable execution of remote operations, and required modifications to the SSF ground and flight system architecture. Time delay compensation techniques such as predictive displays and world model-based force reflection are addressed and collision detection and avoidance strategies to ensure the safety of the on-orbit crew, Orbiter, and SSF are described. Although more time consuming and difficult than IVA controlled teleoperations or manned EVA, ground controlled telerobotic operations offer significant benefits during the SSF assembly phase, and should be considered in assembly planning activities. Author

N91-20674*# Boeing Computer Services Co., Huntsville, AL. Artificial Intelligence Center.
ARCHITECTURE FOR SPACECRAFT OPERATIONS PLANNING
WILLIAM S. DAVIS *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 275-278 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 12/2

A system which generates plans for the dynamic environment of space operations is discussed. This system synthesizes plans by combining known operations under a set of physical, functional, and temperal constraints from various plan entities, which are modeled independently but combine in a flexible manner to suit dynamic planning needs. This independence allows the generation of a single plan source which can be compiled and applied to a variety of agents. The architecture blends elements of temperal logic, nonlinear planning, and object oriented constraint modeling to achieve its flexibility. This system was applied to the domain of the Intravehicular Activity (IVA) maintenance and repair aboard Space Station Freedom testbed. Author

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ROBOTICS & REMOTE OPERATIONS

Simulations, models, analytical techniques, and requirements for remote, automated or robotic mechanical systems. Includes remote control of experiments.

A91-10101#
FLIGHT TELEROBOTIC SERVICER PROGRAM OVERVIEW
D. C. HALEY (Martin Marietta Space Systems Co., Denver, CO) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 3 p.
(AIAA PAPER 90-3702) Copyright

The paper presents a brief overview of the Flight Telerobotic Servicer (FTS) program. Two test flights precede deployment of the operational FTS on a first-element launch of the Space Station Freedom (SSF). Major components of the FTS system include the telerobot, workstations for operation from the shuttle and SSF, and an on-orbit storage facility. Versatility is enhanced by the ability of the FTS to operate from improved worksites which provide all utilities, from the SSF transport systems, and from unimproved worksites using battery power and Ku-band communication. Author

A91-10102#
AUTOMATION AND ROBOTICS TECHNOLOGIES FOR THE MOBILE SERVICING SYSTEM
R. RAVINDRAN, S. S. SACHDEV (Spar Aerospace, Ltd., Toronto, Canada), and D. HUNTER (Canadian Space Agency, Ottawa, Canada) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 11 p.
(AIAA PAPER 90-3703) Copyright

The current status of a program aimed at the development of advanced technologies applicable to the Mobile Servicing System (MSS) is reviewed. The MSS features a large manipulator, the Space Station Remote Manipulator System, and a smaller robotic system, the Special Purpose Dextrous Manipulator. The control system of both manipulators is described, and some advanced automation and robotic technologies being developed for incorporation into the system are discussed. These include advanced vision, an advanced information system, collision control, robotic languages, and expert systems. A robotic ground testbed to be used for developing these technologies is described. V.L.

A91-10103#
AUTOMATION AND ROBOTIC ACTIVITIES IN WP-2
RICK G. NORNHOLM and STEVEN D. FLEISCHAKER (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p.
(AIAA PAPER 90-3704) Copyright

The status of the automation and robotics activities in the Space Station Freedom program's Work Package Two (WP-2) is briefly reviewed. The discussion covers the development of the EVA-Robotic Design Standards document and the Robotic ORU Assembly and Maintenance methodology, robotic simulation efforts, testing and verification of the robot compatibility of hardware, flight Telerobotic Service integration with Space Station hardware, and the Robot Friendly Working Group. V.L.

A91-10105#
SPACE STATION DATA MANAGEMENT SYSTEM SUPPORT OF AUTOMATION AND ROBOTICS
CARLOS B. VALRAND (IBM Corp., Federal Sector Div., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p.
(AIAA PAPER 90-3706) Copyright

The Space Station Freedom Data Management System (DMS) has an open architecture with hardware and software components which support automation and robotics. The DMS provides a man-machine interface and data communications, data management, and data processing for distributed systems and elements. The DMS has a distributed modular architecture which supports stepped increases in operational capability. Support of advanced automation and robotics is accommodated by the modular design, which facilitates both the addition of new hardware and software components and the replacement of old components. Author

A91-12140#
MONITORING AND CONTROL SYSTEMS FOR AUTOMATED PROCESS PLANTS
LARRY C. SCHOOLEY and FRANCOIS E. CELLIER IN: Space mining and manufacturing; Proceedings of the First Annual Invitational Symposium, Tucson, AZ, Oct. 24-26, 1989. Tucson, AZ, NASA Space Engineering Research Center for Utilization of Local Planetary Resources, 1989, p. IV-7 to IV-20. refs

A philosophy of supervisory control of semiautomated process plants in space is discussed. The distribution of machine intelligence between operator site and plant site and the function of the pathways and loops in the system are shown and discussed. Two recent examples of the use of supervisory control of telerobots are reviewed. One involves teleoperation of a forerunner of the Astrometric Telescope Facility to be attached to the Space Station, and the other involves the development of systems and software for remote fluid handling in support of microgravity and life sciences. C.D.

A91-12646
END-POINT CONTROL OF A FLEXIBLE ARM KEEPING A CONSTANT DISTANCE TO FLUCTUATING TARGET
S. CHONAN (Tohoku University, Sendai, Japan) and S. AOSHIMA (Fuji Photo Film Co., Ltd, Tokyo, Japan) Journal of Sound and Vibration (ISSN 0022-460X), vol. 142, Oct. 8, 1990, p. 87-100. refs
Copyright

In this paper a theoretical and experimental study is presented on the control of a single-link flexible arm, the tip of which keeps a constant distance from the fluctuating surface of the target. The relative displacement between the arm and the target is measured by a gap sensor mounted on the tip of the arm. It is then used, together with the estimated relative velocity, as the basis for applying control torque to the other end of the arm. It is shown both theoretically and experimentally that the PD control using the end-point sensing and base torquing is sufficient to make the flexible arm follow the fluctuation of the target. Author

A91-13739#
TELEOPERATED AND AUTOMATIC OPERATION OF TWO ROBOTS IN A SPACE LABORATORY ENVIRONMENT
E. FREUND, CH. BUEHLER, and J. ROSSMANN (Dortmund, Universitaet, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. Research supported by BMFT. refs
(IAF PAPER 90-016) Copyright

A system concept for the control of robots in space by teleoperation is discussed. The concept uses a hierarchical structure which permits the incorporation of robots, manipulators, and hard-automated features on different levels of abstraction. The system's architecture is described, with special emphasis on the overall structure, autonomous operation, teleoperation support, collision avoidance, and a new group concept for multirobot systems. The feasibility of the approach is illustrated by the CIROS (Control of Intelligent Robots in Space) mockup, an experimental multirobot system with two redundant robots working together closely in a space laboratory environment. The sensory equipment and the communication infrastructure are described. C.D.

A91-13740#
TELESCIENCE TESTBED
JACQUES TAILHADES and CLAUDE RICAUD (Matra Espace, Toulouse, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-017) Copyright

In order to assess the Telescience operations concept, a testbed has been developed. Now a second model representative of the Columbus ground and onboard segments is under development. This paper presents the technical definition of the testbeds, and how the utilization problems will be analyzed. Author

A91-13742#
BAROCO - A TESTBED FOR THE PREPARATION OF COLUMBUS PAYLOADS OPERATIONS
JEAN-YVES PRADO, MICHEL DELPECH (CNES, Toulouse, France), JACQUES TAILHADES, THIERRY BLAIS (Matra Espace, Toulouse, France), MICHEL NOUDELMANN (CEA, Saclay, France) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p.
(IAF PAPER 90-019) Copyright

The French space agency CNES plans to develop a testbed called Baroco for testing the operability of French payloads for the Columbus Free Flying Laboratory. This paper briefly discusses the objectives of Baroco and the development and utilization plans. The role of telerobotics in this development is summarized. C.D.

A91-13746#
EMATS, A ROBOT-BASED EQUIPMENT MANIPULATION AND TRANSPORTATION SYSTEM FOR THE COLUMBUS FREE FLYING LABORATORY
P. PUTZ (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), G. COLOMBINA (Tecnospazio S.p.A., Milan, Italy), and W. DE PEUTER (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER 90-024) Copyright

This paper describes the concept for a robot-based Equipment Manipulation and Transportation System (EMATS) for the Columbus Free Flying Laboratory developed under ESA contact by a study team headed by Dornier. EMATS could not only automatically provide the greater part of the payload facility handling and logistics functions during the unmanned microgravity periods, but also perform unmanned servicing operations in conjunction with various logistics vehicles concepts and assist the crew during manned servicing from the Space Station Freedom and from Hermes. To that end, a variety of telerobotics feature are foreseen such as teleoperation and supervised automatic operation from ground or from a small control station aboard the Free Flyer, Hermes, or the S.S. Freedom. The paper summarizes the overall EMATS architecture and illustrates the flexibility of the concept by results from computer graphics simulations. Author

A91-13751
AUTOMATION AND ROBOTICS IMPLEMENTATION FOR COLUMBUS FREE FLYING LABORATORY
E. SCHMIDT, P. FOTH, C. MASSAU, and A. KELLNER (MBB-ERNO, Bremen, Federal Republic of Germany) IAF,

International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-030)

An overview is given of the automation and robotics baseline concept for the Columbus Free Flying Laboratory. The central robot system, on-board robotic mission management, failure detection, failure isolation, and recovery from failure, and payload internal automation are addressed. An implementation approach for the baseline concept is presented, including a first development plan. C.D.

A91-13784*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE SPACE STATION FREEDOM FLIGHT TELEROBOTIC SERVICER - THE DESIGN AND EVOLUTION OF A DEXTEROUS SPACE ROBOT
HARRY G. MCCAIN, JAMES F. ANDARY, DENNIS R. HEWITT (NASA, Goddard Space Flight Center, Greenbelt, MD), and DENNIS C. HALEY (Martin Marietta Space Systems, Inc., Denver, CO) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p.
(IAF PAPER 90-076) Copyright

The Flight Telerobotic Servicer (FTS) will provide a telerobotic capability to the Space Station in the early assembly phases of the program and will be used for assembly, maintenance, and inspection throughout the lifetime of the Station. Here, the FTS design approach to the development of autonomous capabilities is discussed. The FTS telerobotic workstations for the Shuttle and Space Station, and facility for on-orbit storage are examined. The rationale of the FTS with regard to ease of operation, operational versatility, maintainability, safety, and control is discussed. C.D.

A91-13785#
JEMRMS OPERATIONAL PERFORMANCE VERIFICATION APPROACH
K. KURAOKA (NASDA, Tokyo, Japan), K. GOMA, Y. SHINOMIYA, and S. NISHIDA (Toshiba Corp., Kawasaki, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-077) Copyright

The general performance verification concept which JEMRMS (Japanese Experiment Module Remote Manipulator System) will be subjected to during the design, development, test, and evaluation phases of the first Japanese space robotics arms is described. The JEMRMS operational scenario is reviewed, showing a summary of the operational modes. The verification approach is shown for the software and hardware functions, arm control performance, and task planning, operational procedure and training, payload handling, and human-machine interface aspects of operational function. The test bed is described, and tests to confirm the preprogrammed control mode of the main arm and to verify the concept of the main and small fine arm control capability are reviewed. C.D.

A91-13798#
OPERATIONS PROCEDURE PLANNING TOOLS FOR SPACE STATION ROBOTICS TASK ANALYSIS
DAVID G. COOKE (Spar Aerospace, Ltd., Advanced Technology Systems Group, Weston, Canada) and DAVID HUNTER (Canadian Space Agency, Ottawa, Canada) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p.
(IAF PAPER 90-095) Copyright

An evolving methodology for the development, validation, and configuration control of manipulator procedures for the Mobile Servicing Center of the Space Station Freedom is described. The overall development concept and the development tools are described, and an Assisted Mission Planning System, which reduces the engineer's workload and provides rapid, error-free creation of Mobile Servicing System mission procedures is discussed. The procedure development cycle is illustrated by an Integrated Electronics Assembly On-Orbit Replacement Unit changeout, showing how the various tasks are completed in order. C.D.

A91-13998#
SECOND USER REQUIREMENT STUDY AND TESTBED PLAN FOR TELESCIENCE ON THE SPACE STATION
Y. FUJIMORI, K. HIGUCHI, T. KUSUNOSE, H. KIMURA (NASDA, Tokyo, Japan), S. MATSUBARA (Japan Space Utilization Promotion Center, Tokyo) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p.
(IAF PAPER 90-383) Copyright

Results are presented from the first study performed by NASDA and the Japan Space Utilization Promotion Center to determine user requirements for a telescience system which enables ground replacements to observe and conduct space experiments on board JEM. The Second User Requirement Study (SURS) is then outlined. The experiment will study the restrictions imposed by JEM and the JEM Information System specification on the man-machine interface which is important to the payload specialist and users; it will also study the operation and management of an onboard experiment from the ground, and evaluate various hardware technologies. Experimental subjects are listed and include the effect of a round-trip delay of 4 seconds, the effect of data link outage such as the zone of exclusion, an evaluation of efficiency of onboard training, and an evaluation of man-machine interface. The design of the system for the SURS is discussed; a hardware configuration is given; and a software concept is described. L.K.S.

A91-13999#
TELESCIENCE BENEFITS AND CHALLENGES IN THE EARLY SPACE STATION FREEDOM ERA
E. L. SAENGER, G. M. DELANEY, and G. W. MAYBEE (McDonnell Douglas Space Systems Co., Huntsville, AL) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-384) Copyright

This paper summarizes the telescience benefits and challenges presented to potential science users of the Space Station Freedom (SSF). The current U.S. science payloads are listed, along with some typical telescience applications in the microgravity environment. The benefits include increased productivity and involvement of the science community. The challenges encompass the provision of a responsive, low-latency, closed-looped network in the controlled SSF arena. While the possibilities for telescience yields may be great, there are also many challenges to be met, both by the SSF and the user, before these benefits come to fruition. Author

A91-14138#
USING BISENSORY FEEDBACK DISPLAYS FOR SPACE TELEOPERATION
M. J. MASSIMINO (MIT, Cambridge, MA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER ST-90-005) Copyright

This paper investigates the use of tactile and auditory displays to present feedback to the pilot of a spacecraft or the operator of a space teleoperated system. Force feedback is given particular attention for teleoperator scenarios in the presence of a time delay. The motivation for and potential benefits of developing bisensory feedback displays are identified. Pioneering research in developing auditory and tactile displays is discussed. Several models of the human operator concerning the processing of bisensory information are outlined, along with a discussion of presenting redundant information across sensory modalities. Preliminary experimental results concerning sensory substitution of force feedback with a vibrotactile display are presented along with future research plans. Author

A91-14181#
AN AIRLOCK BASED ARCHITECTURE FOR SPACE STATION FREEDOM ASSURED CREW RETURN CAPABILITY
MADHU THANGAVELU (Southern California, University, Los Angeles, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 4 p. refs
(IAF PAPER 90-561) Copyright
An airlock based assured crew return capability architecture for Space Station Freedom (SSF-1) which could be used in the event of a life-threatening emergency is presented. In this system, the airlock and the hyperbaric airlock are designed as modules that could survive reentry. Two concepts are investigated: (1) an ablative/thermal tile heat shield built into the pressure hull of the airlock and (2) a separate heat shield carried up to the SSF-1 and deployed in such a way that it does not interfere with normal airlock operations. It is concluded that the propulsion system needed for maneuvering and de-orbit, sufficient thermal shielding to survive the reentry, and the environment control and life support system integration are the principal issues that need to be studied to prove the feasibility of such an airlock-based crew escape module for SSF-1. R.E.P.

A91-19516* Illinois Univ., Chicago.
FLEXIBILITY EFFECTS ON THE CONTROL SYSTEM PERFORMANCE OF LARGE SCALE ROBOTIC MANIPULATORS
SABRI CETINKUNT (Illinois, University, Chicago) and WAYNE J. BOOK (Georgia Institute of Technology, Atlanta) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 38, Oct.-Dec. 1990, p. 531-556. refs
(Contract NAG1-623; NSF MEA-83-03539)
Copyright
Structural flexibility of robotic manipulators becomes significant and limits the performance of a control system when manipulators are large structures, manipulating on large payloads, and/or operating at high speeds. The question of when a manipulator can be considered rigid or must be considered flexible is studied as a function of manipulator dynamics and task characteristics. Results are interpreted in simple quantitative forms which can be used as design and analysis tools to decide whether or not the manipulator flexibility will be a significant factor for a given task condition. The limitations imposed by the manipulator flexibility on the joint variable feedback control system performance is determined using linear and nonlinear methods. The closed loop eigenstructure behavior of finite dimensional models under joint variable feedback is studied and results are compared with the previously reported results. Author

A91-20483
COMPUTER VISION FOR SPACE APPLICATIONS
FRANK L. VINZ (BDM International, Inc., Huntsville, AL) IN: Intelligent robots and computer vision VIII: Systems and applications; Proceedings of the Meeting, Philadelphia, PA, Nov. 9, 10, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 100-110.
Copyright
Computer vision technology offers potential application for automation of space operations. The merits of computer vision and automation for earth bound operations are magnified when they are applied to space. Human involvement may be greatly reduced for routine operations and the risk to human life may be virtually eliminated. Two applications of this technology are described; one is applied to automatic orbital docking and the other is focused on automation of routine operations within the Space Station. Both application concepts use video cameras as the primary sensor, however, they each employ different techniques. Orbital docking is the more time critical of the two applications and a syntactic image analysis technique for this use is outlined in this report. Author

A91-26608* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE NASA TELEROBOTICS RESEARCH PROGRAM
R. RHOADS STEPHENSON (JPL; California Institute of Technology, Pasadena) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 17-25. refs
Copyright
An account is given to NASA efforts in the development of space telerobotics, which encompass mission analyses, core technology research, systems-integration testbed evaluations, ground-based demonstrations, and flight experiments. Space telerobotics applications encompass (1) The Space Shuttle Satellite Servicing System, (2) the Space Shuttle Orbiter's Remote Manipulator System, (3) the Space Station Freedom's Flight Telerobotics Servicer, Mobile Servicing Center, and Japanese Experiment Module, and (4) planetary rovers. A fundamental role is being played by NASA-Marshall, which possesses a Teleoperator and Robotics Evaluation Facility. O.C.

A91-26620
SIMULATION SYSTEM FOR A SPACE ROBOT USING 6 AXIS SERVOS
H. SHIMOJI, M. INOUE, K. TSUCHIYA (Mitsubishi Electric Corp., Amagasaki, Japan), K. NINOMIYA, I. NAKATANI (Institute of Space and Astronautical Science, Sagamihara, Japan) et al. IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 115-120. refs
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The development of a space robot with a manipulator which is operated to catch and handle a target, in zero gravity environment, is described. In this case, the behavior of the robot main body caused by the reaction force exerted by the manipulator motion has to be taken into consideration in order to control the manipulator correctly. To solve this problem, a ground simulation system combining numerical simulation and servo mechanisms was constructed. On this system, dynamics of the space robot and the target is solved based on the momentum conservation law, and the relative motion between them is realized. Using this simulation system, space robots can be developed efficiently. Author

A91-26825* National Aeronautics and Space Administration, Washington, DC.
TELEROBOTIC CONTROL ISSUES RELATED TO REAL TASK APPLICATIONS IN THE SPACE ENVIRONMENT
WAYNE ZIMMERMAN (NASA, Washington, DC) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 421-441. refs
(AAS PAPER 90-054) Copyright
Recent findings concerning the definition of the expected control environment associated with the Space Station are examined. The range of expected near-term and far-term task applications for robotic systems is provided, and the essential control issues related to the application environment are derived. In addition, an approximate control envelope for teleoperated and autonomous robotic systems is established. B.J.

A91-26833* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TELESCIENCE - OPTIMIZING AEROSPACE SCIENCE RETURN THROUGH GEOGRAPHICALLY DISTRIBUTED OPERATIONS
DARYL N. RASMUSSEN (NASA, Ames Research Center, Moffett Field, CA) and ARSHAD M. MIAN (NASA, Ames Research Center; General Electric Co., Moffett Field, CA) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 591-600. refs
(AAS PAPER 90-003) Copyright
The paper examines the objectives and requirements of teleoperations, defined as the means and process for scientists,

NASA operations personnel, and astronauts to conduct payload operations as if these were colocated. This process is described in terms of Space Station era platforms. Some of the enabling technologies are discussed, including open architecture workstations, distributed computing, transaction management, expert systems, and high-speed networks. Recent testbedding experiments are surveyed to highlight some of the human factors requirements. L.M.

A91-26835* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

WORKSPACE VISUALIZATION AND TIME-DELAY TELEROBOTIC OPERATIONS

P. S. SCHENKER and A. K. BEJCZY (JPL, Pasadena, CA) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 613-624. refs (AAS PAPER 90-005) Copyright

The paper examines the performance of telerobotic tasks where the operator and robot are physically separated, and a comunication time delay of up to several seconds between them exists. This situation is applicable to space robotic servicing-assembly-maintenance operations on low earth or geosynchronous orbits with a ground-based command station. Attention is given to two developments which address advanced time-delay teleoperations for unstructured tasks: (1) the 'phantom robot', real-time predictive graphics simulator developed to allow teleoperator eye-to-hand coordination or robot free-space kinematics under a time delay of several seconds; and (2) shared compliance control, a modified form of automatic electromechanical impedance control employed in parallel with manual position control to permit soft contact and grasp compliance with workpiece geometry under a time delay of several seconds. L.M.

A91-27655

TELEROBOTIC CAPABILITIES FOR SPACE STATION OPERATIONS

DAVID L. AKIN (MIT, Cambridge, MA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 811-820. refs
Copyright

An account is given of the results obtained to date by tests of prospective Space Shuttle-related telerobotics, either in 'pure' form or in conjunction with EVA, for such tasks as structural assembly, maneuvering and docking, and satellite servicing. Attention is given to the cases of a Beam Assembly Teleoperator (BAT), a Multimode Proximity Operations Device (MPOD), and the Apparatus for Space Telerobotics Operations. Results are presented for four series of BAT tests. MPOD results encompass flight-control tests as well as the use of the device as an Astronaut Support Vehicle for both structural assembly and Hubble Space Telescope servicing. O.C.

A91-29110* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

A UNIFIED TELEOPERATED-AUTONOMOUS DUAL-ARM ROBOTIC SYSTEM

SAMAD HAYATI, THOMAS S. LEE, KAM SING TSO, PAUL G. BACKES (JPL, Pasadena, CA), and JOHN LLOYD (McGill University, Montreal, Canada) *IEEE Control Systems Magazine* (ISSN 0272-1708), vol. 11, Feb. 1991, p. 3-8. refs
Copyright

A description is given of complete robot control facility built as part of a NASA telerobotics program to develop a state-of-the-art robot control environment for performing experiments in the repair and assembly of spacelike hardware to gain practical knowledge of such work and to improve the associated technology. The basic architecture of the manipulator control subsystem is presented. The multiarm Robot Control C Library (RCCL), a key software component of the system, is described, along with its implementation on a Sun-4 computer. The system's simulation capability is also described, and the teleoperation and shared control features are explained. I.E.

A91-30051

ADAPTIVE CSI COMPENSATION FOR REDUCED-ORDER-MODEL-BASED CONTROL OF A FLEXIBLE ROBOT MANIPULATOR

ROGER A. DAVIDSON, MARK J. BALAS, and BRIAN T. REISENAUER (Colorado, University, Boulder) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, *Proceedings. Vol. 1.* Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 334-339. University of Colorado-supported research. refs
Copyright

The effectiveness of an adaptive CSI compensation technique is shown. Its basis, the standard RMF (residual mode filter), has the following merits: (1) Residual mode filters have a strong theoretical background and a proven record in simulations with a variety of systems from the eighth-order flexible robot manipulator to a truss-beam model with nearly 1000 modes. (2) The residual mode filter controller-structure interaction (CSI) compensation technique is noniterative in terms of design and can be added to the ROM (reduced order model) compensator without redesign. The adaptive self-tuning RMF has advantages over other CSI compensation techniques. (1) The adaptive, self-tuning RMF is able to compensate for CSI instabilities in both continuous- and discrete-time simulations. (2) The behavior of the adaptive, self-tuning RMF is extremely robust. Stability is achieved even given +/-20 percent error in the FLL (frequency-locked loop) starting frequency from the actual modal frequency of the CSI instability. I.E.

N91-13476*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AN APPLICATION OF MULTIATTRIBUTE DECISION ANALYSIS TO THE SPACE STATION FREEDOM PROGRAM. CASE STUDY: AUTOMATION AND ROBOTICS TECHNOLOGY EVALUATION

JEFFREY H. SMITH, RICHARD R. LEVIN, and ELISABETH J. CARPENTER 1 May 1990 196 p
(Contract NAS7-918)
(NASA-CR-187432; JPL-PUBL-90-12; NAS 1.26:187432) Avail: NTIS HC/MF A09 CSCL 22/2

The results are described of an application of multiattribute analysis to the evaluation of high leverage prototyping technologies in the automation and robotics (A and R) areas that might contribute to the Space Station (SS) Freedom baseline design. An implication is that high leverage prototyping is beneficial to the SS Freedom Program as a means for transferring technology from the advanced development program to the baseline program. The process also highlights the tradeoffs to be made between subsidizing high value, low risk technology development versus high value, high risk technology developments. Twenty one A and R Technology tasks spanning a diverse array of technical concepts were evaluated using multiattribute decision analysis. Because of large uncertainties associated with characterizing the technologies, the methodology was modified to incorporate uncertainty. Eight attributes affected the rankings: initial cost, operation cost, crew productivity, safety, resource requirements, growth potential, and spinoff potential. The four attributes of initial cost, operations cost, crew productivity, and safety affected the rankings the most. Author

N91-13721*# Texas Univ., Austin. Dept. of Mechanical Engineering.

THE EFFECT OF INERTIAL COUPLING IN THE DYNAMICS AND CONTROL OF FLEXIBLE ROBOTIC MANIPULATORS Final Report

DELBERT TESAR, CAROL COCKRELL CURRAN, and PHILIP LEE GRAVES Aug. 1988 166 p
(Contract NAG9-360)
(NASA-CR-187679; NAS 1.26:187679) Avail: NTIS HC/MF A08 CSCL 13/9

A general model of the dynamics of flexible robotic manipulators is presented, including the gross motion of the links, the vibrations of the links and joints, and the dynamic coupling between the gross motions and vibrations. The vibrations in the links may be modeled using lumped parameters, truncated modal summation, a component mode synthesis method, or a mixture of these methods. The local link inertia matrix is derived to obtain the coupling terms between the gross motion of the link and the vibrations of the link. Coupling between the motions of the links results from the kinematic model, which utilizes the method of kinematic influence. The model is used to simulate the dynamics of a flexible space-based robotic manipulator which is attached to a spacecraft, and is free to move with respect to the inertial reference frame. This model may be used to study the dynamic response of the manipulator to the motions of its joints, or to externally applied disturbances. Author

N91-14498*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MANIPULATION HARDWARE FOR MICROGRAVITY RESEARCH
J. N. HERNDON, R. L. GLASSELL, P. L. BUTLER, D. M. WILLIAMS, D. A. ROHN, and J. H. MILLER (Sverdrup Technology, Inc., Brook Park, OH.) 1990 14 p Presented at the American Nuclear Society Winter Meeting, Washington, DC, 11-15 Nov. 1990
(Contract DE-AC05-84OR-21400)
(NASA-TM-103423; NAS 1.15:103423; DE91-002871; CONF-901101-46) Avail: NTIS HC/MF A03 CSCL 22/1

The establishment of permanent low earth orbit occupation on the Space Station Freedom will present new opportunities for the introduction of productive flexible automation systems into the microgravity environment of space. The need for robust and reliable robotic systems to support experimental activities normally intended by astronauts will assume great importance. Many experimental modules on the space station are expected to require robotic systems for ongoing experimental operations. When implementing these systems, care must be taken not to introduce deleterious effects on the experiments or on the space station itself. It is important to minimize the acceleration effects on the experimental items being handled while also minimizing manipulator base reaction effects on adjacent experiments and on the space station structure. NASA Lewis Research Center has been performing research on these manipulator applications, focusing on improving the basic manipulator hardware, as well as developing improved manipulator control algorithms. By utilizing the modular manipulator concepts developed during the Laboratory Telerobotic Manipulator program, Oak Ridge National Laboratory has developed an experimental testbed system called the Microgravity Manipulator, incorporating two pitch-yaw modular positioners to provide a 4 dof experimental manipulator arm. A key feature in the design for microgravity manipulation research was the use of traction drives for torque transmission in the modular pitch-yaw differentials. DOE

N91-15241# Aeritalia S.p.A., Turin (Italy). Space Systems Group.
THERMAL-VACUUM TEST OF IRIS GRABBER MECHANISM
P. PELLEGRINO and R. BIANCO *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 193-207 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Two deployable arms, named grabbers, were designed and manufactured to provide lateral stability for the perigee spinning stage of IRIS, which will be deployed from the Shuttle cargo bay. As far as the environment encountered by the grabber is concerned, the thermal vacuum test was designed to qualify the mechanism design. Interesting aspects of the test including the functional verification of the mechanism, IR lamps utilization, use of strain gauges, are pointed out. ESA

N91-15512* National Aeronautics and Space Administration. Pasadena Office, CA.
REMOTE OBJECT CONFIGURATION/ORIENTATION DETERMINATION Patent
LARRY L. SCHUMACHER, inventor (to NASA) (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) 23 Oct. 1990 7 p Filed 29 Aug. 1988
(NASA-CASE-NPO-17436-1-CU; US-PATENT-4,964,722; US-PATENT-APPL-SN-237035; US-PATENT-CLASS-356-152; US-PATENT-CLASS-356-5; US-PATENT-CLASS-356-141; INT-PATENT-CLASS-G01B-11/26; INT-PATENT-CLASS-G01C-1/00; INT-PATENT-CLASS-G01C-3/08) Avail: US Patent and Trademark Office CSCL 14/2

This invention relates to object detection and location systems and, more particularly, to a method for determining the configuration and location of an object with respect to an X, Y, X coordinate frame. In space applications in particular, there is a need to be able to passively determine the orientation of an object at a distance, for example, in the control of large, flexible space structures. At present, there is no available method or apparatus which will allow the operator to make such a determination. A similar problem and need exists in robotic application. It is the primary object of this invention to provide a system for remotely defining an object's configuration in a manner compatible with a computer's analytical capability.
Official Gazette of the U.S. Patent and Trademark Office

N91-15554*# Oak Ridge National Lab., TN. Robotics and Process Systems Div.
CUSTOM ELECTRONIC SUBSYSTEMS FOR THE LABORATORY TELEROBOTIC MANIPULATOR
R. L. GLASSELL, P. L. BUTLER, J. C. ROWE, and S. D. ZIMMERMANN (TeleRobotics International, Inc., Knoxville, TN.) 1990 10 p Presented at the 4th Topical Meeting on Robotics and Remote Systems, Albuquerque, NM, 24-28 Feb. 1991 Sponsored by NASA, Langley Research Center
(Contract DE-AC05-84OR-21400)
(NASA-CR-187730; NAS 1.26:187730; DE91-004393; CONF-910223-5) Avail: NTIS HC/MF A02 CSCL 13/9

The National Aeronautics and Space Administration (NASA) Space Station Program presents new opportunities for the application of telerobotic and robotic systems. The Laboratory Telerobotic Manipulator (LTM) is a highly advanced 7 degrees-of-freedom (DOF) telerobotic/robotic manipulator. It was developed and built for the Automation Technology Branch at NASA's Langley Research Center (LaRC) for work in research and to demonstrate ground-based telerobotic manipulator system hardware and software systems for future NASA applications in the hazardous environment of space. The LTM manipulator uses an embedded wiring design with all electronics, motor power, and control and communication cables passing through the pitch-yaw differential joints. This design requires the number of cables passing through the pitch/yaw joint to be kept to a minimum. To eliminate the cables needed to carry each pitch-yaw joint's sensor data to the VME control computers, a custom-embedded electronics package for each manipulator joint was developed. The electronics package collects and sends the joint's sensor data to the VME control computers over a fiber optic cable. The electronics package consist of five individual subsystems: the VME Link Processor, the Joint Processor and the Joint Processor power supply in the joint module, the fiber optics communications system, and the electronics and motor power cabling. DOE

N91-15692*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION FREEDOM AND FOR THE US ECONOMY Progress Report No. 11
Nov. 1990 48 p
(NASA-TM-102872; A-90308; NAS 1.15:102872) Avail: NTIS HC/MF A03 CSCL 22/2

The progress made by levels 1, 2, and 3 of the Office of

Space Station in developing and applying advanced automation and robotics technology is described. Emphasis is placed upon the Space Station Freedom Program responses to specific recommendations made in the Advanced Technology Advisory Committee (ATAC) progress report 10, the flight telerobotic servicer, and the Advanced Development Program. Assessments are presented for these and other areas as they apply to the advancement of automation and robotics technology for the Space Station Freedom. Author

N91-16381# Martin Marietta Space Systems, Inc., Denver, CO. Dept. of Research and Technology.
LARGE SPACE MANIPULATORS STUDY Final Report, May 1988 - May 1990
ERIC SCHMITZ and MADISON RAMEY Jun. 1990 59 p
(Contract F49620-88-C-0037)
(AD-A227276; MCR-90-513; AFOSR-90-1031TR) Avail: NTIS HC/MF A04 CSCL 22/1

The derivation of nonlinear dynamic models for a simple 3-D articulated, elastic structure is discussed. Kane's dynamics equations are used to obtain equations of motion is closed form; the bending deformations of the elastic links, modelled as slender elastic beams, are described with the assumed-modes method. A 2-D planar version of the dynamic model is used to predict the dynamic behavior of an experimental, articulated two-link elastic structure. Both links consist of thin elastic beams with rectangular cross section. The outer link has a tip payload of variable mass and moment of inertia. The structure is instrumented with position/rate acceleration sensors mounted at the articulations and at the end-point; strain gauges are mounted along the links at several locations. Close agreement between the analytical predictions and the experimental measurements is documented for modal tests and for slew maneuvers of the structure. The design and implementation of several digital compensators to actively control the single elastic beam as well as the 2-DOF elastic structure are presented. The compensators are obtained using classical design techniques and the Linear Quadratic Gaussian/Loop Transfer Recovery (LQG/LTR) method. GRA

N91-16385*# Oak Ridge National Lab., TN. Robotics and Process Systems Div.
NASA LABORATORY TELEROBOTIC MANIPULATOR CONTROL SYSTEM ARCHITECTURE
J. C. ROWE, P. L. BUTLER, R. L. GLASSELL, and J. N. HERNDON 1991 9 p Presented at the 4th Topical Meeting on Robotics and Remote Systems, Albuquerque, NM, 24-28 Feb. 1991 Sponsored in part by NASA
(Contract DE-AC05-84OR-21400)
(NASA-CR-187751; NAS 1.26:187751; DE91-002880; CONF-910223-2) Avail: NTIS HC/MF A02 CSCL 13/9

In support of the National Aeronautics and Space Administration (NASA) goals to increase the utilization of dexterous robotic systems in space, the Oak Ridge National Laboratory (ORNL) has developed the Laboratory Telerobotic Manipulator (LTM) system. It is a dexterous, dual-arm, force reflecting teleoperator system with robotic features for NASA ground-based research. This paper describes the overall control system architecture, including both the hardware and software. The control system is a distributed, modular, and hierarchical design with flexible expansion capabilities for future enhancements of both the hardware and software. DOE

N91-16386*# Massachusetts Inst. of Tech., Cambridge. Artificial Intelligence Lab.
THE PHD: A PLANAR, HARMONIC DRIVE ROBOT FOR JOINT TORQUE CONTROL M.S. Thesis
BRUCE ROBERT THOMPSON Jul. 1990 115 p Sponsored by NASA, Goddard Space Flight Center
(Contract N00014-86-K-0685)
(NASA-CR-187924; NAS 1.26:187924; AD-A228691; AI-TR-1247) Avail: NTIS HC/MF A06 CSCL 13/9

Many efforts are underway to extend the abilities of robots into the domain of space, where they can be used to perform simple tasks in environments where it is difficult or dangerous for humans to work. One such effort, the flight telerobotic servicer (FTS) is being undertaken for NASA by Martin Marietta. The FTS is a two arm manipulator system mounted on a mobile platform. A third arm is used to anchor the platform while working. The two manipulators on the FTS are seven degree of freedom arms which will be used to perform a variety of tasks. MIT was contracted, in conjunction with the University of Iowa, to build an accurate simulation of a seven degree of freedom manipulator similar to that proposed for the FTS. This thesis documents the development of that model. In order to perform some tasks, the FTS will need some sort of force control ability. To assist in the development of that ability a robot, the PHD, was designed and built with the capability to be used for two purposes. First, it can be used to perform research on joint torque control schemes, and second it can be used to determine the important dynamic characteristics of the harmonic drive gear reducer. The PHD, is a planar, three degree of freedom arm with torque sensors integral to each joint allowing joint torque feedback to be implemented. Preliminary testing using the PHD has shown that a simple linear spring model of the harmonic drive's flexibility is suitable in many situations. GRA

N91-17035*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED AVIONICS CONCEPTS: AUTONOMOUS SPACECRAFT CONTROL
In NASA, Washington, Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 435-450 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

A large increase in space operations activities is expected because of Space Station Freedom (SSF) and long range Lunar base missions and Mars exploration. Space operations will also increase as a result of space commercialization (especially the increase in satellite networks). It is anticipated that the level of satellite servicing operations will grow tenfold from the current level within the next 20 years. This growth can be sustained only if the cost effectiveness of space operations is improved. Cost effectiveness is operational efficiency with proper effectiveness. A concept is presented of advanced avionics, autonomous spacecraft control, that will enable the desired growth, as well as maintain the cost effectiveness (operational efficiency) in satellite servicing operations. The concept of advanced avionics that allows autonomous spacecraft control is described along with a brief description of each component. Some of the benefits of autonomous operations are also described. A technology utilization breakdown is provided in terms of applications. Author

N91-17048*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PAYLOAD DEPLOYMENT SYSTEMS AND ADVANCED MANIPULATORS
In NASA, Washington, Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 657-662 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 05/8

The results of discussions on future development of avionics to support payload deployment systems and advanced manipulators are discussed. The discussions summarized here were held during the Space Transportation Avionics Technology Symposium in Williamsburg, Virginia on November 7 to 9, 1989. Symposium participants agreed that this subpanel would have benefitted from more participation by users. It was suggested that inputs from Shuttle payload users should be incorporated, either by direct discussions with users or by incorporating comments from users as kept by Payload Accommodations. The Jet Propulsion Laboratory (JPL), Goddard, and Langley, as builders of payloads, and the Space Station Utilization Office could also provide useful inputs. Other potential users for future systems should also be identified as early as possible to determine what they anticipate their needs to be. Symposium participants also recognized that payload deployment is normally not a safety critical area, and as such, is vulnerable to budget cuts that defer costs from development to operations. This does give opportunities for upgrades of operational systems, but these must be very cost effective to compete with vehicle requirements that enhance safety or increase lifetime. Author

N91-20642*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RESOLVED RATE AND TORQUE CONTROL SCHEMES FOR LARGE SCALE SPACE BASED KINEMATICALLY REDUNDANT MANIPULATORS
ROBERT W. BAILEY (LinCom Corp., Houston, TX.) and LESLIE J. QUIOCHO *In its* Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 2-8 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

Resolved rate control of kinematically redundant ground based manipulators is a challenging problem. The structural, actuator, and control loop frequency characteristics of industrial grade robots generally allow operation with resolved rate control; a rate command is achievable with good accuracy. However, space based manipulators are different, typically have less structural stiffness, more motor and joint friction, and lower control loop cycle frequencies. These undesirable characteristics present a considerable Point of Resolution (POR) control problem for space based, kinematically redundant manipulators for the following reason: a kinematically redundant manipulator requires an arbitrary constraint to solve for the joint rate commands. A space manipulator will not respond to joint rate commands because of these characteristics. A space based manipulator simulation, including free end rigid body dynamics, motor dynamics, motor striction/friction, gearbox backlash, joint striction/friction, and Space Station Remote Manipulator System type configuration parameters, is used to evaluate the performance of a documented resolved rate control law. Alternate schemes which include torque control are also evaluated. Author

N91-20643*# Teledyne Brown Engineering, Huntsville, AL.
IVA THE ROBOT: DESIGN GUIDELINES AND LESSONS LEARNED FROM THE FIRST SPACE STATION LABORATORY MANIPULATION SYSTEM
CARL R. KONKEL, ALLEN K. POWERS, and J. RUSSELL DEWITT *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 9-14 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

The first interactive Space Station Freedom (SSF) lab robot exhibit was installed at the Space and Rocket Center in Huntsville, AL, and has been running daily since. IntraVehicular Activity (IVA) the robot is mounted in a full scale U.S. Lab (USL) mockup to educate the public on possible automation and robotic applications aboard the SSF. Responding to audio and video instructions at the Command Console, exhibit patrons may prompt IVA to perform a housekeeping task or give a speaking tour of the module. Other exemplary space station tasks are simulated and the public can even challenge IVA to a game of tic tac toe. In anticipation of such a system being built for the Space Station, a discussion is provided of the approach taken, along with suggestions for applicability to the Space Station Environment. Author

N91-20644*# New Mexico Univ., Albuquerque. Dept. of Mechanical Engineering.
A NOVEL DESIGN FOR A HYBRID SPACE MANIPULATOR
MO SHAHINPOOR *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 15-22 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

Described are the structural design, kinematics, and characteristics of a robot manipulator for space applications and use as an articulate and powerful space shuttle manipulator. Hybrid manipulators are parallel-serial connection robots that give rise to a multitude of highly precise robot manipulators. These manipulators are modular and can be extended by additional modules over large distances. Every module has a hemispherical work space and collective modules give rise to highly dexterous symmetrical work space. Some basic designs and kinematic structures of these robot manipulators are discussed, the associated direct and inverse kinematics formulations are presented, and solutions to the inverse kinematic problem are obtained explicitly and elaborated upon. These robot manipulators are shown to have a strength-to-weight ratio that is many times larger than the value that is currently available with industrial or research manipulators. This is due to the fact that these hybrid manipulators are stress-compensated and have an ultralight weight, yet, they are extremely stiff due to the fact that force distribution in their structure is mostly axial. Actuation is prismatic and can be provided by ball screws for maximum precision. Author

N91-20647*# Martin Marietta Space Systems, Inc., Denver, CO.
SSSFD MANIPULATOR ENGINEERING USING STATISTICAL EXPERIMENT DESIGN TECHNIQUES
JOHN BARNES *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 44-52 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

The Satellite Servicer System Flight Demonstration (SSSFD) program is a series of Shuttle flights designed to verify major on-orbit satellite servicing capabilities, such as rendezvous and docking of free flyers, Orbital Replacement Unit (ORU) exchange, and fluid transfer. A major part of this system is the manipulator system that will perform the ORU exchange. The manipulator must possess adequate toolplate dexterity to maneuver a variety of EVA-type tools into position to interface with ORU fasteners, connectors, latches, and handles on the satellite, and to move workpieces and ORUs through 6 degree of freedom (dof) space from the Target Vehicle (TV) to the Support Module (SM) and back. Two cost efficient tools were combined to perform a study of robot manipulator design parameters. These tools are graphical computer simulations and Taguchi Design of Experiment methods. Using a graphics platform, an off-the-shelf robot simulation software package, and an experiment designed with Taguchi's approach, the sensitivities of various manipulator kinematic design parameters to performance characteristics are determined with minimal cost. Author

N91-20653*# Carnegie-Mellon Univ., Pittsburgh, PA. Robotics Inst.
A SIMPLE 5-DOF WALKING ROBOT FOR SPACE STATION APPLICATION
H. BENJAMIN BROWN, JR., MARK B. FRIEDMAN, and TAKEO KANADE *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 91-95 Jan. 1991 Sponsored in part by Shimizu Corp., Japan
Avail: NTIS HC/MF A21 CSCL 13/9

Robots on the NASA space station have a potential range of applications from assisting astronauts during EVA (extravehicular activity), to replacing astronauts in the performance of simple, dangerous, and tedious tasks; and to performing routine tasks such as inspections of structures and utilities. To provide a vehicle for demonstrating the pertinent technologies, a simple robot is being developed for locomotion and basic manipulation on the proposed space station. In addition to the robot, an experimental testbed was developed, including a 1/3 scale (1.67 meter modules) truss and a gravity compensation system to simulate a zero-gravity environment. The robot comprises two flexible links connected by a rotary joint, with a 2 degree of freedom wrist joints and grippers at each end. The grippers screw into threaded holes in the nodes of the space station truss, and enable it to walk by alternately shifting the base of support from one foot (gripper) to the other. Present efforts are focused on mechanical design, application of sensors, and development of control algorithms for lightweight, flexible structures. Long-range research will emphasize development of human interfaces to permit a range of control modes from teleoperated to semiautonomous, and coordination of robot/astronaut and multiple-robot teams. Author

N91-20658*# Spectra Research Systems, Inc., Huntsville, AL.
EVALUATION OF TELEROBOTIC SYSTEMS USING AN INSTRUMENTED TASK BOARD
JOHN D. CARROLL, PAUL A. GIEROW, and THOMAS C. BRYAN *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 126-131 Jan. 1991
(Contract NAS8-36307)
Avail: NTIS HC/MF A21 CSCL 13/9

An instrumented task board was developed at NASA Marshall Space Flight Center (MSFC). An overview of the task board design, and current development status is presented. The task board was originally developed to evaluate operator performance using the Protoflight Manipulator Arm (PFMA) at MSFC. The task board evaluates tasks for Orbital Replacement Unit (ORU), fluid connect and transfers, electrical connect/disconnect, bolt running, and other basic tasks. The instrumented task board measures the 3-D forces and torques placed on the board, determines the robot arm's 3-D position relative to the task board using IR optics, and provides the information in real-time. The PFMA joint input signals can also be measured from a breakout box to evaluate the sensitivity or response of the arm operation to control commands. The data processing system provides the capability for post processing of time-history graphics and plots of the PFMA positions, the operator's actions, and the PFMA servo reactions in addition to real-time force/torque data presentation. The instrumented task board's most promising use is developing benchmarks for NASA centers for comparison and evaluation of telerobotic performance.
Author

N91-20659*# Spar Aerospace Ltd., Weston (Ontario). Space Operations Div.
OPERATIONS WITH THE SPECIAL PURPOSE DEXTROUS MANIPULATOR ON SPACE STATION FREEDOM
B. COX, D. BROWN, and M. HILTZ *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 134-142 Jan. 1991
Sponsored in part by Canadian Space Agency, Houston, TX
Avail: NTIS HC/MF A21 CSCL 13/9

SPAR Canada is actively participating in the Space Station Freedom Program by contributing the Mobile Servicing System (MSS) which will be involved in assembly, maintenance and servicing of both the Space Station and the MSS itself. Part of the MSS is the Special Purpose Dextrous Manipulator (SPDM), a two armed dextrous robot with advanced vision and manipulative capabilities. In addition to Space Station and payload servicing activities the SPDM will be designed to perform self maintenance on the MSS itself. The majority of Space Station equipment will be on orbit for the anticipated 30 year lifespan and the maintenance philosophy will be to repair by the exchange of Orbit Replacement Units or ORUs. The present concept, configuration, and operation of the SPDM and the detailed simulations associated with the maintenance of part of the MSS are described. The Design Reference Mission is the replacement of a Joint Drive Module on the Canadian large payload manipulator, the Space Station Remote Manipulator System. Other Design Reference Missions that were investigated are briefly described, and future operations activity to support the definition of SPDM requirements are discussed.
Author

N91-20660*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A SPACE SERVICING TELEROBOTICS TECHNOLOGY DEMONSTRATION
EDWIN P. KAN and NEVILLE I. MARZWELL *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 143-150 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

Supervised telerobotic controls provide the key to successful remote servicing, as demonstrated in the telerobot testbed of the jet propulsion laboratory. Such advanced techniques and systems are specially applicable to ground-remote operations for servicing tasks, which are to be performed remotely in space and to be operated under human supervision from the ground. Laboratory demonstrations have successfully proven the utility of such techniques and systems. Instrumental to the success of supervised robotic operations are the techniques called object designate and relative target. In addition, a technique called universal camera calibration was also applied in the telerobot testbed. Generalized compliant control techniques were used in the robotic removal and insertion operations. These techniques were proven successful in task situations where preprogrammed automation cannot be adequately exercised due to errors, changes, or omission in the worksite data base.
Author

N91-20661*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE DEVELOPMENT TEST FLIGHT OF THE FLIGHT TELEROBOTIC SERVICER
J. ANDARY, P. SPIDALIERE, and R. SOSNAY (Martin Marietta Corp., Denver, CO.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 151-158 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 22/2

The Development Test Flight (DTF-1) is the first of two shuttle flights to test operations of the Flight Telerobotic Servicer (FTS) in space and to demonstrate its capabilities in performing tasks for Space Station Freedom. The DTF-1 system, which Martin Marietta Astronautics Group is designing and building for the Goddard Space Flight Center, will be flown in December, 1991, as an attached payload on the shuttle. The design of the DTF-1 system, the tests to be performed, and the data to be gathered are discussed.
Author

N91-20666*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
A COLLISION DETECTION ALGORITHM FOR TELEROBOTIC ARMS
DOAN MINH TRAN (ST Systems Corp., Lanham, MD.) and MAUREEN OBRIEN BARTHOLOMEW *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 194-200 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 09/2

The telerobotic manipulator's collision detection algorithm is described. Its applied structural model of the world environment and template representation of objects is evaluated. Functional issues that are required for the manipulator to operate in a more complex and realistic environment are discussed.
Author

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MECHANICAL SYSTEMS

Design and operation of mechanical equipment, including gyroscopes and pointing mechanisms. Includes lubrication and lubricants.

A91-10936#
INTERCONNECTING DEVICES CONCEIVED FOR ON-ORBIT OPERATIONS
JOSEPH P. LAFFIN (G&H Technology, Inc., Santa Monica, CA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 5 p.

Numerous types of electrical interfaces have been utilized on boosters and spacecraft over the many years of the U.S. space program. The definition and standardization of proper families of connectors for use on all spacecraft was given very little attention. Presently, there is a move toward this standardization, so that logistical handling would be facilitated, spacecraft servicing would be enhanced, and astronaut training in the handling of connectors would be simplified. Formalization of this process is now under way at NASA, AIAA, and SAE, and within other working groups. A search is being conducted of connectors that meet the special requirements of space environments and ease of utilization in these environments. Details on cryogenic family conectors, blind-mate ORU interfaces, Robocon connectors, wing-nut connectors, and push/pull connectors are presented. R.E.P.

A91-17845
SPACE AND VACUUM TRIBOLOGY
E. W. ROBERTS and M. J. TODD (National Centre of Tribology, *European Space Tribology Laboratory, Risley, England*) IN: International Congress on Tribology, 5th, Espoo, Finland, June 12-15, 1989, Proceedings. Volume 2. Espoo, Finland, Finnish Society for Tribology, 1989, p. 21-33. Research supported by ESA. refs
Copyright

Lubrication requirements for vacuum utilization may be described in terms of lubricant lifetime, friction properties and the nature and amount of contaminants released by the lubricant. The nature of the challenges to the tribologist by the lubrication of surfaces in a vacuum environment and the way in which they are overcome are discussed. The pros and cons of both wet and dry lubricants for vacuum application are presented. It is concluded that, though there exist liquid lubricants with good vapor pressure and viscosity indexes suitable for space/vacuum application, solid lubricants offer the more flexible and versatile type of lubrication in terms of temperature and shear rate tolerance and in terms of simplicity of design. R.E.P.

A91-17848
TRIBOLOGY OF SPACE MECHANISMS
IU. DROZDOV and V. PUCHKOV (AN SSSR, Institut Mashinovedeniia, Moscow, USSR) IN: International Congress on Tribology, 5th, Espoo, Finland, June 12-15, 1989, Proceedings. Volume 2. Espoo, Finland, Finnish Society for Tribology, 1989, p. 281-288. refs
Copyright

Reliability and life durability of mechanisms, apparatus and appliances in space depend significantly on correct solving tribological problems. The extreme conditions of employment, requirements for minimizing of mass-dimensional parameters and trend for lifetime increase of space vehicle without special maintenance lead to necessity of developing trustworthy methods of calculation, elaborating special materials and reliable construction of friction joints. The basis for wear life estimation of typical friction joints by means of wear criterion are obtained. This method takes account of chemical, physical, mechanic factors influencing wear rate of machine elements. The results of contact interaction research in dry journal bearing are considered. Author

A91-19026#
PREFERRED GIMBAL ANGLES FOR SINGLE GIMBAL CONTROL MOMENT GYROS
S. R. VADALI, S. R. WALKER (Texas A & M University, College Station), and H.-S. OH Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1090-1095. Research supported by the Texas Advanced Research and Technology Program. refs
Copyright

This paper deals with torque command generation using single gimbal control moment gyros. The angular momentum and torque envelopes are assumed to be known a priori. A method based on back integration of the gyro torque equation from desired final conditions is used to determine a family of initial gimbal angles that avoid singularities. Each member of this family is defined as a preferred initial gimbal angle set. The pseudoinverse steering law is used during the numerical integrations. This procedure is demonstrated by means of numerical examples that include attitude control and momentum management of the Space Station Freedom. A feedback control scheme based on 'null motion' is also developed to position the gimbals at preferred angles. Author

A91-25327#
TRIBOLOGY IN SPACE ENVIRONMENT
MIKIO YAMAGUCHI, KIMITOSHI SATOU, TAKASHI HOSOYA, SHIGERU SABURI, and TAKAO OHBA Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 30, Sept. 1990, p. 340-344. In Japanese, with abstract in English. refs

Machine elements for space facilities should be designed taking account of the tribological characteristics such as friction coefficient and wear lifetime, which are greatly influenced by the special space environments: high vacuum, high or low temperature, atomic oxygen, and so on. This paper describes test results obtained within evacuated chambers on earth on the friction properties of ball bearings lubricated with vacuum greases and solid-film lubricants in high and low temperatures, ball screws lubricated with vacuum greases in high and low temperatures, and sliding bearings lubricated with heat-cured solid-film lubricants and with sputtered MoS_2 films. Author

A91-26806
A PRECISION STAR TRACKER FOR THE NINETIES - A SYSTEM GUIDE TO APPLICATIONS
JAMES P. MCQUERRY, RICHARD A. DETERS, and MARK A. RADOVICH, JR. (Ball Aerospace Systems Group, Boulder, CO) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 83-104.
(AAS PAPER 90-014) Copyright

The capabilities of precision star tracker technology based on mosaic array solid-state detectors are examined, with emphasis on applications of platform attitude determination and instrument pointing and control. The specification process is described for the potential user, with emphasis on the interaction of system requirements. The BECD IR&D design is discussed as an example of an existing hardware solution for the 1990s. The IR&D tracker is a modular design that can be easily modified to solve attitude applications problems in the planning phase for this time frame. It is concluded that superior performance can be obtained using mosaic detector sensor tracker where judicious tradeoffs of the key system parameter are taken into account collectively. B.J.

A91-29472#
COMPARISON OF LUBRICANT PERFORMANCE IN AN OSCILLATING SPACECRAFT MECHANISM
D. J. CARRE, P. D. FLEISCHAUER, C. G. KALOGERAS, and H. D. MARTEN (Aerospace Corp., El Segundo, CA) ASME and STLE, Joint Tribology Conference, Toronto, Canada, Oct. 7-10, 1990. 5 p.
(Contract F04701-88-C-0089)
(ASME PAPER 90-TRIB-30)

A life test of lubricants for the R2 shaft bearings of a spacecraft oscillating scanner mechanism was performed under simulated orbital conditions. The lubricant originally used in the application, a chloroarylalkylsiloxane (CAS) oil, and a linear perfluoropolyalkylether (PFPE) oil failed in less than 2500 hr or operation. A polyalpha-olefin (PAO) oil has been running for more than 11,000 hr without any indication of lubricant or system degradation. The performances of the oils are discussed in terms of the boundary lubrication conditions of the test. Author

A91-30116* Fairchild Space Co., Germantown, MD.
A SPACE STATION/PAYLOAD POINTING SYSTEM SIMULATION USING TREETOPS
MOHAN RAM and MOHAMMED SHAMMA (Fairchild Space Co., Germantown, MD) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 2. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 1298-1301. refs
(Contract NAS5-30189)
Copyright

A rigid body model of NASA's Space Station (SS)/Payload

Pointing System (PPS) was built and simulated using the multibody, large angle simulation package TREETOPS, whose name refers to the tree-topology class of structures that may be simulated. SS/PPS data from a previous feasibility study utilizing the MultiOptimal Differential Equation language was used as a test case to evaluate the built-in dynamical formulation capabilities of TREETOPS. The simulation results showed close agreement with NASA-Goddard data, demonstrating the validity of the nonlinear, large angle, multi-degree of freedom TREETOPS model. Author

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THERMAL ENVIRONMENTS & CONTROL

Descriptions of analysis for passive or active thermal control techniques. External and internal thermal experiments and analyses. Trade studies of thermal requirements.

A91-10342#
HEAT PUMP SYSTEMS FOR ENHANCEMENT OF HEAT REJECTION FROM SPACECRAFT
GERSHON GROSSMAN (L'Garde, Inc., Tustin, CA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 635-644. refs
Copyright

Temperature boosting of waste heat from spacecraft by means of heat pumps makes it possible, under some conditions, to achieve considerable savings in radiator area and mass. This study considers several possibilities for employing work-actuated and heat-actuated heat pumps (WAHP and HAHP, respectively) for this purpose. In the former case, the spacecraft power source is required to generate extra power to operate the heat pump; in the latter, use is made of the heat rejected from the power to energize the heat pump. The mass and area savings are calculated for a range of operating parameters including the temperatures of the waste heat from the power source and payload and that of the effective heat sink. The dimensionless parameters governing the behavior are determined. It is shown that for given operating conditions, a proper choice of the temperature boost and the associated heat pump coefficient of performance leads to an optimum in radiator area and system mass savings. A detailed cycle calculation is presented for an absorption heat pump - a particularly promising HAHP with few moving parts. Design considerations are given for space-based WAHP and HAHP systems. Author

A91-12827
THERMAL-HYDRAULICS FOR SPACE POWER, PROPULSION, AND THERMAL MANAGEMENT SYSTEM DESIGN
WILLIAM J. KROTIUK, ED. (General Electric Co., Astro-Space Div., Princeton, NJ) Washington, DC, American Institute of Aeronautics and Astronautics (Progress in Astronautics and Aeronautics. Volume 122), 1990, 354 p. For individual items see A91-12828 to A91-12840.
Copyright

The present volume discusses thermal-hydraulic aspects of current space projects, Space Station thermal management systems, the thermal design of the Space Station Free-Flying Platforms, the SP-100 Space Reactor Power System, advanced multi-MW space nuclear power concepts, chemical and electric propulsion systems, and such aspects of the Space Station two-phase thermal management system as its mechanical pumped loop and its capillary pumped loop's supporting technology. Also discussed are the 'startup thaw' concept for the SP-100 Space Reactor Power System, calculational methods and experimental data for microgravity conditions, an isothermal gas-liquid flow at reduced gravity, low-gravity flow boiling, computations of Space Shuttle high pressure cryogenic turbopump ball bearing two-phase coolant flow, and reduced-gravity condensation. O.C.

A91-12828#
SPACE STATION THERMAL MANAGEMENT SYSTEMS
JOSEPH ALARIO (Grumman Space Systems, Bethpage, NY) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 3-14.
Copyright

Two different two-phase heat-transport/acquisition concepts for thermal management are proposed for early 1990s implementation on the Space Station, together with a constant-temperature heat-collection system (a thermal bus) which enhances the user utility. Both concepts provide higher power levels with flexible increases from 75-kW to up to 125-kW during the 30-yr mission life of the station and the thermal bus permits the use of standard interfaces. In the separated-phase concept, the liquid supply to the heat sources is precisely controlled to match the locally applied heat load. The mixed-phase concept assumes a constant fluid flow, which simplifies the evaporator design but results in a difficult correlation problem associated with the two-phase flow. Two designs for the high-capacity heat-pipe radiator panels are proposed, both based on a monogroove heat-pipe concept. It is suggested that a modular radiator panel satisfies the requirements for both crew safety and system reliability. B.P.

A91-12829#
THERMAL DESIGN OF THE SPACE STATION FREE-FLYING PLATFORMS
C. E. BRAUN (General Electric Co., Princeton, NJ) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 15-28.
Copyright

The paper presents a thermal control subsystem (TCS) designed for the Space Station unmanned free-flying platforms. Design considerations such as modularity, heat acquisition/rejection, longevity, and temperature tolerances have led to a hybrid TCS using a central core fluid loop for the thermal control mechanisms of the platform subsystems. The orbital orientation of a platform is examined to find the best location for the radiator and the cooler. The platform dimensions and the heat-transport requirements are related to the capillary pumped fluid loop which uses ammonia as a working fluid. Even for the worst combination of environmental, equipment operation, and material property assumptions, the TCS meets the thermal requirements with sufficient safety margins. B.P.

A91-12833#
SPACE STATION MECHANICAL PUMPED LOOP
RICHARD BROWN and JOSEPH ALARIO (Grumman Space Systems, Bethpage, NY) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 83-130. refs
Copyright

Several thermal bus concepts for the Space Station are compared. The Grumman separated thermal bus concept is described as a two-phase system using ammonia as a working fluid. The Lockheed thermal bus uses a complex wick control for phase separation in the evaporators. The Boeing/Sundstrand thermal bus is a mixed two-phase flow system. A central heat pipe radiator system, providing a reliable heat-rejection capability for the Space Station, is presented. Its design features modular, high-capacity heat pipe radiator panels which can be replaced on orbit via remote manipulators. B.P.

A91-12834#
CAPILLARY PUMPED LOOP SUPPORTING TECHNOLOGY
C. E. BRAUN (General Electric Co., Princeton, NJ) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 131-139.
Copyright

Space platform thermal control, which includes hardware development and computer software tools, is discussed. Major components of the hardware design such as the evaporator plates, condenser zone, transport lines, and reservoir are summarized. The software uses a FLINT/SINDA 85 code. FLINT is intended to provide a general analysis framework for internal one-dimensional fluid systems and SINDA 85 provides a thermal analysis capability. It is considered that, by complementing the hardware development, the software is able to characterize a two-phase fluid loop behavior during a ground test and under microgravity conditions. A series of flow diagrams and schematics is included. B.P.

A91-13744*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

RESULTS OF THE SYSTEMS AUTONOMY DEMONSTRATION PROJECT

B. J. GLASS (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-022) Copyright

The Systems Autonomy Demonstration Project (SADP) produced a knowledge-based real-time control system for real-time control and fault detection, isolation and recovery (FDIR) of a prototype two-phase Space Station Freedom external control system (TCS). The Thermal Expert System (TEXSYS) was demonstrated in recent tests to be capable of reliable fault anticipation and detection, as well as nominal control of the thermal bus. Performance requirements were addressed by adopting a hierarchical 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, particularly for detection of unforeseen faults and sensor failures. Author

A91-13927#

INVESTIGATIONS OF THERMAL CONTROL COATINGS OPTICAL CHARACTERISTICS ON BOARD NEAR-EARTH ORBITAL STATIONS

A. A. GORODETSKII, S. A. DEMIDOV, and S. F. NAUMOV (Nauchno-Proizvodstvennoe Ob'edinenie Energiia, Kaliningrad, USSR) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-281) Copyright

A reliable method and instrumentation for determining radiation characteristics of spacecraft thermal control coatings is described. The method is based on solving the thermal balance differential equations for flat samples of coating subjected to external heat flows determined by ballistic data and attitude parameters. Data are presented on solar radiation absorptivity of coatings based on ZnO and $BaCO_3$ which confirm the high stability of silicon coatings based on ZnO for orbits at 300-400 km lasting for five years. C.D.

A91-19257#

THERMAL PERFORMANCE OF SPACE STATION 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) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs
(AIAA PAPER 91-0364) Copyright

The pressure distribution of the Space Station thermal pad contact heat exchangers is numerically evaluated utilizing a self-contained general purpose finite element program and experimentally using a relatively new pressure sensitive film. Four load configurations consisting of 4 x 4, 4 x 6, 5 x 7, and 6 x 8 arrays were evaluated. It is shown that the numerical study provided a reasonable representation of the pressure distribution and indicated that the interface pressure distribution variation was directly proportional to the total load and decreased with increasing number of load points. The 5 x 7 array is found to minimize the number of load points but still provide optimum thermal characteristics. The results of the thermal contact conductance enhancement experiments indicated that the thermal contact conductance of the 12.70 x 17.78 cm thermal pads can be enhanced significantly by the addition of a thin coating of indium. R.E.P.

A91-19259*# Lockheed Missiles and Space Co., Sunnyvale, CA.

DEVELOPMENT OF THE SINGLE GRADED GROOVE HIGH-PERFORMANCE HEAT PIPE

J. H. AMBROSE and H. R. HOLMES (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 5 p. Research supported by NASA and McDonnell Douglas Corp. refs
(AIAA PAPER 91-0366) Copyright

This paper describes the development of a new nonarterial heat pipe with a nominal transport capability of 100,000 W in. Data are presented for one-g transport capability as a function of tilt and working fluid quantity. The transport capability agrees well with theoretical predictions. The LMSC Graded Groove Heat Pipe exhibits the high throughput and excellent heat transfer characteristics of earlier arterial designs such as the LMSC Tapered Artery Heat Pipe. At the same time, it suffers none of the priming difficulties associated with the arterial designs. Author

A91-20195*# Grumman Aerospace Corp., Bethpage, NY.

PERFORMANCE RESULTS OF GRUMMAN PROTOTYPE SPACE STATION SPACE ERECTABLE RADIATOR SYSTEM GROUND TEST ARTICLES

FRANCINE GISONDO (Grumman Corp., Aircraft Systems Div., Bethpage, NY) Society of Women Engineers, Annual Student Conference, New York, June 25-30, 1990, Paper. 36 p. Research supported by NASA. refs

The paper addresses individual-radiator performance results of the prototype Space Erectable Radiator System (SERS) in both ambient and thermal vacuum environments. The radiator design utilizing a two-phase fluid loop is outlined, along with SERS design requirements, radiator panel hardware, and whiffletree clamp hardware providing a dry-contact interface of the SERS panel with the heat exchanger of the thermal bus. It is observed that throughout integrated thermal-bus tests, SERS panels managed the load demands whether interfacing with twin condensers, in parallel-flow configuration, or with shear-flow condensers, in a cross-flow configuration. It is found that the insulation losses in the integrated and stand-alone test points are approximately 2 to 6 pct. The motorized whiffletree clamp is seen as performing satisfactorily during remote operations as well as maintaining 28,800-lb force throughout the test duration without requiring further adjustments. V.T.

A91-23755#

CONTROL STRATEGIES FOR THERMALLY INDUCED VIBRATIONS OF SPACE STRUCTURES

F. BERNELLI-ZAZZERA, A. ERCOLI-FINZI, and P. MANTEGAZZA (Milano, Politecnico, Milan, Italy) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 539-551. refs

The paper analyzes, on a particular thin walled long cylinder exposed to sunlight, the effects of different controller structures in controlling the unstably coupled thermal-structural vibrations. Singular value analysis is used to estimate the controllability and observability of the system with several combinations of thermal and structural sensors and actuators. Based on this analysis two feasible suboptimal control laws are devised, that are sufficiently robust to cope with different radiation conditions. Author

A91-24458#

AN INTEGRATED THERMOELASTIC ANALYSIS FOR PERIODICALLY LOADED SPACE STRUCTURES

O. RAND and D. GIVOLI (Technion - Israel Institute of Technology, Haifa) IN: ICAS, Congress, 17th, Stockholm, Sweden, Sept. 9-14, 1990, Proceedings. Vol. 2. Washington, DC, American Institute of Aeronautics and Astronautics, Inc., 1990, p. 1529-1533. Research

supported by the L. Kraus Research Fund. refs
Copyright
An integrated thermoelastic analysis of space structures in periodic motion is performed. To this end, a combined spectral-finite-element method is devised. The thermal problem is strongly nonlinear due to the presence of heat radiation. Any symmetry which the structure may possess with respect to the axis of rotation is exploited in the numerical scheme, and leads to saving in computational cost. A numerical example is presented which demonstrates the performance of the method and its ability to identify some key characteristics in space structure problems.
Author

A91-26058
FACTORS AFFECTING THE SELECTION OF PARAMETERS FOR LOW TEMPERATURE HEAT PIPES FOR SPACECRAFT THERMAL CONTROL
V. F. PRISNIAKOV, IU. K. GONTAREV, IU. V. NAVRUZOV, and V. N. SEREBRIANSKII (Dnepropetrovskii Gosudarstvennyi Universitet, Dnepropetrovsk, Ukrainian SSR) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 4, 1990, p. 307-315. refs
Copyright
Various aspects of heat pipe behavior were studied both theoretically and experimentally. Useful results are presented for a variety of wick structures and working fluids. Both static and dynamic behaviors are covered. This treatment leads to a discussion of how to determine appropriate heat pipe design parameters for space applications.
Author

N91-10104# Pacific Northwest Lab., Richland, WA. Nuclear Systems and Concepts Dept.
ADVANCED CERAMIC FABRIC BODY MOUNTED RADIATOR FOR SPACE STATION FREEDOM PHASE O DESIGN
BRENT J. WEBB, ZEN I. ANTONIAK, and KEITH A. PAULEY Jun. 1990 4 p Presented at the 5th AIAA/ASME Thermal Physics and Heat Transfer Conference, Seattle, WA, 18-20 Jun. 1990
(Contract DE-AC06-76RL-01830)
(DE90-016361; PNL-SA-17526; CONF-900619-7) Avail: NTIS HC/MF A01
A body mounted radiator concept constructed of advanced ceramic fabric materials for use with the Phase O design of Space Station Freedom is described. The radiator is expected to weigh between 1.4 and 3.5 kg/sq m of single sided radiating surface, use ammonia working fluid, be highly deployable, and exhibit good reliability characteristics. This compares well with the 11.8 kg/sq m for two sided radiators proposed for the current space station design.
DOE

N91-10173# Pacific Northwest Lab., Richland, WA.
DESIGN CONSIDERATIONS FOR A CERAMIC FABRIC RADIATOR
K. A. PAULEY, B. J. WEBB, and A. C. KLEIN (Oregon State Univ., Corvallis.) Apr. 1990 10 p Presented at the Engineering, Construction and Operations for Space, Albuquerque, NM, Apr. 1990
(Contract DE-AC06-76RL-01830)
(DE90-016342; PNL-SA-17201; CONF-900442-4) Avail: NTIS HC/MF A02
The design of an Advanced Ceramic Fabric (ACF) thermal management device for use in both interplanetary and near-earth space must consider several important aspects of the environment. First, the radiation field at various locations is dominated by a proton component which deposits its energy on the surface of the device. Second, the ACF materials, as well as pressure liner materials, must also be compatible with the working fluids selected for the system. Third, the fluid dynamics and heat transfer characteristics of this device should be adequately characterized. With the proper consideration of materials and operating conditions, the Bubble Membrane Radiator (BMR) may be utilized for several advanced space missions.
DOE

N91-11792# Missouri Univ., Rolla. Dept. of Mechanical and Aerospace Engineering and Engineering Mechanics.
PHASE CHANGE MATERIAL FOR SPACECRAFT THERMAL MANAGEMENT Final Report, 1 Sep. 1988 - 31 Mar. 1989
J. W. SHEFFIELD and C. WEN Apr. 1990 39 p
(Contract F33615-86-C-2721; AF PROJ. 3145)
(AD-A224865; WRDC-TR-90-2029) Avail: NTIS HC/MF A03 CSCL 22/1
Processes related to phase change encompass a wide range of engineering and scientific disciplines and occur in many applications. Owing to the release or absorption of latent heat, these phase change problems are nonlinear, and exact solutions are limited to a small class of problems involving pure substances in 1-D infinite or semi-infinite domains. Based on an enthalpy formulation, several models were studied for solving the phase change heat transfer problem of melting. A continuum model is presented and utilized in a finite difference numerical method. Thermophysical properties of the PCM (Phase Change Material) such as mass density, specific heat, thermal conductivity, etc., change while the PCM undergoes the solid-liquid phase change. Accommodation methods for these variations were developed and are presented. The mathematical and numerical formulations of the conservation of mass, momentum and energy equations and thermodynamic property equations are presented in detail. Limited preliminary results for P116 wax show velocity vector fields and the liquidus lines during melting.
GRA

N91-12039# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (Germany, F.R.). Dienstleistungsbereich.
IN ORBIT PERFORMANCE OF THE TV-SAT/TDF-1 HEAT PIPE SYSTEM
R. SCHLITT, R. MEYER, R. GIOVANNINI, and G. CLUZET (Aerospatiale, Cannes, France) 1990 18 p
(MBB-UO-0098-90-PUB; ETN-90-97886) Avail: NTIS HC/MF A03
The large heat pipe system developed for a new generation of direct broadcasting satellites of the TV-SAT/TDF family is described. The system consists of 88 axial grooved heat pipes of the aluminum/ammonia type. The design and development phases are summmarized and in-orbit data of satellites are reviewed and compared. A discussion of the lessons learnt aspect of the program is given.
ESA

N91-12740# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
DEVELOPMENT OF A HIGH PERFORMANCE HEAT PIPE FOR THERMAL CONTROL IN FUTURE SPACECRAFT
ROBERT MUELLER (Erno Raumfahrttechnik G.m.b.H. Bremen, Germany, F.R.) 1990 15 p Presented at 7th International Heat Pipe Conference, Binsk, USSR, 21-25 May 1990
(MBB-UO-0090-90-PUB; ETN-90-98157) Avail: NTIS HC/MF A03
The development of a high performance heat pipe design to be used as a thermal bus in medium size platforms and in the radiators of large size space stations is discussed. Circumferential capillary grooves and the separation of the axial fluid flow by an extrusion inserted into the pipe provides the high performance of the heat pipe. In order to demonstrate the feasibility of the concept, two test programs are performed. The first aims to optimize the groove geometry by testing seven evaporator sections in a pumped two phase loop. The test results in maximum heat fluxes of 10.7 W per sq cm and heat transfer coefficients of up to 1.35 W per sq cm K. The second test program is performed on two full scale heat pipes of 1 m length under different tilt conditions. During the tests maximum axial heat loads up to 1200 W with radial heat fluxes of 15.9 W per sq cm are achieved. Under nominal operating conditions the typical heat coefficients are larger than 19.8 per sq cm minus k.
ESA

N91-12954*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FINITE ELEMENT ANALYSIS OF THERMAL DISTORTION EFFECTS ON OPTICAL PERFORMANCE OF SOLAR DYNAMIC CONCENTRATOR FOR SPACE STATION FREEDOM
MICHAEL P. DOHERTY and VITHAL DALSANIA Jul. 1990 18 p Original contains color illustrations
(NASA-TM-102504; E-5305; NAS 1.15:102504) Avail: NTIS HC/MF A03; 3 functional color pages CSCL 20/11

An analysis was performed to predict the thermal distortion of the solar dynamic concentrator for Space Station Freedom in low earth orbit and to evaluate the effects of that thermal distortion on concentrator on-orbit performance. The analysis required substructural finite element modeling of critical concentrator structural subsystems, structural finite element modeling of the concentrator, mapping of thermal loading onto the structural finite element model, and the creation of specialized postprocessors to assist in interpreting results. Concentrator temperature distributions and thermally induced displacements and slope errors and the resulting receiver flux distribution profiles are discussed. Results determined for a typical orbit indicate that concentrator facet rotations are less than 0.2 mrad and that the change in facet radius due to thermal flattening is less than 5 percent. The predicted power loss due to thermal distortion effects is less than 0.3 percent. As a consequence the thermal distortions of the solar dynamic concentrator in low earth orbit will have a negligible effect on the flux distribution profiles within the receiver. Author

N91-15238# Fokker Space and Systems, Amsterdam (Netherlands). Thermal Control Dept.
SCALING DOWN THE ACTIVITIES OF A THERMAL BALANCE TEST EVALUATION
A. KAMP *In* ESA, International Symposium on Environmental Testing For Space Programmes: Test Facilities and Methods p 173-178 Sep. 1990
Copyright Avail: NTIS HC/MF A23

Cost saving in the evaluation of thermal design of spacecraft is investigated. A detailed correlation of the network parameters of a thermal mathematical model of a complete spacecraft with test results consumes typically 3000 man hours and 6 months of throughput time. Alternative evaluations, which do not correlate the model, are able to reduce both effort and schedule to 25 percent. Yet, in most cases these evaluations are able to give sufficient confidence in the model required for flight. For each model node, the extreme of its residual discrepancies between analysis and test is incorporated in the uncertainties for the flight temperatures. After the addition of the new uncertainties, the predictions which are made with the non correlated model, become guaranteed temperatures. They enable the qualification of the design and can be used to verify modifications in the design. The savings in expenses and schedule are at the cost of the optimum achieved in the performance of the design. ESA

N91-15264# Dornier System G.m.b.H., Friedrichshafen (Germany, F.R.).
CRYO-CALIBRATION FACILITY FOR ISOPHOT
W. FRICKE, D. LEMKE, K. PROETEL, B. VOGT, and J. WOLF (Max-Planck-Inst. fuer Astronomie, Heidelberg, Germany, F.R.) *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 375-380 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The cryo calibration facility for ISOPHOT (ISO (Infrared Space Observatory) Photopolarimeter) simulates the thermal and optimal conditions of the ISO spacecraft. The ISOPHOT is one of four scientific instruments at the ISO. The detectors of ISOPHOT require two temperature levels, one between 1.7 to 1.9K and the other between 2.3 to 3.4K. The calibration facility consists of two major parts: the cryostat and the warm vacuum tank. Inside the cryostat the experiment is fixed on a separate support structure with electrical heaters to achieve the upper temperature level. The 2K cooling strap is fixed directly on the liquid helium tank with a temperature of nominal 1.8K. To vary the radiation flux of the infrared beam, which is created and shaped in the warm vacuum tank, the filter wheel inside the cryostat can be moved from outside. In order to achieve the low background condition, the experiment room is equipped with an additional radiation shield and light labyrinths. The results of the facility acceptance test show that all requirements can be fulfilled. ESA

N91-19216*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THERMAL CYCLE TESTING OF SPACE STATION FREEDOM SOLAR ARRAY BLANKET COUPONS
DAVID A. SCHEIMAN and DAVID A. SCHIEMAN (Sverdrup Technology, Inc., Cleveland, OH.) *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 410-420 Jan. 1991
(Contract NAS3-25266)
Avail: NTIS HC/MF A22 CSCL 10/2

Lewis Research Center is presently conducting thermal cycle testing of solar array blanket coupons that represent the baseline design for Space Station Freedom. Four coupons were fabricated as part of the Photovoltaic Array Environment Protection (PAEP) Program, NAS 3-25079, at Lockheed Missile and Space Company. The objective of the testing is to demonstrate the durability or operational lifetime of the solar array welded interconnect design within the durability or operational lifetime of the solar array welded interconnect design within a low earth orbit (LEO) thermal cycling environment. Secondary objectives include the observation and identification of potential failure modes and effects that may occur within the solar array blanket coupons as a result of thermal cycling. The objectives, test articles, test chamber, performance evaluation, test requirements, and test results are presented for the successful completion of 60,000 thermal cycles. Author

N91-19304*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COMPOSITE FLEXIBLE INSULATION FOR THERMAL PROTECTION OF SPACE VEHICLES
DEMETRIUS A. KOURTIDES, HUY K. TRAN, and S. AMANDA CHIU (Sterling Software, Palo Alto, CA.) Feb. 1991 19 p Proposed for presentation at the 37th International SAMPE Symposium and Exhibition, Anaheim, CA, 9-12 Mar. 1992
(NASA-TM-103836; A-91062; NAS 1.15:103836) Avail: NTIS HC/MF A03 CSCL 11/3

A composite flexible blanket insulation (CFBI) system considered for use as a thermal protection system for space vehicles is described. This flexible composite insulation system consists of an outer layer of silicon carbide fabric, followed by alumina mat insulation, and alternating layers of aluminized polyimide film and aluminoborosilicate scrim fabric. A potential application of this composite insulation would be as a thermal protection system for the aerobrake of the aeroassist space transfer vehicle (ASTV). It would also apply to other space vehicles subject to high convective and radiative heating during atmospheric entry. The thermal performance of this composite insulation as exposed to a simulated atmospheric entry environment in a plasma arc test facility is described. Other thermophysical properties which affect the thermal response of this composite insulation is included. It shows that this composite insulation is effective as a thermal protection system at total heating rates up to 30.6 W/sq cm. Author

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POWER SYSTEMS

Analyses, systems and trade studies of electric power generation, storage, conditioning and distribution.

A91-12830#
SP-100 SPACE REACTOR POWER SYSTEM

A. KIRPICH, G. KRUGER, D. MATTEO, and J. STEPHEN (General Electric Co., Princeton, NJ) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 29-39.
Copyright

A generic flight system (GFS) design for a 100-kWe space reactor power (SP-100) system is presented. The design has evolved around issues such as the selection of a lithium liquid-metal-cooled reactor built of refractory metals and permitting operation in the range of 1300-1400 K; heat transport by lithium circulation using thermoelectrically driven liquid-metal pumps; thermoelectric power conversion; and waste heat rejection at approximately 800 K through lithium circulation to potassium heat pipe radiators. Various thermal-hydraulic analytical procedures have been utilized in the design of the reactor, ducting, hot-side and cold-side heat exchangers, circulating pumps, and heat pipe radiators. The physical and performance characteristics of the GFS and its power margins are estimated as a function of mission time. B.P.

A91-12831#
ADVANCED MULTIMEGAWATT SPACE NUCLEAR POWER CONCEPTS
JOHN A. DEARIEN and JUDSON F. WHITBECK (Idaho National Engineering Laboratory, Idaho Falls) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 41-67.

Design requirements for an advanced space-based nuclear-power system are discussed with respect to the advanced weapon systems of the strategic defense initiative (SDI) requiring power in the multimegawatt range. NASA's planning effort to maintain a permanent human presence in space is also taken into consideration. Technology issues in space resulting from spacecraft requirements, microgravity, and safety considerations are discussed, and special attention is paid to the environmental impact of the open-cycle systems and the presence of humans in proximity to nuclear power. B.P.

A91-13441
ION DRAG ON A HIGHLY NEGATIVELY BIASED SOLAR ARRAY
DANIEL E. HASTINGS and MENGU CHO (MIT, Cambridge, MA) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 99-111. refs
(Contract AF-AFOSR-87-0340)
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Highly biased solar arrays are found to have a number of significant interactions with the space environment. The negatively biased parts of the array undergo enhanced ion drag and also suffer from destructive arcing. The enhanced drag suffered by highly biased solar arrays is studied with the PIC code. A new model of the drag is developed and the results are compared to recent experimental work. The drag calculations contain the effect of having the conductor surrounded by dielectrics as well as the charging of the dielectric by electrons. Author

A91-13442
MICROWAVE ENERGY TRANSMISSION EXPERIMENT
HIROSHI MATSUMOTO (Kyoto University, Uji, Japan), NOBUYUKI KAYA (Kobe University, Japan), and MAKOTO NAGATOMO (Institute of Space and Astronautical Science, Sagamihara, Japan) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 113-130. refs
Copyright

A METS (Microwave Energy Transmission in Space) experiment using the future Space Flyer Unit is proposed. Two fundamental areas will be addressed: one is the development of a control system for the microwave beam enabling accurate pointing to the energy receiver, the other problem concerns the study of nonlinear propagation effects of the microwave beam as it passes through space plasmas as well as the effects of the microwave beam on the plasma environment. Author

A91-13443
AN EXPERIMENTAL STIRLING ENGINE FOR USE IN SPACE SOLAR DYNAMIC POWER SYSTEMS - PRELIMINARY TESTS
KUNIHISA EGUCHI, SACHIO OGIWARA, and TSUTOMO FUJIWARA (National Aerospace Laboratory, Chofu, Japan) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 131-147. Research supported by the Science and Technology Agency of Japan. refs
Copyright

The Stirling cycle engine has proved to be the most promising candidate of various thermodynamic cycle engines used to convert solar to electrical energy. As part of the National Aerospace Laboratory's solar dynamic power technology program, the present project has been to design and build a model of a free-piston Stirling engine generator. This paper examines fundamentals of the engine operations and its thermodynamic characteristics. Preliminary results are given, along with comments on future design modifications. Author

A91-13444
STUDY OF PARABOLIC SOLAR CONCENTRATORS
SUMIO KATO, HIROSHI ODA, YASUHIRO TAKESHITA, YOSHINORI SAKAI (Kawasaki Heavy Industries, Ltd., Aircraft Engineering Div., Kakamigahara, Japan), TATSUSABURO NAKAMURA (Kawasaki Heavy Industries, Ltd., Technical Institute, Akashi, Japan) et al. Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 149-162.
Copyright

A conceptual design study of solar concentrators was carried out, and mirror segment models were fabricated and tested. Three kinds of configurations (1.5 kWe, 10 kWe, and 15 kWe) were studied. Analyses of the collector efficiencies, standard errors, and the optical system were performed. Based on this, system specifications and design parameters to minimize optical errors were formulated. Author

A91-13445* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STATION FREEDOM GROWTH POWER REQUIREMENTS
B. D. MEREDITH (NASA, Langley Research Center, Hampton, VA), P. R. AHLF, and R. J. SAUCILLO (McDonnell Douglas Space Systems Co., Washington Operations Div., Rockville, MD) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 163-173. refs
Copyright

Options and scenarios for the evolution of Space Station Freedom beyond the current baseline have been established and analyzed at NASA Langley Research Center to identify growth requirements for the program's Preliminary Requirements Review (PRR). Time-phase requirements for electrical power and other critical resources were determined based upon the future needs of the science, technology and commercial users. In addition, impacts and resource growth were determined for the utilization of station as a transportation node in support of human exploration initiatives to the moon and/or Mars. The set of requirements chosen for the PRR were selected on the basis of their adequacy in accommodating each of the evolution options and scenarios within each option, thereby maximizing future flexibility. In the case of electrical power, growth to 275 kW (average) was determined to be adequate for evolutionary missions and station housekeeping growth, given projections of future earth-to-orbit transportation capabilities. Author

A91-13447* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
HIGH TEMPERATURE SUPERCONDUCTIVITY TECHNOLOGY FOR ADVANCED SPACE POWER SYSTEMS

KARL A. FAYMON, IRA T. MYERS, and DENIS J. CONNOLLY (NASA, Lewis Research Center, Cleveland, OH) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 185-194. refs
Copyright

In 1987, the Lewis Research center of the NASA and the Argonne National Laboratory of the Department of Energy joined in a cooperative program to identify and assess high payoff space and aeronautical applications of high temperature superconductivity (HTSC). The initial emphasis of this effort was limited, and those space power related applications which were considered included microwave power transmission and magnetic energy storage. The results of these initial studies were encouraging and indicated the need of further studies. A continuing collaborative program with Argonne National Laboratory has been formulated and the Lewis Research Center is presently structuring a program to further evaluate HTSC, identify applications and define the requisite technology development programs for space power systems. This paper discusses some preliminary results of the previous evaluations in the area of space power applications of HTSC which were carried out under the joint NASA-DOE program, the future NASA-Lewis proposed program, its thrusts, and its intended outputs and give general insights on the anticipated impact of HTSC for space power applications of the future. Author

A91-13450* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SP-100 POWER SYSTEM DEVELOPMENT STATUS
JACK F. MONDT (JPL, Pasadena, CA) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 241-273.
Copyright

The SP-100 ground engineering system development project objectives, approach and status are described. The SP-100 GES development project is phase II of a three-phase program funded and directed by three United States Federal Agencies (NASA, DOD and DOE) to develop space reactor power systems for space applications in the 10 to 1000 KWe power range. The first phase of the program lasted three years, and this was completed at the end of FY 1985. SP-100 Phase I analytically and experimentally reviewed all near-term space reactor power system candidates and selected one system that best met the project mission requirements for future civilian and military space applications. The SP-100 Phase II started in fiscal year 1986 to develop the Phase I selected space reactor power system to be technically ready for space applications in the mid- to late 1990s. Author

A91-13875#
POWER SUPPLY TECHNOLOGIES - KEYSTONES FOR SPACE AND TERRESTRIAL DEVELOPMENT
A. FRITZSCHE, G. REICH, and W. SCHWARZOTT (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. refs
(IAF PAPER 90-215) Copyright

Terrestrial and space energy systems share such technical requirements as high conversion efficiencies, long service life, high reliability, and substantial adaptability to user requirements, in conjunction with growth capacity. Attention is presently given to current technological possibilities in solar energy utilization, energy storage, and such regenerative media energy-supply concepts as solar cells. Both solar-dynamic and photovoltaic solar systems are discussed; the former may operate according to the Stirling, organic Rankine, or Brayton cycles. In any of these cases, solar dynamic power systems will benefit from extensive existing experience with turbomachinery. O.C.

A91-13876#
MICROWAVE POWER TRANSMISSION SYSTEM - SPACE FLIGHT EXPERIMENT PROGRAM
KAI WHANG, FRANK E. LITTLE, and MIKE O. KENNEDY (Texas A & M University, College Station) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 20 p. refs
(IAF PAPER 90-216)

A concept is discussed of an orbiting power station providing electric power to docked or tethered spacecraft by microwave transmission. The program is suggested to have three phases. The first phase will use a 2.45 GHz system transmitting over a relatively short distance from a microwave transmitter in the Shuttle payload bay to a rectifier antenna (rectenna) attached to the end of a remote manipulator system. In the second phase, the rectenna will be attached to a free-flying stabilized platform operating at a significantly farther distance. This flight will develop methods for targeting, establishment of a pilot beam, and identification of requirements for station-keeping. In the third phase, the energy will be transmitted at higher frequencies, thereby incorporating a smaller rectenna operating over a greater distance. C.D.

A91-13877#
INVESTIGATION OF HIGH EFFICIENT SOLAR ENERGY CONCENTRATORS WITH THE HELP OF THE SOVIET AUTOMATIC UNIVERSAL ORBITAL STATION (AUOS-SM)
V. I. DRANOVSKII and E. I. UVAROV (Yuzhnoye Design Office, Dnepropetrovsk, Ukrainian SSR) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-217)

An experimental solar power plant which is to be used in a planned investigation of the power characteristics of solar energy concentrators with photocells of various designs is briefly discussed. The characteristics of the solar panels and the configuration of the concentrators on the panels are described. The role of the AUOS-SM station in carrying out the experiment is briefly addressed. C.D.

A91-13878#
NEW ARCHITECTURES FOR SPACE POWER SYSTEMS
M. EHSANI, O. BIGLIC, and A. D. PATTON (Texas A & M University, College Station) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p. Research supported by General Dynamics Corp., Texas A & M University, and EPRI. refs
(IAF PAPER 90-218) Copyright

Electric power generation and conditioning have experienced revolutionary development over the past two decades. Furthermore, new materials such as high-energy magnets and high-temperature superconductors are either available or on the horizon. The present work is based on the promise that new technologies are an important driver of new power system concepts and architectures. This observation is born out by the historical evolution of power systems both in terrestrial and aerospace applications. This paper introduces new approaches to designing space power systems by using several new technologies. Author

A91-13879#
REGENERATIVE FUEL CELLS FOR USE IN SPACE STATIONS
UWE BENZ and WERNER TILLMETZ (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p. refs
(IAF PAPER 90-219) Copyright

The conversion and storage of energy with high efficiency and high energy density, respectively, will be an important factor in future space activities as well as for terrestrial applications. The basic concepts of a regenerative fuel cell system (RFCS) based on the immobile alkaline electrolyte technology, which has been identified as the most promising technology for space application, are presented. A system optimization with respect to a minimum overall mass has been performed, and the main design data are given. Some system engineering aspects are discussed, as well as possible interfaces to other space systems. A brief comparison shows that even from a system-mass point of view the RFCS has an advantage over batteries. Author

A91-13880#

RECEIVER DEVELOPMENT FOR A SOLAR DYNAMIC POWER MODULE WITH RESPECT TO SPACE AND TERRESTRIAL APPLICATIONS

DOERTE LAING, SIEGFRIED KRAUSE, and GEROLD NOYES (DLR, Institut fuer Technische Thermodynamik, Stuttgart, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs

(IAF PAPER 90-220) Copyright

A heat-pipe/heat-storage receiver concept for solar dynamic energy conversion units with a Stirling engine for space stations is presented. Theoretical estimates for the heat flows between heat pipe, heat storage, and Stirling heater head are described. The heat transfer from and to the storage elements is adequate in all operation modes and states of loading of the storage. The dish/Stirling technology has also a high terrestrial potential. Therefore, to gain experience, a first heat pipe receiver was built for a terrestrial module, using an SPS V-160 Stirling engine. Test results of the performance tests of the V-160 Stirling heated by a natural gas burner and the heat pipe receiver/Stirling unit, heated by an electrical graphite heater, are presented. The V-160 Stirling showed a good part-load performance and a maximum thermal-to-electric conversion efficiency of 26.5 percent at 8.9 kWc power output. The heat pipe receiver performed without problems. A maximum electrical heating power of 35 kW has been applied. Dynamic system behavior has been tested with rapid changes in power input between 0 and 20 kW. Author

A91-13881#

CERAMIC MATERIALS FOR SPACE STATION'S HEAT OF FUSION THERMAL ENERGY STORAGE

STEFAN WEINGARTNER and JUERGEN BLUMENBERG (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p. refs

(IAF PAPER 90-221) Copyright

Solar-dynamic power modules are planned to be added to the photovoltaic system in the Space Station Freedom phase two configuration in order to minimize solar-collector area. The possibilities to use ceramic materials for advanced storage units in order to improve the storage unit's performance and reduce its weight are considered in this paper. The following three main application perspectives for ceramics were identified and are described in detail: ceramic containment material, ceramic coating of metal containments, and ceramic foam matrix inside a metal containment. An improved storage concept using Si3N4-SiC foam soaked with LiF as storage medium, sealed in a metal containment, is presented. A reduction of storage-system mass by 25 percent compared to state-of-the-art designs is expected. Author

A91-13882#

CERAMIC CANISTERS FOR LITHIUM FLUORIDE THERMAL STORAGE INTEGRATED WITH SOLAR DYNAMIC SPACE POWER SYSTEMS

F. LINDNER and H. J. STAEHLE (DLR, Institut fuer Technische Thermodynamik, Stuttgart, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p. refs

(IAF PAPER 90-222) Copyright

Ceramic canisters using LiF for latent heat storage in solar dynamic power systems at temperatures between 800 and 900 C are discussed. The canister integration into heat pipes or assembly on the outside of heat pipes are examined, and the canister design is addressed. A related experiment expected to be carried out as part of the TEXUS program is briefly described. The sealing of the canisters is discussed. C.D.

A91-13884#

OPTIMIZATION OF A CASSEGRAINIAN COLLECTOR/RECEIVER-SYSTEM FOR SOLAR-DYNAMIC SPACE POWER GENERATION

W. ZOERNER, W. SEDLMAIR, and JUERGEN BLUMENBER (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. refs

(IAF PAPER 90-224) Copyright

A simulation of a solar collector/receiver system (CRS) of the Cassegrain type is discussed. The aperture optimization is demonstrated, and the effects of pointing errors and mirror slope errors are reported. It is shown that the latter have a negligible effect on CRS performance. The characteristics of Newtonian CRSs, asymmetric Newtonian CRSs, and Cassegrain CRSs are reviewed. C.D.

A91-14246*# Physical Sciences, Inc., Andover, MA.

THRESHOLD VOLTAGE FOR ARCING ON NEGATIVELY BIASED SOLAR ARRAYS

DANIEL E. HASTINGS, GUY WEYL, and DONALD KAUFMAN (Physical Sciences, Inc., Andover, MA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 539-544. refs

(Contract NAS3-25402)

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The arcing that has been found to occur when negatively biased high-voltage solar arrays in LEO lie at a critical voltage with respect to the plasma environment is presently proposed to be due to a breakdown of gas emitted under electron bombardment from the solar cells' cover-glass. The elements of the model for this phenomenon include an electron current flow from the interconnect to a neighboring cover-glass, which desorbs neutral molecules under the electron bombardment. The neutral molecules form a gas over the interconnect, and this gas breaks down when the voltage over the interconnect is sufficiently high. Specific scaling predictions are made on the basis of the geometric structure and gas in question. O.C.

A91-14248*# Physikalisch-Technische Studien G.m.b.H., Freiburg (Germany, F.R.).

PARTICLE-IN-CELL SIMULATIONS OF SHEATH FORMATION AROUND BIASED INTERCONNECTORS IN A LOW-EARTH-ORBIT PLASMA

H. THIEMANN (Physikalisch-Technische Studien GmbH, Freiburg im Breisgau, Federal Republic of Germany) and R. W. SCHUNK (Utah State University, Logan) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 554-562. refs

(Contract NAG3-792; F49620-86-C-0109; ESA-6469/85-NL/IW)

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The interaction between satellite solar arrays and the LEO plasma is presently studied with particle-in-cell simulations in which an electrical potential was suddenly applied to the solar cell interconnector. The consequent temporal response was followed for the real O(+)-electron mass ratio in the cases of 100- and 250-V solar cells, various solar cell thicknesses, and solar cells with secondary electron emission. Larger applied potentials and thinner solar cells lead to greater initial polarization surface charges, and therefore longer discharging and shielding times. When secondary electron emission from the cover glass is brought to bear, however, the potential structure is nearly planar, allowing constant interaction between plasma electrons and cover glass; a large fraction of the resulting secondary electrons is collected by the interconnector, constituting an order-of-magnitude increase in collected current. O.C.

A91-14249#

WHERE DO NEGATIVELY BIASED SOLAR ARRAYS ARC?

H. THIEMANN (Physikalisch-Technische Studien GmbH, Freiburg im Breisgau, Federal Republic of Germany), R. W. SCHUNK (Utah State University, Logan), and K. BOGUS (ESTEC, Noordwijk, Netherlands) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 563-565. refs

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Experimental results are presented from solar array-LEO plasma interaction ground tests for the case of negatively biased solar array modules, with a view to the relationship between the degree of degradation of a sample and a given voltage regime. The novel failure mode studied in this negative voltage range occurs at solar cell edges, rather than at the interconnectors, as in other experiments. The arc discharges between solar cell edge regions and Kapton foil begin at voltages of -200 V; arc discharges occur only once at a given location. O.C.

A91-22099
SPACE POWER SYSTEMS [KOSMICHESKIE ENERGOSISTEMY]
VLADIMIR A. VANKE, LEONID V. LESKOV, and ALEKSANDR V. LUK'IANOV Moscow, Izdatel'stvo Mashinostroenie, 1990, 144 p. In Russian. refs
Copyright

The current status of space power systems designed for a wide range of commercial applications is reviewed, and future prospects for such systems are discussed. Space-based solar power stations supplying electric power for earth applications are described, as are solar reflectors for providing light on earth and other systems. Attention is also given to the development and applications of space transportation systems and to the use of extraterrestrial resources for construction in space. The cost effectiveness of the above systems is discussed. V.L.

A91-23004
SPACE POWER SYSTEMS REQUIREMENTS AND ISSUES - THE NEXT DECADE
LOWELL D. MASSIE (USAF, Aero Propulsion and Power Laboratory, Wright-Patterson AFB, OH) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 5, Dec. 1990, p. 4-9. refs
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Some of the more important space power technology issues, requirements, and challenges of the 1990s are described, and the impact of new component technology on the overall performance of space power systems is assessed. Advanced component, subsystem and system technologies that will significantly affect the performance, reliability, and survivability of next-generation baseload and burst mode space power systems are emphasized. Technology disciplines related to power sources (solar/nuclear and chemical), power conversion, energy storage, power conditioning/distribution and control, and waste-heat acquisition, transport, and rejection are primarily addressed. For some of them, performance trends that can be used as the basis for projecting future advanced power-system performance are developed. Performance capabilities for several different types of space power system for both baseload and burst mode applications are postulated on the basis of evolving technology and point designs that incorporate projections of advanced component capabilities. I.E.

A91-23008
ELECTRICAL POWER SUBSYSTEM INITIAL SIZING
ROBERT L. MOSER (Martin Marietta Astronautics Group, Denver, CO) IEEE Aerospace and Electronic Systems Magazine (ISSN 0885-8985), vol. 5, Dec. 1990, p. 29-34. refs
Copyright

The basics of performing the initial electrical power subsystem sizing for a spacecraft using solar cells for an energy source and batteries for energy storage are covered. The basic engineering inputs are described. The outputs are the first estimate of the number of solar cells, the solar array area, and the number of batteries required. A spreadsheet program to keep track of the inputs, perform the calculations, and document the inputs and outputs was written. I.E.

A91-23075
AMPLITUDE SCALING OF SOLAR ARRAY DISCHARGES
A. BOGORAD, C. BOWMAN, L. RAYADURG (General Electric Co., Astro-Space Div., Princeton, NJ), T. STERNER, J. LOMAN (General Electric Co., Astro-Space Div., Philadelphia, PA) et al. (IEEE, DNA, JPL, et al., Annual Conference on Nuclear and Space Radiation Effects, 27th, Reno, NV, July 16-20, 1990) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 37, pt. 1, Dec. 1990, p. 2112-2119. Research supported by General Electric Co. refs
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The problem of finding accurate scaling rules for solar arrays is addressed. Sections of a solar panel of four different sizes were charged in a 20-keV monoenergetic electron beam. The measured amplitudes of discharge transients coupled into power lines scaled linearly with the length of the rows of parallel-connected solar cells in the solar cell circuits. The authors describe the experimental determination of solar-array discharge scaling with area, with coverglass thickness, with solar-cell size, and with the number of cells, either in series or in parallel, in a circuit on a solar array. I.E.

A91-23076
INTERPRETATION OF HIGH VOLTAGE SOLAR ARRAY DISCHARGE EXPERIMENTS
N. JOHN STEVENS, CAROL S. UNDERWOOD, and MICHAEL R. JONES (TRW Space and Technology Group, Redondo Beach, CA) (IEEE, DNA, JPL, et al., Annual Conference on Nuclear and Space Radiation Effects, 27th, Reno, NV, July 16-20, 1990) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. 37, pt. 1, Dec. 1990, p. 2120-2127. refs
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High-voltage operation of photovoltaic power sources in low earth orbit is limited by the probability of discharges in the array. Laboratory experiments were conducted to characterize these discharges. A model is proposed that suggests that experiments conducted to date have measured transients related to the discharging of the solar cell cover glass as a result of a discharge rather than the discharge itself. A system analysis approach is adopted to model the discharge transient. It is found that the experimental transients could be modeled as the decharging of the solar cell cover glass through the adhesive resistance. Ion current collection by the interconnects after the discharge could be modeled as an equivalent inductor. The predictions of this model are shown to be in excellent agreement with the data. I.E.

A91-26061
MULTI-MEGAWATT SPACE POWER REACTORS
JOHN A. DEARIEN and JUDSON F. WHITBECK (Idaho National Engineering Laboratory, Idaho Falls) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 4, 1990, p. 325-348.
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In response to the needs of the Strategic Defense Initiative and long-range space-exploration and extraterrestrial basing by NASA, concepts for nuclear power systems in the multimegawatt levels are being evaluated. The requirements for these power systems are being driven primarily by the need to minimize weight and maximize safety and reliability. This paper discusses the present requirements for space-based advanced power systems, technological issues associated with the development of these advanced nuclear power systems, and some of the concepts proposed for generating large amounts of power in space. Author

A91-26063* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EVOLUTIONARY PATH TO SATELLITE SOLAR POWER SYSTEMS
GEOFFREY A. LANDIS (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 4, 1990, p. 365-371. refs
Copyright

A difficulty with proposals for satellite solar power systems is the absence of a plausible evolutionary pathway to development of systems on the scale required. One possible pathway is discussed, where the required technologies are developed and refined on an incremental scale. The initial stages of the process are development of ground-based photovoltaic power and of beamed power systems for space use. Author

A91-27691
A MISSION TO EARTH - GLOBAL RURAL ELECTRIFICATION
RAYMOND S. LEONARD (Ad Astra, Ltd., Santa Fe, NM) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1175-1184. Research supported by Ad Astra, Ltd. refs
Copyright

In pursuit of space-based 'missions to earth' addressing such progressive aspirations as the general improvement of living standards for developing nations, a technological requirements and economic feasibility evaluation is conducted on the distribution of electrical power to Third World rural areas from orbit. The furnishing of power by such means offers a moral rationale for the undertaking of space exploration and industrialization. A capital recovery factor equation is used to calculate launch and hardware costs for a photovoltaic generation/microwave-transmission demonstration system, in constant 1988 dollars; an overall cost of less than $0.5 billion is obtained for the demonstrator, by comparison with $77 million for a terrestrial system of comparable output. O.C.

A91-30892* Purdue Univ., West Lafayette, IN.
SIMULATION AND DYNAMIC PERFORMANCE OF A 20-KHZ SPACECRAFT POWER SYSTEM
O. WASYNCZUK (Purdue University, West Lafayette, IN) and P. C. KRAUSE (P.C. Krause and Associates, Inc., West Lafayette, IN) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 343-347.
(Contract NAS8-38035)
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A candidate 20-kHz spacecraft power system which includes a series-parallel combination of four Mapham inverters connected to several types of loads is described. A computer simulation of the power system is used to illustrate its steady-state and dynamic performance on an end-to-end basis. Comparisons with measured data are made. It is shown that significant distortion of the 20-kHz bus voltage can occur due to the switching of the load converters. This distortion can be reduced by including a shunt-connected parallel resonant filter on the 20-kHz side of the load converter. It is also shown that the distortion can be reduced by using a pulse-density-modulated switching strategy. I.E.

N91-10618*# Alabama Univ., Huntsville.
NETWORK, SYSTEM, AND STATUS SOFTWARE ENHANCEMENTS FOR THE AUTONOMOUSLY MANAGED ELECTRICAL POWER SYSTEM BREADBOARD. VOLUME 1: PROJECT SUMMARY Research Report, Jun. 1988 - May 1990
JAMES W. MCKEE 1990 19 p
(Contract NAG8-720)
(NASA-CR-185880; NAS 1.26:185880; REPT-90-18-VOL-1)
Avail: NTIS HC/MF A03 CSCL 09B

This volume (1 of 4) gives a summary of the original AMPS software system configuration, points out some of the problem areas in the original software design that this project is to address, and in the appendix collects all the bimonthly status reports. The purpose of AMPS is to provide a self reliant system to control the generation and distribution of power in the space station. The software in the AMPS breadboard can be divided into three levels: the operating environment software, the protocol software, and the station specific software. This project deals only with the operating environment software and the protocol software. The present station specific software will not change except as necessary to conform to new data formats. E.R.

N91-10619*# Alabama Univ., Huntsville.
NETWORK, SYSTEM, AND STATUS SOFTWARE ENHANCEMENTS FOR THE AUTONOMOUSLY MANAGED ELECTRICAL POWER SYSTEM BREADBOARD. VOLUME 2: PROTOCOL SPECIFICATION Research Report, Jun. 1988 - May 1990
JAMES W. MCKEE 1990 119 p
(Contract NAG8-720)
(NASA-CR-185881; NAS 1.26:185881; REPT-90-18-VOL-2)
Avail: NTIS HC/MF A06 CSCL 09B

This volume (2 of 4) contains the specification, structured flow charts, and code listing for the protocol. The purpose of an autonomous power system on a spacecraft is to relieve humans from having to continuously monitor and control the generation, storage, and distribution of power in the craft. This implies that algorithms will have been developed to monitor and control the power system. The power system will contain computers on which the algorithms run. There should be one control computer system that makes the high level decisions and sends commands to and receive data from the other distributed computers. This will require a communications network and an efficient protocol by which the computers will communicate. One of the major requirements on the protocol is that it be real time because of the need to control the power elements. E.R.

N91-10620*# Alabama Univ., Huntsville.
NETWORK, SYSTEM, AND STATUS SOFTWARE ENHANCEMENTS FOR THE AUTONOMOUSLY MANAGED ELECTRICAL POWER SYSTEM BREADBOARD. VOLUME 3: COMMANDS SPECIFICATION Research Report, Jun. 1988 - May 1990
JAMES W. MCKEE 1990 15 p
(Contract NAG8-720)
(NASA-CR-185882; NAS 1.26:185882; REPT-90-18-VOL-3)
Avail: NTIS HC/MF A03 CSCL 09B

This volume (3 of 4) contains the specification for the command language for the AMPS system. The volume contains a requirements specification for the operating system and commands and a design specification for the operating system and command. The operating system and commands sits on top of the protocol. The commands are an extension of the present set of AMPS commands in that the commands are more compact, allow multiple sub-commands to be bundled into one command, and have provisions for identifying the sender and the intended receiver. The commands make no change to the actual software that implement the commands. E.R.

N91-10621*# Alabama Univ., Huntsville.
NETWORK, SYSTEM, AND STATUS SOFTWARE ENHANCEMENTS FOR THE AUTONOMOUSLY MANAGED ELECTRICAL POWER SYSTEM BREADBOARD. VOLUME 4: GRAPHICAL STATUS DISPLAY Research Report, Jun. 1988 - May 1990
JAMES W. MCKEE 1990 56 p
(Contract NAG8-720)
(NASA-CR-185879; NAS 1.26:185879; REPT-90-18-VOL-4)
Avail: NTIS HC/MF A04 CSCL 09B

This volume (4 of 4) contains the description, structured flow charts, prints of the graphical displays, and source code to generate the displays for the AMPS graphical status system. The function of these displays is to present to the manager of the AMPS system a graphical status display with the hot boxes that allow the manager to get more detailed status on selected portions of the AMPS system. The development of the graphical displays is divided into two processes; the creation of the screen images and storage of them in files on the computer, and the running of the status program which uses the screen images. E.R.

N91-11053*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
ANALYSIS AND DESIGN OF A HIGH POWER, DIGITALLY-CONTROLLED SPACECRAFT POWER SYSTEM Semiannual Report

F. C. LEE and B. H. CHO 16 May 1990 126 p
(Contract NAG5-1232)
(NASA-CR-186546; NAS 1.26:186546) Copyright Avail: NTIS HC/MF A07 CSCL 10B

The progress to date on the analysis and design of a high power, digitally controlled spacecraft power system is described. Several battery discharger topologies were compared for use in the space platform application. Updated information has been provided on the battery voltage specification. Initially it was thought to be in the 30 to 40 V range. It is now specified to be 53 V to 84 V. This eliminated the tapped-boost and the current-fed auto-transformer converters from consideration. After consultations with NASA, it was decided to trade-off the following topologies: (1) boost converter; (2) multi-module, multi-phase boost converter; and (3) voltage-fed push-pull with auto-transformer. A non-linear design optimization software tool was employed to facilitate an objective comparison. Non-linear design optimization insures that the best design of each topology is compared. The results indicate that a four-module, boost converter with each module operating 90 degrees out of phase is the optimum converter for the space platform. Large-signal and small-signal models were generated for the shunt, charger, discharger, battery, and the mode controller. The models were first tested individually according to the space platform power system specifications supplied by NASA. The effect of battery voltage imbalance on parallel dischargers was investigated with respect to dc and small-signal responses. Similarly, the effects of paralleling dischargers and chargers were also investigated. A solar array and shunt model was included in these simulations. A model for the bus mode controller (power control unit) was also developed to interface the Orbital replacement Unit (ORU) model to the platform power system. Small signal models were used to generate the bus impedance plots in the various operating modes. The large signal models were integrated into a system model, and time domain simulations were performed to verify bus regulation during mode transitions. Some changes have subsequently been incorporated into the models. The changes include the use of a four module boost discharger, and a new model for the mode controller, which includes the effects of saturation. The new simulations for the boost discharger show the improvement in bus ripple that can be achieved by phase-shifted operation of each of the boost modules. Author

N91-12080# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Stuttgart (Germany, F.R.). Inst. fuer Technische Physik.
LASER TECHNOLOGY FOR SPACE TASKS
UWE BRAUCH, WOLFGANG SCHALL, GERHARD SPINDLER, WOLFRAM WITTWER, and EBERHARD ZEYFANG Apr. 1990 52 p In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-1246)
(DLR-MITT-90-10; ISSN-0176-7739; ETN-90-98048) Copyright Avail: NTIS HC/MF A04; DLR, VB-PL-DO, Postfach 90 60 58, 5000 Cologne, Fed. Republic of Germany, HC 20 Deutsche marks

The possibilities of using lasers for energy supply, transport and debris elimination in space are studied. Laser cutting has been successful for aluminum, titanium and their alloys, and ceramics and composites, for space structures. Optimal photoelectric convectors of laser light to electric energy show a high efficiency, such as thermic lasers, which seem a good alternative to chemical and electrical energy vectors for low Earth orbital stations. For the estimation of the debris size, the focusing of a laser beam with lenses or a little mirror is possible with mean power lasers. It is concluded that laser technology shows a high potential for the future and needs a better development. ESA

N91-12748*# Martin Marietta Corp., Denver, CO. Astronautics Group.
SPACE STATION AUTOMATION OF COMMON MODULE POWER MANAGEMENT AND DISTRIBUTION, VOLUME 2 Final Report
B. ASHWORTH, J. RIEDESEL, C. MYERS, L. JAKSTAS, and D. SMITH Jul. 1990 463 p
(Contract NAS8-36433)
(NASA-CR-184035; NAS 1.26:184035; MCR-89-516-VOL-2) Avail: NTIS HC/MF A20 CSCL 22/2

The new Space Station Module Power Management and Distribution System (SSM/PMAD) testbed automation system is described. The subjects discussed include testbed 120 volt dc star bus configuration and operation, SSM/PMAD automation system architecture, fault recovery and management expert system (FRAMES) rules english representation, the SSM/PMAD user interface, and the SSM/PMAD future direction. Several appendices are presented and include the following: SSM/PMAD interface user manual version 1.0, SSM/PMAD lowest level processor (LLP) reference, SSM/PMAD technical reference version 1.0, SSM/PMAD LLP visual control logic representation's (VCLR's), SSM/PMAD LLP/FRAMES interface control document (ICD) , and SSM/PMAD LLP switchgear interface controller (SIC) ICD. Author

N91-13986# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID. Strategic Defense Initiative Organization.
SP-100 FROM GROUND DEMONSTRATION TO FLIGHT VALIDATION
DAVID BUDEN 1989 3 p Presented at the Winter Meeting of the American Nuclear Society (ANS) and Nuclear Power and Technology Exhibit, San Francisco, CA, 26-30 Nov. 1989
(Contract DE-AC07-76ID-01570)
(DE91-001869; EGG-M-89286; CONF-891103-78) Avail: NTIS HC/MF A01

The SP-100 program is in the midst of developing and demonstrating the technology of a liquid metal cooled, fast reactor using thermoelectric thermal-to-electric conversion devices for space power applications in the range of 10s to 100s of kilowatts. The current Ground Engineering System (GES) design and development phase will demonstrate the readiness of the technology building blocks and the system to proceed to flight system validation. This phase includes the demonstration of a 2.4 MW thermal reactor in the Nuclear Assembly Test (NAT) and aerospace subsystem in the Integrated Assembly Test (IAT). The next phase in the SP-100 development, now being planned, is to be a flight demonstration of the readiness of the technology to be incorporated into future military and civilian missions. DOE

N91-13987# Idaho National Engineering Lab., Idaho Falls.
UNIQUE FEATURES OF SPACE REACTORS
DAVID BUDEN 1990 7 p Presented at the American Nuclear Society Topical Meeting on Safety of Non-Commercial Nuclear Reactor Research and Irradiation Facilities, Boise, ID, 30 Sep. - 3 Oct. 1990
(Contract DE-AC07-76ID-01570)
(DE91-001910; EGG-M-90309; CONF-900917-24) Avail: NTIS HC/MF A02

Space reactors are designed to meet a unique set of requirements; they must be sufficiently compact to be launched in a rocket to their operational location, operate for many years without maintenance and servicing, operate in extreme environments, and reject heat by radiation to space. To meet these restrictions, operating temperatures are much greater than in terrestrial power plants, and the reactors tend to have a fast neutron spectrum. Currently, a new generation of space reactor power plants is being developed. The major effort is in the SP-100 program, where the power plant is being designed for seven years of full power, and no maintenance operation at a reactor outlet operating temperature of 1350 K. DOE

N91-14817*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRELIMINARY SURVEY OF 21ST CENTURY CIVIL MISSION APPLICATIONS OF SPACE NUCLEAR POWER
JOHN C. MANKINS, J. OLIVIERI, and A. HEPENSTAL Mar. 1987 123 p Sponsored by NASA, Washington, DC
(NASA-TM-101249; JPL-D-3547; NAS 1.15:101249) Avail: NTIS HC/MF A06 CSCL 20/8

The purpose was to collect and categorize a forecast of civilian space missions and their power requirements, and to assess the suitability of an SP-100 class space reactor power system to those missions. A wide variety of missions were selected for examination. The applicability of an SP-100 type of nuclear power system was assessed for each of the selected missions; a strawman nuclear power system configuration was drawn up for each mission. The main conclusions are as follows: (1) Space nuclear power in the 50 kW sub e plus range can enhance or enable a wide variety of ambitious civil space mission; (2) Safety issues require additional analyses for some applications; (3) Safe space nuclear reactor disposal is an issue for some applications; (4) The current baseline SP-100 conical radiator configuration is not applicable in all cases; (5) Several applications will require shielding greater than that provided by the baseline shadow-shield; and (6) Long duration, continuous operation, high reliability missions may exceed the currently designed SP-100 lifetime capabilities. Author

N91-15297*# Boeing Aerospace Co., Seattle, WA.
SOLAR DYNAMIC HEAT RECEIVER TECHNOLOGY Final Report
LEIGH M. SEDGWICK Jan. 1991 133 p
(Contract NAS3-24669)
(NASA-CR-187040; NAS 1.26:187040; D180-32598-1) Avail: NTIS HC/MF A07 CSCL 22/2

A full-size, solar dynamic heat receiver was designed to meet the requirements specified for electrical power modules on the U.S. Space Station, Freedom. The heat receiver supplies thermal energy to power a heat engine in a closed Brayton cycle using a mixture of helium-xenon gas as the working fluid. The electrical power output of the engine, 25 kW, requires a 100 kW thermal input throughout a 90 minute orbit, including when the spacecraft is eclipsed for up to 36 minutes from the sun. The heat receiver employs an integral thermal energy storage system utilizing the latent heat available through the phase change of a high-temperature salt mixture. A near eutectic mixture of lithium fluoride and calcium difluoride is used as the phase change material. The salt is contained within a felt metal matrix which enhances heat transfer and controls the salt void distribution during solidification. Fabrication of the receiver is complete and it was delivered to NASA for verification testing in a simulated low-Earth-orbit environment. This document reviews the receiver design and describes its fabrication history. The major elements required to operate the receiver during testing are also described. Author

N91-15628*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
IMPEDANCES OF ELECTROCHEMICALLY IMPREGNATED NICKEL ELECTRODES AS FUNCTIONS OF POTENTIAL, KOH CONCENTRATION, AND IMPREGNATION METHOD
MARGARET A. REID May 1989 12 p Presented at the 1st International Symposium on Electrochemical Impedance Spectroscopy, Bombannes, France, 22-26 May 1989; sponsored in part by the Centre Nationale Research Society, and the University of Paris
(NASA-TM-103283; E-5738; NAS 1.15:103283) Avail: NTIS HC/MF A03 CSCL 10/1

Impedances of fifteen electrodes form each of the four U.S. manufactures were measured at 0.200 V vs. the Hg/HgO reference electrode. This corresponds to a voltage of 1.145 for a Ni/H2 cell. Measurements were also made of a representative sample of these at 0.44 V. At the higher voltage, the impedances were small and very similar, but at the lower voltage there were major differences between manufacturers. Electrodes from the same manufacturers showed only small differences. The impedances of electrodes from two manufacturers were considerably different in 26 percent KOH from those in 31 percent KOH. These preliminary results seen to correlate with the limited data from earlier life testing of cells from these manufacturers. The impedances of cells being tested for Space Station Freedom are being followed, and more impendance measurements of electrodes are being performed as functions of manufacturer, voltage, electrolyte concentration, and cycle history in hopes of finding better correlations of impedance with life. Author

N91-17452*# Lockheed Sanders, Inc., Nashua, NH.
ADVANCED STIRLING RECEIVER DEVELOPMENT PROGRAM, PHASE 1 Final Report, Dec. 1988 - Jul. 1990
CHARLES A. LURIO 18 Jul. 1990 119 p
(Contract NAS3-25471)
(NASA-CR-185281; NAS 1.26:185281) Avail: NTIS HC/MF A06 CSCL 10/2

Critical technology experiments were designed and developed to evaluate the Stirling cavity heat pipe receiver for a space solar power system. Theoretical criteria were applied to the design of a module for containing energy storage phase change material while avoiding thermal ratcheting. Zero-g drop tower tests, without phase change, were conducted to affirm that the bubble location required to avoid ratcheting could be achieved without the use of container materials that are wetted by the phase change material. A full scale module was fabricated, but not tested. A fabrication method was successfully developed for the sodium evaporator dome, with a sintered screen wick, to be used as the focal point for the receiver. Crushing of the screen during hydroforming was substantially reduced over the results of other researchers by using wax impregnation. Superheating of the sodium in the wick under average flux conditions is expected to be under 10K. A 2000K furnace which will simulate solar flux conditions for testing the evaporator dome was successfully built and tested. Author

N91-17734*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE ENVIRONMENT POWER SYSTEM ANALYSIS TOOL DEVELOPMENT PROGRAM
GARY A. JONGEWARD, ROBERT A. KUHARSKI, ERIC M. KENNEDY, N. JOHN STEVENS, RAND M. PUTNAM, JAMES C. ROCHE, and KATHERINE G. WILCOX (Systems Science and Software, La Jolla, CA.) *In* NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 352-357 Dec. 1990
Avail: NTIS HC/MF A16 CSCL 20/9

The Environment Power System Analysis Tool (EPSAT) is being developed to provide space power system design engineers with an analysis tool for determining system performance of power systems in both naturally occurring and self-induced environments. The program is producing an easy to use computer aided engineering (CAE) tool general enough to provide a vehicle for technology transfer from space scientists and engineers to power system design engineers. The results of the project after two years of a three year development program are given. The EPSAT approach separates the CAE tool into three distinct functional units: a modern user interface to present information, a data dictionary interpreter to coordinate analysis; and a data base for storing system designs and results of analysis. Author

N91-18987*# Auburn Univ., AL. Dept. of Electrical Engineering.
CURRENT LIMITING REMOTE POWER CONTROL MODULE
DOUGLAS C. HOPKINS *In* Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 09/1

The power source for the Space Station Freedom will be fully utilized nearly all of the time. As such, any loads on the system will need to operate within expected limits. Should any load draw an inordinate amount of power, the bus voltage for the system may sag and disrupt the operation of other loads. To protect the bus and loads some type of power interface between the bus and each load must be provided. This interface is most crucial when load faults occur. A possible system configuration is presented. The proposed interface is the Current Limiting Remote Power Controller (CL-RPC). Such an interface should provide the following power functions: limit overloading and resulting undervoltage; prevent catastrophic failure and still provide for redundancy management within the load; minimize cable heating;

and provide accurate current measurement. A functional block diagram of the power processing stage of a CL-RPC is included. There are four functions that drive the circuit design: rate control of current; current sensing; the variable conductance switch (VCS) technology; and the algorithm used for current limiting. Each function is discussed separately. Author

N91-19019*# Texas A&M Univ., College Station. Dept. of Electrical Engineering.

IMPLEMENTATION STRATEGIES FOR LOAD CENTER AUTOMATION ON THE SPACE STATION MODULE/POWER MANAGEMENT AND DISTRIBUTION TESTBED

KAREN WATSON *In* Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 6 p Oct. 1990

(Contract NGT-01-002-099)

Avail: NTIS HC/MF A16 CSCL 22/2

The Space Station Module/Power Management and Distribution (SSM/PMAD) testbed was developed to study the tertiary power management on modules in large spacecraft. The main goal was to study automation techniques, not necessarily develop flight ready systems. Because of the confidence gained in many of automation strategies investigated, it is appropriate to study, in more detail, implementation strategies in order to find better trade-offs for nearer to flight ready systems. These trade-offs particularly concern the weight, volume, power consumption, and performance of the automation system. These systems, in their present implementation are described. Y.S.

N91-19177*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

MULTI-DIMENSIONAL MODELING OF A THERMAL ENERGY STORAGE CANISTER M.S. Thesis - Cleveland State Univ., Dec. 1990

THOMAS W. KERSLAKE Jan. 1991 192 p

(NASA-TM-103731; E-5966; NAS 1.15:103731) Avail: NTIS HC/MF A09 CSCL 10/3

The Solar Dynamic Power Module being developed for Space Station Freedom uses a eutectic mixture of LiF-CaF2 phase change material (PCM) contained in toroidal canisters for thermal energy storage. Presented are the results from heat transfer analyses of a PCM containment canister. One and two dimensional finite difference computer models are developed to analyze heat transfer in the canister walls, PCM, void, and heat engine working fluid coolant. The modes of heat transfer considered include conduction in canister walls and solid PCM, conduction and pseudo-free convection in liquid PCM, conduction and radiation across PCM vapor filled void regions, and forced convection in the heat engine working fluid. Void shape, location, growth or shrinkage (due to density difference between the solid and liquid PCM phases) are prescribed based on engineering judgment. The PCM phase change process is analyzed using the enthalpy method. The discussion of the results focuses on how canister thermal performance is affected by free convection in the liquid PCM and void heat transfer. Characterizing these effects is important for interpreting the relationship between ground-based canister performance (in 1-g) and expected on-orbit performance (in micro-g). Void regions accentuate canister hot spots and temperature gradients due to their large thermal resistance. Free convection reduces the extent of PCM superheating and lowers canister temperatures during a portion of the PCM thermal charge period. Surprisingly small differences in canister thermal performance result from operation on the ground and operation on-orbit. This lack of a strong gravity dependency is attributed to the large contribution of container walls in overall canister energy redistribution by conduction. Author

N91-19179*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

KEY ISSUES IN SPACE NUCLEAR POWER

HENRY W. BRANDHORST Jan. 1991 8 p Presented at the 8th Symposium on Space Nuclear Power Systems, Albuquerque, NM, 6-10 Jan. 1991; sponsored in part by New Mexico Univ., Strategic Defense Initiative Organization, DOE, AF

(NASA-TM-103656; E-5847; NAS 1.15:103656) Avail: NTIS HC/MF A02 CSCL 10/2

The future appears rich in missions that will extend the frontiers of knowledge, human presence in space, and opportunities for profitable commerce. Key to the success of these ventures is the availability of plentiful, cost effective electric power and assured, low cost access to space. While forecasts of space power needs are problematic, an assessment of future needs based on terrestrial experience has been made. These needs fall into three broad categories: survival, self sufficiency, and industrialization. The cost of delivering payloads to orbital locations from LEO to Mars has been determined and future launch cost reductions projected. From these factors, then, projections of the performance necessary for future solar and nuclear space power options has been made. These goals are largely dependent upon orbital location and energy storage needs. Finally the cost of present space power systems has been determined and projections made for future systems. Author

N91-19182*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY, 1989

Washington Jan. 1991 515 p Tenth conference held in Cleveland, OH, 7-9 Nov. 1989

(NASA-CP-3107; E-5728; NAS 1.55:3107) Avail: NTIS HC/MF A22 CSCL 10/2

Remarkable progress on a wide variety of approaches in space photovoltaics, for both near and far term applications is reported. Papers were presented in a variety of technical areas, including multi-junction cell technology, GaAs and InP cells, system studies, cell and array development, and non-solar direct conversion. Five workshops were held to discuss the following topics: mechanical versus monolithic multi-junction cells; strategy in space flight experiments; non-solar direct conversion; indium phosphide cells; and space cell theory and modeling.

N91-19183*# National Aeronautics and Space Administration, Washington, DC.

THE OAST SPACE POWER PROGRAM

GARY L. BENNETT *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 3-17 Jan. 1991

Avail: NTIS HC/MF A22 CSCL 10/2

The NASA Office of Aeronautics and Space Technology (OAST) space power program was established to provide the technology base to meet power system requirements for future space missions, including the Space Station, earth orbiting spacecraft, lunar and planetary bases, and solar system exploration. The program spans photovoltaic energy conversion, chemical energy conversion, thermal energy conversion, power management, thermal management, and focused initiatives on high-capacity power, surface power, and space nuclear power. The OAST space power program covers a broad range of important technologies that will enable or enhance future U.S. space missions. The program is well under way and is providing the kind of experimental and analytical information needed for spacecraft designers to make intelligent decisions about future power system options. Author

N91-19197*# Boeing Aerospace Co., Seattle, WA.

AN APPROACH FOR CONFIGURING SPACE PHOTOVOLTAIC TANDEM ARRAYS BASED ON CELL LAYER PERFORMANCE

C. S. FLORA and P. A. DILLARD *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 167-179 Jan. 1991

Avail: NTIS HC/MF A22 CSCL 10/2

Meeting solar array performance goals of 300 W/Kg requires use of solar cells with orbital efficiencies greater than 20 percent. Only multijunction cells and cell layers operating in tandem produce this required efficiency. An approach for defining solar array design concepts that use tandem cell layers involve the following: transforming cell layer performance at standard test conditions to on-orbit performance; optimizing circuit configuration with tandem cell layers; evaluating circuit sensitivity to cell current mismatch; developing array electrical design around selected circuit; and predicting array orbital performance including seasonal variations. Author

N91-19198*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
REVIEW OF THIN FILM SOLAR CELL TECHNOLOGY AND APPLICATIONS FOR ULTRA-LIGHT SPACECRAFT SOLAR ARRAYS
GEOFFREY A. LANDIS *In its* Space Photovoltaic Research and Technology, 1989 p 180-203 Jan. 1991
Avail: NTIS HC/MF A22 CSCL 10/2

Developments in thin-film amorphous and polycrystalline photovoltaic cells are reviewed and discussed with a view to potential applications in space. Two important figures of merit are discussed: efficiency (i.e., what fraction of the incident solar energy is converted to electricity), and specific power (power to weight ratio). Author

N91-19211*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GAP BETAVOLTAIC CELLS AS A POWER SOURCE
F. S. POOL, PAUL M. STELLA, and B. ANSPAUGH *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 359-370 Jan. 1991
Avail: NTIS HC/MF A22 CSCL 10/2

Maximum power output for the GaP cells of this study was found to be on the order of 1 microW. This resulted from exposure to 200 and 40 KeV electrons at a flux of 2 x 10(exp 9) electrons/sq cm/s, equivalent to a 54 mCurie source. The efficiencies of the cells ranged from 5 to 9 percent for 200 and 40 KeV electrons respectively. The lower efficiency at higher energy is due to a substantial fraction of energy deposition in the substrate, further than a diffusion length from the depletion region of the cell. Radiation damage was clearly observed in GaP after exposure to 200 KeV electrons at a fluence of 2 x 10(exp 12) electrons/sq cm. No discernable damage was observed after exposure to 40 KeV electrons at the same fluence. Analysis indicates that a GaP betavoltaic system would not be practical if limited to low energy beta sources. The power available would be too low even in the ideal case. By utilizing high activity beta sources, such as Sr-90/Y-90, it may be possible to achieve performance that could be suitable for some space power applications. However, to utilize such a source the problem of radiation damage in the beta cell material must be overcome. Author

N91-19212*# Chronos Research Labs., Inc., San Diego, CA.
LOW COST SPACE POWER GENERATION
RANDALL B. OLSEN *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 371-381 Jan. 1991
Avail: NTIS HC/MF A22 CSCL 10/2

The success of this study has given a method of fabricating durable copolymer films without size limitations. Previously, only compression molded samples were durable enough to generate electrical energy. The strengthened specimens are very long lived materials. The lifetime was enhanced at least a factor of 1,300 in full pyroelectric conversion cycle experiments compared with extruded, non-strengthened film. The new techniques proved so successful that the lifetime of the resultant copolymer samples was not fully characterized. The lifetime of these new materials is so long that accelerated tests were devised to probe their durability. After a total of more than 67 million high voltage electrical cycles at 100 C, the electrical properties of a copolymer sample remained stable. The test was terminated without any detectable degradation to allow for other experiments. One must be cautious in extrapolating to power cycle performance, but 67 million electrical cycles correspond to 2 years of pyroelectric cycling at 1 Hz. In another series of experiments at reduced temperature and electrical stress, a specimen survived over one-third of a billion electrical cycles during nearly three months of continuous testing. The radiation-limited lifetimes of the copolymer were shown to range from several years to millions of years for most earth orbits. Thus, the pyroelectric copolymer has become a strong candidate for serious consideration for future spacecraft power supplies. Author

N91-19213*# Solarex Corp., Rockville, MD. Aerospace Div.
SPACEFLIGHT PERFORMANCE OF SEVERAL TYPES OF SILICON SOLAR CELLS ON THE LIPS 3 SATELLITE
J. SILVER and D. WARFIELD *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 385-388 Jan. 1991
Avail: NTIS HC/MF A22 CSCL 10/2

Results from exposure of several types of Solarex silicon cells to a space environment for nearly two years on the LIPS 3 satellite are presented. Experiments include standard thickness (10 mil) cells with and without back surface fields, and ultrathin (2 mil) cells also with and without back surface fields. A comparison between a widely used coverslide adhesive, DC 93-500 and a potential alternate is also presented. The major findings from the data are that the 2 mil cells without a back surface field show the smallest normalized short circuit current degradation and that the 10 mil back surface field cells show the greatest absolute power output for the radiation exposures and temperatures encountered. The new encapsulant (McGhan Nusil CV-2500) exhibits a degradation comparable to DC 93-500. A comparison is made with each of the cell types in this experiment with expectations based on JPL Radiation Handbook data. Author

N91-19214*# Wayne State Univ., Detroit, MI. Inst. for Manufacturing Research.
ANNEALING CHARACTERISTICS OF IRRADIATED HYDROGENATED AMORPHOUS SILICON SOLAR CELLS
J. S. PAYSON, S. ABDULAZIZ, Y. LI, and J. R. WOODYARD *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 389-399 Jan. 1991
Avail: NTIS HC/MF A22 CSCL 10/2

It was shown that 1 MeV proton irradiation with fluences of 1.25E14 and 1.25E15/sq cm reduces the normalized I(sub SC) of a-Si:H solar cell. Solar cells recently fabricated showed superior radiation tolerance compared with cells fabricated four years ago; the improvement is probably due to the fact that the new cells are thinner and fabricated from improved materials. Room temperature annealing was observed for the first time in both new and old cells. New cells anneal at a faster rate than old cells for the same fluence. From the annealing work it is apparent that there are at least two types of defects and/or annealing mechanisms. One cell had improved I-V characteristics following irradiation as compared to the virgin cell. The work shows that the photothermal deflection spectroscopy (PDS) and annealing measurements may be used to predict the qualitative behavior of a-Si:H solar cells. It was anticipated that the modeling work will quantitatively link thin film measurements with solar cell properties. Quantitative predictions of the operation of a-Si:H solar cells in a space environment will require a knowledge of the defect creation mechanisms, defect structures, role of defects on degradation, and defect passivation and annealing mechanisms. The engineering data and knowledge base for justifying space flight testing of a-Si:H alloy based solar cells is being developed. Author

N91-19215*# Applied Solar Energy Corp., City of Industry, CA.
OPTIMIZATION AND PERFORMANCE OF SPACE STATION FREEDOM SOLAR CELLS
S. KHEMTHONG, N. HANSEN, and M. BOWER *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 400-409 Jan. 1991
Avail: NTIS HC/MF A22 CSCL 10/2

High efficiency, large area and low cost solar cells are the drivers for Space Station solar array designs. The manufacturing throughput, process complexity, yield of the cells, and array manufacturing technique determine the economics of the solar array design. The cell efficiency optimization of large area (8 x 8 m), dielectric wrapthrough contact solar cells are described. The results of the optimization are reported and the solar cell performance of limited production runs is reported. Author

N91-19217*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

THE ADVANCED PHOTOVOLTAIC SOLAR ARRAY (APSA) TECHNOLOGY STATUS AND PERFORMANCE

PAUL M. STELLA and RICHARD M. KURLAND (TRW Space Technology Labs., Redondo Beach, CA.) *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 421-432 Jan. 1991

Avail: NTIS HC/MF A22 CSCL 10/2

In 1985, the Jet Propulsion Laboratory initiated the Advanced Photovoltaic Solar Array (APSA) program. The program objective is to demonstrate a producible array system by the early 1990s with a specific performance of at least 130 W/kG (beginning-of-life) as an intermediate milestone towards the long range goal of 300 W/kG. The APSA performance represents an approximately four-fold improvement over existing rigid array technology and a doubling of the performance of the first generation NASA/OAST SAFE flexible blanket array of the early 1980s. Author

N91-19220*# Aerospace Corp., Los Angeles, CA. Chemistry and Physics Lab.

STRATEGY IN SPACE FLIGHT EXPERIMENTS

DEAN MARVIN and JAMES SEVERNS (Naval Research Lab., Washington, DC.) *In* NASA, Lewis Research Center, Space Photovoltaic Research and Technology, 1989 p 469-473 Jan. 1991

Avail: NTIS HC/MF A22 CSCL 10/2

The main topics of the workshop were the evaluation of both the need for flight testing of solar array hardware and the opportunities for such testing. Spacecraft charging effects, array dynamics, cost-effectiveness, and methods of flight planning were also discussed. B.G.

N91-19462*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

ETARA PC VERSION 3.3 USER'S GUIDE: RELIABILITY, AVAILABILITY, MAINTAINABILITY SIMULATION MODEL

DAVID J. HOFFMAN and LARRY A. VITERNA Feb. 1991 65 p

(NASA-TM-103751; E-6003; NAS 1.15:103751) Avail: NTIS HC/MF A04 CSCL 14/4

A user's manual describing an interactive, menu-driven, personal computer based Monte Carlo reliability, availability, and maintainability simulation program called event time availability reliability (ETARA) is discussed. Given a reliability block diagram representation of a system, ETARA simulates the behavior of the system over a specified period of time using Monte Carlo methods to generate block failure and repair intervals as a function of exponential and/or Weibull distributions. Availability parameters such as equivalent availability, state availability (percentage of time as a particular output state capability), continuous state duration and number of state occurrences can be calculated. Initial spares allotment and spares replenishment on a resupply cycle can be simulated. The number of block failures are tabulated both individually and by block type, as well as total downtime, repair time, and time waiting for spares. Also, maintenance man-hours per year and system reliability, with or without repair, at or above a particular output capability can be calculated over a cumulative period of time or at specific points in time. Author

N91-20561# Sandia National Labs., Albuquerque, NM.

MODELS FOR MULTIMEGAWATT SPACE POWER SYSTEMS

M. W. EDENBURN Jun. 1990 104 p

(Contract DE-AC04-76DP-00789)

(DE91-008008; SAND-86-2742) Avail: NTIS HC/MF A06

This report describes models for multimegawatt, space power systems which Sandia's Advanced Power Systems Division has constructed to help evaluate space power systems for SDI's Space Power Office. Five system models and models for associated components are presented for both open (power system waste products are exhausted into space) and closed (no waste products) systems: open, burst mode, hydrogen cooled nuclear reactor - turboalternator system; open, hydrogen-oxygen combustion turboalternator system; closed, nuclear reactor powered Brayton cycle system; closed, liquid metal Rankine cycle system; and closed, in-core, reactor thermionic system. The models estimate performance and mass for the components in each of these systems. DOE

N91-20678*# Decision-Science Applications, Inc., Arlington, VA.

AN INTELLIGENT VALUE-DRIVEN SCHEDULING SYSTEM FOR SPACE STATION FREEDOM WITH SPECIAL EMPHASIS ON THE ELECTRIC POWER SYSTEM

JOSEPH C. KRUPP *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 296-300 Jan. 1991

Avail: NTIS HC/MF A21 CSCL 10/2

The Electric Power Control System (EPCS) created by Decision-Science Applications, Inc. (DSA) for the Lewis Research Center is discussed. This system makes decisions on what to schedule and when to schedule it, including making choices among various options or ways of performing a task. The system is goal-directed and seeks to shape resource usage in an optimal manner using a value-driven approach. Discussed here are considerations governing what makes a good schedule, how to design a value function to find the best schedule, and how to design the algorithm that finds the schedule that maximizes this value function. Results are shown which demonstrate the usefulness of the techniques employed. Author

N91-20685*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

AUGMENTATION OF THE SPACE STATION MODULE POWER MANAGEMENT AND DISTRIBUTION BREADBOARD

BRYAN WALLS, DAVID K. HALL, and LOUIS F. LOLLAR *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 355-359 Jan. 1991

Avail: NTIS HC/MF A21 CSCL 10/2

The space station module power management and distribution (SSM/PMAD) breadboard models power distribution and management, including scheduling, load prioritization, and a fault detection, identification, and recovery (FDIR) system within a Space Station Freedom habitation or laboratory module. This 120 VDC system is capable of distributing up to 30 kW of power among more than 25 loads. In addition to the power distribution hardware, the system includes computer control through a hierarchy of processes. The lowest level consists of fast, simple (from a computing standpoint) switchgear that is capable of quickly safing the system. At the next level are local load center processors, (LLP's) which execute load scheduling, perform redundant switching, and shed loads which use more than scheduled power. Above the LLP's are three cooperating artificial intelligence (AI) systems which manage load prioritizations, load scheduling, load shedding, and fault recovery and management. Recent upgrades to hardware and modifications to software at both the LLP and AI system levels promise a drastic increase in speed, a significant increase in functionality and reliability, and potential for further examination of advanced automation techniques. The background, SSM/PMAD, interface to the Lewis Research Center test bed, the large autonomous spacecraft electrical power system, and future plans are discussed. Author

N91-20688*# Inference Corp., El Segundo, CA.

A FRAMEWORK FOR BUILDING REAL-TIME EXPERT SYSTEMS

S. DANIEL LEE *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 375-382 Jan. 1991

Avail: NTIS HC/MF A21 CSCL 09/2

The Space Station Freedom is an example of complex systems that require both traditional and artificial intelligence (AI) real-time methodologies. It was mandated that Ada should be used for all *new software development projects. The station also requires* distributed processing. Catastrophic failures on the station can cause the transmission system to malfunction for a long period of time, during which ground-based expert systems cannot provide any assistance to the crisis situation on the station. This is even more critical for other NASA projects that would have longer transmission delays (e.g., the lunar base, Mars missions, etc.). To address these issues, a distributed agent architecture (DAA) is proposed that can support a variety of paradigms based on both traditional real-time computing and AI. The proposed testbed for DAA is an autonomous power expert (APEX) which is a real-time monitoring and diagnosis expert system for the electrical power distribution system of the space station. Author

N91-20689*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AUTONOMOUS POWER EXPERT SYSTEM ADVANCED DEVELOPMENT
TODD M. QUINN (Sverdrup Technology, Inc., Brook Park, OH.) and JERRY L. WALTERS *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 383-390 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 10/2

The autonomous power expert (APEX) system is being developed at Lewis Research Center to function as a fault diagnosis advisor for a space power distribution test bed. APEX is a rule-based system capable of detecting faults and isolating the probable causes. APEX also has a justification facility to provide natural language explanations about conclusions reached during fault isolation. To help maintain the health of the power distribution system, additional capabilities were added to APEX. These capabilities allow detection and isolation of incipient faults and enable the expert system to recommend actions/procedure to correct the suspected fault conditions. New capabilities for incipient fault detection consist of storage and analysis of historical data and new user interface displays. After the cause of a fault is determined, appropriate recommended actions are selected by rule-based inferencing which provides corrective/extended test procedures. Color graphics displays and improved mouse-selectable menus were also added to provide a friendlier user interface. A discussion of APEX in general and a more detailed description of the incipient detection, recommended actions, and user interface developments during the last year are presented. Author

N91-20728*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
FINDINGS OF THE JOINT WORKSHOP ON EVALUATION OF IMPACTS OF SPACE STATION FREEDOM GROUND CONFIGURATIONS
DALE C. FERGUSON, DAVID B. SNYDER, and RALPH CARRUTH (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 689-694 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 22/2

At the workshop, experts from the plasma interactions community evaluated the impacts of environmental interactions on the Space Station Freedom (SSF) under each of the proposed grounding schemes. The grounding scheme chosen for the SSF power system was found to have serious implications for SSF design. Interactions of the SSF power system and structure with the low Earth orbit (LEO) plasma differ significantly between different proposed grounding schemes. Environmental constraints will require modification of current SSF designs under any grounding scheme. Maintaining the present negative-grounding scheme compromises SSF safety, structural integrity, and electromagnetic compatibility. It also will increase contamination rates over alternative grounding schemes. One alternative, positive grounding of the array, requires redesign of the primary power system in work package four. Floating the array reduces the number of circuit *changes to work package four but adds new hardware. Maintaining* the current design will affect all work packages; however, no *impacts were identified on work packages one, two, or three by* positively grounding or floating the array, with the possible exception of extra corona protection in multi-wire connectors. Author

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ELECTRONIC SYSTEMS & EQUIPMENT

Design and operation of electrical equipment such as motors, switch gear, connectors and other fixtures.

A91-30893*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
INDUCTION MOTOR CONTROL
IRVING G. HANSEN (NASA, Lewis Research Center, Cleveland, OH) IN: NAECON 90; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 21-25, 1990. Vol. 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1990, p. 348-350. Previously announced in STAR as N90-19234.

Electromechanical actuators developed to date have commonly ultilized permanent magnet (PM) synchronous motors. More recently switched reluctance (SR) motors have been advocated due to their robust characteristics. Implications of work which utilized induction motors and advanced control techniques are discussed. When induction motors are operated from an energy source capable of controlling voltages and frequencies independently, drive characteristics are obtained which are superior to either PM or SR motors. By synthesizing the machine frequency from a high-frequency carrier (nominally 20 kHz), high efficiencies, low distortion, and rapid torque response are available. At this time multiple horsepower machine drives were demonstrated, and work is on-going to develop a 20 hp average, 40 hp peak class of aerospace actuators. This effort is based upon high-frequency power distribution and management techniques developed by NASA for Space Station Freedom. Author

N91-14373*# Martin Marietta Corp., Denver, CO. Astronautics Group.
SPACE STATION COMMON MODULE NETWORK TOPOLOGY AND HARDWARE DEVELOPMENT Final Report
P. ANDERSON, L. BRAUNAGEL, S. CHWIRKA, M. FISHMAN, K. FREEMAN, D. EASON, D. LANDIS, L. LECH, J. MARTIN, J. MCCORKLE et al. Jul. 1990 226 p
(Contract NAS8-36583)
(NASA-CR-184034; NAS 1.26:184034; MCR-90-536) Avail: NTIS HC/MF A11 CSCL 22/2

Conceptual space station common module power management and distribution (SSM/PMAD) network layouts and detailed network evaluations were developed. Individual pieces of hardware to be developed for the SSM/PMAD test bed were identified. A technology assessment was developed to identify pieces of equipment requiring development effort. Equipment lists were developed from the previously selected network schematics. Additionally, functional requirements for the network equipment as well as other requirements which affected the suitability of specific items for use on the Space Station Program were identified. Assembly requirements were derived based on the SSM/PMAD developed requirements and on the selected SSM/PMAD network concepts. Basic requirements and simplified design block diagrams are included. DC remote power controllers were successfully integrated into the DC Marshall Space Flight Center breadboard. Two DC remote power controller (RPC) boards experienced mechanical failure of UES 706 stud-mounted diodes during mechanical installation of the boards into the system. These broken diodes caused input to output shorting of the RPC's. The UES 706 diodes were replaced on these RPC's which eliminated the problem. The DC RPC's as existing in the present breadboard *configuration do not provide ground fault protection because the* RPC was designed to only switch the hot side current. If ground fault protection were to be implemented, it would be necessary to design the system so the RPC switched both the hot and the return sides of power. K.S.

N91-17028*# National Aeronautics and Space Administration, Washington, DC.
RELIABILITY AND QUALITY EEE PARTS ISSUES
DAN BARNEY and IRWIN FEIGENBAUM (Vitro Corp., Washington, DC.) *In its* Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 247-273 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 09/4

NASA policy and procedures are established which govern the selection, testing, and application of electrical, electronic, and electromechanical (EEE) parts. Recent advances in the state-of-the-art of electronic parts and associated technologies can significantly impact the electronic designs and reliability of NASA space transportation avionics. Significant issues that result from these advances are examined, including: recent advances in microelectronics technology (as applied to or considered for use in NASA projects); electron packaging technology advances (concurrent with, and as a result of, the development of the advanced microelectronic devices); availability of parts used in space avionics; and standardization and integration of parts activities between projects, centers, and contractors. B.G.

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DATA & COMMUNICATION SYSTEMS

Communication and data storage or retrieval systems. Includes control systems and also computer networks and software.

A91-10073*# NASA Space Station Program Office, Reston, VA.
SPACE STATION FREEDOM DATA ASSESSMENT STUDY
ANNGIENETTA R. JOHNSON and JOSEPH DESKEVICH (NASA, Space Station Freedom Program Office, Reston, VA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 1ρ p. refs
(AIAA PAPER 90-3655) Copyright

The SSF Data Assessment Study was initiated to identify payload and operations data requirements to be supported in the Space Station era. To initiate the study payload requirements from the projected SSF user community were obtained utilizing an electronic questionnaire. The results of the questionnaire were incorporated in a personal computer compatible database used for mission scheduling and end-to-end communications analyses. This paper discusses data flow paths and associated latencies, communications bottlenecks, resource needs versus availability, payload scheduling 'warning flags' and payload data loading requirements for each major milestone in the Space Station buildup sequence. This paper also presents the statistical and analytical assessments produced using the data base, an experiment scheduling program, and a Space Station unique end-to-end simulation model. The modeling concepts and simulation methodologies presented in this paper provide a foundation for forecasting communication requirements and identifying modeling tools to be used in the SSF Tactical Operations Planning (TOP) process. Author

A91-10074*# Booz-Allen and Hamilton, Inc., Bethesda, MD.
THE EXPANDED ROLE OF COMPUTERS IN SPACE STATION FREEDOM REAL-TIME OPERATIONS
R. PAUL CRAWFORD (Booz-Allen and Hamilton, Inc., Bethesda, MD) and KATHLEEN V. CANNON (NASA, Space Station Freedom Program Office, Reston, VA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p.
(AIAA PAPER 90-3656) Copyright

The challenges that NASA and its international partners face in their real-time operation of the Space Station Freedom necessitate an increased role on the part of computers. In building the operational concepts concerning the role of the computer, the Space Station program is using lessons learned experience from past programs, knowledge of the needs of future space programs, and technical advances in the computer industry. The computer is expected to contribute most significantly in real-time operations by forming a versatile operating architecture, a responsive operations tool set, and an environment that promotes effective and efficient utilization of Space Station Freedom resources. Author

A91-10941#
CALS AND SPACE SOFTWARE - HOW CALS CAN BE APPLIED TO THE USE OF SPACE SOFTWARE
D. ALBERG HORTON (Honeywell, Inc., Minneapolis, MN) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 6 p.

This paper discusses the new CALS software requirements and how these requirements can be used with the Space Station implementation. Methods by which logistics management can control Space Station software, and implement CALS functions into Space Station software are covered. Author

A91-12382* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CCSDS ADVANCED ORBITING SYSTEMS - INTERNATIONAL DATA COMMUNICATIONS STANDARDS FOR THE SPACE STATION FREEDOM
ADRIAN J. HOOKE (JPL, Pasadena, CA) IEEE Network (ISSN 0890-8044), vol. 4, Sept. 1990, p. 13-16. refs
Copyright

Established in 1982, the Consultative Committee for Space Data Systems (CCSDS) is an international organization that is staffed by data-handling experts from nearly all of the world's major space agencies. Its goal is to develop standard data-communications techniques so that several agencies may cross-support each other's data flow and thus allow complex, international missions to be flown. Under the general umbrella of Advanced Orbiting Systems (AOS), an international CCSDS task force was formed in 1985 to develop standard data-communications concepts for manned missions, such as the Space Station Freedom and the Hermes space plane, and large unmanned vehicles, such as polar orbiting platforms. The history of the CCSDS and the development of the AOS recommendation are reviewed, and the user services and protocols embodied in its systems architecture are introduced. I.E.

A91-12384* McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
OVERVIEW OF THE SPACE STATION COMMUNICATIONS NETWORKS
JOSEPH F. SMITH (McDonnell Douglas Space Systems Co., Huntington Beach, CA), DANIEL WILLETT (NASA, Johnson Space Center, Houston, TX), and SUNIL PAUL (Booz, Allen and Hamilton, Inc., Bethesda, MD) IEEE Network (ISSN 0890-8044), vol. 4, Sept. 1990, p. 22-28. refs
Copyright

Within the Space Station Freedom program, the communications and data-processing capabilities that will be used to handle the operational and scientific information needs will be provided by a Space Station information and communications system. This system will be composed of a variety of elements, networks, and subnetworks. The networks and how they are interconnected are described. The discussion covers communications system elements and services, elements of the onboard systems, wide-area transport network elements, and command and control elements. I.E.

A91-12385
DATA SERVICES FOR SPACE STATION FREEDOM
C. R. EASTON and J. F. SMITH (McDonnell Douglas Space Systems Co., Huntington Beach, CA) IEEE Network (ISSN 0890-8044), vol. 4, Sept. 1990, p. 29-32.
Copyright

The data services to be provided between the Space Station Freedom and users on the ground are described from a user perspective. These services consist of path service on the onboard LAN to provide minimum service and maximum throughput for telemetry, ISO protocol services on the LAN to provide robust end-to-end communications and applications services, path and bitstream services over dedicated high-rate links from payloads to communications and tracking system input ports for telemetry, audio service for two-way voice communications with the ground, and video services for two-way videoconferencing and standard video-image data. The Space Station will use virtual channels (VCs) to deliver predefined data sets (packaged in a VC) to the correct destinations in both the ground-to-space and space-to-ground directions. I.E.

A91-12918
SPACE-COMMUNICATIONS ANTENNAS [ANTENNY KOSMICHESKOI SVIAZI]
NIKOLAI D. KOZYREV Moscow, Izdatel'stvo Radio i Sviaz', 1990, 160 p. In Russian. refs
Copyright

This textbook examines the design principles, requirements, and technical characteristics of earth-station and space-station antennas. Methods for realizing high gain and low noise temperature are examined along with ways to enhance antenna performance. Particular attention is given to the antenna-feed sections of earth stations. B.J.

A91-13743*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
COST-EFFECTIVE IMPLEMENTATION OF INTELLIGENT SYSTEMS
HENRY LUM, JR. (NASA, Ames Research Center, Moffett Field, CA) and EWALD HEER (Heer Associates, Inc., La Canada, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-021) Copyright

Significant advances have occurred during the last decade in knowledge-based engineering research and knowledge-based system (KBS) demonstrations and evaluations using integrated intelligent system technologies. Performance and simulation data obtained to date in real-time operational environments suggest that cost-effective utilization of intelligent system technologies can be realized. In this paper the rationale and potential benefits for typical examples of application projects that demonstrate an increase in productivity through the use of intelligent system technologies are discussed. These demonstration projects have provided an insight into additional technology needs and cultural barriers which are currently impeding the transition of the technology into operational environments. Proposed methods which addresses technology evolution and implementation are also discussed. Author

A91-13781#
SPACE STATION DATA MANAGEMENT SYSTEM ARCHITECTURE
PAT WILHELM and GEORGE BUTLER (McDonnell Douglas Space Systems Co., Space Station Div., Huntington Beach, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 14 p.
(IAF PAPER 90-073) Copyright

An overview is given of the Space Station Data Management System (DMS) architecture. The components and units of the DMS software architecture and the DMS hardware are itemized and discussed. The standard data processor, multipurpose application console, mass storage unit, time generation unit, ring concentrator, bridge and gateways, and multiplexer/demultiplexer are examined, presenting block diagrams. A summarized description is given of the DMS software products. C.D.

A91-13782#
COLUMBUS AVIONICS AND SPACE STATION FREEDOM
DIDIER PERARNAUD and JEAN-PIERRE CAU (Matra Espace, Toulouse, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.
(IAF PAPER 90-074)

In the global context of Columbus avionics, this paper describes Columbus Data Management System from the viewpoint of the interoperability within Space Station Freedom. After a brief overview of DMS hardware and software architecture, the major issues of interoperability are reviewed: the networking and the role of OSI standards, the International Payload Rack concept, the workstation crew interface, and the high level control and monitoring. The paper highlights the concepts selected, the progress made in certain areas, and the work still ahead of us in other domains. Author

A91-14045#
A EUROPEAN ADVANCED DATA RELAY SYSTEM
AGOSTINO DE AGOSTINI (ESA, Directorate of Telecommunications, Paris, France), ANTONIO PUCCIO, and GLULLO ZANOTTI (Telespazio S.p.A., Rome Italy) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 16 p.
(IAF PAPER 90-454) Copyright

The purpose of the study is to select the most attractive configuration(s) for an advanced data relay system to be employed at the beginning of the next century. A users scenario with such user classes as a manned in-orbit infrastructure and related support, launchers/transit vehicles, earth observation spacecraft, automatic microgravity free flyers, and scientific spacecraft is considered. System architecture is discussed in terms of configuration analysis and resources definition. The analysis of the space segment contains the definition of link requirements and payloads, as well as mass/power budget and accommodations on space platforms, and the ground segment is assessed from the system-facility and user earth-terminal points of view. Cost analysis and trade-offs are presented, and the key parameters such as the zone of exclusion, service availability, service continuity, intersatellite link implementation, feeder link, platform configuration, ground infrastructure, and economic viability are considered. V.T.

A91-14077#
A STRATEGY FOR IDENTIFICATION AND DEVELOPMENT OF SAFETY CRITICAL SOFTWARE EMBEDDED IN COMPLEX SPACE SYSTEMS
JUERGEN WUNRAM (MBB/ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p. refs
(IAF PAPER 90-557) Copyright

Software used in safety-critical applications demands new concepts for high-integrity systems with embedded software. Categorization and implementation requirements with the overall intent to prevent reliance of safety on complex design components, to reduce the amount of safety critical software, and to separate the remaining critical part from noncritical software applications, are presented. The purpose of the Software Criticality Analysis (SCA), which has been developed for the Columbus Program, is to analyze the system for implementation of those requirements. All software components will be catagorized according to their involvement in critical functions. The SCA is demonstrated taking the rendezvous and berthing function of the Columbus Free Flyer with the Space Station Freedom as an example. A characterization of managerial, development, analysis, and assurance techniques is given. Author

A91-14956#
COLUMBUS DATA MANAGEMENT SYSTEM
JEAN CLAUDE PALOUS (Matra Espace, Toulouse, France) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 8 p.
(AIAA PAPER 90-5029) Copyright

The architecture of the Columbus Data Management System (DMS) which is used in the Columbus Attached Laboratory of the Space Station Freedom to support crew and ground in their operation of payloads is described. The Columbus is planned to stay in orbit for 30 years, but its equipment is not expected to survive such a long period without replacement. Some flexibility of the equipment in accommodating new developments is also desired. In order to satisfy these requirements, a modular design for the DMS hardware and software is proposed. The DMS is expected to provide a set of standard services to its different users such as processing capabilities, access to equipment through a variety of interfaces, access to the ground through telemetry, and accommodation of a wide variety of payloads. B.P.

A91-14958*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

SPACEFLIGHT OPTICAL DISK RECORDER DEVELOPMENT

THOMAS A. SHULL and PAMELA L. RINSLAND (NASA, Langley Research Center, Hampton, VA) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 11 p. refs

(AIAA PAPER 90-5031) Copyright

A NASA program to develop a high performance (high rate, high capacity) rewriteable optical disk recorder for spaceflight applications is presented. An expandable, adaptable system concept is proposed based on disk drive modules and a modular controller. Drive performance goals are 10 Gbyte capacity, 300 Mb transfer rate, 10 to the -12th corrected bit-error rate, and 150 msec access time. The preliminary design for an expandable controller is presented. System goals are up to 160 Gbyte capacity at up to 1.8 Gb/sec rate with concurrent I/O, asynchronous data transfer, and 2-5-year operating life in orbit. Projected system environment and operational scenarios based on Polar Orbiting Platform applications are discussed. Author

A91-14959*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

HIGH RATE SCIENCE DATA HANDLING ON SPACE STATION FREEDOM

THOMAS H. HANDLEY, JR. and RICHARD C. MASLINE (JPL, Pasadena, CA) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 9 p.

(AIAA PAPER 90-5032) Copyright

A study by NASA's User Information System Working Group for Space Station Freedom (SSF) has determined that the proposed onboard Data Management System, as initially configured, will be incapable of handling the data-generation rates typical of numerous scientific sensor payloads; many of these generate data at rates in excess of 10 Mbps, and there are at least four cases of rates in excess of 300 Mbps. The SSF Working Group has accordingly suggested an alternative conceptual architecture based on technology expected to achieve space-qualified status by 1995. The architecture encompasses recorders with rapid data-ingest capabilities and massive storage capabilities, optical delay lines allowing the recording of only the phenomena of interest, and data flow-compressing image processors. O.C.

A91-14960*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

HIGH PERFORMANCE VLSI TELEMETRY DATA SYSTEMS

J. CHESNEY, N. SPECIALE, W. HORNER, and S. SABIA (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 14 p. refs

(AIAA PAPER 90-5033) Copyright

NASA-Goddard has over the last five years developed generic ground telemetry data system elements addressing the budget limitations-driven demand for greater modularity, flexibility, and interchangeability. These design solutions, which may be characterized as a 'functional components approach' encompasses both hardware and software components; the former involve telemetry application-specific ICs for data rate requirements of up to 300 Mbps, while the latter extend to embedded local software intelligence. Attention is given to the consequences of the functional components approach for VLSI components. O.C.

A91-14961#

MASS MEMORY TECHNOLOGIES FOR THE COLUMBUS DMS

F. PITTERMANN, F. J. ROMBECK, and H. REFFEL (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 9 p.

(AIAA PAPER 90-5034) Copyright

Future architectural and technological developments of the Columbus data management system (DMS) are discussed and related to target costs. It is pointed out that the manned space flights require mass memories of several hundred megabytes, and that these demands can be satisfied by implementing new technologies such as magnetic disk, optical disk, and large semiconductor memories. The data base architecture and the document file architecture are considered, and special attention is given to the hardware technology aspects of the data base mass memory and the document file mass memory. In ground data base applications, the magnetic disk is considered to be the most popular mass memory unit due to its low price and high capacity and reliability. B.P.

A91-14964*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

PERSPECTIVES ON NASA FLIGHT SOFTWARE DEVELOPMENT - APOLLO, SHUTTLE, SPACE STATION

JOHN R. GARMAN (NASA, Johnson Space Center, Houston, TX) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 8 p.

(AIAA PAPER 90-5040) Copyright

Flight data systems' software development is chronicled for the period encompassing NASA's Apollo, Space Shuttle, and (ongoing) Space Station Freedom programs, with attention to the methodologies and 'development tools' employed in each case and their mutual relationships. A dominant concern in all three programs has been the accommodation of software change; it has also been noted that any such long-term program carries the additional challenge of identifying which elements of its software-related 'institutional memory' are most critical, in order to preclude their loss through the retirement, promotion, or transfer of its 'last expert'. O.C.

A91-14971#

THE APPLICATIONS OF DATA SYSTEMS STANDARDS TO THE SPACE STATION FREEDOM PROJECT

J. F. SMITH and C. R. EASTON (McDonnell Douglas Space Systems Co., Huntington Beach, CA) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 9 p. refs

(AIAA PAPER 90-5048) Copyright

A Space Station Freedom information and communications system will provide a communications interconnection between the user provided equipment or applications onboard the station, and the user/customer facilities on the ground. The communications system will provide a number of data services for the users/customers of the Space Station Freedom. These services include a low overhead Path Service for telemetry, an ISO Service for the computer-to-computer data services, a low functionality bitstream service as a service of last resort, and audio and video services for the use of the crew, operations, and payloads. This paper will define each of these services that are provided by this information & communications system, giving the reader an understanding of what type of operations a user of the Freedom may enjoy. Author

A91-14972*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.

CCSDS TRANSFER FRAMES IN THE REALTIME NASA/DLR LINK FOR THE SPACELAB-D2 MISSION

ANGELITA C. KELLY (NASA, Goddard Space Flight Center, Greenbelt, MD), MANFRED DREXLER, and NORBERT JANSEN (DLR, Oberpfaffenhofen, Federal Republic of Germany) AIAA and NASA, International Symposium on Space Information

Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 12 p.
(AIAA PAPER 90-5049) Copyright

The German Space Operations Center (GSOC) Spacelab D2 mission system is a forerunner of the GSOC system which will accept 'virtual channel' transfer frame data directly from the NASA Consumer Data and Operations System (and/or the equivalent European and Japanese ground data handling systems). This experience with the Consultative Committee for Space Data Systems (CCSDS) will prepare GSOC to implement an effective and efficient system for control of payloads and for the handling of CCSDS-format data well into the 21st century. O.C.

A91-14973*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATION OF CCSDS PACKET TELEMETRY RECOMMENDATIONS BY JPL
K. I. MOYD and M. L. MACMEDAN (JPL, Pasadena, CA) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 6 p.
(AIAA PAPER 90-5050) Copyright

The Consultative Committee for Space Data Systems (CCSDS) has adopted three Recommendations dealing with telemetry for conventional missions: Packet Telemetry, Telemetry Channel Coding and Time Code Formats. The currently flying JPL spacecraft were designed prior to the adoption of these Recommendations. Future JPL missions will be compatible, as will the Deep Space Network and Space Flight Operations Center. This paper discusses ways in which application of the Recommendations causes or allows functions to be done differently from previous JPL projects, including the impact on timing and on telemetry adaptability.
Author

A91-14974#
DATA AND OBJECT STANDARDS FOR THE SPACE STATION FREEDOM PROGRAM
LEE NEITZEL (CTA, Inc., Houston, TX), VIRGIL ENOS, and JEFF MALLIOS (McDonnell Douglas Space Systems Co., Houston, TX) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 12 p.
(AIAA PAPER 90-5052) Copyright

Because of the scale and distributed nature of the Space Station Freedom Program (SSFP), it is essential that uniform data standards be defined and baselined early in the program. This paper reviews an integrated set of object oriented standards proposed for the definition of SSFP onboard and ground objects. These standards provide for object definitions that are consistent with the IRDS Dictionary Standard, the ISO Directory Standard, and the National Institute of Technology GOSIP standards. Author

A91-14983*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
INTEROPERABILITY AMONG SPACE STATION FREEDOM DATA SYSTEMS - A FIELD TEST OF STANDARDS
VIRGINIA A. WHITELAW and WALTER S. MARKER (NASA, Johnson Space Center, Houston, TX) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 9 p.
(AIAA PAPER 90-5064) Copyright

A development status evaluation is presented for NASA efforts toward the achievement of interoperability among Space Station Freedom (SSF) data systems, despite the complexity created by the number and wide distribution of such systems, the intensive international participation, and the use of time-phased development cycles. Four areas have been identified as essential: communications interoperability, data interoperability, and crew and payload interface interoperability. Accelerated efforts are needed to define and refine detailed interface designs before developments by each of the SSF's international partners come to take fundamentally incompatible courses. O.C.

A91-14989#
HOOD, A DESIGN METHOD FOR SPACE INDUSTRY
BERTRAND LABREUILLE and JEAN FRANCOIS MULLER (Matra Espace, Toulouse, France) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 10 p. refs
(AIAA PAPER 90-5074) Copyright

HOOD (hierarchical object-oriented design) is the ESA recommended design method for the major space programs such as Hermes and Columbus. This paper provides an overview of the HOOD method and how it fits into the software-development life cycle for large space systems. The design process interacts with many different other activities such as requirement phase, coding phase, and reuse activities. The choice of a design method has also some impacts on project management and quality assurance issues. Author

A91-14991#
THE EUROPEAN SPACE SOFTWARE DEVELOPMENT ENVIRONMENT
A. J. SCHEFFER (ESTEC, Noordwijk, Netherlands) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 6 p.
(AIAA PAPER 90-5076) Copyright

The status and build-up of the initial versions of the project specific Software Development Environment (SDE) are described and the efforts undertaken to harmonize these SDEs into one common SDE is highlighted. The ESA Software Engineering Standards have significantly contributed to the standardization of the software development life cycle, the procedures and phasing of software reviews and the contents of the applicable software documentation. The need for SDEs were formulated and the first efforts started to arrive at a common SDE for Hermes, Columbus, and other future ESA programs. Such a common SDE would not only combine development efforts but would also make better utilization of the limited industrial capacity, reduce the training requirements for software engineers, and avoid the installation of different SDEs at industrial subcontractors. R.E.P.

A91-14993#
SOFTWARE REUSE - THE CHALLENGE OF THE 90'S IN SOFTWARE DEVELOPMENT
BERNARD DURIN, JEANNETTE ABADIR, and BERNARD MOUTON (Matra Espace, Toulouse, France) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 10 p. refs
(AIAA PAPER 90-5080) Copyright

An overview of the technical problems of reusing software components in large space systems development is presented and the Reuse System process model is described. This system was planned to develop successively a mockup, a prototype, and the reuse system that will be integrated into a real Software Development Environment. Finally, a report is made on the experiments and implementations carried out or planned to validate the feasibility of the concepts and to put reuse into practice.
R.E.P.

A91-14995*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH RATE INFORMATION SYSTEMS - ARCHITECTURAL TRENDS IN SUPPORT OF THE INTERDISCIPLINARY INVESTIGATOR
THOMAS H. HANDLEY, JR. and LARRY E. PREHEIM (JPL, Pasadena, CA) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 13 p. refs
(AIAA PAPER 90-5084) Copyright

Data systems requirements in the Earth Observing System (EOS) Space Station Freedom (SSF) eras indicate increasing data volume, increased discipline interplay, higher complexity and broader data integration and interpretation. A response to the needs of the interdisciplinary investigator is proposed, considering the increasing complexity and rising costs of scientific investigation. The EOS Data Information System, conceived to be a widely distributed system with reliable communication links between central processing and the science user community, is described.

Details are provided on information architecture, system models, intelligent data management of large complex databases, and standards for archiving ancillary data, using a research library, a laboratory and collaboration services. R.E.P.

A91-14996*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
MULTI-MISSION SPACE SCIENCE DATA PROCESSING SYSTEMS - PAST, PRESENT, AND FUTURE
WILLIAM H. STALLINGS (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 5 p. refs
(AIAA PAPER 90-5085) Copyright

Packetized telemetry that is consistent with the international Consultative Committee for Space Data Systems (CCSDS) has been baselined for future NASA missions such as Space Station Freedom. Some experiences from past and present multimission systems are examined, including current experiences in implementing a CCSDS standard packetized data processing system, relative to the effectiveness of the multimission approach in lowering life cycle cost and the complexity of meeting new mission needs. It is shown that the continued effort toward standardization of telemetry and processing support will permit the development of multimission systems needed to meet the increased requirements of future NASA missions. R.E.P.

A91-14998*# Computer Sciences Corp., Beltsville, MD.
NASA COMMUNICATIONS AUGMENTATION NETWORK
GUY C. OMIDYAR (NASA, Communications Technology Group; Computer Sciences Corp., Beltsville, MD), THOMAS E. BUTLER, and STRATON C. LAIOS (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 13 p.
(AIAA PAPER 90-5087) Copyright

The NASA Communications (Nascom) Division of the Mission Operations and Data Systems Directorate (MO&DSD) is to undertake a major initiative to develop the Nascom Augmentation (NAUG) network to achieve its long-range service objectives for operational data transport to support the Space Station Freedom Program, the Earth Observing System (EOS), and other projects. The NAUG is the Nascom ground communications network being developed to accommodate the operational traffic of the mid-1990s and beyond. The NAUG network development will be based on the Open Systems Interconnection Reference Model (OSI-RM). This paper describes the NAUG network architecture, subsystems, topology, and services; addresses issues of internetworking the Nascom network with other elements of the Space Station Information System (SSIS); discusses the operations environment. This paper also notes the areas of related research and presents the current conception of how the network will provide broadband services in 1998. Author

A91-15007#
OVERVIEW OF THE SOFTWARE REPLACEABLE UNIT CONCEPT AND MECHANISMS SUPPORTED BY THE COLUMBUS DATA MANAGEMENT SYSTEM
BERTRAND LABREUILLE (Matra Espace, Toulouse, France) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 11 p.
(AIAA PAPER 90-5098) Copyright

The software replaceable unit (SWRU) concept developed for the Columbus on-board software is described together with the corresponding mechanisms supported by the Columbus Data Management System. Results are presented on two test-bed activities commissioned by ESA, which were designed to verify the SWRU concept by focusing on Ada and distributed operating system issues. The results confirm the technical feasibility of the SWRU concept and prove that it is possible to combine Ada and the SWRU concept. I.S.

A91-19626* Litton Guidance and Control Systems, Woodland Hills, CA.
FIBER OPTIC SYSTEMS FOR MOBILE PLATFORMS III; PROCEEDINGS OF THE MEETING, BOSTON, MA, SEPT. 7, 8, 1989
NORRIS E. LEWIS, ED. (Litton Systems, Inc., Poly-Scientific Div., Blacksburg, VA) and EMERY L. MOORE, ED. (Litton Industries, Guidance and Control Systems Div., Woodland Hills, CA) Meeting sponsored by SPIE, New Mexico State University, JPL, et al. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 1173), 1990, 208 p. For individual items see A91-19627 to A91-19634.
(SPIE-1173) Copyright

Various papers on fiber optic systems for mobile platforms are presented. Individual topics addressed include: architecture for fiber optic sensors and actuators in aircraft propulsion systems, fiber optic sensor system readiness for aircraft, microphone headset compatible with power by light, wavelength-division-multiplexed fiber optic sensors for aircraft applications, development of fly-by-light systems, fiber-optic-based inertial measurement unit, fault-tolerant architecture for a fly-by-light flight control computer, optically powered sensors for EMI-immune aviation sensing systems, infrared fiber optic fire sensors for space station applications. Papers on shipboard and automotive applications of fiber optic systems are also included. C.D.

A91-20221
THE RISK AREAS IN ON-BOARD SPACE SYSTEM DEVELOPMENT
MALCOLM IRVING and JOHN LEE (Logica Aerospace and Defence, Ltd., London, England) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, Jan. 1991, p. 9-11.
Copyright

The risk areas associated with the development of on-board software applications are assessed and the management and technical risks for on-board software and the ground systems needed to develop it are considered. It is noted that risk management is needed to ensure that the cost stays within budget, that the schedule is achievable, and the system is technically feasible. It is suggested that the examination of risk areas should be performed in the early phases of the software life-cycle. Among the most critical risks cited for on-board software developments are composition of consortia driven by political and funding concerns, rather than capability; lack of software engineering experience in space software; and the facts that system design must integrate software requirements with the more traditional hardware requirements at an early stage and that software development must be constrained by cost and schedule. L.K.S.

A91-20222
DAPRES, THE ARCHIVING CHALLENGE
G. SMETS (Logica, S.A., Brussels, Belgium) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, Jan. 1991, p. 13-18. refs
Copyright

The development of a data preservation system (Dapres) for use by ESA and employing helical scan recorders conforming to the MIL-STD 2179 standard is discussed. Dapres is primarily intended to capture and archive data from future ESA earth observation satellites and manned or man-tended platforms. A mission summary for future ESA activities believed to have an impact on the requirements of Dapres is presented and potential and actual users, including the Columbus Free Flying Laboratory, the Columbus Polar Platform, and the Hermes Spaceplane are cited. Main operation and performance requirements from ESA relevant to the data recorder include long-term operational use, high data rate and capacity, off-the-shelf hardware, and readily available media. It is suggested that the most promising digital recorder format which addresses such requirements is the 19 mm format. Both the 19 mm format and MIL-STD 2179 are defined and their relationships to Dapres architechture are detailed. L.K.S.

A91-22816* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
TRANSCEIVER FOR SPACE STATION FREEDOM
M. FITZMAURICE (NASA, Goddard Space Flight Center, Greenbelt, MD) and R. BRUNO (Stanford Telecommunications, Inc., Reston, VA) IN: Free-space laser communication technologies II; Proceedings of the Meeting, Los Angeles, CA, Jan. 15-17, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 439-448. refs
Copyright

This paper describes the design of the Laser Communication Transceiver (LCT) system which was planned to be flight tested as an attached payload on Space Station Freedom. The objective in building and flight-testing the LCT is to perform a broad class of tests addressing the critical aspects of space-based optical communications systems, providing a base of experience for applying laser communications technology toward future communications needs. The LCT's functional and performance requirements and capabilities with respect to acquisition, spatial tracking and pointing, communications, and attitude determination are discussed. I.S.

A91-22817* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FREE-SPACE OPTICAL COMMUNICATIONS IN SUPPORT OF FUTURE MANNED SPACE FLIGHT
ELAINE M. STEPHENS (NASA, Johnson Space Center, Houston, TX) IN: Free-space laser communication technologies II; Proceedings of the Meeting, Los Angeles, CA, Jan. 15-17, 1990. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 449-455. refs
Copyright

Four areas of research in optical communications in support of future manned space missions being carried out at Johnson Space Center are discussed. These are the Space Station Freedom proximity operations, direct LEO-to-ground communications, IR voice communications inside manned spacecraft, and deep space and lunar satellite operations. The background, requirements, and scenario for each of these areas of research are briefly described. C.D.

A91-22909
SYSTEM CONCEPTS FOR THE EUROPEAN DATA RELAY SYSTEM
ALBERTO MORANDO, RICCARDO GIUBILEI, GIACINTO LOSQUADRO (Selenia Spazio S.p.A., Rome, Italy), FRANCESCO VATALARO (Roma II, Universita, Rome, Italy), and WERNER SCHREITMUELLER (Informationstechnische Gesellschaft, European Conference on Satellite Communications, 1st (ECSC-1), Munich, Federal Republic of Germany, Nov. 28-30, 1989) Space Communications (ISSN 0924-8625), vol. 7, Nov. 1990, p. 365-383.
Copyright

The paper presents the concepts and design parameters assessed during the phase A2 of the Data Relay System (DRS) study in the period from spring 1988 to spring 1989. Starting from the service requirements and system architecture emerged from the previous study phases, frequency plans, coverage zones, and link design including the forward and return links are discussed. The DRS satellite (DRSS) payload is provided with transparent transponders in both directions, from ground to the user spacecraft and vice versa. The communication repeaters are complemented with auxiliary assemblies and with an antenna subsystem different for any of three reference systems. Attention is focused on the DRS ground-segment architecture, and it is noted that in addition to providing two-way relay of data communication, DRS will offer services for localization of user spacecraft via DRSS. V.T.

A91-25775
SPACE SMARTS
FRANK COLUCCI Space (ISSN 0267-954X), vol. 7, Jan.-Feb. 1991, p. 38-42.
Copyright

A review is presented of design and development work in space data processors at the Honeywell Space Systems Group in Florida. Space computers, some hardened for the first time against radiation from both man-made nuclear events and the natural space environment, are described. A specific illustration of this is the Space Shuttle main engine control which monitors some 120 engine parameters 50 times per second and operates the actuators that control the liquid-fueled engine through its eight minute burn. It is further pointed out that Space Station processors will be tied together by three different data buses, each with its own protocol, while the backbone of the data management system will be an optical fiber distributed data interface handling up to 100 Mbits/sec. Radiation hardening without heavy shielding can be accomplished in several ways, i.e., at the materials level, by insulating substrates which can limit the photo-currents generated by a nuclear event, and at the topological level, by spacing transistors so that photocurrents cannot concentrate at any particular node. R.E.P.

A91-26826
ARTIFICIAL INTELLIGENCE CONTRIBUTIONS TO SPACECRAFT AUTONOMY
LORRAINE M. FESQ, AMY STEPHAN, and SUZANNE M. SELLERS (TRW Space and Technology Group, Redondo Beach, CA) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 443-457. Research supported by TRW, Inc. refs
(AAS PAPER 90-055) Copyright

Various aspects of spacecraft autonomy, from detecting and isolating failures to responding in a unique and unknown environment, are examined, and ways in which AI can enhance current capabilities in these areas are discussed. AI techniques have been successfully applied to two aspects of dynamic command generation: systems (ASCON and CCC) have been developed which can automatically generate and verify simple command sequences for spacecraft reconfiguration. Current research in predictive monitoring and reasoning under uncertainty is also reviewed. L.M.

A91-27427#
A FLEXIBLE OBJECT ORIENTED SPACECRAFT OPERATING SYSTEM (FOS)
DAVE LADOUCEUR (Orbital Sciences Space Technology Laboratory, Boulder, CO) IN: Annual AIAA/Utah State University Conference on Small Satellites, 4th, Logan, UT, Aug. 27-30, 1990, Proceedings. Vol. 2. Logan, UT, Utah State University, 1990, 9 p.

This paper presents an FOS that can provide a building block by which software designed for space applications may be malleable, reusable and safe. The ability to redistribute several pieces of an algorithm simplifies the development of applications and experiments that cannot all be accomplished on-orbit. Simulations and prototyping may be run utilizing actual flight code. It is noted that almost any microprocessor can be utilized for this operating system, though processors with built-in high speed communication links and fast context switching would greatly enhance total system throughput. R.E.P.

A91-27572
GAAS FET AMP LAUNCHES 16 W FOR SPACE STATION
JACK BROWNE Microwaves & RF (ISSN 0745-2993), vol. 30, Feb. 1991, p. 114, 116, 117.
Copyright

The paper presents a high-power amplifier for NASA's Space Station Freedom, to be employed to relay communications signals to a geostationary satellite. The GaAs FET amplifier produces + 42-dBm output power and 43-dB small-signal gain across a 240-MHz bandwidth centered at 15 GHz while transmitting offset quadrature-phase-shift-keying signals. The amplifier circuitry combines hybrid and monolithic fabrication techniques, with multilevel circuit boards within a single enclosure. Passive components are created through a five-mask-step thin-film process fabricated on alumina substrates; then discrete GaAs FETs are added to the circuit boards to achieve the necessary gain and power levels. Attention is focused on the development of GaAs FET devices and heat dissipation. V.T.

A91-28475* American Inst. of Aeronautics and Astronautics, Washington, DC.
SPACE INFORMATION SYSTEMS IN THE SPACE STATION ERA; PROCEEDINGS OF THE AIAA/NASA INTERNATIONAL SYMPOSIUM ON SPACE INFORMATION SYSTEMS, WASHINGTON, DC AND GREENBELT, MD, JUNE 22, 23, 1987
MIREILLE GERARD, ED. and PAMELA W. EDWARDS, ED. (AIAA, Washington, DC) Symposium sponsored by AIAA and NASA,. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 324 p. No individual items are abstracted in this volume.
(Contract NAS5-29463)
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Technological and planning issues for data management, processing, and communication on Space Station Freedom are discussed in reviews and reports by U.S., European, and Japanese experts. The space-information-system strategies of NASA, ESA, and NASDA are discussed; customer needs are analyzed; and particular attention is given to communication and data systems, standards and protocols, integrated system architectures, software and automation, and plans and approaches being developed on the basis of experience from past programs. Also included are the reports from workshop sessions on design to meet customer needs, the accommodation of growth and new technologies, and system interoperability. T.K.

N91-10606*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
PROCEEDINGS OF THE THIRTEENTH ANNUAL SOFTWARE ENGINEERING WORKSHOP
Nov. 1988 363 p Workshop held in Greenbelt, MD, 30 Nov. 1988
(NASA-TM-103314; SEL-88-004; NAS 1.15:103314) Avail: NTIS HC/MF A16 CSCL 09B

Topics covered in the workshop included studies and experiments conducted in the Software Engineering Laboratory (SEL), a cooperative effort of NASA Goddard Space Flight Center, the University of Maryland, and Computer Sciences Corporation; software models; software products; and software tools.

N91-10611*# International Business Machines Corp., Houston, TX.
KNOWLEDGE-BASED ASSISTANCE IN COSTING THE SPACE STATION DMS
TROY HENSON and KYLE RONE *In* NASA, Goddard Space Flight Center, Proceedings of the Thirteenth Annual Software Engineering Workshop 18 p Nov. 1988
Avail: NTIS HC/MF A16 CSCL 09B

The Software Cost Engineering (SCE) methodology developed over the last two decades at IBM Systems Integration Division (SID) in Houston is utilized to cost 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 an internal-use-only, PC-based prototype that integrates algorithmic tools with knowledge-based decision support assistants. This prototype Software Cost Engineering Automation Tool (SCEAT) is being employed to assist in the DMS costing exercises. At the same time, DMS costing serves as a forcing function and provides a platform for the continuing, iterative development, calibration, and validation and verification of SCEAT. The data that forms the cost engineering database is derived from more than 15 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

N91-11389*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
PROCEEDINGS OF THE FIRST NASA ADA USERS' SYMPOSIUM
Dec. 1988 227 p Symposium held in Greenbelt, MD, 1 Dec. 1988
(NASA-TM-102941; SEL-88-005; NAS 1.15:102941) Avail: NTIS HC/MF A11 CSCL 09B

Ada has the potential to be a part of the most significant change in software engineering technology within NASA in the last twenty years. Thus, it is particularly important that all NASA centers be aware of Ada experience and plans at other centers. Ada activity across NASA are covered, with presenters representing five of the nine major NASA centers and the Space Station Freedom Program Office. Projects discussed included - Space Station Freedom Program Office: the implications of Ada on training, reuse, management and the software support environment; Johnson Space Center (JSC): early experience with the use of Ada, software engineering and Ada training and the evaluation of Ada compilers; Marshall Space Flight Center (MSFC): university research with Ada and the application of Ada to Space Station Freedom, the Orbital Maneuvering Vehicle, the Aero-Assist Flight Experiment and the Secure Shuttle Data System; Lewis Research Center (LeRC): the evolution of Ada software to support the Space Station Power Management and Distribution System; Jet Propulsion Laboratory (JPL): the creation of a centralized Ada development laboratory and current applications of Ada including the Real-time Weather Processor for the FAA; and Goddard Space Flight Center (GSFC): experiences with Ada in the Flight Dynamics Division and the Extreme Ultraviolet Explorer (EUVE) project and the implications of GSFC experience for Ada use in NASA. Despite the diversity of the presentations, several common themes emerged from the program: Methodology - NASA experience in general indicates that the effective use of Ada requires modern software engineering methodologies; Training - It is the software engineering principles and methods that surround Ada, rather than Ada itself, which requires the major training effort; Reuse - Due to training and transition costs, the use of Ada may initially actually decrease productivity, as was clearly found at GSFC; and real-time work at LeRC, JPL and GSFC shows that it is possible to use Ada for real-time applications. Author

N91-12425*# Lockheed Missiles and Space Co., Sunnyvale, CA.
EFFECT OF SCIENCE LABORATORY CENTRIFUGE OF SPACE STATION ENVIRONMENT
NANCY SEARBY *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 17 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

It is argued that it is essential to have a centrifuge operating during manned space station operations. Background information and a rationale for the research centrifuge are given. It is argued that we must provide a controlled acceleration environment for comparison with microgravity studies. The lack of control groups in previous studies throws into question whether the obseved effects were the result of microgravity or not. The centrifuge could be used to provide a 1-g environment to supply specimens free of launch effects for long-term studies. With the centrifuge, the specimens could be immediately transferred to microgravity without undergoing gradual acclimation. Also, the effects of artificial gravity on humans could be investigated. It is also argued that the presence of the centrifuge on the space station will not cause undo vibrations or other disturbing effects. Author

N91-12742# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.). Space Systems Group.
COLUMBUS GENERIC ELEMENT MANAGEMENT AND PLANNING CONCEPT
J. SVED and H. LUTTMANN 1990 6 p Prepared in cooperation with Erno Raumfahrttechnik G.m.B.H., Bremen, Fed. Republic of Germany

(MBB-UO-0101-90-PUB; ETN-90-98159) Avail: NTIS HC/MF A02

The current status of development of the Columbus onboard autonomous control function concept which is known as the System and Mission Management (SMM) and the complementary execution timeline planning methodology that uses Columbus era computer tools is summarized. It is concluded that the potential exists to condense the documentation tree for payload integration with respect to the operations planning and execution support information by understanding and using the Columbus Generic Element Manager command mechanism and data structure. ESA

N91-13087*# Research Inst. for Advanced Computer Science, Moffett Field, CA.

SOFTWARE ENGINEERING AND THE ROLE OF ADA: EXECUTIVE SEMINAR

GLENN B. FREEDMAN 31 May 1987 140 p Seminar held in Clear Lake, TX

(Contract NCC9-16)

(NASA-CR-187266; NAS 1.26:187266) Avail: NTIS HC/MF A07 CSCL 09/2

The objective was to introduce the basic terminology and concepts of software engineering and Ada. The life cycle model is reviewed. The application of the goals and principles of software engineering is applied. An introductory understanding of the features of the Ada language is gained. Topics addressed include: the software crises; the mandate of the Space Station Program; software life cycle model; software engineering; and Ada under the software engineering umbrella. B.G.

N91-13095*# Softech, Inc., Houston, TX.

ADA/POSIX BINDING: A FOCUSED ADA INVESTIGATION

SUE LEGRAND 17 Oct. 1988 16 p Prepared for Houston Univ., Clear Lake, TX

(Contract NCC9-16)

(NASA-CR-187398; NAS 1.26:187398) Avail: NTIS HC/MF A03 CSCL 09/2

NASA is seeking an operating system interface definition (OSID) for the Space Station Program (SSP) in order to take advantage of the commercial off-the-shelf (COTS) products available today and the many that are expected in the future. NASA would also like to avoid the reliance on any one source for operating systems, information system, communication system, or instruction set architecture. The use of the Portable Operating System Interface for Computer Environments (POSIX) is examined as a possible solution to this problem. Since Ada is already the language of choice for SSP, the question of an Ada/POSIX binding is addressed. The intent of the binding is to provide access to the POSIX standard operation system (OS) interface and environment, by which application portability of Ada applications will be supported at the source code level. A guiding principle of Ada/POSIX binding development is a clear conformance of the Ada interface with the functional definition of POSIX. The interface is intended to be used by both application developers and system implementors. The objective is to provide a standard that allows a strictly conforming application source program that can be compiled to execute on any conforming implementation. Special emphasis is placed on first providing those functions and facilities that are needed in a wide variety of commercial applications Author

N91-13096*# Research Inst. for Advanced Computer Science, Moffett Field, CA.

A STUDY OF SYSTEM INTERFACE SETS (SIS) FOR THE HOST, TARGET AND INTEGRATION ENVIRONMENTS OF THE SPACE STATION PROGRAM (SSP) Final Report

CHARLES MCKAY, DAVID AUTY, and KATHY ROGERS (Rockwell International Corp., Houston, TX.) 30 Jun. 1987 96 p

(Contract NCC9-16)

(NASA-CR-187399; NAS 1.26:187399) Avail: NTIS HC/MF A05 CSCL 09/2

System interface sets (SIS) for large, complex, non-stop, distributed systems are examined. The SIS of the Space Station Program (SSP) was selected as the focus of this study because an appropriate virtual interface specification of the SIS is believed to have the most potential to free the project from four life cycle tyrannies which are rooted in a dependance on either a proprietary or particular instance of: operating systems, data management systems, communications systems, and instruction set architectures. The static perspective of the common Ada programming support environment interface set (CAIS) and the portable common execution environment (PCEE) activities are discussed. Also, the dynamic perspective of the PCEE is addressed. Author

N91-13906*# Softech, Inc., Houston, TX.

SECURITY FOR SAFETY CRITICAL SPACE BORNE SYSTEMS

SUE LEGRAND 31 Dec. 1987 37 p Prepared in cooperation with Houston Univ., Clear Lake, TX

(Contract NCC9-16)

(NASA-CR-187656; NAS 1.26:187656) Avail: NTIS HC/MF A03 CSCL 09/2

The Space Station contains safety critical computer software components in systems that can affect life and vital property. These components require a multilevel secure system that provides dynamic access control of the data and processes involved. A study is under way to define requirements for a security model providing access control through level B3 of the Orange Book. The model will be prototyped at NASA-Johnson Space Center. Author

N91-14574*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

HIGH RESOLUTION, HIGH FRAME RATE VIDEO TECHNOLOGY

Washington May 1990 102 p Workshop held in Cleveland, OH, 11-12 May 1988 List of attendees included as supplement

(NASA-CP-3080; E-5044; NAS 1.55:3080) Avail: NTIS HC/MF A06 CSCL 14/2

Papers and working group summaries presented at the High Resolution, High Frame Rate Video (HHV) Workshop are compiled. HHV system is intended for future use on the Space Shuttle and Space Station Freedom. The Workshop was held for the dual purpose of: (1) allowing potential scientific users to assess the utility of the proposed system for monitoring microgravity science experiments; and (2) letting technical experts from industry recommend improvements to the proposed near-term HHV system. The following topics are covered: (1) State of the art in the video system performance; (2) Development plan for the HHV system; (3) Advanced technology for image gathering, coding, and processing; (4) Data compression applied to HHV; (5) Data transmission networks; and (6) Results of the users' requirements survey conducted by NASA.

N91-14576*# Analex Corp., Cleveland, OH.

DATA TRANSMISSION NETWORKS

ROBERT ALEXOVICH *In* NASA, Lewis Research Center, High Resolution, High Frame Rate Video Technology p 18-26 May 1990

Avail: NTIS HC/MF A06 CSCL 14/2

A task order was written by the High Resolution, High Frame Rate Video Technology (HHVT) project engineers to investigate data compression techniques that could be applied to the HHVT system, and both existing and planned downlink/uplink capabilities of the Space Shuttle and Space Station Freedom. The following tasks were included: (1) Investigate signal channel availability and determine both the maximum possible data rate and the average data rate; (2) Identify time blocks for HHVT video transmission assuming time sharing and interruptions in the communication links; (3) Determine the bit error rates to be expected; and (4) Define the transmit and receive interfaces. A summary chart of the data transmission capabilities for Tracking and Data Relay Satellite System (TDRSS), the Space Shuttle, Space Station Freedom, Spacelab, and USLab are also presented. Y.S.

N91-14577*# Analex Corp., Cleveland, OH.
DATA COMPRESSION APPLIED TO HHVT
WILLIAM K. THOMPSON *In* NASA, Lewis Research Center, High Resolution, High Frame Rate Video Technology p 27-36 May 1990
Avail: NTIS HC/MF A06 CSCL 14/2

A task order was written by the High Resolution, High Frame Rate Video Technology (HHVT) project engineers to study data compression techniques that could be applied to the HHVT system. Specifically, the goals of the HHVT data compression study are to accomplish the following: (1) Determine the downlink capabilities of the Space Shuttle and Space Station Freedom to support HHVT data (i.e., determine the maximum data rates and link availability); (2) Determine current and projected capabilities of high speed storage media to support HHVT data by determining their maximum data acquisition/transmission rates and volumes; (3) Identify which experiment in the HHVT Users' Requirement data base need data compression, based on the experiments' imaging requirements; (4) Select the best data compression technique for each of these users by identifying a technique that provides compression but minimizes distortion; and (5) Investigate state-of-the-art technologies for possible implementation of selected data compression techniques. Data compression will be needed because of the high data rates and larger volumes of data that will result from the use of digitized video onboard the Space Shuttle and Space Station Freedom. Y.S.

N91-15278# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Mathematics and Software Div.
THE ESA TEST DATA ANALYSIS SYSTEM (TDAS)
S. BATTRICK *In its* International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 459-464 Sep. 1990
Copyright Avail: NTIS HC/MF A23

A substantial part of the spacecraft design process consists of developing mathematical models to predict its performance throughout its operational life time. These models have to be validated by comparing their predictions for the spacecraft's performance during environmental tests with the measured performance. The comparison may suggest modifications, either to the model or to the test itself. However, the procedures currently in use can take several months. The primary goal of the TDAS project is to provide the specialist research and development engineers working in the various disciplines (currently structural, thermal, and electromagnetic compatibility) with a set of software tools that will facilitate the analysis of test results and their comparison with theoretical predictive data. The prototype baseline TDAS provides a friendly user interface and hardware portable tools for acquiring data from test facilities that support a defined test data output format, for storing all data within a TDAS database, and for manipulating, analyzing, comparing, and displaying data. ESA

N91-17038*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED SOFTWARE INTEGRATION: THE CASE FOR ITV FACILITIES
JOHN R. GARMAN *In* NASA, Washington, Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 475-487 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 09/2

The array of technologies and methodologies involved in the development and integration of avionics software has moved almost as rapidly as computer technology itself. Future avionics systems involve major advances and risks in the following areas: (1) Complexity; (2) Connectivity; (3) Security; (4) Duration; and (5) Software engineering. From an architectural standpoint, the systems will be much more distributed, involve session-based user interfaces, and have the layered architectures typified in the layers of abstraction concepts popular in networking. Typified in the NASA Space Station Freedom will be the highly distributed nature of software development itself. Systems composed of independent components developed in parallel must be bound by rigid standards and interfaces, the clean requirements and specifications. Avionics software provides a challenge in that it can not be flight tested until the first time it literally flies. It is the binding of requirements for such an integration environment into the advances and risks of future avionics systems that form the basis of the presented concept and the basic Integration, Test, and Verification concept within the development and integration life cycle of Space Station Mission and Avionics systems. Author

N91-17342*# David Sarnoff Research Center, Princeton, NJ.
LINEAR LASER DIODE ARRAYS FOR IMPROVEMENT IN OPTICAL DISK RECORDING Final Report, 2 Sep. 1989 - 30 Jun. 1990
G. A. ALPHONSE, D. B. CARLIN, and J. C. CONNOLLY Dec. 1990 52 p
(Contract NAS1-18226)
(NASA-CR-182098; NAS 1.26:182098) Avail: NTIS HC/MF A04 CSCL 20/4

The development of individually addressable laser diode arrays for multitrack magneto-optic recorders for space stations is discussed. Three multi-element channeled substrate planar (CSP) arrays with output power greater than 30 mW with linear light vs current characteristics and stable single mode spectra were delivered to NASA. These devices have been used to demonstrate for the first time the simultaneous recording of eight data tracks on a 14-inch magneto-optic erasable disk. The yield of these devices is low, mainly due to non-uniformities inherent to the LPE growth that was used to fabricate them. The authors have recently developed the inverted CSP, based on the much more uniform MOCVD growth techniques, and have made low threshold quantum well arrays requiring about three times less current than the CSP to deliver 30 mW CW in a single spatial mode. The inverted CSP is very promising for use in space flight recorder applications. Author

N91-17582*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
PROCEEDINGS OF THE 2ND NASA ADA USER'S SYMPOSIUM
Nov. 1989 309 p Symposium held in Greenbelt, MD, 30 Nov. 1989
(NASA-TM-103407; NAS 1.15:103407; SEL-89-008) Avail: NTIS HC/MF A14 CSCL 09/2

Several presentations, mostly in viewgraph form, on various topics relating to Ada applications are given. Topics covered include the use of Ada in NASA, Ada and the Space Station, the software support environment, Ada in the Software Engineering Laboratory, Ada at the Jet Propulsion Laboratory, the Flight Telerobotic Servicer, and lessons learned in prototyping the Space Station Remote Manipulator System control. Author

N91-18329*# 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, and R. BARTS Feb. 1991 56 p
(Contract NAG1-859)
(NASA-CR-187954; NAS 1.26:187954) Avail: NTIS HC/MF A04 CSCL 20/14

The following subject areas are covered: General Reflector Antenna Systems Program version 7(GRASP7); Multiple Reflector Analysis Program for Cylindrical Antennas (MRAPCA); Tri-Reflector 2D Synthesis Code (TRTDS); a geometrical optics and a physical optics synthesis techniques; beam scanning reflector, the type 2 and 6 reflectors, spherical reflector, and multiple reflector imaging systems; and radiometric array design. Y.S.

N91-18623*# National Aeronautics and Space Administration, Washington, DC.
A NASA INITIATIVE: SOFTWARE ENGINEERING FOR RELIABLE COMPLEX SYSTEMS
LEE B. HOLCOMB *In* Houston Univ., RICIS 1987 Symposium. Executive Summary 26 p 1987
Avail: NTIS HC/MF A15 CSCL 09/2

The objective is the development of methods, technology, and skills that will enable NASA to cost-effectively specify, build, and manage reliable software which can evolve and be maintained over an extended period. The need for such software is rooted in the increasing integration of software and computing components into NASA systems. Current NASA Software Engineering expertise was applied toward some of the largest reliable systems including: shuttle launch; ground support; shuttle simulation; minor control; satellite tracking; and scientific data systems. Unfortunately, no theory exists for reliable complex software systems. NASA is seeking to fill this theoretical gap through a number of approaches. One such approach is to conduct research on theoretical foundations for managing complex software systems. It includes: communication models, new and modified paradigms, and life-cycle models. Another approach is research in the theoretical foundations for reliable software development and validation. It focuses upon formal specifications, programming languages, software engineering systems, software reuse, formal verification, and software safety. Further approaches involve benchmarking a NASA software environment, experimentation within the NASA context, evolution of present NASA methodology, and transfer of technology to the space station software support environment. Y.S.

N91-19016*# Kentucky Univ., Lexington. Dept. of Electrical Engineering.
DESIGN AND IMPLEMENTATION OF A GROUND CONTROL CONSOLE PROTOTYPE FOR OMV
BRUCE L. WALCOTT *In* Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 14/2

One of the primary uses of the Flat Floor facility of The Marshall Flight Center is to perform autonomous and teleoperated docking of vehicles similar to NASA's Orbital Maneuvering Vehicle (OMV). Using both the air-bearing vehicle and the 8 DOF Dynamic Overhead Target Simulator (DOTS) in tandem, even the most difficult OMV docking problems can be simulated. The OMV was planned to be flown from the ground by a pilot via teleoperation. Specifications were developed for a prototype Ground Control Console (GCC) from where the vehicle will be flown. In order for testing of the OMV to occur at Flat Floor facility, this GCC must be replicated. The project was divided into three primary tasks: (1) the design and development of the video display; (2) the design and development of the switch panel using the micro switch programmable display pushbutton switches; and (3) the design and development of the hand controllers. A final task is to perform system integration on the results of these three primary tasks. Y.S.

N91-19729*# National Aeronautics and Space Administration, Washington, DC.
THE ROLE OF SOFTWARE ENGINEERING IN THE SPACE STATION PROGRAM
DANA HALL *In* Houston Univ., RICIS 1988 Symposium Proceedings. Presentation appendix 11 p 1988
Avail: NTIS HC/MF A07 CSCL 09/2

Software engineering applications snapshots within the Space Station Freedom Program; software engineering and Ada training; software reuse; hierarchial command and control; program characteristics; integrated, international environments; software production, integration, and management; and integrated simulation environment are outlined in viewgraph format. B.G.

N91-20684*# Mitre Corp., Houston, TX.
A FAILURE MANAGEMENT PROTOTYPE: DR/RX
DAVID G. HAMMEN, CAROLYN G. BAKER, CHRISTINE M. KELLY, and CHRISTOPHER A. MARSH *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 347-354 Jan. 1991
(Contract NAS9-18057)
Avail: NTIS HC/MF A21 CSCL 14/4

This failure management prototype performs failure diagnosis and recovery management of hierarchical, distributed systems. The prototype, which evolved from a series of previous prototypes following a spiral model for development, focuses on two functions: (1) the diagnostic reasoner (DR) performs integrated failure diagnosis in distributed systems; and (2) the recovery expert (Rx) develops plans to recover from the failure. Issues related to expert system prototype design and the previous history of this prototype are discussed. The architecture of the current prototype is described in terms of the knowledge representation and functionality of its components. Author

N91-20698*# Inference Corp., El Segundo, CA.
ART-ADA: AN ADA-BASED EXPERT SYSTEM TOOL
S. DANIEL LEE and BRADLEY P. ALLEN *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 456-463 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 09/2

The Department of Defense mandate to standardize on Ada as the language for software systems development has resulted in increased interest in making expert systems technology readily available in Ada environments. NASA's Space Station Freedom is an example of the large Ada software development projects that will require expert systems in the 1990's. Another large scale application that can benefit from Ada based expert system tool technology is the Pilot's Associate (PA) expert system project for military combat aircraft. Automated Reasoning Tool (ART) Ada, an Ada Expert system tool is described. ART-Ada allow applications of a C-based expert system tool called ART-IM to be deployed in various Ada environments. ART-Ada is being used to implement several prototype expert systems for NASA's Space Station Freedom Program and the U.S. Air Force. Author

N91-20701*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE ADVANCED SOFTWARE DEVELOPMENT WORKSTATION PROJECT
ERNEST M. FRIDGE, III and CHARLES L. PITMAN *In its* Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 477-480 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 09/2

The Advanced Software Development Workstation (ASDW) task is researching and developing the technologies required to support Computer Aided Software Engineering (CASE) with the emphasis on those advanced methods, tools, and processes that will be of benefit to support all NASA programs. Immediate goals are to provide research and prototype tools that will increase productivity, in the near term, in projects such as the Software Support Environment (SSE), the Space Station Control Center (SSCC), and the Flight Analysis and Design System (FADS) which will be used to support the Space Shuttle and Space Station Freedom. Goals also include providing technology for development, evolution, maintenance, and operations. The technologies under research and development in the ASDW project are targeted to provide productivity enhancements during the software life cycle phase of enterprise and information system modeling, requirements generation and analysis, system design and coding, and system use and maintenance. On-line user's guides will assist users in operating the developed information system with knowledge base expert assistance. Author

N91-20718*# Lockheed Engineering and Sciences Co., Houston, TX.
DEVELOPING THE HUMAN-COMPUTER INTERFACE FOR SPACE STATION FREEDOM
KRITINA L. HOLDEN *In* NASA, Lyndon B. Johnson Space Center,

Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 588-594 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 09/2

For the past two years, the Human-Computer Interaction Laboratory (HCIL) at the Johnson Space Center has been involved in prototyping and prototype reviews of in support of the definition phase of the Space Station Freedom program. On the Space Station, crew members will be interacting with multi-monitor workstations where interaction with several displays at one time will be common. The HCIL has conducted several experiments to begin to address design issues for this complex system. Experiments have dealt with design of ON/OFF indicators, the movement of the cursor across multiple monitors, and the importance of various windowing capabilities for users performing multiple tasks simultaneously. Author

N91-20785*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
RESEARCH IN SOFTWARE ALLOCATION FOR ADVANCED MANNED MISSION COMMUNICATIONS AND TRACKING SYSTEMS Final Report
TOM WARNAGIRIS, BILL WOLFF, and ANTONE KUSMANOFF (Southwest Research Inst., San Antonio, TX.) Dec. 1990 87 p
(Contract NCC9-16)
(NASA-CR-188114; NAS 1.26:188114) Avail: NTIS HC/MF A05 CSCL 09/2

An assessment of the planned processing hardware and software/firmware for the Communications and Tracking System of the Space Station Freedom (SSF) was performed. The intent of the assessment was to determine the optimum distribution of software/firmware in the processing hardware for maximum throughput with minimum required memory. As a product of the assessment process an assessment methodology was to be developed that could be used for similar assessments of future manned spacecraft system designs. The assessment process was hampered by changing requirements for the Space Station. As a result, the initial objective of determining the optimum software/firmware allocation was not fulfilled, but several useful conclusions and recommendations resulted from the assessment. It was concluded that the assessment process would not be completely successful for a system with changing requirements. It was also concluded that memory requirements and hardware requirements were being modified to fit as a consequence of the change process, and although throughput could not be quantitized, potential problem areas could be identified. Finally, inherent flexibility of the system design was essential for the success of a system design with changing requirements. Recommendations resulting from the assessment included development of common software for some embedded controller functions, reduction of embedded processor requirements by hardwiring some Orbital Replacement Units (ORUs) to make better use of processor capabilities, and improvement in communications between software development personnel to enhance the integration process. Lastly, a critical observation was made regarding the software integration tasks did not appear to be addressed in the design process to the degree necessary for successful satisfaction of the system requirements. Author

N91-20788*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION STUDY. DELIVERY 1: SURVEY AND INTERVIEW QUESTIONS
22 Jun. 1990 17 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188111; NAS 1.26:188111) Avail: NTIS HC/MF A03 CSCL 09/2

The NASA funded questionnaire is presented to help define the state-of-the-practice in the formal evaluation of Expert Systems on current NASA and industry applications. The answers to this questionnaire, together with follow-up interviews, will provide realistic answers to the following questions: (1) How much evaluation is being performed; (2) What evaluation techniques are in use; and (3) What, if any, are the unique issues in evaluating Expert Systems. Y.S.

N91-20789*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION SURVEY. DELIVERY 2: SURVEY RESULTS
15 Aug. 1990 40 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188110; NAS 1.26:188110) Avail: NTIS HC/MF A03 CSCL 09/2

The purpose is to determine the state-of-the-practice in Verification and Validation (V and V) of Expert Systems (ESs) on current NASA and industry applications. This is the first task of the series which has the ultimate purpose of ensuring that adequate ES V and V tools and techniques are available for Space Station Knowledge Based Systems development. The strategy for determining the state-of-the-practice is to check how well each of the known ES V and V issues are being addressed and to what extent they have impacted the development of ESs. Y.S.

N91-20790*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION STUDY. PHASE 2: REQUIREMENTS IDENTIFICATION. DELIVERY 1: UPDATED SURVEY REPORT
14 Dec. 1990 58 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188109; NAS 1.26:188109) Avail: NTIS HC/MF A04 CSCL 09/2

The purpose is to report the state-of-the-practice in Verification and Validation (V and V) of Expert Systems (ESs) on current NASA and Industry applications. This is the first task of a series which has the ultimate purpose of ensuring that adequate ES V and V tools and techniques are available for Space Station Knowledge Based Systems development. The strategy for determining the state-of-the-practice is to check how well each of the known ES V and V issues are being addressed and to what extent they have impacted the development of Expert Systems. Y.S.

N91-20791*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION STUDY. PHASE 2: REQUIREMENTS IDENTIFICATION. DELIVERY 2: CURRENT REQUIREMENTS APPLICABILITY
31 Jan. 1991 28 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188108; NAS 1.26:188108) Avail: NTIS HC/MF A03 CSCL 09/2

The second phase of a task is described which has the ultimate purpose of ensuring that adequate Expert Systems (ESs) Verification and Validation (V and V) tools and techniques are available for Space Station Freedom Program Knowledge Based Systems development. The purpose of this phase is to recommend modifications to current software V and V requirements which will extend the applicability of the requirements to NASA ESs. Y.S.

N91-20792*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION SURVEY. DELIVERY 3: RECOMMENDATIONS
31 Aug. 1990 46 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188107; NAS 1.26:188107) Avail: NTIS HC/MF A03 CSCL 09/2

The purpose is to determine the state-of-the-practice in Verification and Validation (V and V) of Expert Systems (ESs) on current NASA and Industry applications. This is the first task of a series which has the ultimate purpose of ensuring that adequate ES V and V tools and techniques are available for Space Station Knowledge Based Systems development. The strategy for determining the state-of-the-practice is to check how well each of the known ES V and V issues are being addressed and to what extent they have impacted the development of ESs. Y.S.

N91-20793*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION SURVEY, DELIVERY 4 Final Report
14 Sep. 1990 50 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188106; NAS 1.26:188106) Avail: NTIS HC/MF A03 CSCL 09/2

The purpose is to determine the state-of-the-practice in Verification and Validation (V and V) of Expert Systems (ESs) on current NASA and Industry applications. This is the first task of a series which has the ultimate purpose of ensuring that adequate ES V and V tools and techniques are available for Space Station Knowledge Based Systems development. The strategy for determining the state-of-the-practice is to check how well each of the known ES V and V issues are being addressed and to what extent they have impacted the development of ESs. Author

N91-20794*# International Business Machines Corp., Houston, TX.
EXPERT SYSTEM VERIFICATION AND VALIDATION SURVEY. DELIVERY 5: REVISED Final Report
31 Oct. 1990 56 p Prepared in cooperation with International Business Machines Corp., Houston, TX
(Contract NCC9-16)
(NASA-CR-188105; NAS 1.26:188105) Avail: NTIS HC/MF A04 CSCL 09/2

The purpose is to determine the state-of-the-practice in Verification and Validation (V and V) of Expert Systems (ESs) on current NASA and Industry applications. This is the first task of a series which has the ultimate purpose of ensuring that adequate ES V and V tools and techniques are available for Space Station Knowledge Based Systems development. The strategy for determining the state-of-the-practice is to check how well each of the known ES V and V issues are being addressed and to what extent they have impacted the development of ESs. Author

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LIFE SCIENCES/HUMAN FACTORS/SAFETY

Studies, models, planning, analyses and simulations of habitability issues. Includes the performance and well-being of the crew and crew rescue.

A91-10026*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
A REVIEW OF THE HABITABILITY ASPECTS OF PRIOR SPACE FLIGHTS FROM THE FLIGHT CREW PERSPECTIVE WITH AN ORIENTATION TOWARD DESIGNING SPACE STATION FREEDOM
J. H. STRAMLER (NASA, Johnson Space Center; Barrios Technology, Inc., Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p. refs
(AIAA PAPER 90-3567)

Habitability is a very important issue in long-duration spaceflight. With this concern, a review of much of the existing U.S. Skylab, Spacelab, and some Soviet literature on habitability aspects of long-duratioin space flight was completed for the Astronaut Space Station Support Office. The data were organized to follow as closely as possible the SSF distributed systems, such as Life Support, Data Management, etc. A new definition of habitability is proposed. Author

A91-10072*# NASA Space Station Program Office, Reston, VA.
SPACE STATION FREEDOM ON-ORBIT CREW TIME AVAILABILITY - A LIMITED RESOURCE
JERRY J. GAREGNANI (NASA, Space Operations Div., Reston, VA) and MICHELLE C. ALLEN (Booz-Allen and Hamilton, Inc., Bethesda, MD) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(Contract NASW-4300)
(AIAA PAPER 90-3653) Copyright

Because of the enormity, complexity, and duration of the Space Station Freedom (SSF) project, the available crew time is at a premium. This paper discusses the methodology for determining, early in the program, estimates of crew time which will be available within pressurized areas of intravehicular activity, from the First Element Launch (FEL) throughout the lifetime of the SSF. The methodology utilizes the baseline assembly sequence (November 1989) as a guideline. The total hours provided are categorized by periods, where a period is comprised of the time between two major SSF Program assembly milestones; e.g., FEL to Man Tended Capability (MTS), MTS to Permanently Manned Capability (PMC), or PMC to Assembly Complete (AC). After AC, total available crew time is presented on a yearly basis. I.S.

A91-10116*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ECLSS DEVELOPMENT FOR FUTURE SPACE MISSIONS
PAUL O. WIELAND and WILLIAM R. HUMPHRIES (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p. refs
(AIAA PAPER 90-3728) Copyright

The Environmental Control and Life Support System (ECLSS) for Space Station Freedom is presently under development. Three areas of concern for longer duration missions are recycling of mass, monitoring and controlling the ECLSS, and controlling trace contaminants and microorganisms. The goal is to 'close the loop' for water and oxygen much more than has been done on previous missions. Alternative technologies for performing each of the ECLSS functions are being developed and evaluated as part of the selection process for choosing the technologies to use on Freedom. Methods to automatically monitor and control the ECLSS are being investigated. The instrumentation needs are being determined in order to focus effort where most needed. Research is also underway to improve methods of monitoring and controlling trace contaminants and microorganisms. Author

A91-10132*# Texas Univ., Austin.
STRATEGIES FOR CREW SELECTION FOR LONG DURATION MISSIONS
ROBERT L. HELMREICH (Texas, University, Austin), ALBERT W. HOLLAND, PATRICIA A. SANTY (NASA, Johnson Space Center, Houston, TX), ROBERT M. ROSE (Minnesota, University, Minneapolis), and TERRY J. MCFADDEN AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 6 p. refs
(Contract NCC2-286)
(AIAA PAPER 90-3762)

Issues surrounding psychological reactions to long duration spaceflight are discussed with respect to the definition of criteria for selecting crewmembers for such expeditions. Two broad dimensions of personality and behavior are defined - Instrumentality including achievement orientation, leadership, and ability to perform under pressure and Expressivity encompassing interpersonal sensitivity and competence. A strategy for validating techniques to select in candidates with the optimum psychological profile to perform successfully on long duration missions is described. Author

A91-10133#
PSYCHOSOCIAL SUPPORT FOR LONG-DURATION SPACE CREWS
NICK KANAS (USVA, Medical Center; California, University, San Francisco) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p. refs
(AIAA PAPER 90-3763)
The effects of long space missions on the psychological well-being and interpersonal relationships of crew members are discussed, summarizing the results of experimental simulations, studies on earth-based analogs such as submarine voyages and Antarctic expeditions, and reports on the Soviet space experience. A number of typical problems are identified, and the implications for crew selection, preflight training, in-flight support, and postflight debriefing are explored. It is pointed out that the procedures for deep-space missions such as a Mars landing, where crews will be isolated for months or years, should be different than those for near-earth missions such as the Space Station, where crews can be rotated at regular intervals. T.K.

A91-10137#
SAFETY RISK ASSESSMENT ON THE SPACE STATION FREEDOM
STAN KAPLAN (PLG, Inc., Newport Beach, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p.
(AIAA PAPER 90-3771) Copyright
The discipline of probabilistic risk assessment (PRA), viewed as both a part of the design process and a conceptual framework for all the laboratories and contractors, is discussed with respect to the Space Station Freedom. The basic premise is that risk is a property of an engineered system just like weight, thrust, and payload capacity. A quantitative definition of risk is given; sets of scenarios are identified and structured into categories which constitute the basis of a risk model. B.P.

A91-13075
ROCKET-SPACE TECHNOLOGY SAFETY
V. M. FILIN (Nauchno - Proizvodstvennoe Ob'edinenie Energiia, Moscow, USSR) SSI Update - High Frontier Newsletter (ISSN 0898-8242), vol. 16, July-Aug. 1990, p. 1-8.
Copyright
The paper classifies emergencies in flight into three categories: catastrophic, critical, and controlled. A general scheme of spacecraft safety assurance is presented, and it is pointed out that failures, disasters, and incidents are caused by engineering system failures, environmental effects or unforeseen external circumstances, and/or by crew and operator errors. Radiation danger for spacecraft crew and dangers of collision with space objects in orbit are also considered. Safety measures and main design parameters including the flight profile, redundancy levels, spacecraft operating life margins, propellant components, and spacecraft configuration are outlined. Space program safety assurance along with emergency survival aids, diagnostic systems, failure-localization aids, and quality of crew and operator training are discussed. V.T.

A91-13774*# Boeing Co., Huntsville, AL.
SPACE STATION FREEDOM PRESSURIZED ELEMENT DESIGNS
RICHARD L. GRANT (Boeing Defense and Space Group, Huntsville, AL) and GEORGE D. HOPSON (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 15 p.
(IAF PAPER 90-065)
An overview is given of the pressurized modules of Space Station Freedom. The common design of the modules is described, and the unique features of the U.S. Laboratory/Habitation Module are summarized. The logistics elements and resource nodes for the modules are addressed, and the processes used to manufacture them are discussed. C.D.

A91-13780*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM PRESSURIZED ELEMENT INTERIOR DESIGN PROCESS
GEORGE D. HOPSON (NASA, Marshall Space Flight Center, Huntsville, AL), JOHN AARON (NASA, Johnson Space Center, Houston, TX), and RICHARD L. GRANT (Boeing Aerospace and Electronics, Huntsville, AL) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 29 p. Previously announced in STAR as N90-28597.
(IAF PAPER 90-071)
The process used to develop the on-orbit working and living environment of the Space Station Freedom has some very unique constraints and conditions to satisfy. The goal is to provide maximum efficiency and utilization of the available space, in on-orbit, zero G conditions that establishes a comfortable, productive, and safe working environment for the crew. The Space Station Freedom on-orbit living and working space can be divided into support for three major functions: (1) operations, maintenance, and management of the station; (2) conduct of experiments, both directly in the laboratories and remotely for experiments outside the pressurized environment; and (3) crew related functions for food preparation, housekeeping, storage, personal hygiene, health maintenance, zero G environment conditioning, and individual privacy, and rest. The process used to implement these functions, the major requirements driving the design, unique considerations and constraints that influence the design, and summaries of the analysis performed to establish the current configurations are described. Sketches and pictures showing the layout and internal arrangement of the Nodes, U.S. Laboratory and Habitation modules identify the current design relationships of the common and unique station housekeeping subsystems. The crew facilities, work stations, food preparation and eating areas (galley and wardroom), and exercise/health maintenance configurations, waste management and personal hygiene area configuration are shown. U.S. Laboratory experiment facilities and maintenance work areas planned to support the wide variety and mixtures of life science and materials processing payloads are described. Author

A91-13787#
RESULT FROM SCIENTIFIC PROGRAM 'SHIPKA' OUTBOARD 'MIR' STATION
B. BONEV, L. FILIPOV (B'lgarska Akademiia na Naukite, Institut za Kosmicheski Izsledvaniia, Sofia, Bulgaria), V. BALEBANOV, V. RODIN (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR), S. SAVCHENKO (Glavkosmos SSSR, Moscow, USSR) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 14 p.
(IAF PAPER 90-082)
The main scientific parts of the program for the flight of the second Bulgarian cosmonaut, known as the Shipka program are: space physics, remote sensing of the earth, medicine and biology, and material sciences. The results obtained during the flight (June 7-17, 1988) and after this period were given in the final report on the program. This paper will consider some of the results which represent particular interest in the mentioned field. Author

A91-13797#
CREW ON-BOARD OPERATIONS - FROM PAST MISSIONS TO COLUMBUS
JAMES R. KASS, ERICH SCHAFHAUSER (OHB System GmbH, Bremen, Federal Republic of Germany), and CARLO VIBERTI (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p. refs
(IAF PAPER 90-094) Copyright
In order to prepare for the European participation in the Space Station Freedom (SSF) a study has been carried out with ESA on the subject of crew on-board tasks aboard Columbus. The study commenced with analyses of relevant past manned missions of the Russian, U.S., and European programs. The lessons learned from these past missions were then comparatively reviewed in the light of requirements for Columbus; examination covered the

areas of hardware, MMI, operations, and ground support. Recommendations were then made to ameliorate the work and life of the crew in space, and increase the efficiency of on-board tasks, as well as scientific return. Author

A91-14070*# *National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.*

INTERACTION OF SPACE RADIATION WITH MATTER

L. W. TOWNSEND and J. W. WILSON (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. refs

(IAF PAPER 90-543) Copyright

The physical interactions of high-energy space radiations with bulk matter are described with particular emphasis on the nuclear and electromagnetic interactions of solar and galactic cosmic rays. Methods of incorporating these interactions into radiation transport models which accurately describe the propagation of the incident cosmic rays and their subsequent-generation reaction products are also explained. Representative results for solar and galactic cosmic ray doses and dose equivalents are presented for various aluminum and water absorber depths. For the first time, the main contributions to human exposure in space from galactic cosmic rays will be presented on a component by component basis, including a breakdown of the dose-equivalent contributions into primary ions, heavy fragments, alpha particles, neutrons, and protons. For the galactic cosmic ray environment outside of the earth's magnetosphere, over 70 percent of the total dose equivalent results from only seven nuclear species (hydrogen, helium, carbon, oxygen, silicon, magnesium, and iron ions). Of these, the largest single contributor is cosmic ray iron and its secondaries, which account for nearly one-fourth of the unshielded total dose equivalent during solar minimum. Author

A91-14075*# National Aeronautics and Space Administration, Washington, DC.

CRITICAL SAFETY ASSURANCE FACTORS FOR MANNED SPACECRAFT - A FIRE SAFETY PERSPECTIVE

GEORGE A. RODNEY (NASA, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. refs

(IAF PAPER 90-555) Copyright

Safety assurance factors for manned spacecraft are discussed with a focus on the Space Station Freedom. A hazard scenario is provided to demonstrate a process commonly used by safety engineers and other analysts to identify onboard safety risks. Fire strategies are described, including a review of fire extinguishing agents being considered for the Space Station. Lessons learned about fire safety technology in other areas are also noted. NASA and industry research on fire safety applications is discussed. NASA's approach to ensuring safety for manned spacecraft is addressed in the context of its multidiscipline program. L.K.S.

A91-14079#

DESIGN ASPECTS OF A RESCUE SYSTEM FOR MANNED SPACEFLIGHT

J. PULS (DLR, Oberpfaffenhofen, Federal Republic of Germany) and A. WALBRODT (Muenchen, Technische Universitaet, Munich, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p. refs

(IAF PAPER 90-560) Copyright

Risks, hazards, and scenarios of rescue missions, as well as related design aspects and evaluation criteria of manned spacecraft rescue systems are discussed. In order to identify an optimized rescue system, different concepts are analyzed and the results are presented in a table. An additional rescue concept, termed the 'lifting body' concept, is also considered. Based on a combination of the lifting body concept with other concepts such as the MBB LB-10, an advanced rescue vehicle capable of retrieving three astronauts to earth is proposed. Availability of such a vehicle, docked at the space station, is recommended at all times. B.P.

A91-14131*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

MARS MISSION GRAVITY PROFILE SIMULATION

LAWRENCE H. KUZNETZ (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 23 p. refs

(IAF PAPER 90-671)

A flight experiment designed to determine the need for artificial gravity for Mars mission architectures at earlier stages of the design process is proposed. The Soviet Mir space station, the NASA Space Shuttle, and the resources of NASA Ames Research Center would be used to duplicate in the terrestrial environment the complete Mars-mission gravity profile in order to assess the need for artificial gravity. All mission phases of 1 G would be on earth; all mission phases of zero or micro G would be in space aboard Mir; and all launch, ascent, orbit, deorbit, approach, departure, and descent G loads would be provided by actual spacecraft in operations that could be designed to simulate the actual G loads, while the Mars stay time would be simulated on earth or in a variable-gravity research facility in space. Methods of simulating activities on the Martian surface are outlined along with data monitoring, countermeasures, and launch site and vehicle selection criteria. V.T.

A91-14135#

DETERMINATION OF THE OPTIMAL CONFIGURATION OF ARTIFICIAL GRAVITY SPACE HABITATS BASED UPON CORIOLIS ACCELERATIONS

ANDREI POLUNIN and PATRICK COLBECK (International Space University, Strasbourg, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs

(IAF PAPER ST-90-001) Copyright

The first generation of rotating artificial gravity space habitats will be severely constrained in size and scope. As the size of rotating facilities decreases, the rotation rate required to obtain a given simulated level of gravity increases. This increase in rotation rate is constrained by the ability of the human vestibular system to adapt to the dynamic effects of a rotating environment, most notably Coriolis accelerations. A mathematical model of the accelerations incurred by humans in a rotating artificial gravity habitat is used in order to assist spacecraft designers in developing a habitat that minimizes the detrimental effects of Coriolis accelerations upon crew performance. The stability of suggested configurations and its relation to the orientation of the major traffic axes is addressed. A baseline configuration is suggested. Author

A91-14164#

FIRST RESULTS OF PO2 EXAMINATIONS IN THE CAPILLARY BLOOD OF COSMONAUTS DURING A LONG-TERM SPACE FLIGHT IN THE SPACE STATION 'MIR' (EXPERIMENT 'OXITEST')

H. HAASE (Institute of Aviation Medicine, Koenigsbrueck, Federal Republic of Germany), V. M. BARANOV, N. M. ASIAMOLOVA, V. V. POLIAKOV, IU. G. AVAKIAN (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p. refs

(IAF PAPER 90-518) Copyright

The pO2 in arterialized capillary blood has been determined with a measuring device especially developed for the use in space. A clear drop in the pO2 during the flight by 12 to 30 percent compared with the preflight values is found. The decrease in pO2 is attributed to a disturbance of the ventilation/perfusion ratio as a consequence of the hypervolaemia in the thoracic region conditioned by weightlessness. The decreased pO2 values found could point to the fact that weightlessness leads to a minor to moderate but clinically not relevant impaired diffusion. Author

A91-14165#
TEMPORARY RESULTS OF THE EXAMINATION OF THE AUDITION OF COSMONAUTS DURING A LONG-TERM FLIGHT IN THE SPACE STATION 'MIR' WITH THE AUDIOMETER 'ELBE-2' (EXPERIMENT 'AUDIO-2')
W. PROEHL, J. BIRKE (Institute of Aviation Medicine, Koenigsbrueck, Federal Republic of Germany), and M. V. NEFEDOVA (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 4 p.
(IAF PAPER 90-519) Copyright

In-flight hearing experiments performed on six Mir cosmonauts are presented. Air and bone conduction thresholds for clear sounds are found to be between 0.25 and 6.0 kHz; frequency, amplitude modulation, and discomfort thresholds are between 0.5 and 6.0 kHz. A comparison between the pre-flight and post-flight hearing data is drawn. Data from cosmonauts using noise protection equipment during 150-241 flight days show similarities. Differences are observed in the data from cosmonauts with 366 flight days and, in one case, the hearing did not return to normal even 71 days after the landing. B.P.

A91-14177#
CREW WORKLOAD DURING INTERNAL SERVICING OF THE COLUMBUS FREE-FLYER BY HERMES
F. WINISDOERFFER and P. BERTHE (Aerospatiale, Division Systemes Strategiques et Spatiaux, Les Mureaux, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p.
(IAF PAPER 90-541) Copyright

This paper presents a first attempt to address the problem of verifying the adequacy of the pressurized volumes of Hermes with the presence of man on-board. A brief description of the Stage 0 Configuration is presented. Then the various means of simulation are described and assessed for their apparent validity. A full-scale mock-up of the pressurized volumes has been built to verify the feasibility of the operations. But the complex operational setting required to assess the workload was not achieved in a satisfactory manner. The demonstration of the geometrical feasibility of the operations was achieved, data related to their duration was also produced, indicating that transfer operations in Hermes are foreseen to be less time consuming than the installation and check-out of the payload in Columbus. Author

A91-14234#
PSYCHOLOGICAL, PSYCHIATRIC, AND INTERPERSONAL ASPECTS OF LONG-DURATION SPACE MISSIONS
NICK KANAS (USVA, Medical Center, San Francisco, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept-Oct. 1990, p. 457-463. refs

Through an analysis of reports from manned American and Soviet space missions and earth-bound simulations, several psychological, psychiatric, and interpersonal issues can be identified that could affect the success of the Space Station and other long-duration space ventures. Psychological issues include sleep problems, alteration in time sense, demographic effects, career motivation, transcendent experiences, homesickness, and alteration in perceptual sensitivities. Psychiatric issues include anxiety, depression and psychosis, psychosomatic symptoms, emotional problems related to the stage of the mission, and postflight personality changes. Interpersonal issues include interpersonal tension, decreased cohesiveness over time, need for privacy, and task vs emotional leadership. Steps can be taken to minimize the impact of these issues, both before and during the mission. Author

A91-14237*# California Univ., Davis.
HUMAN FACTORS IN SPACECRAFT DESIGN
ALBERT A. HARRISON (California, University, Davis) and MARY M. CONNORS (NASA, Ames Research Center, Moffett Field, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 478-481. refs
Copyright

This paper describes some of the salient implications of evolving mission parameters for spacecraft design. Among the requirements for future spacecraft are new, higher standards of living, increased support of human productivity, and greater accommodation of physical and cultural variability. Design issues include volumetric allowances, architecture and layouts, closed life support systems, health maintenance systems, recreational facilities, automation, privacy, and decor. An understanding of behavioral responses to design elements is a precondition for critical design decisions. Human factors research results must be taken into account early in the course of the design process. Author

A91-14238*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PSYCHOLOGICAL HEALTH MAINTENANCE ON SPACE STATION FREEDOM
PATRICIA A. SANTY (NASA, Johnson Space Center, Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 482-485. refs
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The scheduling of crew rotations at intervals of as much as 180 days on NASA's Space Station Freedom entails that the cumulative effects of psychological, emotional, and social stressors on astronauts be monitored. The Space Station's Health Maintenance Facility (HMF) will furnish preventive, diagnostic, and therapeutic assistance for significant psychiatric and interpersonal problems. Mental health professionals must be part of the team of medical personnel charged with facilitating the physiological and phychological transition from earth to space and back. An account is presently given of the critical factors to be addressed by HMF personnel on extended-duration missions. O.C.

A91-14740* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LIFE SUPPORT SYSTEMS RESEARCH AT THE JOHNSON SPACE CENTER
D. L. HENNINGER (NASA, Johnson Space Center, Houston, TX) IN: Lunar base agriculture: Soils for plant growth. Madison, WI, American Society of Agronomy, Inc., Crop Science Society of America, Inc., and Soil Science Society of America, Inc., 1989, p. 173-192. refs
Copyright

The bioregenerative life support systems research at Johnson Space Center focuses on the use of lunar regolith as a plant growth medium. Current dissolution experiments are being conducted to ascertain the response of lunar regolith to various solvents and weathering environments. The transformation of lunar minerals into minerals such as zeolites which would be more conducive to plant growth is also investigated. A study is currently underway to examine the ability of zeolite/apatite mixtures to provide N, P, and K through dissolution and ion exchange. The development and characterization of simulated lunar regolith for preliminary experimentation are also discussed. The life support systems technology used on the Mercury, Gemini, Apollo, and Shuttle missions is reviewed and current research on regenerative life support systems technology for potential use in Space Station Freedom is discussed. L.K.S.

A91-18735
LIFE SCIENCES ISSUES AFFECTING SPACE EXPLORATION
JOEL I. LEONARD (Lockheed Engineering and Sciences Co., Washington, DC), R. J. WHITE, L. LEVETON, K. GAISER, and R. TEETER (ZARM, MBB-ERNO, OHB-System, et al., International Microgravity Congress, 1st, Bremen, Federal Republic of Germany, Sept. 24-26, 1990) Microgravity Science and Technology (ISSN 0938-0108), vol. 3, Dec. 1990, p. 173-179. refs
Copyright

Critical factors in the support of manned space exploration which are under study by the NASA Life Sciences programs encompass protection from space radiation, reduced-gravity countermeasures and artificial gravity, medical care, life-support systems, and human behavior in an extraterrestrial environment. Sites for research facilities analogous to planetary outposts are being considered in Antarctica and comparably remote settings, and closed ecological life support systems are to be tested both in terrestrial laboratories and the projected Space Station. Both the Space Shuttle and Spacelab will be used for short-duration life-support simulations. It is anticipated that lunar facilities will be essential for preparations for Mars missions. O.C.

A91-19294*# Boeing Co., Huntsville, AL.
PRACTICAL RESPONSE TO RADIATION ASSESSMENT FOR SPACECRAFT DESIGN
M. H. APPLEBY, E. R. TANNER, II (Boeing Co., Huntsville, AL), J. E. NEALY (NASA, Langley Research Center, Hampton, VA), S. P. RYDER, and E. L. PIKE (Intergraph Corp., Huntsville, AL) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p. refs
(AIAA PAPER 91-0425) Copyright

An innovative radiative assessment system that combines the advantages of computer-aided design and enhanced radiative transport codes is described. An analysis of a Space Station habitat module is carried out. A scheme that makes it possible to account for anisotropies existing in the radiation environment of LEO is developed. K.K.

A91-19634* Lockheed Engineering and Sciences Co., Houston, TX.
INFRARED FIBER-OPTIC FIRE SENSORS - CONCEPTS AND DESIGNS FOR SPACE STATION APPLICATIONS
RALPH M. TAPPHORN (Lockheed Engineering and Sciences Co., Houston, TX) and ALAN R. PORTER (NASA, White Sands Test Facility, Las Cruces, NM) IN: Fiber optic systems for mobile platforms III; Proceedings of the Meeting, Boston, MA, Sept. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 188-200. Research sponsored by NASA. refs
Copyright

Various design configurations used for testing IR fiber-optic (IFO) fire-sensor concepts are presented. Responsibility measurements conducted to select the best concept are reviewed. The results indicate that IFO fire-sensor systems based on distributed fiber sensors are feasible for future aerospace applications. For Space Station Freedom, these systems offer alternative fire detectors for monitoring areas within equipment or stage compartments where the ventilation may be inadequate for proper operation of smoke detectors. They also allow a large number of areas to be monitored by a single central detector unit, which reduces the associated cost and weight. C.D.

A91-22194#
AN ANTARCTIC CROSSING AS AN ANALOGUE FOR LONG-TERM MANNED SPACEFLIGHT
H. URSIN (Bergen, Universitetet, Norway), J. COLLET (ESA, Directorate of Space Station and Microgravity, Paris, France), and JEAN-LOUIS ETIENNE ESA Bulletin (ISSN 0376-4265), no. 64, Nov. 1990, p. 44-49.
Copyright

In 1988 the Long-Term Program Office (LTPO) of the ESA Directorate of Space Station and Microgravity established an intellectual infrastructure to collaborate with scientific experts in the field, and to perform exploratory studies on human factors. Among the challenges encountered during manned space missions are isolation, a hostile environment, danger, confinement, and the difficulties of a small group living together in close proximity for long periods. In the framework of the European Manned Space Infrastructure studies, the LTPO has performed investigations in some of these areas. This paper details the lessons learned from the Transantarctica expedition which took place from July 27, 1989 to March 3, 1990. It involved crossing the Antarctic from the Peninsula to the South Pole, to the Soviet Vostok base, and then to the Mirny base. The 5763-km trip was completed successfully by six men on skis and a team of dogs pulling equipment on sledges. L.K.S.

A91-23426* Ministry of Health of the USSR, Moscow.
HUMANS IN EARTH ORBIT AND PLANETARY EXPLORATION MISSIONS; IAA MAN IN SPACE SYMPOSIUM, 8TH, TASHKENT, UZBEK SSR, SEPT. 29-OCT. 3, 1990, SELECTION OF PAPERS
A. I. GRIGOR'EV, ED. (Institut Mediko-Biologicheskikh Problem, Moscow, USSR), K. E. KLEIN, ED. (DLR, Cologne, Federal Republic of Germany), and A. NICOGOSSIAN, ED. (NASA, Life Sciences Div., Washington, DC) Symposium organized by IAA and IAF; Supported by AN SSSR, Ministerstvo Zdravookhraneniia SSSR, Sovet Interkosmos, et al. Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, 362 p. For individual items see A91-23427 to A91-23472.
Copyright

The present conference on findings from space life science investigations relevant to long-term earth orbit and planetary exploration missions, as well as considerations for future research projects on these issues, discusses the cardiovascular system and countermeasures against its deterioration in the microgravity environment, cerebral and sensorimotor functions, findings to date in endocrinology and immunology, the musculoskeletal system, and health maintenance and medical care. Also discussed are radiation hazards and protective systems, life-support and habitability factors, and such methodologies and equipment for long space mission research as the use of animal models, novel noninvasive techniques for space crew health monitoring, and an integrated international aerospace medical information system. O.C.

A91-23427
PRELIMINARY MEDICAL RESULTS OF THE MIR YEAR-LONG MISSION
A. I. GRIGOR'EV, S. A. BUGROV, V. V. BOGOMOLOV, A. D. EGOROV, I. B. KOZLOVSKAIA (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) et al. (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 1-8.
Copyright

Mir's December 21, 1987-December 21, 1988 (366-day) mission encompassed medical investigations of physiological responses to long microgravity exposure; in addition to conducting detailed examination of cardiovascular and other systems in flight, the efficacy of countermeasures against physiological deterioration was assessed. Cosmonaut physiology was carefully monitored after return to earth as well. The readaptation process was notably similar to that experienced after flights of 6-11 months. No qualitatively distinctive changes were observed in vital body systems at the end of the mission, pointing to further prolongations of space missions. O.C.

A91-23441
ACTIVITY OF THE SYMPATHOADRENAL SYSTEM IN COSMONAUTS DURING 25-DAY SPACE FLIGHT ON STATION MIR
R. KVETNANSKY, P. BLAZICEK (Slovenska Akademia Vied, Ustav Experimentalnej Endokrinologie, Bratislava, Czechoslovakia), V. B. NOSKOV, I. A. POPOVA (Institut Mediko-Biologicheskikh Problem, Moscow, USSR), C. GHARIB (Lyon I, Universite, Villeurbanne, France) et al. (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 109-116. refs
Copyright

Cosmonaut sympathoadrenal system activity was studied by way of measurements of plasma, urinary catecholamines, and their metabolites and conjugates. The results obtained suggest that, in the comparatively short period of about nine days of space habitation, the sympathoadrenal system was somewhat activated, thereby indicating a mildly stressful influence's exertion by the initial phase of spaceflight. Such a short mission did not, by comparison with a long-term one, powerfully activate the sympathoadrenal system during the process of readaptation to earth gravity. While weightlessness is not a stressful factor in this system's activation, it sensitizes responsiveness during readaptation to earth gravity. O.C.

A91-23443

IMMUNE RESISTANCE OF MAN IN SPACE FLIGHTS

IRINA V. KONSTANTINOVA (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 123-127. refs

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The ability of PHA lymphocyte reactivity, T-helper activity, and NK capacity to recognize and destroy their targets has been noted in tests on 72 Salyut 6, 7, and Mir cosmonauts to decrease during the first week after prolonged (3-11-month) space flights. Alterations are also noted in the ultrastructure of the NK secretory and locomotor apparatus. The production of alpha-interferon remained unchanged, while that of gamma-interferon either rose or decreased. Several cosmonauts are noted to have shown a trend toward increased osteoclast-activating factor production. These reductions in immune system function may exacerbate the risks of disease during prolonged space flights. O.C.

A91-23444

THE STATE OF HUMAN BONE TISSUE DURING SPACE FLIGHT

V. S. OGANOV, A. S. RAKHMANOV, V. E. NOVIKOV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR), S. T. ZATSEPIN, S. S. RODIONOVA (Tsentral'nyi Nauchno-Issledovatel'skii Institut Travmatologii i Ortopedii, Moscow, USSR) et al. (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 129-133. refs

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Bone tissue studies have been conducted on cosmonauts after 4-8-month space flights, and their results have been compared with data from healthy individuals during head-down tilt studies lasting 370 days. The noninvasive methods of computer tomography and gamma-photon absorptiometry have revealed either a decrease in the vertebral spongy mineral's density or an increase by a comparable magnitude relative to an individual cosmonaut's preflight values. It is noted that, during clinical studies of osteoporosis, both vertebral mineral density ratios and the presence or absence of vertebral compression fractures are not equal in different age groups. O.C.

A91-23451 National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

THE PHYSIOLOGY OF SPACECRAFT AND SPACE SUIT ATMOSPHERE SELECTION

J. M. WALIGORA, D. J. HORRIGAN (NASA, Johnson Space Center, Houston, TX), and A. NICOGOSSIAN (NASA, Life Sciences Div., Washington, DC) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 171-177. refs

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Factors which are considered in arriving at control values and control ranges of the parameters established for spacecraft and space suit environments include physiological, engineering, operational cost, and safety considerations. A number of physiological considerations are discussed, including hypoxia and hyperoxia, hypercapnia, temperature regulation, and decompression sickness. The impact of these considerations on space craft and space suit atmosphere selection is considered. The past experience in controlling these parameters in the U.S. and Soviet spacecraft and space suits and the associated physical responses are also reviewed. Physiological factors currently under investigation are discussed, including decompression sickness. L.K.S.

A91-23452

OUR EXPERIENCE IN THE EVALUATION OF THE THERMAL COMFORT DURING THE SPACE FLIGHT AND IN THE SIMULATED SPACE ENVIRONMENT

LUDVIK NOVAK (Universita J. E. Purkyne, Brno, Czechoslovakia) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 179-186. refs

Copyright

A mathematical model is used to examine the effects of hypogravity on the heat output by spontaneous convection. The structure of heat output in an adult male in thermoneutral conditions is outlined. Calculations are made of dry heat output, noting that it is possible to express the three forms of dry heat output by means of linear equations. The use of an electric dynamic katathermometer and the effect of microgravity on the heat output are discussed, and the effects of microgravity on skin temperature and thermal comfort are examined. L.K.S.

A91-23453

EVA MEDICAL PROBLEMS

A. S. BARER (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 187-193. refs

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The experience gained in the USSR allows the following conclusions to be made: physiological responses to EVA do not depend on flight duration in qualitative and quantitative terms. Physiological responses to EVA are mainly determined by the following factors: (1) physiological activities; (2) space suit environmental parameters; and (3) physiological stress. This paper reviews problems associated with altitude decompression sickness as well as thermal regulation of the body, visual function and physiological psychological stress, and individual EVA experience in physiological responses. Author

A91-23454

EUROPEAN EVA DECOMPRESSION SICKNESS RISKS

LORENZ VOGT, JUERGEN WENZEL (DLR, Institut fuer Flugmedizin, Cologne, Federal Republic of Germany), A. I. SKOOG, S. LUCK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), and BENGT SVENSSON (ESTEC, Mechanical System Dept., Noordwijk, Netherlands) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 195-205. refs

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The results of an ESA study on decompression sickness risks for European EVA are presented and discussed. The investigation included crew selection and criteria for EVA astronauts, medical monitoring procedures during EVA, and therapeutic measures. The pressure reduction from the Hermes cabin pressure of 1013 hPa will pose a risk of decompression sickness (DCS) for the EVA crewmember. On the basis of a critical review of literature in the fields of diving and aerospace medicine, recommendations are given for specific decompression procedures for such EVA situations. An R factor of 1.2 and a tissue half-time of 360 minutes in a single-tissue model have been identified as appropriate operational values. Oxygen prebreathing times are proposed for both direct pressure reduction from 1013 hPa to a suit pressure of 500 hPa and for staged decompression using a 700 hPa intermediate stage in the spacecraft cabin. Factors which influence individual susceptibility to DCS are also identified. L.K.S.

A91-23456

REAL TIME QUALITY FACTOR AND DOSE EQUIVALENT METER 'CIRCE' AND ITS USE ON-BOARD THE SOVIET ORBITAL STATION 'MIR'

V. D. NGUYEN, P. BOUISSET, N. PARMENTIER (CEA, Fontenay-aux-Roses, France), I. A. AKATOV, V. M. PETROV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) et al. (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th,

Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 217-226. refs
Copyright

The CIRCE experiment, which recorded the dose rate and quality factor values inside the Mir station, is described. Results obtained with a new active dose equivalent meter based on microdosimetric techniques and using a low pressure tissue equivalent proportional counter are presented. It is shown that the CIRCE devise is a practical tool for systematic real-time dosimetry in shuttle flights and in space stations. K.K.

A91-23458
RADIATION PROTECTION STRATEGIES IN HERMES MISSIONS
J. C. BOURDEAUD'HUI, N. FEUILLAIS, and J.-M. CONTANT (Aerospatiale, Les Mureaux, France) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 233-244.
Copyright

The radiation environment in circumterrestial space is discussed, and doses received over several Hermes missions are predicted. Various strategies for avoiding dangerous dose levels are examined. For low inclination orbits and orbits of 28.5-deg inclination (which will be used most frequently by Hermes), the danger from radiation is found to be low. The dose level during EVA can be reduced by correct planning of the time out. During an anomalously large solar event, special precautions may need to be taken, depending on the orbit used, and in polar missions an emergency return should be planned for. A.F.S.

A91-23459
GERMAN CELSS RESEARCH WITH EMPHASIS ON THE C.E.B.A.S.-PROJECT
VOLKER BLUEM (Bochum, Ruhr-Universitaet, Federal Republic of Germany) and KARLHEINZ KREUZBERG (DLR, Cologne, Federal Republic of Germany) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 245-252. refs
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The various components and goals of the German CELSS research program is described. The program covers both animal and plant systems under microgravity. The current activities of the German Federal Ministry of Research and Technology (BMFT) and of the German Aerospace Establishment (DLR) in the field of closed and controlled biological life support system research is presented. A short overview is then given of the most advanced project in this field, the Aquarack project. S.A.V.

A91-23463
PROVIDING A SOUND HABITAT FOR MAN IN SPACE
MARIA STRANGER-JOHANNESSEN (Centre for Industrial Research, Oslo, Norway) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 275-277. refs
Copyright

The problem of microbial growth on materials in a closed environment is discussed, drawing inferences from analogous situations which occur in new buildings which are more tightly sealed and widely employ air conditioning. It is noted that the 'sick building syndrome' has contributed to serious problems such as legionnaire's disease and that the potential of such microbiological hazards must be researched and guarded against in long-term space habitats. ESA has begun work on microbial contamination control measures and requirements. Procedures are being established as a basis for the microbiological cleanliness of the manned space environment and for the avoidance of microbiological growth on materials and equipment. Several testing techniques are being studied which will allow both a rapid screening of materials' resistance to microbiological growth and proper durability testing of materials and equipment to be used for up to 30 years in space habitats. L.K.S.

A91-23465* National Aeronautics and Space Administration, Washington, DC.
NEUROSCIENCES RESEARCH IN SPACE - FUTURE DIRECTIONS
FRANK M. SULZMAN and JAMES W. WOLFE (NASA, Washington, DC) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 289-293. refs
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In order to gain a better understanding of the effects of long-duration space missions on the central nervous system, near-term research, to take place from 1990-1995, will be directed at investigating the acute effects of microgravity and the 'space adaptation syndrome'. These include experiments scheduled for the Spacelab Life Sciences 1 which is designed to evaluate changes in the visual, vestibular, and proprioceptive systems. An extensive series of experiments, collectively termed Microgravity Vestibular Investigations (MVI), is also planned for the IML-1 mission to be flown in 1992. The IML-2 mission will emphasize behavior and performance, biological rhythms, and further vestibular studies. Mid-term goals, projected to be achieved from 1995-2000, include the use of new technology such as magnetic recording techniques. Long-term goals are also discussed including studies dealing with neuronal plasticity and sensory substitution, augmentation, and robotic telepresence. L.K.S.

A91-23466* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MAN IN SPACE - THE USE OF ANIMAL MODELS
RODNEY W. BALLARD and KENNETH A. SOUZA (NASA, Ames Research Center, Moffett Field, CA) (IAA, IAF, AN SSSR, et al., Symposium on Man in Space, 8th, Tashkent, Uzbek SSR, Sept. 29-Oct. 3, 1990) Acta Astronautica (ISSN 0094-5765), vol. 23, 1991, p. 295-297.
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The use of animal surrogates as experimental subjects in order to provide essential missing information on the effects of long-term spaceflights, to validate countermeasures, and to test medical treatment techniques is discussed. Research needs also include the definition of biomedical adaptations to flight, and the developments of standards for safe space missions to assure human health and productivity during and following flight. NASA research plans in this area are outlined. Over the next 40 years, NASA plans to concentrate on the use of rodents and nonhuman primates as the models of choice for various physiological responses observed in humans during extended stays in space. This research will include flights on the Space Shuttle, unmanned biosatellites, and the Space Station Freedom. L.K.S.

A91-26834* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
APPLIED HUMAN FACTORS RESEARCH AT THE NASA JOHNSON SPACE CENTER HUMAN-COMPUTER INTERACTION LABORATORY
MARIANNE RUDISILL (NASA, Johnson Space Center, Houston, TX) and TIMOTHY D. MCKAY (Lockheed Engineering and Sciences Co., Houston, TX) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 601-611. refs
(AAS PAPER 90-004) Copyright

The applied human factors research program performed at the NASA Johnson Space Center's Human-Computer Interaction Laboratory is discussed. Research is conducted to advance knowledge in human interaction with computer systems during space crew tasks. In addition, the Laboratory is directly involved in the specification of the human-computer interface (HCI) for space systems in development (e.g., Space Station Freedom) and is providing guidelines and support for HCI design to current and future space missions. Author

A91-27666
A SPACE STATION TRASH RECOVERY AND RECYCLING SYSTEM
THOMAS C. TAYLOR (Global Outpost, Inc., Alexandria, VA), DAVID NIXON (Future Systems, Los Angeles, CA), and JAN KAPLICKY (Future Systems, London, England) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 927-935.
Copyright
The quantity of trash produced on the Space Station during its lifetime will be substantial and will include useful waste materials. Given the high cost of transportation to orbit, it can be retained there for eventual recycling rather than returned to earth. A trash management system enanbles crews to discard trash by type and store it in modular packages which are periodically removed by EVA to an external adjacent holding point. The holding point is visited annually by OMV and trash packages are removed to remote long-term storage which utilizes a Shuttle External Tank as a depository platform. The External Tank is modified to support eventual recycling hardware to process the stored waste material into useful components on-orbit. A system of this type has three potential benefits: it can liberate valuable Space Station internal stowage volume from dedicated trash storage; it can initiate long-term stockpiling of useful raw materials on-orbit for future use; and it can encourage commercial initiatives in the field of materials processing in space. Author

A91-27686* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
AN INTRODUCTION TO PRESSURIZED VOLUMES IN SPACE
MICHAEL ROBERTS (NASA, Johnson Space Center, Houston, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1132-1141. refs
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It is recommended that designers of pressurized space habitations follow a three-step process in the preliminary design process. They must begin by defining the environment in which the habitat is to operate and the functions to be performed within the habitat; they can the proceed with design in view of the five requirements of failure-resilience, reliability, habitability, transportability, and constructibility. The final preliminary design step is a refinement of the basic concept by taking environmental and functional requirements into consideration in all requisite detail. It is only at this last stage that the designer may note whether a basic configuration is altogether unworkable. O.C.

A91-27707* McDonnell-Douglas Space Systems Co., Houston, TX.
IMPLICATIONS OF THE NEW RADIATION EXPOSURE LIMITS ON SPACE STATION FREEDOM CREWS
M. STANFORD (McDonnell Douglas Space Systems Co., Space Station Div., Houston, TX) and D. S. NACHTWEY (NASA, Johnson Space Center, Houston, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1326-1333. refs
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Levels of acceptable risk of radiation exposure for SSF crews have been studied. Since the cancer risk per dose equivalent has increased over the last decade, new dose-equivalent limits have been recommended. An astronaut may not receive more than a depth-dose equivalent of 50 rem/year. It is found that a 180-day stay aboard Freedom could result in a worst case depth-dose of 30 rem, and a 180-day mission in a nominally shielded spacecraft in a constant atmospheric density orbit with a varying altitude could result in a depth-dose equivalent of 10 rem. This is twice the annual allowable dose-equivalent for terrestrial radiation workers. It is noted that the present understanding of the biological effectiveness of high-LET radiation is not adequate for accurate health risk assessments and that further research is necessary. O.G.

A91-27712
ARTIFICIAL GRAVITY - HUMAN FACTORS DESIGN REQUIREMENTS
STEPHEN D. CAPPS (Boeing Aerospace and Electronics, Huntsville, AL) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1374-1382. refs
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The effects of prolonged exposure to weightlessness on humans are considered. The challenge of creating environments conducive to the average human as well as creating the means of human survival for extended space flight and settlement is examined. Since the environment created by spinning a vehicle differs substantially from earth gravity, design limitations such as artificial gravity level, gravity gradient, Coriolis forces, tangential motion, and locomotion are analyzed. The results of adaptation schedule experiments are presented. A set of human factors design requirements pertaining to the upper level of angular velocity, upper and lower gravity levels, gravity gradients, radial traffic, transport across spin axis, and human activity at the hub is recommended. Rotating habitats are considered to be the only comprehensive solution for determining the exact human factors envelope. O.G.

A91-27743#
SAFETY IN SPACE FLIGHT [VEILIGHEID BINNEN DE RUIMTEVAART]
R. A. BOSMAN (Fokker Space and Systems, Amsterdam, Netherlands) Ruimtevaart, vol. 39, Dec. 1990, p. 8-14. In Dutch.
The problem of crew safety in manned space missions is examined in a brief review article. The dangerous situation which arose in July 1990 is described, when two cosmonauts on the Soviet Mir space station were unable to close the airlock door after an EVA. The fundamental principles of risk assessment are summarized, and the construction of an overall safety plan for a space mission is explained. Particular attention is given to design and operational safety analyses, intrinsic safety in design, added safety features, alarm systems, emergency systems, and design verification by testing and simulation. Diagrams, drawings, and tables are provided. T.K.

A91-27807#
LIFTING ENTRY RESCUE VEHICLE CONFIGURATION
J. PETER REDING and HAROLD O. SVENDSEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Nov.-Dec. 1990, p. 606-612. Previously cited in issue 21, p. 3503, Accession no. A88-50588. refs
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A91-30296
SPACE SAFETY AND RESCUE 1988-1989
GLORIA W. HEATH, ED. (SAR-ASSIST, Inc., Greenwich, CT) San Diego, CA, Univelt, Inc. (Science and Technology Series. Vol. 77), 1990, 497 p. For individual items see A91-30297 to A91-30298.
Copyright
The current status of space safety and rescue programs is examined in reviews and reports presented at the 21st and 22nd annual symposia (1988 and 1989). Topics addressed include the ESA and NASA space safety strategies, safety problems of EVA space suits, the Hermes crew-escape module, the problems of orbital debris, hazardous-waste disposal in space, the use of IRAS to detect space debris above 900 km, and the planetary protection policy for preserving pristine celestial environments. (With the exception of the two papers abstracted in this issue of IAA, all of the papers presented at the conference were abstracted in 1988, 1989, or 1990.) D.G.

A91-30584
MEDICAL SUPPORT ON MIR
A. D. EGOROV, A. I. GRIGOR'EV, and V. V. BOGOMOLOV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) Space (ISSN 0267-954X), vol. 7, Mar.-Apr. 1991, p. 27, 29.
Copyright

Medical support available on long-term flights aboard Mir is considered. Support is available in order to keep the crew physically and mentally fit for peak performance while in space and to minimize any physical complications that might arise during reentry. Regular medical examinations are carried out and continuous monitoring is performed at the powered stages of flight and during the preparation and conduct of EVA. Countermeasures currently used during missions to prevent body adaptation to microgravity are discussed. These include physical exercises, specific drugs, effects regulating nutrition and fluid content of the body, optimization of the environmental parameters such as work/rest cycles and psychological support measures, readaptation to earth's gravity using lower body negative pressure leotards and anti-g suits, and muscle electrostimulation. Problems associated with prolonged exposure to the microgravity environment, such as fluid displacement and calcium loss, are discussed. L.K.S.

A91-31449
PSYCHOSOCIAL SUPPORT FOR COSMONAUTS
NICK KANAS (USVA, Medical Center, San Francisco, CA) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 62, April 1991, p. 353-355. refs
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Based on a meeting with members of Psychological Support Group for cosmonauts, along with serveral referenced documents, the author summarizes the Soviet experience in dealing with psychological and interpersonal factors related to long-duration space missions. Cosmonaut selection and training procedures following the principle of 'neuropsychological resistance' formulated by Gorbov. Inflight monitoring uses the macroanalysis of crew speech characteristics as an indicator of psychological state. Psychosocial problems include 'asthenia' and interpersonal tension. Support efforts focus on enhancing behavioral and autonomic adaptation, planning flexible work/rest schedules, improving the space station environment, arranging relevant free time activities, and helping crews readjust to earth postflight. Attention is paid to changes in cosmonat preferences and sensitivities as the mission progresses. The use of support activities is believed to be positively associated with the health and performance of cosmonaut space crews. Author

N91-10103*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM (ECLSS) PHASE 3 SIMPLIFIED INTEGRATED TEST TRACE CONTAMINANT CONTROL SUBSYSTEM PERFORMANCE
J. L. PERRY Washington Oct. 1990 30 p
(NASA-TM-4202; NAS 1.15:4202) Avail: NTIS HC/MF A03 CSCL 22B

Space Station Freedom environmental control and life support system testing has been conducted at Marshall Space Flight Center since 1986. The phase 3 simplified integrated test (SIT) conducted from July 30, 1989, through August 11, 1989, tested an integrated air revitalization system. During this test, the trace contaminant control subsystem (TCCS) was directly integrated with the bleed stream from the carbon dioxide reduction subsystem. The TCCS performed as expected with minor anomalies. The test set the basis for further characterizing the TCCS performance as part of advance air revitalization system configurations. Author

N91-10555# Joint Publications Research Service, Arlington, VA.
PROTECTIVE FUNCTIONS OF SKIN Abstract Only
O. V. IGNATOVA, A. A. BERLIN, Z. P. PAK, and I. G. POPOV *In its* JPRS Report: Science and Technology. USSR: Life Sciences p 1 26 Jul. 1990 Transl. into ENGLISH from Kosmicheskaya Biologiya I Aviakosmicheskaya Meditsina, Moscow (USSR), v. 23, no. 6, Nov. - Dec. 1989 p 15-19
Avail: NTIS HC/MF A03

A brief review is presented of changes in the protective functions of the skin under conditions of space flight. In general, confinement aboard space ships has been accompanied by loss of bactericidal properties and changes in the normal skin flora, changes that have been reported to persist for prolonged periods of time. It is generally accepted that the microclimatic conditions lead to functional changes in the skin that alter the normal pH, fatty acid, and amino acid profiles. The net change is a reduction in the bactericidal potency of the skin, and a change in the skin flora. Changes in bacterial flora in themselves eliminate normal bacterial antagonism. Finally, morphological changes in the epidermis further compromise the barrier function of the skin. Author

N91-10574*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WORKSHOP ON EXERCISE PRESCRIPTION FOR LONG-DURATION SPACE FLIGHT
BERNARD A. HARRIS, JR., ed. and DONALD F. STEWART, ed. Washington Oct. 1989 125 p Workshop held in Houston, TX, 1986
(NASA-CP-3051; S-597; NAS 1.55:3051) Avail: NTIS HC/MF A06 CSCL 06P

The National Aeronautics and Space Administration has a dedicated history of ensuring human safety and productivity in flight. Working and living in space long term represents the challenge of the future. Our concern is in determining the effects on the human body of living in space. Space flight provides a powerful stimulus for adaptation, such as cardiovascular and musculoskeletal deconditioning. Extended-duration space flight will influence a great many systems in the human body. We must understand the process by which this adaptation occurs. The NASA is agressively involved in developing programs which will act as a foundation for this new field of space medicine. The hallmark of these programs deals with prevention of deconditioning, currently referred to as countermeasures to zero g. Exercise appears to be most effective in preventing the cardiovascular and musculoskeletal degradation of microgravity.

N91-10575*# Methodist Hospital, Indianapolis, IN. Dept. of Medical Research.
US SPACE FLIGHT EXPERIENCE. PHYSICAL EXERTION AND METABOLIC DEMAND OF EXTRAVEHICULAR ACTIVITY: PAST, PRESENT, AND FUTURE
THOMAS P. MOORE *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 3-13 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

A review of physical exertion and metabolic demands of extravehicular activity (EVA) on U.S. astronauts is given. Information is given on EVA during Gemini, Apollo and Skylab missions. It is noted that nominal EVA's should not be overstressful from a cardiovascular standpoint; that manual-intensive EVA's such as are planned for the construction phase of the Space Station can and will be demanding from a muscular standpoint, primarily for the upper extremities; that off-nominal unplanned EVA's can be physically demanding both from an endurance and from a muscular standpoint; and that crewmembers should be physically prepared and capable of performing these EVA's at any time during the mission. Author

N91-10577*# Methodist Hospital, Indianapolis, IN.
THE HISTORY OF IN-FLIGHT EXERCISE IN THE US MANNED SPACE PROGRAM
THOMAS P. MOORE *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 19-21 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

A historical perspective on in-flight exercise in the U.S. manned space program is given. We have learned a great deal in the 25 years since the inception of Project Mercury. But, as we look forward to a Space Station and long-duration space flight, we must recognize the challenge that lies ahead. The importance of maintenance of the crewmember's physical condition during long stays in weightlessness is a prime concern that should not be minimized. The challenge lies in the design and development of exercise equipment and protocols that will prevent or minimize the deleterious sequelae of long-duration space flight while maximizing valuable on-orbit crew time. Author

N91-10578*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WORK, EXERCISE, AND SPACE FLIGHT. 1: OPERATIONS, ENVIRONMENT, AND EFFECTS OF SPACEFLIGHT
WILLIAM THORNTON *In its* Workshop on Exercise Prescription for Long-Duration Space Flight p 23-30 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

The selection, training, and operations of space flight impose significant physical demands which seem to be adequately met by the existing physical training facilities and informal individual exercise programs. The professional astronaut population has, by selection, better than average health and physical capacity. The essentials of life on earth are adequately met by the spacecraft. However, as the human body adapts to weightlessness, it is compromised for the usual life on earth, but readaptation is rapid. Long term flight without countermeasures will produce major changes in the cardiovascular, respiratory, musculoskeletal and neuromuscular systems. There is strong theoretical and experimental evidence from 1-g studies and limited in-flight evidence to believe that exercise is a key counter-measure to many of these adaptations. Author

N91-10579*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WORK, EXERCISE, AND SPACE FLIGHT. 3: EXERCISE DEVICES AND PROTOCOLS
WILLIAM THORNTON *In its* Workshop on Exercise Prescription for Long-Duration Space Flight p 31-42 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

Preservation of locomotor capacity by earth equivalent, exercise in space is the crucial component of inflight exercise. At this time the treadmill appears to be the only way possible to do this. Work is underway on appropriate hardware but this and a proposed protocol to reduce exercise time must be tested. Such exercise will preserve muscle, bone Ca(++) and cardiovascular-respiratory capacity. In addition, reasonable upper body exercise can be supplied by a new force generator/measurement system-optional exercise might include a rowing machine and bicycle ergometer. A subject centered monitoring-evaluation program will allow real time adjustments as required. Absolute protection for any astronaut will not be possible and those with hypertrophied capacities such as marathoners or weight lifters will suffer significant loss. However, the program described should return the crew to earth with adequate capacity of typical activity on earth including immediate ambulation and minimal recovery time and without permanent change. An understanding of the practical mechanics and biomechanics involved is essential to a solution of the problem. Author

N91-10580*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE MEDICINE CONSIDERATIONS: SKELETAL AND CALCIUM HOMEOSTASIS
VICTOR B. SCHNEIDER *In its* Workshop on Exercise Prescription for Long-Duration Space Flight p 47-52 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

Based on the information obtained from space missions, particularly Skylab and the longer Salyut missions, it is clear that bone and mineral metabolism is substantially altered during space flight. Calcium balance becomes increasingly more negative throughout the flight, and the bone mineral content of the os calcis declines. The major health hazards associated with skeletal changes include the signs and symptoms of hypercalcemia with rapid bone turnover, the risk of kidney stones because of hypercalciuria, the lengthy recovery of lost bone mass after flight, the possibility of irreversible bone loss (particularly the trabecular bone), the possible effects of metastated calcification in the soft tissues, and the possible increase in fracture potential. For these reasons, major efforts need to be directed toward elucidating the fundamental mechanisms by which bone is lost in space and developing more effective countermeasures to prevent both short-term and long-term complications. Author

N91-10581*# Creighton Univ., Omaha, NE.
CHANGES IN MINERAL METABOLISM WITH IMMOBILIZATION/SPACE FLIGHT
J. C. GALLAGHER *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 53-55 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

Researchers are still unsure of the accuracy of previous bone density measurements of their significance following a period of weightlessness. Rapid technological advances in the measurement of bone density will enable us now to measure bone density accurately at multiple sites in the skeleton with doses of radiation less than that given by a spine x ray. It may not be possible to obtain this type of information before the next series of space flights take place, although the bed-rest model may provide supporting information. Extensive testing of bone density on every astronaut should be performed before and after the space flight. Prevention and treatment can only be undertaken after gathering sufficient baseline information. The use of exercise in preventing bone loss is still highly speculative, but represents a relatively easy approach to the problem in terms of study. Author

N91-10582*# West Virginia Univ., Morgantown. Dept. of Physiology and Neurology
A UNIQUE PROBLEM OF MUSCLE ADAPTATION FROM WEIGHTLESSNESS: THE DECELERATION DEFICIENCY
WILLIAM T. STAUBER *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 57-59 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

Decelerator problems of the knee are emphasized since the lower leg musculature is known to atrophy in response to weightlessness. However, other important decelerator functions are served by the shoulder muscles, in particular the rotator cuff muscles. Problems in these muscles often result in tears and dislocations as seen in baseball pitchers. It is noteworthy that at least one device currently exists that can measure concentric and eccentric muscle loading including a submaximal simulated free weight exercise (i.e., force-controlled) and simultaneously record integrated EMG analysis appropriate for assessment of all muscle functional activities. Studies should be undertaken to provide information as to the performance of maximal and submaximal exercise in space travelers to define potential problems and provide rationale for prevention. Author

N91-10583*# Pennsylvania State Univ., University Park. Center for Locomotion Studies.
BIOMEDICAL PERSPECTIVES ON LOCOMOTION IN NULL GRAVITY
PETER R. CAVANAGH *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 61-67 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

A number of important features of various locomotor activities are discussed, and approaches to the study of these activities in the context of space flight are suggested. In particular, the magnitude of peak forces and the rates of change of force during terrestrial cycling, walking, and running are compared. It is shown that subtle changes in the conditions and techniques of locomotion can have a major influence on the biomechanical consequences to the skeleton. The various hypotheses that identify locomotor exercise as a countermeasure to bone demineralization during weightlessness deserve to be tested with some degree of biomechanical rigor. Various approaches for achieving such scrutiny are discussed. Author

N91-10584*# California Univ., Los Angeles. Dept. of Kinesiology.
EXERCISE ISSUES RELATED TO THE NEUROMUSCULAR FUNCTION AND ADAPTATION TO MICROGRAVITY
REGGIE EDGERTON *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 77-78 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

Explored here is the question of whether astronauts can perform extravehicular activities effectively, efficiently, and productively. The loss of muscle mass, movement control, central nervous system function, muscle atrophy and fatigue, all consequent to weightlessness exposure, are discussed. The author recommends more research in these areas. Author

N91-10585*# Bionetics Corp., Cocoa Beach, FL. Biomedical Operations and Research Office.
CONSIDERATIONS FOR AN EXERCISE PRESCRIPTION
VICTOR A. CONVERTINO *In* NASA, Johnson Space Center, Workshop on Exercise Prescription for Long-Duration Space Flight p 99-105 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

A number of past and most recent research findings that describe some of the physiological responses to exercise in man and their relationship with exposure to various gravitational environments are discussed. Most of the data pertain to adaptations of the cardiovascular and body fluid systems. It should be kept in mind that the data from studies on microgravity simulation in man include exposures of relatively short duration (5 hours to 14 days). However, it is argued that the results may provide important guidelines for the consideration of many variables which are pertinent to the development of exercise prescription for long-duration space flight. The following considerations for exercise prescriptions during long-duration space flight are noted: (1) Relatively high aerobic fitness and strength, especially of the upper body musculature, should be a criterion for selection of astronauts who will be involved in EVA, since endurance and strength appear to be predominant characteristics for work performance. (2) Some degree of upper body strength will probably be required for effective performance of EVA. However, the endurance and strength required by the upper body for EVA can probably be obtained through preflight exercise prescription which involves swimming. (3) Although some degree of arm exercise may be required to maintain preflight endurance and strength, researchers propose that regular EVA will probably be sufficient to maintain the endurance and strength required to effectively perform work tasks during space flight. (4) A minimum of one maximal aerobic exercise every 7 to 10 days during space flight may be all that is necessary for maintenance of normal cardiovascular responsiveness and replacement of body fluids for reentry following prolonged space flight. (5) The possible reduction in the amount of exercise required for maintenance of cardiovascular system and body fluids in combination with the use of electromyostimulation (EMS) or methods other than conventional exercise for maintaining size and strength of muscles and bones needs great consideration for further research. These approaches represent a potential solution to the problem of compromising valuable time for exercise that is needed for daily operations. Author

N91-10586*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
WORK, EXERCISE, AND SPACE FLIGHT. 2: MODIFICATION OF ADAPTATION BY EXERCISE (EXERCISE PRESCRIPTION)
WILLIAM THORNTON *In its* Workshop on Exercise Prescription for Long-Duration Space Flight p 107-115 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

The fundamentals of exercise theory on earth must be rigorously understood and applied to prevent adaptation to long periods of weightlessness. *Locomotor activity, not weight, determines* the capacity or condition of the largest muscles and bones in the body and usually also determines cardio-respiratory capacity. Absence of this activity results in rapid atrophy of muscle, bone, and cardio-respiratory capacity. Upper body muscle and bone are less affected depending upon the individual's usual, or 1-g, activities. Methodology is available to prevent these changes but space operations demand that it be done in the most efficient fashion, i.e., shortest time. At this point in time we can reasonably select the type of exercise and methods of obtaining it, but additional work in 1-g will be required to optimize the time. Author

N91-10588*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SUMMARY AND RECOMMENDATIONS FOR INITIAL EXERCISE PRESCRIPTION
DONALD F. STEWART and BERNARD A. HARRIS, JR. (Space Biomedical Research Inst., Houston, TX.) *In its* Workshop on Exercise Prescription for Long-Duration Space Flight p 125-130 Oct. 1989
Avail: NTIS HC/MF A06 CSCL 06P

The recommendations summarized herein constitute a basis on which an initial exercise prescription can be formulated. It is noteworthy that any exercise program designed currently would be an approximation. Examination of the existing space-flight data reveals a scarcity of in-flight data on which to rigorously design an exercise program. The relevant experience within the U.S. space program (with regard to long-duration space flight) is limited to the Skylab Program. Lessons learned from Skylab are relevant to the design of a Space Station exercise program, especially with regard to the total length of exercise time required, cardiovascular (CV) deconditioning/reconditioning, and bone loss. Certain observations of the U.S.S.R. exercise activities can also contribute to the formulation of an exercise prescription of Space Station. Reportedly, the U.S.S.R. uses both a bicycle ergometer and a treadmill device on long-duration missions with some degree of success. Using the third crew of Salyut 6, which was a 175-day stay, as a representative mission, the typical time dedicated to exercise varies from 2 to 3 hours per day. In addition, the cosmonauts wear an elasticized suit, called a penquin suit, for time periods ranging from 12 to 16 hours per day. This device provides a load across the axial skeleton against which the wearer must exert himself. Despite these extensive countermeasures, the effects of adaptation are not totally prevented. Author

N91-10843*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MARSHALL SPACE FLIGHT CENTER CFD OVERVIEW
LUKE A. SCHUTZENHOFER *In* NASA, Ames Research Center, NASA Computational Fluid Dynamics Conference. Volume 1: Sessions 1-6 p 65-94 Sep. 1989
Avail: NTIS HC/MF A20; 25 functional color pages CSCL 01A

Computational Fluid Dynamics (CFD) activities at Marshall Space Flight Center (MSFC) have been focused on hardware specific and research applications with strong emphasis upon benchmark validation. The purpose here is to provide insight into the MSFC CFD related goals, objectives, current hardware related CFD activities, propulsion CFD research efforts and validation program, future near-term CFD hardware related programs, and CFD expectations. The current hardware programs where CFD has been successfully applied are the Space Shuttle Main Engines (SSME), Alternate Turbopump Development (ATD), and Aeroassist Flight Experiment (AFE). For the future near-term CFD hardware related activities, plans are being developed that address the implementation of CFD into the early design stages of the Space Transportation Main Engine (STME), Space Transportation Booster Engine (STBE), and the Environmental Control and Life Support System (ECLSS) for the Space Station. Finally, CFD expectations in the design environment will be delineated. Author

N91-11356*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RADIOLOGICAL HEALTH RISKS TO ASTRONAUTS FROM SPACE ACTIVITIES AND MEDICAL PROCEDURES

LEIF E. PETERSON (Kelsey Seybold Clinic, P.A., Houston, TX.) and D. STUART NACHTWEY Aug. 1990 23 p
(NASA-TM-102164; S-610; NAS 1.15:102164) Avail: NTIS HC/MF A03 CSCL 06S

Radiation protection standards for space activities differ substantially from those applied to terrestrial working situations. The levels of radiation and subsequent hazards to which space workers are exposed are quite unlike anything found on Earth. The new more highly refined system of risk management involves assessing the risk to each space worker from all sources of radiation (occupational and non-occupational) at the organ level. The risk coefficients were applied to previous space and medical exposures (diagnostic x ray and nuclear medicine procedures) in order to estimate the radiation-induced lifetime cancer incidence and mortality risk. At present, the risk from medical procedures when compared to space activities is 14 times higher for cancer incidence and 13 times higher for cancer mortality; however, this will change as the per capita dose during Space Station Freedom and interplanetary missions increases and more is known about the risks from exposure to high-LET radiation. Author

N91-13481*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
INTEGRATED LAUNCH AND EMERGENCY VEHICLE SYSTEM Patent Application
JAMES A. MARTIN, inventor (to NASA) 31 Aug. 1990 17 p
(NASA-CASE-LAR-13780-1; NAS 1.71:LAR-13780-1; US-PATENT-APPL-SN-575737) Avail: NTIS HC/MF A03 CSCL 22/2

A heavy launch vehicle is disclosed for placing a payload into a spatial earth orbit including an expendable, multi-container, propellant tank having a plurality of winged booster propulsion modules releasably disposed about one end thereof; and a payload supported by adapter structure at the other end. The preferred payload is an entry module adapted to be docked to a space station and used as a return vehicle for the space station crew, as scheduled, or in emergency situations. Alternately, the payload may include communication satellites, supplies, equipment and/or structural elements for the space station. The winged propulsion modules are released from the expendable propellant tank in pairs and return to Earth in a controlled glide, for safe landing at or near the launch site and prepared for reuse. The rocket engines for each propulsion module are dual-fuel, dual-mode engines and use methane-oxygen and hydrogen-oxygen, respectively, from the multi-containers of the propellant tank. When the propulsion modules are released from the expendable propellant tank, the rocket engines are pivotally moved into the module cargo bay for the return glide flight. NASA

N91-13483*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ASSURED CREW RETURN VEHICLE Patent Application
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 ROSS, inventor (to NASA) 28 Dec. 1989 87 p
(NASA-CASE-MSC-21536-1; NAS 1.71:MSC-21536-1; US-PATENT-APPL-SN-458476) Avail: NTIS HC/MF A05

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 sheild 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. NASA

N91-13842*# National Aeronautics and Space Administration, Washington, DC.
BIOLOGICAL LIFE SUPPORT TECHNOLOGIES: COMMERCIAL OPPORTUNITIES
MARK NELSON, ed. and GERALD SOFFEN, ed. (Space Biospheres Ventures, Oracle, AZ.) Nov. 1990 117 p Workshop held in Tucson, AZ, 30 Oct. - 1 Nov. 1989
(NASA-CP-3094; NAS 1.55:3094) Avail: NTIS HC/MF A06 CSCL 06/3

The papers from the workshop on Biological Life Support Technologies: Commercial Opportunities are presented. The meeting attracted researchers in environmental and bioregenerative systems. The role of biological support technologies was evaluated in the context of the global environmental challenge on Earth and the space exploration initiative, with its goal of a permanent space station, lunar base, and Mars exploration.

N91-13843*# Paine (Thomas) Associates, Los Angeles, CA.
BIOSPHERES AND SOLAR SYSTEM EXPLORATION
THOMAS O. PAINE *In* NASA, Washington, Biological Life Support Technologies: Commercial Opportunities p 1-11 Nov. 1990
Avail: NTIS HC/MF A06 CSCL 06/3

The implications of biosphere technology is briefly examined. The exploration status and prospects of each world in the solar system is briefly reviewed, including the asteroid belt, the moon, and comets. Five program elements are listed as particularly critical for future interplanetary operations during the coming extraterrestrial century. They include the following: (1) a highway to Space (earth orbits); (2) Orbital Spaceports to support spacecraft assembly, storage, repair, maintenance, refueling, launch, and recovery; (3) a Bridge Between Worlds to transport cargo and crews to the moon and beyond to Mars; (4) Prospecting and Resource Utilization Systems to map and characterize the resources of planets, moons, and asteroids; and (5) Closed Ecology Biospheres. The progress in these five field is reviewed. E.R.

N91-13847*# Space Biospheres Ventures, Oracle, AZ. Dept. of Medical Operations.
BIOMEDICAL PROGRAM AT SPACE BIOSPHERES VENTURES
ROY WALFORD *In* NASA, Washington, Biological Life Support Technologies: Commercial Opportunities p 41-44 Nov. 1990
Avail: NTIS HC/MF A06 CSCL 06/3

There are many similarities and some important differences between potential health problems of Biosphere 2 and those of which might be anticipated for a space station or a major outpost on Mars. The demands of time, expense, and equipment would not readily allow medical evacuation from deep space for a serious illness or major trauma, whereas personnel can easily be evacuated from Biosphere 2 if necessary. Treatment facilities can be somewhat less inclusive, since distance would not compel the undertaking of heroic measures or highly complicated surgical procedures on site, and with personnel not fully trained for these procedures. The similarities are given between medical requirements of Biosphere 2 and the complex closed ecological systems of biospheres in space or on Mars. The major problems common to all these would seem to be trauma, infection, and toxicity. It is planned that minor and moderate degrees of trauma, including debridement and suturing of wounds, x ray study of fractures, will be done within Biosphere 2. Bacteriologic and fungal infections, and possibly allergies to pollen or spores are expected to be the commonest medical problem within Biosphere 2. E.R.

N91-13848*# National Aeronautics and Space Administration, Washington, DC.
THE NASA CELSS PROGRAM
MAURICE M. AVERNER *In its* Biological Life Support Technologies: Commercial Opportunities p 45-46 Nov. 1990
Avail: NTIS HC/MF A06 CSCL 06/3

The NASA Controlled Ecological Life Support System (CELSS) program was initiated with the premise that NASA's goal would eventually include extended duration missions with sizable crews requiring capabilities beyond the ability of conventional life support technology. Currently, as mission duration and crew size increase, the mass and volume required for consumable life support supplies also increase linearly. Under these circumstances the logistics arrangements and associated costs for life support resupply will adversely affect the ability of NASA to conduct long duration missions. A solution to the problem is to develop technology for the recycling of life support supplies from wastes. The CELSS concept is based upon the integration of biological and physico-chemical processes to construct a system which will produce food, potable water, and a breathable atmosphere from metabolic and other wastes, in a stable and reliable manner. A central feature of a CELSS is the use of green plant photosynthesis to produce food, with the resulting production of oxygen and potable water, and the removal of carbon dioxide. Author

N91-13849*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
THE CELSS BREADBOARD PROJECT: PLANT PRODUCTION
WILLIAM M. KNOTT *In* NASA, Washington, Biological Life Support Technologies: Commercial Opportunities p 47-52 Nov. 1990
Avail: NTIS HC/MF A06 CSCL 06/3

NASA's Breadboard Project for the Controlled Ecological Life Support System (CELSS) program is described. The simplified schematic of a CELSS is given. A modular approach is taken to building the CELSS Breadboard. Each module is researched in order to develop a data set for each one prior to its integration into the complete system. The data being obtained from the Biomass Production Module or the Biomass Production Chamber is examined. The other primary modules, food processing and resource recovery or waste management, are discussed briefly. The crew habitat module is not discussed. The primary goal of the Breadboard Project is to scale-up research data to an integrated system capable of supporting one person in order to establish feasibility for the development and operation of a CELSS. Breadboard is NASA's first attempt at developing a large scale CELSS. E.R.

N91-13850*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CELSS RESEARCH AND DEVELOPMENT PROGRAM
DAVID BUBENHEIM *In* NASA, Washington, Biological Life Support Technologies: Commercial Opportunities p 53-59 Nov. 1990
Avail: NTIS HC/MF A06 CSCL 06/3

Research in Controlled Ecological Life Support Systems (CELSS) conducted by NASA indicate that plant based systems are feasible candidates for human support in space. Ames has responsibility for research and development, systems integration and control, and space flight experiment portions of the CELSS program. Important areas for development of new methods and technologies are biomass production, waste processing, water purification, air revitalization, and food processing. For the plant system, the approach was to identify the flexibility and response time for the food, water, and oxygen production, and carbon dioxide consumption processes. Tremendous increases in productivity, compared with terrestrial agriculture, were realized. Waste processing research emphasizes recycle (transformation) of human wastes, trash, and inedible biomass to forms usable as inputs to the plant production system. Efforts to improve efficiency of the plant system, select new CELSS crops for a balanced diet, and initiate closed system research with the Crop Growth Research Chambers continue. The System Control and Integration program goal is to insure orchestrated system operation of the biological, physical, and chemical operation of the biological, physical, and chemical component processors of the CELSS. Space flight studies are planned to verify adequate operation of the system in reduced gravity or microgravity environments. Author

N91-13854*# Space Industries, Inc., Houston, TX.
BUSINESS AND LIFE IN SPACE
JOSEPH ALLEN *In* NASA, Washington, Biological Life Support Technologies: Commercial Opportunities p 88-95 Nov. 1990
Avail: NTIS HC/MF A06 CSCL 06/3

The life support systems in the machine called the Space Shuttle is discussed and later about life support systems in a little cocoon that is far smaller than the shuttle; the more common term is a space suit. E.R.

N91-14378*# Battelle Columbus Labs., OH.
DEFINITION OF EXPERIMENTS TO INVESTIGATE FIRE SUPPRESSANTS IN MICROGRAVITY Final Report
JAMES J. REUTHER Dec. 1990 64 p
(Contract NAS3-25362)
(NASA-CR-185295; NAS 1.26:185295; BCO-JJR-90-1348) Avail: NTIS HC/MF A04 CSCL 22/2

Defined and justified here are the conceptual design and operation of a critical set of experiments expected to yield information on suppressants and on suppressant delivery systems under realistic spacecraft-fire conditions (smoldering). Specific experiment parameters are provided on the solid fuel (carbon), oxidants (habitable spacecraft atmospheres), fuel/oxidant supply, mixing mode, and rate (quiescent and finite; ventilated and replenishable), ignition mode, event, and reignition tendency, fire-zone size, fire conditions, lifetime, and consequences (toxicity), suppressants (CO_2, H_2O, N_2) and suppressant delivery systems, and diagnostics. Candidate suppressants were identified after an analysis of how reduced gravity alters combustion, and how these alterations may influence the modes, mechanisms, and capacities of terrestrial agents to suppress unwanted combustion, or fire. Preferred spacecraft suppression concepts included the local, near-quiescent application of a gas, vapor, or mist that has thermophysical fire-suppression activity and is chemically inert under terrestrial (normal gravity) combustion conditions. The scale, number, and duration (about 1 hour) of the proposed low-gravity experiments were estimated using data not only on the limitations imposed by spacecraft-carrier (Shuttle or Space Station Freedom) accommodations, but also data on the details and experience of standardized smolder-suppression experiments at normal gravity. Deliberately incorporated into the conceptual design was sufficient interchangeability for the prototype experimental package to fly either on Shuttle now or Freedom later. This flexibility is provided by the design concept of up to 25 modular fuel canisters within a containment vessel, which permits both integration into existing low-gravity in-space combustion experiments and simultaneous testing of separate experiments to conserve utilities and time. Author

N91-14719*# Jeanneret and Associates, Inc., Houston, TX.
POSITION REQUIREMENTS FOR SPACE STATION PERSONNEL AND LINKAGES TO PORTABLE MICROCOMPUTER PERFORMANCE ASSESSMENT
P. R. JEANNERET Feb. 1988 103 p Prepared in cooperation with Essex Corp., Orlando, FL
(Contract NAS9-17326)
(NASA-CR-185606; NAS 1.26:185606; EOTR-88-11) Avail: NTIS HC/MF A06 CSCL 05/8

The development and use of a menu of performance tests that can be self-administered on a portable microcomputer are investigated. In order to identify, develop, or otherwise select the relevant human capabilities/attributes to measure and hence include in the performance battery, it is essential that an analysis be conducted of the jobs or functions that will be performed throughout a space shuttle mission. The primary job analysis instrument, the Position Analysis Questionnaire (PAQ), is discussed in detail so the reader will have sufficient background for understanding the application of the instrument to the various work activities included within the scope of the study, and the derivation of the human requirements (abilities/attributes) from the PAQ analyses. The research methodology is described and includes the procedures used for gathering the PAQ data. The results are presented in detail with specific emphasis on identifying critical requirements that can be measured with a portable computerized assessment battery. A discussion of the results is given with implications for future research. Author

N91-15267# Intespace, Toulouse (France).
INTESPACE SAFETY SYSTEM FOR IPA FULL TANKS SPACECRAFT VIBRATION TESTS
A. EMERY *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 389-391 Sep. 1990
Copyright Avail: NTIS HC/MF A23

The filling of the spacecraft tanks with isopropylic alcohol (IPA) during a vibration test increases the fire and explosion hazard. The safety system, based on the nitrogen storage capability of a test house, is described. A safety console is designed for a constant monitoring of the IPA vapors and oxygen rate around the spacecraft. The test volume is reduced by a confinement tent. In the case of a leak: IPA is retained in a half full of water gutter; the test is aborted, the electrical power supplies are cut off; the test volume is inerted using a constant temperature 6 kg/s GN2 supplier. ESA

N91-15930*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION FREEDOM TOXIC AND REACTIVE MATERIALS HANDLING
CHARLES R. BAUGHER, ed. Washington Jul. 1990 703 p
Workshop held in Huntsville, AL, 29 Nov. - 1 Dec. 1988; sponsored by Teledyne Brown Engineering
(Contract NAS8-36122)
(NASA-CP-3085; M-638; NAS 1.55:3085) Avail: NTIS HC/MF A99 CSCL 22/2

Viable research in materials processing in space requires the utilization of a wide variety of chemicals and materials, many of which are considered toxic and/or highly reactive with other substances. A realistic view of the experiments which are most likely to be accomplished in the early Space Station phases are examined and design issues addressed which are related to their safe implementation. Included are discussions of materials research on Skylab, Spacelab, and the Shuttle mid-deck; overviews of early concepts for specialized Space Station systems designed to help contain potential problems; descriptions of industrial experience with ground-based research; and an overview of the state-of-the-art in contamination detection systems.

N91-15931*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
PANEL SUMMARY OF RECOMMENDATIONS
BONNIE J. DUNBAR, MARTIN E. COLEMAN, and KENNETH L. MITCHELL *In its* Space Station Freedom Toxic and Reactive Materials Handling 10 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The following Space Station internal contamination topics were addressed: past flight experience (Skylab and Spacelab missions); present flight activities (Spacelabs and Soviet Space Station Mir); future activities (materials science and life science experiments); Space Station capabilities (PPMS, FMS, ECLSS, and U.S. Laboratory overview); manned systems/crew safety; internal contamination detection; contamination control - stowage and handling; and contamination control - waste gas processing. Space Station design assumptions are discussed. Issues and concerns are discussed as they relate to (1) policy and management, (2) subsystem design, (3) experiment design, and (4) internal contamination detection and control. The recommendations generated are summarized. Author

N91-15932*# Pogue (William), Springdale, AR.
PAST EXPERIENCE SKYLAB MISSION
WILLIAM POGUE *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 7p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The design of the Skylab missions, 1973 to 1974, was intended to exclude any direct handling of hazardous, toxic, or reactive materials. The materials processing facility and multipurpose furnace provided a contained environment for conducting metals melting, brazing, sphere forming, and crystal growth experiments. At the end of the third mission, following the completion of all other experiments, the materials processing facility was used for a series of flammability experiments. The flammability tests were done last because of the contamination expected from the burning of the materials within the facility. The flammability tests demonstrated a number of peculiar effects that have implications for future design (fire detection, location, and suppression/control). Although the results of the flammability tests contain lessons appropriate to planning, a number of events during the flight illustrate situations or conditions that pose considerations beyond the commonly accepted range of concern for safety-related matters. This presentation includes a discussion of: Skylab flammability studies and the implications for fire suppression/control; false fire alarms and the Skylab fire detection system; space environmental effects on materials that are normally benign; spills/release of contaminants; the detrimental effect that the release of non-hazardous materials have on detection systems; and the problem of locating sources/originating point of hazards. Author

N91-15933*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACELAB D-1 MISSION
BONNIE J. DUNBAR *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 8 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The Spacelab D-1 (Deutchland Eins) Mission is discussed from the points of view of safety, materials handling, and toxic materials; the laboratory and equipment used; and some of the different philosophies utilized on this flight. How to enhance scientific return at the same time as being safe was examined. B.G.

N91-15934*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACELAB 3 MISSION
BONNIE P. DALTON *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 39 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/1

Spacelab-3 (SL-3) was the first microgravity mission of extended duration involving crew interaction with animal experiments. This interaction involved sharing the Spacelab environmental system, changing animal food, and changing animal waste trays by the crew. Extensive microbial testing was conducted on the animal specimens and crew and on their ground and flight facilities during all phases of the mission to determine the potential for cross contamination. Macroparticulate sampling was attempted but was unsuccessful due to the unforseen particulate contamination occurring during the flight. Particulate debris of varying size (250 micron to several inches) and composition was recovered post flight from the Spacelab floor, end cones, overhead areas, avionics fan filter, cabin fan filters, tunnel adaptor, and from the crew module. These data are discussed along with solutions, which were implemented, for particulate and microbial containment for future flight facilities. Author

N91-15935*# Teledyne Brown Engineering, Huntsville, AL.
TOXIC AND REACTIVE MATERIAL HANDLING ON SPACELAB J AND USML-1
JACK DASHNER *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 41 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Spacelab J and USML-1 provide prime examples of materials which are toxic at ambient conditions or toxic during the processing stages. The experimentation requirements are outlined in relation to toxicity and reactive materials handling. Triple containment is the preferred method for prevention of toxic material release in habitable areas for catastrophic hazards. The containments must be adequate for the intended use and environment. When operations preclude triple containment, innovative methods should be explored. B.G.

N91-15936*# National Aeronautics and Space Administration, Washington, DC.
SESSION 2 SUMMARY AND KEY ISSUES IDENTIFICATION
JUDITH ROBEY *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 9 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Identification of specific areas for the technology development; payload/facility requirements; crew safety as the highest priority for the space station; identification of preliminary operational constraints (facilities/experiments requiring specialized equipment and/or procedures, and crew limitations and protective gear requirements); frame of reference of baseline of applicable waste handling experience; use of the workshop as a basis for assessing the current and applicable space station requirements; provision of an educational, and informational forum for government employees, contractors, experimental facility developers, and potential hardware suppliers involved with the Space Station program; and documentation of workshop results and follow-on study issues are examined. B.G.

N91-15937*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SPACE STATION PRESSURIZED LABORATORY SAFETY GUIDELINES
LES MCGONIGAL *In its* Space Station Freedom Toxic and Reactive Materials Handling 8 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Before technical safety guidelines and requirements are established, a common understanding of their origin and importance must be shared between Space Station Program Management, the User Community, and the Safety organizations involved. Safety guidelines and requirements are driven by the nature of the experiments, and the degree of crew interaction. Hazard identification; development of technical safety requirements; operating procedures and constraints; provision of training and education; conduct of reviews and evaluations; and emergency preplanning are briefly discussed. B.G.

N91-15938*# Longwood Coll., Farmville, VA.
INTERDEPENDENCE OF SCIENCE REQUIREMENTS AND SAFETY LIMITATIONS ON THE SPACE STATION
PATRICK G. BARBER *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 14 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

One of the benefits of experimentation on the Space Station is the ability to carry out the experiment, to immediately analyze the results, to calculate improved experimental parameters, and to quickly repeat the experiment. In this improved mode of operation there are new safety considerations that must be addressed in the design stages of both the station and the experiments. Some of the chemical and procedural requirements are shared, and some of the earth-bound storage, dispensing, and disposal techniques that may assist in the development of analogous procedures for the Space Station are discussed. Author

N91-15939*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DESIGN AND DEVELOPMENT OF A SPACE STATION HAZARDOUS MATERIAL SYSTEM FOR ASSESSING CHEMICAL COMPATIBILITY
RICHARD T. CONGO *In its* Space Station Freedom Toxic and Reactive Materials Handling 52 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

As the Space Station nears reality in funding support from Congress, NASA plans to perform over a hundred different missions in the coming decade. Incrementally deployed, the Space Station will evolve into modules linked to an integral structure. Each module will have characteristic functions, such as logistics, habitation, and materials processing. Because the Space Station is to be user friendly for experimenters, NASA is anticipating that a variety of different chemicals will be taken on-board. Accidental release of these potentially toxic chemicals and their chemical compatibility is the focus of this discourse. The Microgravity Manufacturing Processing Facility (MMPF) will contain the various facilities within the U.S. Laboratory (USL). Each facility will have a characteristic purpose, such as alloy solidification or vapor crystal growth. By examining the proposed experiments for each facility, identifying the chemical constituents, their physical state and/or changes, byproducts and effluents, those payloads can be identified which may contain toxic, explosive, or reactive compounds that require processing or containment in mission peculiar waste management systems. Synergistic reactions from mixed effluent streams is of major concern. Each experiment will have it own data file, complete with schematic, chemical listing, physical data, etc. Chemical compatibility information from various databases will provide assistance in the analysis of alternate disposal techniques (pretreatment, separate storage, etc.). Along with data from the Risk Analysis of the Proposed USL Waste Management System, accidental release of potentially toxic and catastrophic chemicals would be eliminated or reduced. Author

N91-15940*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DISCOURSE FOR SLIDE PRESENTATION: AN OVERVIEW OF CHEMICAL DETECTION SYSTEMS
RANDY ALAN PETERS, THEODORE J. GALEN (Krug International, Houston, TX.), and DUANE L. PIERSON *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials and Handling 7 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 06/11

A brief overview of some of the analytical techniques currently used in monitoring and analyzing permanent gases and selected volatile organic compound in air are presented. Some of the analytical considerations in developing a specific method are discussed. Four broad groups of hardware are discussed: compound class specific personal monitors, gas chromatographic systems, infrared spectroscopic systems, and mass spectrometric residual gas analyzer systems. Three types of detectors are also discussed: catalytic sensor based systems, photoionization detectors, and wet or dry chemical reagent systems. Under gas chromatograph based systems five detector systems used in combination with a GC are covered: thermal conductivity detectors, photoionization detectors, Fourier transform infrared spectrophotometric systems, quadrapole mass spectrometric systems, and a relatively recent development, a surface acoustic wave vapor detector. Author

N91-15943*# Oak Ridge National Lab., TN.
IMPORTANCE OF BIOLOGICAL SYSTEMS IN INDUSTRIAL WASTE TREATMENT POTENTIAL APPLICATION TO THE SPACE STATION
NATHANIEL REVIS and GEORGE HOLDSWORTH *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 19 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 06/11

In addition to having applications for waste management issues on planet Earth, microbial systems have application in reducing waste volumes aboard spacecraft. A candidate for such an application is the space station. Many of the planned experiments generate aqueous waste. To recycle air and water the contaminants from previous experiments must be removed before the air and water can be used for other experiments. This can be achieved using microorganisms in a bioreactor. Potential bioreactors (inorganics, organics, and etchants) are discussed. Current technologies that may be applied to waste treatment are described. Examples of how biological systems may be used in treating waste on the space station. B.G.

N91-15944*# Innovative Engineering, Inc., Santa Clara, CA.
CONTROLLED DECOMPOSITION AND OXIDATION: A TREATMENT METHOD FOR GASEOUS PROCESS EFFLUENTS
ROGER J. B. MCKINLEY, SR. *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials

Handling 10 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 13/2

The safe disposal of effluent gases produced by the electronics industry deserves special attention. Due to the hazardous nature of many of the materials used, it is essential to control and treat the reactants and reactant by-products as they are exhausted from the process tool and prior to their release into the manufacturing facility's exhaust system and the atmosphere. Controlled decomposition and oxidation (CDO) is one method of treating effluent gases from thin film deposition processes. CDO equipment applications, field experience, and results of the use of CDO equipment and technological advances gained from the field experiences are discussed. Author

N91-15945*# Chemical Research and Development Center, Aberdeen Proving Ground, MD.
THE REACTIVE BED PLASMA SYSTEM FOR CONTAMINATION CONTROL
JOSEPH G. BIRMINGHAM, ROBERT R. MOORE, and TONY R. PERRY *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 30 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 13/2

The contamination control capabilities of the Reactive Bed Plasma (RBP) system is described by delineating the results of toxic chemical composition studies, aerosol filtration work, and other testing. The RBP system has demonstrated its capabilities to decompose toxic materials and process hazardous aerosols. The post-treatment requirements for the reaction products have possible solutions. Although additional work is required to meet NASA requirements, the RBP may be able to meet contamination control problems aboard the Space Station. Author

N91-16008*# North Carolina State Univ., Raleigh. Dept. of Mechanical and Aerospace Engineering
DESIGN AND FABRICATION OF THE NASA HL-20 FULL SCALE RESEARCH MODEL Final Report
K. DEAN DRIVER and ROBERT J. VESS 25 Jan. 1991 101 p
Sponsored in part by NASA, Langley Research Center
(Contract NAGW-1331)
(NASA-CR-187801; NAS 1.26:187801) Avail: NTIS HC/MF A06 CSCL 01/3

A full-scale engineering model of the HL-20 Personnel Launch System (PLS) was constructed for systems and human factors evaluation. Construction techniques were developed to enable the vehicle to be constructed with a minimum of time and cost. The design and construction of the vehicle are described. Author

N91-16034# Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.).
THE SPACE FLIGHTS: SECOND GERMAN SPACELAB MISSION D-2 AND MIR 1992 [DIE RAUMFLUEGE ZWEITE DEUTSCHE SPACELAB-MISSION D-2 UND MIR '92]
8 Oct. 1990 39 p In GERMAN
(REPT-25/90; ETN-91-98551) Avail: NTIS HC/MF A03

The German research programs of the Spacelab missions are presented. The following topics were studied: fluid physics (capillarity, Marangoni convection), crystallography, biology, human physiology (heart function, respiration), robotics, microgravity, Earth observation (cartography), astronomy. The institutes which cooperated in these programs are reviewed. Some experiments are more precisely described, such as diffusion in metallic fusion, crystalization of biologic macromolecules or doximetry of spatial radiation. The experiments of Mir mission are also depicted, which are based on physiology and radiation protection. ESA

N91-16570# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
COMMON APPROACH FOR PLANETARY HABITATION SYSTEMS IMPLEMENTATION
FRANK STEINSIEK and UWE APEL 1990 11 p Presented at the 20th International Conference on Environmental Systems, Williamsburg, VA, 9-12 Jul. 1990 Previously announced in IAA as A90-49425 Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H.
(MBB-UO-0115-90-PUB; ETN-91-98549) Avail: NTIS HC/MF A03

Possible concepts for orbital, lunar and Martian habitations are based on ESA-European Manned Space Infrastucture (EMSI) program philosophy are presented. The key requirements for the design of an orbital habitat were reviewed, such as atmospheric pressure, temperature, radiation and gravity levels. The human factors such as life cycle, ergonomy and psychological needs were examined. A common approach for these three cases may be to use as much available hardware in each step of the scenario as possible. The implementation of the habitation systems offers the possibility to work in an evolutionary way, starting with the EMSI Columbus based hardware. ESA

N91-17025*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ASSURED CREW RETURN CAPABILITY CREW EMERGENCY RETURN VEHICLE (CERV) AVIONICS
HARVEY DEAN MYERS *In* NASA, Washington, Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 163-177 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The Crew Emergency Return Vehicle (CERV) is being defined to provide Assured Crew Return Capability (ACRC) for Space Station Freedom. The CERV, in providing the standby lifeboat capability, would remain in a dormat mode over long periods of time as would a lifeboat on a ship at sea. The vehicle must be simple, reliable, and constantly available to assure the crew's safety. The CERV must also provide this capability in a cost effective and affordable manner. The CERV Project philosophy of a simple vehicle is to maximize its useability by a physically deconditioned crew. The vehicle reliability goes unquestioned since, when needed, it is the vehicle of last resort. Therefore, its systems and subsystems must be simple, proven, state-of-the-art technology with sufficient redundancy to make it available for use as required for the life of the program. The CERV Project Phase 1'/2 Request for Proposal (RFP) is currently scheduled for release on October 2, 1989. The Phase 1'/2 effort will affirm the existing project requirements or amend and modify them based on a thorough evaluation of the contractor(s) recommendations. The system definition phase, Phase 2, will serve to define CERV systems and subsystems. The current CERV Project schedule has Phase 2 scheduled to begin October 1990. Since a firm CERV avionics design is not in place at this time, the treatment of the CERV avionics complement for the reference configuration is not intended to express a preference with regard to a system or subsystem. Author

N91-17120 Tennessee Univ., Knoxville.
DESIGN AND DEVELOPMENT OF A SPACE STATION HAZARDOUS MATERIALS INFORMATION SYSTEM FOR ASSESSING CHEMICAL COMPATIBILITY Ph.D. Thesis
RICHARD THOMAS CONGO 1990 293 p
Avail: Univ. Microfilms Order No. DA9030696

The need for and development of a modeling process which will perform chemical and material compatibility analyses for the Space Station Microgravity and Material Processing Facility (MMPF) is addressed. The modeling process includes development of a data base containing physical, chemical, toxicological, reactive, corrosive, and incompatibility properties for materials to be used in construction of the Space Station Freedom or in experiments to be conducted onboard. The underlying hypothesis of the modeling process is that by knowing the number of chemical incompatibilities, hazards, and corrosivities for any given facility or mission, one can modify or substitute chemicals for a facility or facility manifest to reduce the number of chemical incompatibilities, hazards, and corrosivities thus reducing the number of potential safety problems aboard the Space Station MMPF. The proposed process was developed into a computerized system with the aid of a relational data base and the development of application programs. An experiment was performed to validate the proposed model. This experiment consisted of utilizing the computerized

system to identify the number of chemical incompatibilities, hazards and corrosivities for a given facility and a mission. The chemical requirements for the facility were modified utilizing substitute chemicals where appropriate, and the mission set was modified by replacing facilities with substitute facilities. The model was utilized to identify any reduction in the number of chemical incompatibilities, hazards, and corrosivities resulting from the substitutions. The results of the study and the experiments establish both the process and the hypothesis to be accurate.
Dissert. Abstr.

N91-18126*# University of Central Florida, Orlando.
POSTLANDING OPTIMUM DESIGNS FOR THE ASSURED CREW RETURN VEHICLE
KENNETH C. HOSTERMAN and LOREN A. ANDERSON *In* USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 35-39 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

The optimized preliminary engineering design concepts for postlanding operations of a water-landing Assured Crew Return Vehicle (ACRV) during a medical rescue mission are presented. Two ACRVs 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 optimized configuration of the ACRV is based on an Apollo command module (ACM) derivative. The scenario assumes landing a sick or injured crewmember on water with the possibility of a delayed rescue. Design emphasis is placed on four major areas. First is the design of a mechanism that provides a safe and time-critical means of removing the sick or injured crewmember from the ACRV. Support to the assisting rescue personnel is also provided. Second is the design of a system that orients and stabilizes the craft after landing so as to cause no further injury or discomfort to the already ill or injured crewmember. Third is the design of a system that provides full medical support to a sick or injured crewmember aboard the ACRV from the time of separation from the space station to rescue by recovery forces. Last is the design of a system that provides for the comfort and safety of the entire crew after splashdown up to the point of rescue. The four systems are conceptually integrated into the ACRV. Author

N91-18137*# Kansas State Univ., Manhattan.
AUTOMATION OF CLOSED ENVIRONMENTS IN SPACE FOR HUMAN COMFORT AND SAFETY
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 99-103 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 06/11

The Environmental Control and Life Support System (ECLSS) for the Space Station Freedom and future colonization of the Moon and Mars presents new challenges for present technologies. Current plans call for a crew of 8 to live in a safe, shirt-sleeve environment for 90 days without ground support. Because of these requirements, all life support systems must be self-sufficient and reliable. The ECLSS is composed of six subsystems. The temperature and humidity control (THC) subsystem maintains the cabin temperature and humidity at a comfortable level. The atmosphere control and supply (ACS) subsystem insures proper cabin pressure and partial pressures of oxygen and nitrogen. To protect the space station from fire damage, the fire detection and suppression (FDS) subsystem provides fire sensing alarms and extinguishers. The waste management (WM) subsystem compacts solid wastes for return to Earth, and collects urine for water recovery. Because it is impractical, if not impossible, to supply the station with enough fresh air and water for the duration of the space station's extended mission, these elements are recycled. The atmosphere revitalization (AR) subsystem removes CO2 and other dangerous contaminants from the air. The water recovery and management (WRM) subsystem collects and filters condensate from the cabin to replenish potable water supplies, and processes urine and other waste waters to replenish hygiene water supplies. These subsystems are not fully automated at this time. Furthermore, the control of these subsystems is not presently integrated; they are largely independent of one another. A fully integrated and automated ECLSS would increase astronauts' productivity and contribute to their safety and comfort. The Kansas State University Advanced Design Team is in the process of researching and designing controls for the automation of the ECLSS for Space Station Freedom and beyond. The approach chosen to solve this problem is to divide the design into three phases. The first phase is to research the ECLSS as a whole system and then concentrate efforts on the automation of a single subsystem. The AR subsystem was chosen for our focus. During the second phase, the system control process will then be applied to the AR subsystem.
Author

N91-18142*# Michigan Univ., Ann Arbor.
PROJECT EGRESS: THE DESIGN OF AN ASSURED CREW RETURN VEHICLE FOR THE SPACE STATION
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 129-135 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

Keeping preliminary studies by NASA in mind, an Assured Crew Return Vehicle (ACRV) was developed. The system allows the escape of one or more crew members from Space Station Freedom in case of emergency. The design of the vehicle addresses propulsion, orbital operations, reentry, landing and recovery, power and communication, and life support. In light of recent modifications in Space Station design, Project EGRESS (Earthbound Guaranteed ReEntry from Space Station) pays particular attention to its impact on Space Station operations, interfaces and docking facilities, and maintenance needs. A water landing, medium lift vehicle was found to best satisfy project goals of simplicity and cost efficiency without sacrificing the safety and reliability requirements. With a single vehicle, one injured crew member could be returned to Earth with minimal pilot involvement. Since the craft is capable of returning up to five crew members, two such permanently docked vehicles would allow full evacuation of the Space Station. The craft could be constructed entirely with available 1990 technology and launched aboard a shuttle orbiter. Author

N91-18573*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MICROBIOLOGY ON SPACE STATION FREEDOM
DUANE L. PIERSON, ed., MICHAEL R. MCGINNIS, ed., S. K. MISHRA, ed., and CHRISTINE F. WOGAN, ed. (Krug International, Houston, TX.) Washington Feb. 1991 40 p Conference held in Houston, TX, 6-8 Nov. 1989
(NASA-CP-3108; S-619; NAS 1.55:3108) Avail: NTIS HC/MF A03 CSCL 06/3

This panel discussion convened in Houston, Texas, at the Lunar and Planetary Institute, on November 6 to 8, 1989, to review NASA's plans for microbiology on Space Station Freedom. A panel of distinguished scientists reviewed, validated, and recommended revisions to NASA's proposed acceptability standards for air, water, and internal surfaces on board Freedom. Also reviewed were the proposed microbiology capabilities and monitoring plan, disinfection procedures, waste management, and clinical issues. In the opinion of this advisory panel, ensuring the health of the Freedom's crews requires a strong goal-oriented research effort to determine the potential effects of microorganisms on the crewmembers and on the physical environment of the station. Because there are very few data addressing the fundamental question of how microgravity influences microbial function, the panel recommended establishing a ground-based microbial model of Freedom, with subsequent evaluation using in-flight shuttle data. Sampling techniques and standards will be affected by both technological advances in microgravity-compatible instrumentation, and by changes in the microbial population over the life of the station. Author

N91-19005*# Alabama Univ., Tuscaloosa. Dept. of Industrial Engineering.
EMERGENCY EGRESS REQUIREMENTS FOR SPACE STATION FREEDOM

PAUL S. RAY *In its* Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 22/2

There is a real concern regarding the requirements for safe emergency egress from the Space Station Freedom (SSF). The possible causes of emergency are depressurization due to breach of the station hull by space debris, meteoroids, seal failure, or vent failure; chemical toxicity; and a large fire. The objectives of the current study are to identify the tasks required to be performed in emergencies, establish the time required to perform these tasks, and to review the human equipment interface in emergencies. It was found that a fixed time value specified for egress has shifted focus from the basic requirements of safe egress, that in some situations the crew members may not be able to complete the emergency egress tasks in three minutes without sacrificing more than half of the station, and that increased focus should be given to human factors aspects of space station design. Author

N91-19014*# New Mexico Highlands Univ., Las Vegas. Dept. of Engineering Technology.
BIOREGENERATIVE LIFE SUPPORT
BILL TAYLOR *In* Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 5 p Oct. 1990
(Contract NGT-01-002-099)
Avail: NTIS HC/MF A16 CSCL 06/11

Bioregenerative life support systems utilize plant growth for food, water, and atmosphere revitalization. Simulation studies of a simplified model are presented that suggest survivability in the face of partial plant growth chamber failure. Simulation studies demonstrate the potential for a bioregenerative life support system on an extended mission. In addition to robustness and survivability in terms of the food supply, the plant growth chamber produces exactly the right amount of oxygen for the crew's metabolic needs. The amount of water taken up by the plants during food production is balanced by the crew's metabolic water production. Y.S.

N91-19576# Institute of Biomedical Problems, Moscow (USSR).
MEDICAL RESULTS OF THE FOURTH PRIME EXPEDITION ON THE ORBITAL STATION MIR
A. I. GRIGORIEV, V. V. POLIAKOV, V. V. BOGOMOLOV, A. D. EGOROV, I. D. PESTOV, and I. B. KOZLOVSKAYA *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 19-22 Nov. 1990
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The medical objectives of the fourth prime expedition on the orbital station MIR were to monitor the cabin environmental parameters, to control prophylactic measures, and to implement the program of medical investigations. Participation of a trained physician helped to increase the reliability of medical support and to enlarge the scope of medical experiments in flight. The health condition and work capacity of the cosmonauts at different flight stages and after recovery remained satisfactory. Functional changes were adequate to the exposure and reflected both the general pattern of adaptative changes and the specific features of individual crew members. ESA

N91-19583# Udine Univ. (Italy). Inst. of Biology.
PEDALLING IN SPACE TO SIMULATE GRAVITY: THE TWIN-BIKE SYSTEM
GIULIOANDREA ANTONUTTO, CARLO CAPELLI, and PIETRO E. DIPRAMPERO *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 59-62 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

Microgravity leads to progressive musculoskeletal decay. This results in a significant decrease of the exercise capacity and in orthostatic intolerance, this last manifesting itself upon the return to Earth. Thus, without appropriate countermeasures, long term manned space flights may be seriously jeopardized. A simple mechanical system that may partially obviate the above problems is proposed. The system consists of two mechanically coupled bicycles riding along the inner wall of a cylindrical space module. The bikes' motion induces a force which stimulates gravity on the exercising subjects. The biomechanical and bioenergetical aspects of such a system are discussed. It is concluded that by appropriately selecting the radial dimensions of this last in order to minimize vestibular disturbances, head to feet acceleration gradients and manufacturing costs, it may be possible to combine exercise and simulated gravity, with no need for additional external power.
ESA

N91-19588# Innsbruck Univ. (Austria). Klinik fuer Neurologie.
COORDINATION OF EYE, HEAD AND ARM MOVEMENTS IN WEIGHTLESSNESS
MEINHARD BERGER, F. GERSTENBRAND, MIKLOS MAROSI, E. KARAMAT, ARMIN MUIGG, T. MELICHAR, R. SCHAUER, I. B. KOZLOVSKAYA, A. SOKOLOV, and M. BELAEVA (Institute of Biomedical Problems, Moscow, USSR) *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 79-81 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

The experiment MONIMIR will be part of the investigation program of the Austrian Sovjet spaceflight AUSTROMIR in November 1991. In this experiment the coordination and adaptation of the eye, head and arm movement in microgravity will be investigated. The following tests will take place: preprogrammed movements on acoustic and visual targets; tracking movements on visual targets; memory movements; influence of neck reflexes on arm movements; biomechanics of the cervical spine; T-reflex (patellar reflex). The methods and equipment to be used are briefly described. ESA

N91-19595# Graz Univ. (Austria). Physiologisches Inst.
IS PHYSIOLOGICAL TREMOR (MICROVIBRATION) INFLUENCED BY MICROGRAVITY
EUGEN GALLASCH, N. BURLATSCHKOWA, I. BELJAJEVA (Institute of Biomedical Problems, Moscow, USSR), M. MOSER, and I. KENNER *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 107-110 Nov. 1990
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Many studies have been done to analyze the mechanism of tremors, however there are still many controversies. The use of microgravity conditions may open a wide experimental field in which many questions about the origin of tremors can be reinvestigated. In a joint space flight USSR-Austria (Project AUSTROMIR) a program to take tremor recordings at rest and during different tasks from one cosmonaut by means of two accelerometers is prepared. From these measurements new insight into the complex sensori motor interactions of the musculoskeletal control system during adaptation is expected. ESA

N91-19603*# Vanderbilt Univ., Nashville, TN. Dept. of Mechanical Engineering.
SKELETAL ADAPTATION IN ALTERED GRAVITY ENVIRONMENTS
TONY S. KELLER and ALVIN M. STRAUSS *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 141-147 Nov. 1990 Sponsored by NASA
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It is generally agreed that the single factor that most limits human survivability in non Earth environments is the phenomenon of bone demineralization and the medical problems induced by the subsequent imbalance in the calcium metabolism. Alterations of skeletal properties occur as a result of disturbances in the normal mechanical loading environment of bone. These alterations or adaptations obey physical laws, but the precise mathematical relationship remains to be determined. Principles governing unloading and overloading of bone are gaining more attention as a consequence of the planning of manned space stations, Moon and Mars bases and spaceflights of long duration. A mathematical framework which allows for the prediction of skeletal adaptation on Earth and in non Earth gravity environments by power law relationships is presented. ESA

N91-19617# Institute of Biomedical Problems, Moscow (USSR).
THE BIOLOGICAL AND MEDICAL PROGRAMME OF THE MANNED ARAGATZ MISSION ON THE MIR SPACE STATION
A. KOTOVSKAIA and DIDIER VASSAUX (Centre National de la Recherche Scientifique, Paris, France) *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 207-214 Nov. 1990
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The program of biological and medical experiments within the Aragatz program was a logical extension of French-Soviet cooperation in the space biology and medicine fields, and particularly of the studies carried out during the first French-Soviet flight on the Salyut 7 station in 1982, which were continued during the 237 day flight of 1984. This program filled about half the planned crew workload and covered the main topics of space physiology and medicine. The measurements taken on the crew before the flight, during the first half of the mission, and shortly before and after their return to Earth correspond to seven experiments, two of which were performed exclusively on the ground. The overall aim was to make pertinent use of a flight having an original duration of four weeks to gain a deeper understanding of the physiological mechanisms involved in the adaptation to weightlessness and, more generally, to the space environment. ESA

N91-19656# Dornier System G.m.b.H., Friedrichshafen (Germany, F.R.).
PLANT PRODUCTION AS PART OF A CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM (CELSS)
KATJA DAVID, ROBERT BACKHAUS (Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne, Germany, F.R.), and AKE INGEMAR SKOOG *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 431-434 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

To reduce logistics costs of long distance and long duration manned space missions, resupply has to be reduced by recycling and in orbit production of consumables. An essential biochemical reaction in view of the life support requirements is the photosynthesis performed by algae and higher plants. For system closure it is needed in order to close the carbon loop. In contrast to a natural ecosystem, a controlled ecological life support system (CELSS) is designed to meet only human requirements and has to have a stable performance in every subsystem. Therefore, and because of the miniaturization of the system buffer, capacity and tolerable variability are extremely reduced. The critical features of plant production in an artificial ecosystem like a CELSS are presented. ESA

N91-19662# Technische Univ., Vienna (Austria). Inst. of Plant Physiology.
PRODUCTIVITY AND PHOTOSYNTHESIS OF SELECTED CROP PLANTS UNDER ORBITAL LIGHT CONDITIONS: AN APPROACH TO SOLAR POWERED CELSS
HEIDEMARIE V. HURTL, REINHARD A. SACHER, and KARL M. BURIAN *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 467-470 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

Controlled ecological life support systems (CELSS) based upon higher plants might use natural sunlight rather than artificial illumination. In the case of a CELSS for a future space station in low Earth obit (LEO), these plants would have to deal with extremely short light/dark cycles. Due to the 90 minutes revolution period of the station, plants would be subjected to 60 minutes sunlight, followed by 35 minutes darkness in shade. These orbital light/dark cycles (60 minutes/30 minutes) were simulated in a growth chamber, accompanied by control experiments under longday conditions (16 hours light/8 hours dark) in a second chamber. Biometric and gas-exchange measurements showed decreased productivity and carbon uptake in soybean (Glycine max L.), mung bean (Phaseolus mungo L.), and millet (Sorghum bicolor L.) under orbital light conditions. ESA

N91-19679# Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires.
NEW EXPERIMENTAL APPROACH IN QUALITY FACTOR AND DOSE EQUIVALENT DETERMINATION DURING A LONG TERM MANNED SPACE MISSION
VAN DAT NGUYEN, P. BOUISSET, N. PARMENTIER, M. SIEGRIST, Y. A. AKATOV, V. V. ARCHANGELSKY, S. VOROJTSOV, S. B. KOSLOVA, V. G. MITRIKAS, V. M. PETROV (Institute of Biomedical Problems, Moscow, USSR) et al. *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 555-558 Nov. 1990
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Due to high LET (Linear Energy Transfer) particles existing in space environment, the knowledge of the quality factor is one of priority in radiation protection efforts. During the French Soviet space mission Aragatz, the experiment CIRCE (complex beam in space counter integrator) had recorded dose equivalent and quality factor values inside the MIR station. Results obtained with a new experimental approach by using an active dose equivalent meter based on microdosimetric techniques and a low pressure tissue equivalent proportional counter are presented. In terms of lineal energy, the CIRCE device works in the 0.3 to 1200 keV micron range in tissue. The average dose equivalent is eoual to 0.6 mSv. per day and the mean value of quality factor is equal to 1.9. Through the SAA the dose equivalent rate rapidly increases until 1.20 mSv./h and the corresponding quality factor decreases to 1.4. ESA

N91-19684# Institute of Biomedical Problems, Moscow (USSR).
PRINCIPLE AND REALIZATION OF THE INSTRUMENT USED FOR THE CIRCE EXPERIMENT ON BOARD THE MIR STATION
V. M. PETROV, J. A. AKATOV, S. B. KOZLOVA, VAN DAT NGUYEN, J. KERLAU, M. SIEGRIST, and J. F. ZWILLING (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 577-580 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

Absorbed dose and dose equivalent measurements on board the MIR station used a microdosimetric system CIRCE made in France. The system includes the tissue equivalent proportional counter and electronic unit based on a microprocessor. Metrological characteristics on the CIRCE device are given. The accuracy of the measurements is 10 percent. The measurement results were recorded on the special memory unit SERCOM. The metrological characteristics of the CIRCE device were investigated with accelerators and neutron and gamma sources. ESA

N91-19689# Lyon-1 Univ., Villeurbanne (France). Lab. d'Environ. Physiologie.
VOLUME REGULATING HORMONES, FLUID AND ELECTROLYTE MODIFICATIONS DURING THE ARAGATZ MISSION (MIR STATION)
GUILLEMETTE GAUQUELIN, G. GEELEN, C. GHARIB, A. I. GRIGORIEV, ANTONIO GUELL, R. KVETNANSKY, L. MACHO, V. NOSKOV, P. PASI, J. SOUKANOV (Institute of Biomedical Problems, Moscow, USSR) et al. *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 603-608 Nov. 1990 Sponsored in part by CNES
(Contract DRET-89-237)
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

During a 25 day flight on board the MIR station parameters involved in blood volume regulation were studied. Blood samples were taken to determine electrolytes and osmolality. Epinephrine, norepinephrine, dopamine, Anti Diurectic Hormone (ADH), Atrial

Natriuretic Factor (ANF), Plasma Renin Activity (PRA), aldosterone, and cortisol, were measured at days 9 and 20 of the spaceflight. Urine was collected at days 5 and 19 to measure the same parameters (except PRA). The modifications of these hormones (generally increased) are discussed and compared to previous flights. Three factors may account for the results, especially the increase in ADH: the well known initial fluid shift in weightlessness and the adaptative mechanisms following this phase, stress, and environmental factors (CO2 and temperature). ESA

N91-19692# Centre National de la Recherche Scientifique, Paris (France). Lab. de Physiologie Neurosensorielle.
GAZE CONTROL AND SPATIAL MEMORY IN WEIGHTLESSNESS
CLAUDIE ANDRE-DESHAYS, I. ISRAEL, A. BERTHOZ, K. E. POPOV, and M. I. LIPSCHITS (Academy of Sciences, USSR, Moscow) *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 617-621 Nov. 1990 Sponsored by CNES
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Visual information is quite important for spatial orientation, and still more necessary when other sensory inputs may be altered, as in weightlessness. In order to study gaze control, during the long duration flight named Aragatz on board of the MIR Space Station, a series of experiments were performed which explored the different oculomotor subsystems involved in the control of gaze during orientation to a fixed visual target and when tracking a moving target, and the performances of the saccadic system during orientation to remembered target positions, in complete darkness. Two cosmonauts participated in these experiments. The results showed changes in the saccadic system with a decrease of reaction time (an increase in eye peak velocity, an improvement of saccade accuracy), and an increase of the memory guided saccades. ESA

N91-19694# Centre National de la Recherche Scientifique, Paris (France). Lab. de Physiologie Neurosensorielle.
MENTAL ROTATION OF THREE-DIMENSIONAL SHAPES IN MICROGRAVITY
YOANI MATSAKIS, A. BERTHOZ, M. I. LIPSCHITS, and VICTOR S. GURFINKEL (Academy of Sciences, USSR, Moscow) *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 625-629 Nov. 1990
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Previous experiments have suggested that gravity could exert a constraint on visual image processing. This hypothesis was investigated using a mental rotation task involving three dimensional objects during a 26 day orbital flight aboard the Soviet MIR Station. The analysis of cosmonauts' response times showed that the average rotation time per degree was shorter in flight than on ground. This decay seemed to be mainly attributable to responses implying roll axis rotations. These results are congruent with the gravity constraint hypothesis in the sense that weightlessness provided a release of this constraint, modifying the dynamic characteristics of the rotation process. As roll rotations do not alter the two dimensional image of objects' projection onto the retina, mental rotation processes could apply differently to two dimensional retinotopic or viewer centered representations and to three dimensional object centered representations. ESA

N91-19696# Giessen Univ. (Germany, F.R.). Strahlenzentrum.
POTENTIALS, MESSAGE AND CHALLENGES OF LIFE SCIENCE RESEARCH IN SPACE
JUERGEN KIEFER *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 639-642 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

The question of whether life science research in space can contribute to the solution of fundamental biological questions is considered. The possibility of this may seem absurd considering how hostile the space environment is to living things. The lack of atmosphere and low temperatures can be overcome technically by comparatively simple means, but radiation and microgravity remain. The possible influences of microgravity on basic biological processes is considered and several achievements and promises of space biology demonstrated in papers at the conference are discussed. ESA

N91-19697*# National Aeronautics and Space Administration, Washington, DC.
THE 1989-1990 NASA SPACE BIOLOGY ACCOMPLISHMENTS
THORA W. HALSTEAD, ed. Feb. 1991 226 p Prepared in cooperation with George Washington Univ., Washington, DC
(Contract NASW-4324)
(NASA-TM-4258; NAS 1.15:4258) Avail: NTIS HC/MF A11 CSCL 06/3

Individual technical summaries of research projects on NASA's Space Biology Program for research conducted during the period May 1989 to April 1990 are presented. This program is concerned with using the unique characteristics of the space environment, particularly microgravity, as a tool to advance the following: (1) knowledge in the biological sciences; (2) understanding of how gravity has shaped and affected life on the Earth; and (3) understanding of how the space environment affects both plants and animals. The summaries for each project include a description of the research, a list of accomplishments, an explanation of the significance of the accomplishments, and a list of publications. DOE

N91-20630*# Space Station Engineering and Integration Contractor, North Olmsted, OH.
AN ASSESSMENT OF THE SPACE STATION FREEDOM PROGRAM'S LEAKAGE CURRENT REQUIREMENT Final Report
MICHAEL NAGY Mar. 1991 16 p Prepared for NASA, Lewis Research Center, Cleveland, OH
(Contract NASW-4300)
(NASA-CR-187077; NAS 1.26:187077; PSL-450-RP91-003A)
Avail: NTIS HC/MF A03 CSCL 06/11

The Space Station Freedom Program requires leakage currents to be limited to less than human perception level, which NASA presently defines as 5 mA for dc. The origin of this value is traced, and the literature for other dc perception threshold standards is surveyed. It is shown that while many varying standards exist, very little experimental data is available to support them. Author

N91-20631*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
METHOD FOR OPTIMAL CONFIGURATION OF AN ECLSS ON THE SPACE STATION FREEDOM
MARSTON J. GOULD Feb. 1991 23 p
(NASA-TM-104040; NAS 1.15:104040) Avail: NTIS HC/MF A03 CSCL 06/11

The establishment of a permanently manned Space Station represents a substantial challenge in the design of a life support system, specifically in the need to supply a large crew for missions of extended duration. The Space Station will evolve by time phased modular increments delivered and supplied by the Space Shuttle and other advanced launch systems. With the addition of each subsequent phase or alteration of mission duties, the requirements of the Station may differ from previous phases of development. With the addition of future crews and pressurized volume throughout the lifetime of the Space Station, change-out of individual subsystems may be necessary in order to meet the performance, safety, and reliability levels required from the Environmental Control and Life Support System (ECLSS). The analysis of this system growth demands the capability for advanced, integrated assessment techniques so that the unique mission drivers during each phase and mission scenario may be identified and evaluated. In order to determine the impacts of the interdependency between the ECLSS, the crew, the various user experiments, and the other distributed systems, consideration must be given to all Space Station resources and requirements during the initial and subsequent evolution phase. Therefore, it is necessary for analysis efforts to study the long term effects of established designs. These studies must quantify the optimal degree of loop closure within the capabilities of existing and future technologies including any resulting maintenance and logistics requirements. In addition, the necessity for subsystem retrofit during the lifetime of the Station must be examined. The source of system requirements due to long term exposure to the microgravity environment is illustrated, the criticality of the ECLSS functions is reviewed, and a method is described to develop an optimal design during each configuration based on the cross-consumption of Station resources. A comparison utilizing this procedure is discussed. Author

N91-20641*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FOURTH ANNUAL WORKSHOP ON SPACE OPERATIONS APPLICATIONS AND RESEARCH (SOAR 90)
ROBERT T. SAVELY, ed. Washington Jan. 1991 495 p
Workshop held in Albuquerque, NM, 26-28 Jun. 1990; sponsored by NASA, Washington, AF, and New Mexico Univ.
(NASA-CP-3103-VOL-1; S-618-VOL-1; NAS 1.55:3103-VOL-1)
Avail: NTIS HC/MF A21 CSCL 12/1

The proceedings of the SOAR workshop are presented. The technical areas included are as follows: Automation and Robotics; Environmental Interactions; Human Factors; Intelligent Systems; and Life Sciences. NASA and Air Force programmatic overviews and panel sessions were also held in each technical area.

N91-20683*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
INTELLIGENT MONITORING AND DIAGNOSIS SYSTEMS FOR THE SPACE STATION FREEDOM ECLSS
BRANDON S. DEWBERRY and JAMES R. CARNES (Boeing Co., Huntsville, AL.) *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 338-343 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 05/8

Specific activities in NASA's environmental control and life support system (ECLSS) advanced automation project that is designed to minimize the crew and ground manpower needed for operations are discussed. Various analyses and the development of intelligent software for the initial and evolutionary Space Station Freedom (SSF) ECLSS are described. The following are also discussed: (1) intelligent monitoring and diagnostics applications under development for the ECLSS domain; (2) integration into the MSFC ECLSS hardware testbed; and (3) an evolutionary path from the baseline ECLSS automation to the more advanced ECLSS automation processes. Author

N91-20702*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FOURTH ANNUAL WORKSHOP ON SPACE OPERATIONS APPLICATIONS AND RESEARCH (SOAR 90)
ROBERT T. SAVELY, ed. Washington Jan. 1991 316 p
Workshop held in Albuquerque, NM, 26-28 Jun. 1990; sponsored by NASA, Washington, AF, and New Mexico Univ.
(NASA-CP-3103-VOL-2; S-618-VOL-2; NAS 1.55:3103-VOL-2)
Avail: NTIS HC/MF A14 CSCL 12/1

The papers from the symposium are presented. Emphasis is placed on human factors engineering and space environment interactions. The technical areas covered in the human factors section include: satellite monitoring and control, man-computer interfaces, expert systems, AI/robotics interfaces, crew system dynamics, and display devices. The space environment interactions section presents the following topics: space plasma interaction, spacecraft contamination, space debris, and atomic oxygen interaction with materials. Some of the above topics are discussed in relation to the space station and space shuttle.

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ORBITS & ORBITAL TRANSFER

Maintenance of space station or other large structures in their orbits, as well as transfer between orbits. Includes docking with servicing or transfer vehicles.

A91-10925*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SATELLITE SERVICER SYSTEM FLIGHT DEMONSTRATION PROGRAM
JAMES S. MOORE (NASA, Johnson Space Center, Houston, TX), GEORGE M. LEVIN (NASA, Washington, DC), and NEAL ELY (USAF; DOE, Germantown, MD) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 7 p.

The major hardware elements, demonstration objectives, and technical approaches, as well as existing and developing technologies for applicability to the Satellite Servicer System (SSSFD) program are presented. In a project to develop the capability of servicing satellites in remote locations, NASA and SDI have planned a series of flights to demonstrate autonomous rendezvous and docking, supervised autonomous fluid transfer, and supervised autonomous orbital replacement unit exchange. Program objectives, design reference mission, and flight demonstrations are described. The expanded capability demonstrated by the SSSFD program will provide alternatives to excessive dependence on ground operations personnel and training, increase the reach into unique space environments, and decrease the costs of managing and operating space assets. R.E.P.

A91-10942#
BEHAVIOR OF LOCAL INVENTORIES AT REMOTE SITES
WILLIAM C. LEWIS IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 26 p.

The hardware and techniques used to produce the Space Transportation System Orbiting Vehicle (STS OV) are well suited to week long missions to and from low earth orbit. They are less well suited to longer missions. This paper estimates the support requirements for the Extended Duration Orbiter and Space Station Freedom. It also specifies where appropriate equipment characteristics and operational techniques would reduce equipment support requirements to desirable levels. Author

A91-12277
THE INFLUENCE OF AERODYNAMIC FORCES ON LOW EARTH ORBITS
R. CROWTHER (Logica Space and Defence Systems, PLC, Cobham, England) and J. STARK (Southampton, University, England) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 23-33. refs
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The influence of free molecular aerodynamic forces on a satellite in low earth orbit is considered. The methods available for calculating the aerodynamic coefficients of complex vehicles is discussed and applied to the test case of ERS-1. The changes in the orbit of ERS-1 under the influence of aerodynamic forces are determined and the relative influence of the modeling parameters compared. Author

A91-12306
ATTITUDE AND RELATIVE POSITION MEASUREMENT ON BOARD THE COLUMBUS MTFF
G. GRISERI and A. VAISSIERE (Matra Espace, Velizy-Villacoublay, France) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 465-477.
Copyright

This paper presents the Attitude and Rendezvous Measurement Assembly (ARMA) of the serviceable Resource Module (Columbus MTFF). The MTFF will offer multiplayload microgravity support. Payload exchange and spacecraft servicing will be performed by Hermes and Freedom, which requires passive and active rendezvous operations. Author

A91-12327
OPTIMIZATION OF THE PHASING STRATEGY BETWEEN HERMES AND THE SPACE STATION [OPTIMISATION DE LA STRATEGIE DE PHASAGE ENTRE LA NAVETTE HERMES ET UNE STATION SPATIALE]
FRANCOIS DUFOUR, JEAN-MICHEL ENJALBERT, JACQUES BERNUSSOU, JEAN-MARIE GARCIA (CNRS, Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse, France), JEROME LEGENNE (CNES, Toulouse, France) et al. IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 773-791. In French. refs
Copyright
The paper examines the optimization of phasing maneuvers which are intended to recover the initial angular gap between Hermes and the Space Station. The combined effects of atmospheric drag and nonuniform gravitational forces must be taken into account since they have a considerable effect on the trajectories. In addition, the control strategy must take into account such constraints as the crew in-flight time table and the visibility of the geostationary relay satellites. The optimal solution to the phasing problem in the deterministic case with minimum energy consumption is presented. B.J.

A91-12328
IN-ORBIT RENDEZVOUS - GUIDANCE AND CONTROL STRATEGIES FOR HOMING AND CLOSING PHASES
ERIC DESPLATS and CALIXTE CHAMPETIER (Matra Espace, Toulouse, France) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 793-822. refs
Copyright
Some guidance and control concepts which can be used during the homing and closing stages of the in-orbit rendezvous are examined with particular reference to the HERMES-CFF mission. A comparative analysis of guidance and control strategies is performed in terms of performance and robustness using simulation results obtained with a realistic navigation model. Recommendations concerning the selection of an appropriate strategy are given. V.L.

A91-12331
ON-BOARD EXPERT SYSTEM FOR MANNED RENDEZ-VOUS OPERATION ASSISTANCE
A. DE SAINT-VINCENT (Matra, S.A., Toulouse, France) and PH. MARCHAL (CNES, Toulouse, France) IN: Space dynamics; Proceedings of the International Symposium, Toulouse, France, Nov. 6-10, 1989. Toulouse, France, Cepadues-Editions, 1990, p. 853-863. refs
Copyright
A 'rendezvous operator assistant concept' is currently being studied by MATRA. It is a real time interactive system, based on AI techniques and directed toward situation assessment and short-term reactions for safety, and also mission replanning. The paper describes the system functionalities and preliminary breadboarding, and addresses the main original features raised by the rendezvous problematics, such as the man-machine interaction and the real-time aspects. Author

A91-13749#
VISUAL SENSING FOR AUTONOMOUS RENDEZVOUS AND DOCKING
MIKIO FUKASE, TSUGITO MARUYAMA, TAKASHI UCHIYAMA (Fujitsu Laboratories, Ltd., Mechatronics-in-Space Laboratory, Kawasaki, Japan), OSAMU OKAMOTO, and ISAO YAMAGUCHI (National Aerospace Laboratory, Chofu, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-027) Copyright
This paper describes how to automatically estimate the distance and attitude of a target which are required to obtain for rendezvous and docking (RVD) by using visual sensing. When model features are extracted by using visual sensors, the main problems for visual sensors are poor lighting conditions and limited processing capacity in earth orbit. The present algorithm can be made robust under poor lighting conditions by using region data which can help its internal data cope with changing lighting conditions. It is also important for lightening the calculation load to decrease number of features for matching. The features selected are region-area and its relational arrangement. The distance and attitude of a target was estimated by using such simple data. When RVD-required data are actually obtained automatically by using this method, these features must be extracted automatically from an actual image. The extraction of these region data automatically from an actual image by band-pass binary, labeling, and interframe logical operation, was based on region-growing which lost few features under poor lighting conditions. Author

A91-13760#
AN EVOLUTIONARY APPROACH TOWARDS UNMANNED ORBITAL SERVICING
U. BECKER and L. KERSTEIN (MBB/ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p. refs
(IAF PAPER 90-044) Copyright
A system-oriented approach for the definition of an in-orbit servicing technology concept is presented. Using projected servicing applications and EVA capabilities as reference, servicing functions and requirements are systematically derived to define technology solutions that can be applied to the individual servicing fields. Finally, the technology solutions identified are evaluated and arranged in an overall evolutionary servicing technology development frame that is taken as a baseline for the conceptual definition of an unmanned in-orbit servicing element. R.E.P.

A91-13761#
UNMANNED SERVICING OF EARTH OBSERVATION SYSTEMS IN SUNSYNCHRONOUS ORBITS
JACK SLINEY, BILL ROBERTSON, TOM MISENCIK, and JEANNIE LEE (Dynamics Research Corp., Arlington, VA) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 13 p. refs
(IAF PAPER 90-045) Copyright
The feasibility of servicing or reboosting earth observation spacecraft that are in or near sun-synchronous orbits through the use of an unmanned servicing vehicle is examined. Both qualitative and quantitative evaluations are made of how earth observation systems in inclinations between 96 and 100 degrees may be periodically serviced utilizing a transfer vehicle and other components needed to carry out the support mission. Consideration is given to the NASA developed OMV and other transfer vehicles that utilize electrical or other advanced propulsion systems. A quantitative assessment is also made of the subsystem redundancy requirements in the design for an earth observation satellite which is periodically serviced as compared with design requirements for an unserviceable spacecraft. The advantages of servicing with respect to preplanned product improvements are discussed. R.E.P.

A91-13769#
CNES RENDEZ-VOUS AND DOCKING ACTIVITY...WITH A VIEW TO HERMES
PH. MARCHAL (CNES, Toulouse, France) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p. refs
(IAF PAPER 90-057) Copyright
An overview is presented of the achievements of CNES rendezvous and docking research performed over the past five

years, with an emphasis on the implications for the Hermes program. Candidate sensor technologies, ground-based mockup systems for docking, and expert systems are examined. Baseline scenarios and strategies are outlined. C.D.

A91-13843*# National Aeronautics and Space Administration, Washington, DC.

REQUIREMENTS FOR A NEAR-EARTH SPACE TUG VEHICLE

CHARLES R. GUNN (NASA, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 7 p.

(IAF PAPER 90-165) Copyright

The requirement for a small but powerful space tug, which will be capable of autonomous orbital rendezvous, docking and translating cargos between near-earth orbits by the end of this decade to support the growing national and international space infrastructure focused near the Space Station Freedom, is described. An aggregate of missions drives the need for a space tug including reboosting decaying satellites back to their operational altitudes, retrieving failed or exhausted satellites to Shuttle or SSF for on-orbit refueling or repair, and transporting a satellite servicer system with an FTS to ailing satellites for supervised in-place repair. It is shown that the development and operation of a space tug to perform such numerous missions is more cost effective than separate module and satellite systems to perform the same tasks. R.E.P.

A91-13952

APPLICATION OF GPS FOR HERMES RENDEZ-VOUS NAVIGATION

E. T. HESPER, B. A. C. AMBROSIUS, R. J. SNIJDERS, and K. F. WAKKER (Delft, Technische Universiteit, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. refs

(IAF PAPER 90-337)

This paper investigates the possibility of applying the Navstar GPS for rendezvous navigation and docking in LEO, by performing an error analysis on a typical rendezvous mission between the European spaceplane Hermes and the Columbus Free Flying Laboratory. The error model included nondynamic as well as dynamic error sources, such as the gravity field, drag, and GPS ephemerides. In addition, the effects of failures and degraded tracking capabilities were investigated. Results of simulations show that the Navstar GPS can be extremely useful for the navigation of rendezvous missions. I.S.

A91-17423#

THE GPS INTEGRATED NAVIGATION AND ATTITUDE-DETERMINATION SYSTEM (GINAS)

R. LUCAS and M. MARTIN-NEIRA (ESTEC, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 14, no. 3, 1990, p. 289-302. refs

Copyright

When the European Columbus Free-Flying Laboratory is orbiting the earth at a speed of 7 km/s, the Global Positioning System (GPS) will allow its instantaneous position to be determined on-board, independently of the ground, to an accuracy of better than 100 m. When the European spaceplane Hermes and the Columbus elements are performing rendezvous maneuvers, they will also be relying on GPS measurements to compute the remaining distance to contact. For the first flight of Hermes itself, there will be no pilot on board and GPS-based navigation will be used for this first mission and the landing. This paper describes the results of GPS field-measurement experiments conducted at ESTEC's radio-navigation testbed laboratory, including a novel 'GPS integrated navigation and attitude-determination system'. Author

A91-19028#

GUIDANCE AND CONTROL FOR COOPERATIVE TETHER-MEDIATED ORBITAL RENDEZVOUS

DALE G. STUART (TRW Space and Technology Group, Redondo Beach, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 13, Nov.-Dec. 1990, p. 1102-1108. Previously cited in issue 21, p. 3505, Accession no. A88-50261. refs

Copyright

A91-19144*# McDonnell-Douglas Space Systems Co., Houston, TX.

SOLAR F10.7 RADIATION - A SHORT TERM MODEL FOR SPACE STATION APPLICATIONS

JOHN D. VEDDER and JILL L. TABOR (McDonnell Douglas Space Systems Co., Houston, TX) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs

(Contract NAS9-17885)

(AIAA PAPER 91-0116) Copyright

A new method is described for statistically modeling the F10.7 component of solar radiation for 91-day intervals. The resulting model represents this component of the solar flux as a quasi-exponentially correlated, Weibull distributed random variable, and thereby demonstrates excellent agreement with observed F10.7 data. Values of the F10.7 flux are widely used in models of the earth's upper atmosphere because of its high correlation with density fluctuations due to solar heating effects. Because of the direct relation between atmospheric density and drag, a realistic model of the short term fluctuation of the F10.7 flux is important for the design and operation of Space Station Freedom. The method of modeling this flux described in this report should therefore be useful for a variety of Space Station applications. Author

A91-19307*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

RECENT IMPROVEMENTS IN ATMOSPHERIC ENVIRONMENT MODELS FOR SPACE STATION APPLICATIONS

B. JEFFREY ANDERSON, RONNIE J. SUGGS (NASA, Marshall Space Flight Center, Huntsville, AL), ROBERT E. SMITH, MICHAEL HICKEY, and KAREN CATLETT (FWG Associates, Inc., Huntsville, AL) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs

(AIAA PAPER 91-0452)

The capability of empirical models of the earth's thermosphere must continually be updated if they are to keep pace with their many applications in the aerospace industry. This paper briefly summarizes the progress of several such efforts in support of the Space Station Program. The efforts consists of the development of data bases, analytical studies of the data, and evaluation and intercomparison of thermosphere models. A geomagnetic storm model of Slowey does not compare as well to the MSIS-86 model as does the Marshall Engineering Thermosphere (MET). LDEF orbit decay data is used to evaluate the performance of the MET and MSIS-86 during a period of high solar activity; equal to or exceeding the highest levels that existed during the time of the original data sets upon which these models are based. Author

A91-19464*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.

A COMPARISON OF ACCELERATION CONTROL AND PULSE CONTROL IN SIMULATED 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) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 12 p. refs

(AIAA PAPER 91-0787) Copyright

Results are reported from a study designed to compare acceleration control with pulse control in simulated spacecraft docking maneuvers. Nine commercial airline pilots served as test subjects and the simulated remote dockings of an orbital maneuvering vehicle (OMV) to a space station were initiated from 50, 100, and 150 meters along the station's minus velocity vector. The trials were grouped into blocks of 18 consisting of six repetitions of the three ranges. It was found that mission duration was lower with pulse mode, while fuel consumption was lower with acceleration mode. It is suggested that this result is most likely specific to the thruster values that are being used. L.K.S.

A91-19506
DOCKING TARGET DESIGN AND SPACECRAFT TRACKING SYSTEM STABILITY
JOSEPH G. BAILEY and RICHARD A. MESSNER (New Hampshire, University, Durham) IN: Intelligent robots and computer vision VIII: Algorithms and techniques; Proceedings of the Meeting, Philadelphia, PA, Nov. 6-10, 1989. Part 2. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 820-831. refs
Copyright
Researchers at NASA's Johnson Space Center wish to provide automatic docking capabilities to spacecraft whose only guidance signals are the images of docking targets. The proposed docking system exploits the invariant properties of log-polar and Cartesian image mapping in an iterative tracking scheme that uses correlation filtering. In trade for the beneficial invariance properties of the image transforms, their sensitivity to certain tracking disturbances can cause instability and loss of tracking. This paper presents simulation studies to determine how different classes of simple target patterns affect the stability of the tracking system. The main goal is to determine empirical guidelines for designing targets that optimize tracking performance. Author

A91-19508* Transition Research, Inc., Danbury, CT.
TRACKING ALGORITHMS USING LOG-POLAR MAPPED IMAGE COORDINATES
CARL F. R. WEIMAN (Transitions Research Corp., Danbury, CT) and RICHARD D. JUDAY (NASA, Johnson Space Center, Houston, TX) IN: Intelligent robots and computer vision VIII: Algorithms and techniques; Proceedings of the Meeting, Philadelphia, PA, Nov. 6-10, 1989. Part 2. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 843-853. refs
(Contract NAS9-17990)
Copyright
The use of log-polar image sampling coordinates rather than conventional Cartesian coordinates offers a number of advantages for visual tracking and docking of space vehicles. Pixel count is reduced without decreasing the field of view, with commensurate reduction in peripheral resolution. Smaller memory requirements and reduced processing loads are the benefits in working environments where bulk and energy are at a premium. Rotational and zoom symmetries of log-polar coordinates accommodate range and orientation extremes without computational penalties. Separation of radial and rotational coordinates reduces the complexity of several target centering algorithms, described below. Author

A91-19643
IMPROVED FUZZY PROCESS CONTROL OF SPACECRAFT AUTONOMOUS RENDEZVOUS USING A GENETIC ALGORITHM
C. L. KARR (U.S. Bureau of Mines, Tuscaloosa, AL), L. M. FREEMAN, and D. L. MEREDITH (Alabama, University, Tuscaloosa) IN: Intelligent control and adaptive systems; Proceedings of the Meeting, Philadelphia, PA, Nov. 7, 8, 1989. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 274-288. refs
Copyright
A fuzzy logic controller (FLC) is developed to control a mathematical model that simulates the autonomous rendezvous of two spacecraft, one actively doing the rendezvous, the other passively orbiting. A simple three-operator genetic algorithm is used to improve the performance of the rendezvous FLC. The FLC is able to maintain control over the spacecraft by relying exclusively on fuzzy rules to determine its next action. C.D.

A91-21985
NUMERICAL ESTIMATES OF SECULAR EFFECTS IN THE TRANSLATIONAL-ROTATIONAL MOTION OF AN ORBITAL STATION WITH 'MARTIAN' GRAVITY ON BOARD [CHISLENNYE OTSENKI VEKOVYKH EFFEKTOV V POSTUPATEL'NO-VRASHCHATEL'NOM DVIZHENII ORBITAL'NOI STANTSII, OBLADAIUSHCHEI 'MARSIANSKOI' TIAZHEST'IU NA BORTU]
D. Z. KOENOV (Tadzhikskii Gosudarstvennyi Universitet, Dushanbe, Tadzhik SSR) Akademiia Nauk Tadzhikskoi SSR, Doklady (ISSN 0002-3469), vol. 33, no. 4, 1990, p. 232-235. In Russian.
Copyright
Attention is given to an orbital station consisting of two identical cylindrical spacecraft with symmetrical wings (solar arrays); connected by a long tether, the two craft rotate about an axis that passes through their common center of mass. It is assumed that a Martian type of gravity has been created on board. Numerical estimates show that, in the course of a single mean solar day, the station performs more than 15.5 revolutions around the earth. B.J.

A91-22097
PRINCIPLES OF SPACECRAFT FLIGHT CONTROL (2ND REVISED AND ENLARGED EDITION) [OSNOVY UPRAVLENIIA POLETOM KOSMICHESKIKH APPARATOV /2ND REVISED AND ENLARGED EDITION/]
ANATOLII P. RAZYGRAEV Moscow, Izdatel'stvo Mashinostroenie, 1990, 480 p. In Russian. refs
Copyright
The principles of the design of spacecraft flight control systems and their components are presented. In particular, attention is given to the classification of spacecraft flight control systems; requirements for spacecraft orientation and stabilization systems; postcutoff orientation and stabilization, and powered stabilization. The discussion also covers spacecraft guidance in orbit transfers; guidance of spacecraft during landing on the moon and planets with rarefied atmospheres; spacecraft guidance during landing on the earth and other planets with dense atmospheres; and spacecraft guidance during docking. V.L.

A91-22939*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REDUCED-DYNAMIC TECHNIQUE FOR PRECISE ORBIT DETERMINATION OF LOW EARTH SATELLITES
S. C. WU, T. P. YUNCK, and C. L. THORNTON (JPL, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Jan.-Feb. 1991, p. 24-30. Previously cited in issue 02, p. 150, Accession no. A89-12633. refs
Copyright

A91-26643
NAVIGATION, GUIDANCE AND CONTROL SUBSYSTEM OF SPACE FLYER UNIT
T. NISHIMURA (Institute of Space and Astronautical Science, Sagamihara, Japan), M. KAWACHI, T. YAMAGUCHI, M. SATO, and K. TSUKAHARA (Mitsubishi Electric Corp., Kamakura Works, Japan) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 267-272. refs
Copyright
The Space Flyer Unit (SFU), a retrievable and reusable platform which will be utilized for many kinds of scientific and engineering experiments in space, such as material processing and space observations, is described. The design status of autonomous navigation and guidance logic for rendezvous with STS, and operation in the proximity of STS, are discussed. In addition, two critical issues concerning attitude control are addressed: actuator sizing compatibility for many kinds of mission operations and stabilization for flexible appendages such as solar paddles. L.K.S.

A91-26801
GUIDANCE AND CONTROL 1990; PROCEEDINGS OF THE ANNUAL ROCKY MOUNTAIN GUIDANCE AND CONTROL CONFERENCE, KEYSTONE, CO, FEB. 3-7, 1990
ROBERT D. CULP, ED. (Colorado, University, Boulder) and ARLO D. GRAVSETH, ED. (Martin Marietta Corp., Astronautics Group, Denver, CO) *Conference sponsored by AAS.* San Diego, CA, Univelt, Inc., 1990, 676 p. For individual items see A91-26802 to A91-26837.
Copyright
Advances in guidance, navigation, and control are presented in reviews, reports, and storyboard displays. Consideration is given to on-orbit alignment and calibration of satellites, autonomy and adaptive control, and aerospace human factors. Particular papers are presented on simulation studies of the GOES-1 Image Navigation and Registration System; an optical locator for horizon sensing; the astrometric calibration of the HST fine guidance sensors; and early mission characterization of the Galileo attitude control subsystem. B.J.

A91-27123#
ATTITUDE AND ORBITAL MODELLING OF SOLAR-SAIL SPACECRAFT
F. ANGRILLI and S. BORTOLAMI (Padua, Universita, Italy) ESA Journal (ISSN 0379-2285), vol. 14, no. 4, 1990, p. 431-446. refs
Copyright
This paper describes the attitude and orbital dynamics of a solar-sail spacecraft, proposed for entry in the Space Sail Cup race in 1992, by Aeritalia, which is coordinating the efforts of a group of companies and universities. It proposes a mathematical model for the spacecraft, using computerized simulation to determine optimum maneuvers for geocentric orbital flight and attitude control. Simulation is also used to examine mission duration to lunar fly-by (600-700 days), the importance of single actions affecting the system (thrust of solar radiation, gravity gradient, etc.), and the possibility of simplifying the modeling of the whole system. Moreover, simulation can predict the response of the system to various types of maneuvers and thus furnish performance data for attitude-control mechanisms and on-board sensors. Some results and simple examples are also presented regarding the behavior of the system, composed of two jointed bodies, and the effects of the gravity gradient and the force of solar radiation.
Author

A91-27811*# Sterling Software, Palo Alto, CA.
EFFECT OF AN ANOMALOUS THRUSTER INPUT DURING A SIMULATED DOCKING MANEUVER
ADAM R. BRODY (Sterling Software, Palo Alto, CA) and STEPHEN R. ELLIS (NASA, Ames Research Center, Moffett Field, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Nov.-Dec. 1990, p. 630-633. Previously cited in issue 06, p. 778, Accession no. A90-19894. refs
Copyright

A91-29761# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COLLISION DETECTION FOR SPACECRAFT PROXIMITY OPERATIONS
ROBIN M. VAUGHAN (JPL, Pasadena, CA), EDWARD V. BERGMANN (Charles Stark Draper Laboratory, Inc., Cambridge, MA), and BRUCE K. WALKER (Cincinnati, University, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 225-229. refs
(Contract NAS9-17560)
Copyright
A new collision detection algorithm has been developed for use when two spacecraft are operating in the same vicinity. The two spacecraft are modeled as unions of convex polyhedra, where the resulting polyhedron many be either convex or nonconvex. The relative motion of the two spacecraft is assumed to be such that one vehicle is moving with constant linear and angular velocity with respect to the other. Contacts between the vertices, faces, and edges of the polyhedra representing the two spacecraft are shown to occur when the value of one or more of a set of functions is zero. The collision detection algorithm is then formulated as a search for the zeros (roots) of these functions. Special properties of the functions for the assumed relative trajectory are exploited to expedite the zero search. The new algorithm is the first algorithm that can solve the collision detection problem exactly for relative motion with constant angular velocity. This is a significant improvement over models of rotational motion used in previous collision detection algorithms. Author

A91-30019*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SOLAR ARRAY ORIENTATIONS FOR A SPACE STATION IN LOW EARTH ORBIT
GEOFFREY A. LANDIS and CHENG-YI LU (NASA, Lewis Research Center, Cleveland, OH) Journal of Propulsion and Power (ISSN 0748-4658), vol. 7, Jan.-Feb. 1991, p. 123-125. refs
Copyright
A large portion of the drag of a space station in LEO is generated by its solar array; for a baseline 25-kW solar array in 334-km orbit, 1800 kg of reboost propellant/year is needed to counteract solar array drag. A study is conducted of the drag reduction potential of three possible solar array orientations: sun-pointing, sun-pointing during illumination/edge-on during eclipse, and edge-on during entire orbit. An 18.5-percent drag-makeup propellant reduction is found to be obtainable with the sun-pointing/edge-on eclipse orientation technique. O.C.

A91-31427
DRAG AND AERO-TORQUE FOR CONVEX SHELLS OF REVOLUTION IN LOW EARTH ORBIT
WILLIAM C. STONE and CHRISTOPH WITZGALL (NIST, Gaithersburg, MD) Journal of Aerospace Engineering (ISSN 0893-1321), vol. 4, April 1991, p. 145-163. refs
Copyright
A numerical procedure is described in which the aerodynamic drag and torque are calculated for convex shells of revolution for any given angle of attack based on free molecular flow theory. Assumptions are that the center of gravity lies on the axis of revolution and that there are no significant appendages. The contours of the shells are considered to consist of strictly cancave ascending and descending portions connecting smoothly to an optional horizontal middle section. Each portion is described by a series of parametric equations. The drag profile, that is, the projection of the entire shell, is approximated by the convex envelope of finitely many ellipses. The area of the drag profile and its center of area moment are then calculated and permit determination of drag force and aerodynamic torque. For a given shell, the functional dependence of drag area and aerodynamic eccentricity on the angle of attack can be expressed to a high degree of accuracy in the least-squares sense by polynomials of low degree suitable for processing in real time. Author

N91-11798*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
XENON ION PROPULSION FOR ORBIT TRANSFER
V. K. RAWLIN, M. J. PATTERSON, and R. P. GRUBER Jul. 1990 30 p Presented at the 21st International Electric Propulsion Conference, Orlando, FL, 18-20 Jul. 1990; sponsored in part by AIAA, DGLR, and JSASS
(NASA-TM-103193; E-5586; NAS 1.15:103193; AIAA-90-2527)
Avail: NTIS HC/MF A03 CSCL 21/8
For more than 30 years, NASA has conducted an ion propulsion program which has resulted in several experimental space flight demonstrations and the development of many supporting technologies. Technologies appropriate for geosynchronous stationkeeping, earth-orbit transfer missions, and interplanetary missions are defined and evaluated. The status of critical ion propulsion system elements is reviewed. Electron bombardment ion thrusters for primary propulsion have evolved to operate on xenon in the 5 to 10 kW power range. Thruster efficiencies of 0.7 and specific impulse values of 4000 s were documented. The baseline thruster currently under development by NASA LeRC

includes ring-cusp magnetic field plasma containment and dished two-grid ion optics. Based on past experience and demonstrated simplifications, power processors for these thrusters should have approximately 500 parts, a mass of 40 kg, and an efficiency near 0.94. Thrust vector control, via individual thruster gimbals, is a mature technology. High pressure, gaseous xenon propellant storage and control schemes, using flight qualified hardware, result in propellant tankage fractions between 0.1 and 0.2. In-space and ground integration testing has demonstrated that ion propulsion systems can be successfully integrated with their host spacecraft. Ion propulsion system technologies are mature and can significantly enhance and/or enable a variety of missions in the nation's space propulsion program. Author

N91-12590*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PATHFINDER AUTONOMOUS RENDEZVOUS AND DOCKING PROJECT Annual Report, 1989
STEPHEN LAMKIN, ed. and WAYNE MCCANDLESS, ed. (Lockheed Engineering and Sciences Co., Houston, TX.) Aug. 1990 146 p
(NASA-TM-102163; S-607; NAS 1.15:102163) Avail: NTIS HC/MF A07 CSCL 01/2

Capabilities are being developed and demonstrated to support manned and unmanned vehicle operations in lunar and planetary orbits. In this initial phase, primary emphasis is placed on definition of the system requirements for candidate Pathfinder mission applications and correlation of these system-level requirements with specific requirements. The FY-89 activities detailed are best characterized as foundation building. The majority of the efforts were dedicated to assessing the current state of the art, identifying desired elaborations and expansions to this level of development and charting a course that will realize the desired objectives in the future. Efforts are detailed across all work packages in developing those requirements and tools needed to test, refine, and validate basic autonomous rendezvous and docking elements. Author

N91-16044# Sandia National Labs., Albuquerque, NM.
SENSOR-BASED AUTOMATED DOCKING OF LARGE PAYLOADS
W. D. DROTNING 1990 11 p Presented at the American Nuclear Society Annual Meeting, Nashville, TN, 10-14 Jun. 1990
(Contract DE-AC04-76DP-00789)
(DE90-011020; SAND-90-0348C; CONF-900608-17) Avail: NTIS HC/MF A03

A multiple degree of freedom robotic system is described for the sensor-based, automated remote manipulation and precision docking of large payloads. Computer vision and ultrasonic proximity sensing are used to control the automated precision docking of a large object with a passive target cavity. Real-time sensor processing and model-based analysis are used to control payload position to a precision of +/-0.5 mm. DOE

N91-17020*# National Aeronautics and Space Administration, Washington, DC.
SPACE TRANSPORTATION AVIONICS TECHNOLOGY SYMPOSIUM. VOLUME 2: CONFERENCE PROCEEDINGS
Aug. 1990 742 p Symposium held in Williamsburg, VA, 7-9 Nov. 1989
(NASA-CP-3081-VOL-2; NAS 1.55:3081-VOL-2) Avail: NTIS HC/MF A99 CSCL 22/2

The focus of the symposium was to examine existing and planned avionics technology processes and products and to recommend necessary changes for strengthening priorities and program emphases. Innovative changes in avionics technology development and design processes are needed to support the increasingly complex, multi-vehicle, integrated, autonomous space-based systems. Key technology advances make such a major initiative viable at this time: digital processing capabilities, integrated on-board test/checkout methods, easily reconfigurable laboratories, and software design and production techniques.

N91-17024*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM AVIONICS TECHNOLOGY
A. EDWARDS *In its* Space Transportation Avionics Technology Symposium. Volume 2: Conference Proceedings p 129-162 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The Space Station Freedom Program (SSFP) encompasses the design, development, test, evaluation, verification, launch, assembly, and operation and utilization of a set of spacecraft in low earth orbit (LEO) and their supporting facilities. The spacecraft set includes: the Space Station Manned Base (SSMB), a European Space Agency (ESA) provided Man-Tended Free Flyer (MTFF) at an inclination of 28.5 degrees and nominal attitude of 410 km, a USA provided Polar Orbiting Platform (POP), and an ESA provided POP in sun-synchronous, near polar orbits at a nominal altitude of 822 km. The SSMB will be assembled using the National Space Transportation System (NSTS). The POPs and the MTFF will be launched by Expendable Launch Vehicles (ELVs): a Titan 4 for the US POP and an Ariane for the ESA POP and MTFF. The US POP will for the most part use derivatives of systems flown on unmanned LEO spacecraft. The SSMB portion of the overall program is presented. Author

N91-17047*# TRW Defense Systems Group, Houston, TX.
PAYLOAD ACCOMMODATIONS. SATELLITE SERVICING SUPPORT
ROSCOE LEE *In* NASA, Washington, Space Transportation Avionics Technolody Symposium. Volume 2: Conference Proceedings p 647-656 Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The proposed technology studies discussed at the Space Transportation Avionics Symposium in Williamsburg, VA on 7 to 9 November 1989, are discussed. The discussions and findings of the Payload Accommodations Subpanel are also summarized. The major objective of the proposed focused technology development is to develop and demonstrate (ground and flight) autonomous rendezvous, proximity operations, and docking/berthing capabilities to support satellite servicing. It is expected that autonomous rendezvous and docking (AR and D) capabilities will benefit both the users (e.g., satellite developers and operators) and the transportation system developers and operators. AR and D will provide increased availability of rendezvous and docking services by reducing the operational constraints associated with current capabilities. These constraints include specific lighting conditions, continuous space-to-ground communications, and lengthy ground tracking periods. AR and D will provide increased cost efficiency with the potential for reduced propellant expenditures and workloads (flight and/or ground crews). The AR and D operations will be more consistent, allowing more flexibility in the design of the satellite control system and docking/berthing mechanisms. Author

N91-17071*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A TRAJECTORY PLANNING SCHEME FOR SPACECRAFT IN THE SPACE STATION ENVIRONMENT M.S. Thesis - University of California
JEFFREY ALAN SOLLER, ARTHUR J. GRUNWALD, and STEPHEN R. ELLIS Jan. 1991 56 p
(NASA-TM-102866; A-90287; NAS 1.15:102866) Avail: NTIS HC/MF A04 CSCL 22/1

Simulated annealing is used to solve a minimum fuel trajectory problem in the space station environment. The environment is special because the space station will define a multivehicle environment in space. The optimization surface is a complex nonlinear function of the initial conditions of the chase and target crafts. Small permutations in the input conditions can result in abrupt changes to the optimization surface. Since no prior knowledge about the number or location of local minima on the surface is available, the optimization must be capable of functioning on a multimodal surface. It was reported in the literature that the simulated annealing algorithm is more effective on such surfaces than descent techniques using random starting points. The simulated annealing optimization was found to be capable of identifying a minimum fuel, two-burn trajectory subject to four constraints which are integrated into the optimization using a barrier method. The computations required to solve the optimization are fast enough that missions could be planned on board the space station. Potential applications for on board planning of missions are numerous. Future research topics may include optimal planning of multi-waypoint maneuvers using a knowledge base to guide the optimization, and a study aimed at developing robust annealing schedules for potential on board missions. Author

N91-17085*# McDonnell-Douglas Space Systems Co., Houston, TX. Engineering Services.
SPACE STATION FREEDOM ALTITUDE STRATEGY
BRIAN M. MCDONALD and SCOTT B. TEPLITZ *In* NASA, Goddard Space Flight Center, Flight Mechanics/Estimation Theory Symposium, 1990 p 197-211 Dec. 1990
Avail: NTIS HC/MF A23 CSCL 22/1

The Space Station Freedom (SSF) altitude strategy provides guidelines and assumptions to determine an altitude profile for Freedom. The process for determining an altitude profile incorporates several factors such as where the Space Shuttle will rendezvous with the SSF, when reboosts must occur, and what atmospheric conditions exist causing decay. The altitude strategy has an influence on all areas of SSF development and mission planning. The altitude strategy directly affects the micro-gravity environment for experiments, propulsion and control system sizing, and Space Shuttle delivery manifests. Indirectly the altitude strategy influences almost every system and operation within the Space Station Program. Evolution of the SSF altitude strategy has been a very dynamic process over the past few years. Each altitude strategy in turn has emphasized a different consideration. Examples include a constant Space Shuttle rendezvous altitude for mission planning simplicity, or constant micro-gravity levels with its inherent emphasis on payloads, or lifetime altitudes to provide a safety buffer to loss of control conditions. Currently a new altitude strategy is in development. This altitude strategy will emphasize Space Shuttle delivery optimization. Since propellant is counted against Space Shuttle payload-to-orbit capacity, lowering the rendezvous altitude will not always increase the net payload-to-orbit, since more propellant would be required for reboost. This altitude strategy will also consider altitude biases to account for Space Shuttle launch slips and an unexpected worsening of atmospheric conditions. Safety concerns will define a lower operational altitude limit, while radiation levels will define upper altitude constraints. The evolution of past and current SSF altitude strategies and the development of a new altitude strategy which focuses on operational issues as opposed to design are discussed. Author

N91-18156*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
THREE ORBITAL TRANSFER VEHICLES
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 221-227 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

Aerospace engineering students at the Virginia Polytechnic Institute and State University undertook three design projects under the sponsorship of the NASA/USRA Advanced Space Design Program. All three projects addressed cargo and/or crew transportation between low Earth orbit and geosynchronous Earth orbit. Project SPARC presents a preliminary design of a fully reusable, chemically powered aeroassisted vehicle for a transfer of a crew of five and a 6000 to 20000 pound payload. The ASTV project outlines a chemically powered aeroassisted configuration that uses disposable tanks and a relatively small aerobrake to realize propellant savings. The third project, LOCOST, involves a reusable, hybrid laser/chemical vehicle designed for large cargo (up to 88,200 pounds) transportation. Author

N91-20657*# Lockheed Engineering and Sciences Co., Houston, TX. Dept. of Simulation Development.
BERTHING SIMULATOR FOR SPACE STATION AND ORBITER
SAM VEERASAMY *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 120-125 Jan. 1991
Avail: NTIS HC/MF A21 CSCL 13/9

The development of a real-time man-in-the-loop berthing simulator is in progress at NASA Lyndon B. Johnson Space Center (JSC) to conduct a parametric study and to measure forces during contact conditions of the actual docking mechanisms for the Space Station Freedom and the orbiter. In berthing, the docking ports of the Space Station and the orbiter are brought together using the orbiter robotic arm to control the relative motion of the vehicles. The berthing simulator consists of a dynamics docking test system (DDTS), computer system, simulator software, and workstations. In the DDTS, the Space Station, and the orbiter docking mechanisms are mounted on a six-degree-of-freedom (6 DOF) table and a fixed platform above the table. Six load cells are used on the fixed platform to measure forces during contact conditions of the docking mechanisms. Two Encore Concept 32/9780 computers are used to simulate the orbiter robotic arm and to operate the berthing simulator. A systematic procedure for a real-time dynamic initialization is being developed to synchronize the Space Station docking port trajectory with the 6 DOF table movement. The berthing test can be conducted manually or automatically and can be extended for any two orbiting vehicles using a simulated robotic arm. The real-time operation of the berthing simulator is briefly described. Author

N91-20714*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
RECOVERY FROM AN ANOMALOUS THRUSTER INPUT DURING A SIMULATED DOCKING MANEUVER
ADAM R. BRODY (Sterling Software, Moffett Field, CA.) and STEPHEN R. ELLIS *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 557-560 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 22/2

An experiment was performed in the Space Station Proximity Operations Simulator at the NASA Ames Research Center. Five test subjects were instructed to perform twenty simulated remote docking maneuvers of an orbital maneuvering vehicle (OMV) to the space station in which they were located. The OMV started from an initial range of 304.8 m (1000 ft) on the space station's negative velocity vector. Anomalous out-of-plane thruster firings of various magnitudes (simulating a faulty thruster) occurred at one of five ranges from the target. Initial velocity, range of anomalous burn, and magnitude of anomalous burn were the factors varied. In addition to whether the trial was successful, time and fuel to return to a nominal trajectory, total mission duration, total fuel consumption, and time histories of commanded burns were recorded. Analysis of the results added support to the hypothesis that slow approach velocities are not inherently safer than their more rapid counterparts. Naive subjects were capable of docking successfully at velocities faster than those prescribed by the 0.1 percent rule even when a simulated faulty thruster disturbed the nominal trajectory. Little to no justification for slow approach velocities remains from a human factors standpoint. Author

N91-20815*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
FUZZY LOGIC IN AUTONOMOUS ORBITAL OPERATIONS
ROBERT N. LEA and YASHVANT JANI (LinCom Corp., Houston, TX.) *In its* Proceedings of the Second Joint Technology Workshop on Neural Networks and Fuzzy Logic, Volume 2 p 81-110 Feb. 1991
Avail: NTIS HC/MF A13 CSCL 09/2

Fuzzy logic can be used advantageously in autonomous orbital operations that require the capability of handling imprecise measurements from sensors. Several applications are underway to investigate fuzzy logic approaches and develop guidance and control algorithms for autonomous orbital operations. Translational as well as rotational control of a spacecraft have been demonstrated using space shuttle simulations. An approach to a camera tracking system has been developed to support proximity operations and traffic management around the Space Station Freedom. Pattern recognition and object identification algorithms currently under development will become part of this camera system at an appropriate level in the future. A concept to control environment and life support systems for large Lunar based crew quarters is also under development. Investigations in the area of reinforcement learning, utilizing neural networks, combined with a fuzzy logic controller, are planned as a joint project with the Ames Research Center. Author

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PROPULSION SYSTEMS/FLUID MANAGEMENT

Descriptions, analyses, and subsystem requirements of propellant/fluid management, and propulsion systems for attitude control, orbital maintenance and transfer maneuvers for the station and supporting vehicles.

A91-10112*# McDonnell-Douglas Space Systems Co., Huntington Beach, CA.
CRYOGENIC PROPELLANT MANAGEMENT ARCHITECTURES TO SUPPORT THE SPACE EXPLORATION INITIATIVE
E. C. CADY (McDonnell Douglas Space Systems Co., Huntington Beach, CA), R. R. CORBAN, and S. M. STEVENSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 11 p.
(Contract NAS3-25810)
(AIAA PAPER 90-3713) Copyright

The initial results of a current study to develop fuel system architectures to support the lunar requirements of the Space Exploration Initiative (SEI) are reported. The study includes the development and assessment of propellant management facility concepts, supporting infrastructure, operations analysis, and identification of impact on current programs, including Space Station Freedom, Earth-to-Orbit vehicles, and the Space Transfer Vehicle. The cryogenic propellant management architectures are evaluated using criteria that have been defined to provide for minimum subjective assessment and effective data reliability. V.L.

A91-10174*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
EVOLUTIONARY USE OF NUCLEAR ELECTRIC PROPULSION
K. J. HACK, J. A. GEORGE, J. P. RIEHL (NASA, Lewis Research Center, Cleveland, OH), and J. H. GILLAND (Sverdrup Technology, Inc., Cleveland, OH) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 21 p. refs
(AIAA PAPER 90-3821)

Evolving new propulsion technologies through a rational and conscious effort to minimize development costs and program risks while maximizing the performance benefits is intuitively practical. A phased approach to the evolution of nuclear electric propulsion from use on planetary probes, to lunar cargo vehicles, and finally to manned Mars missions with a concomitant growth in technology is considered. Technology levels and system component makeup are discussed for nuclear power systems and both ion and magnetoplasmadynamic thrusters. Mission scenarios are described, which include analysis of a probe to Pluto, a lunar cargo mission, Martian split, all-up, and quick-trip mission options. Evolutionary progression of the use of NEP in such missions is discussed. Author

A91-10928#
ON-ORBIT REFUELING OF SATELLITES USING A ROBOTIC SYSTEM
STACEY K. OWENS (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 7 p. refs

This paper addresses the issues involved in on-orbit refueling of satellites by using a robotic servicer and/or full automation. The work performed and accomplished in five technical areas at Rockwell International is presented. Propellant transfer methods are described. Servicer side and receiver side refueling concepts are discussed, refueling guidelines and system design concepts are suggested, and the advantages of such approaches are summarized. Author

A91-12832#
PROPULSION SYSTEMS
R. JOSEPH CASSADY (Rocket Research Co., Redmond, WA) IN: Thermal-hydraulics for space power, propulsion, and thermal management system design. Washington, DC, American Institute of Aeronautics and Astronautics, 1990, p. 69-80.
Copyright

Various types of spacecraft propulsion systems and environmental conditions are discussed together with specific thermal-hydraulic problems each type may encounter. The chemical propulsion systems are represented by bipropellant and monopropellant liquid rockets. The electrical propulsion systems are represented by resistors, arcjets, and ion thrusters. Thermal-hydraulic problems related to both chemical and electrical propulsion systems are also discussed. B.P.

A91-13731#
DIVA - FLIGHT DEMONSTRATION OF A 1 KW ARCJET PROPULSION SYSTEM
MARIANO ANDRENUCCI (Pisa, Universita, Italy), GIUSEPPE BAIOCCHI, WILLIAM DEININGER (BPD Difesa e Spazio, Colleferro, Italy), and ALESSANDRO TRIPPI (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-006) Copyright

The paper describes a preliminary study of an Arcjet Flight Demonstration Experiment (DIVA) recently carried out for ESA within the framework of its Technology Demonstration Program (TDP). Two potential carriers were considered for the experiment: the retrievable platform EURECA and the low cost Ariane Technology Platform ARTEP. Several possible experiments were identified and analyzed with respect to the experiment objectives. For the options considered the following were defined: overall layout of the entire experiment on the carrier; detailed operation mode; propellant mass; definition of interfaces; mass, power and thermal budgets for each element of the experiment; contamination effects and possible constraints induced by the experiment to the carrier mission and vice-versa. The candidate options were traded off and a configuration was finally selected. The option chosen is based on the EURECA carrier and a 1 KW arcjet. Author

A91-13968
EXPERIMENTAL RESEARCHES ON FLUID PHYSICS ABOARD MANNED ORBITAL STATIONS - OUTCOMES AND PROSPECTS
M. S. AGAFONOV, V. N. GOLUBEV, V. L. LEVTOV, L. V. LESKOV, M. Z. MUKHOIAN et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-369)

Experimental research on hydrodynamics carried out under microgravity conditions is reviewed. Convective flow induced by thermocapillary effects were observed under orbital flight conditions for the first time. The heat and mass transfer in fluids with free surfaces was shown to be controlled by Marangoni convection under these conditions. The behavior of gas inclusions in irregularly heated fluid was studied in an unstationary temperature field. Thermocapillary drift of the inclusions was shown to be the dominant mechanism of their motion. Drift velocities considerably exceeded theoretical expectations. Background convective flows in an unheated cylindrical cell filled with ethanol were investigated. The results showed that small temperature drops could cause thermocapillary convection. Methods of controlling this convection were studied, and the influence of low-frequency vibrations on the behavior of gas-liquid systems, thermocapillary heat, and mass transport were examined. C.D.

A91-13969#
A NEW FACILITY FOR FLUID SCIENCES - THE LIQUID STRUCTURE FACILITY
J. C. LEGROS, O. DUPONT (Bruxelles, Universite Libre, Brussels, Belgium), P. HOLBROUCK, P. VERHAERT (Verhaert Design and Development, Antwerp, Belgium), and G. BEKAERT (Societe Anonyme Belge de Constructions Aeronautiques, Brussels, Belgium) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 13 p.
(IAF PAPER 90-373) Copyright
The Liquid Structure Facility (LSF), an efficient scientific instrument for a large class of fluid physics investigations, is discussed. The temperature of the experimental volume is accurately controlled in the LSF by a liquid thermoregulated loop. The LSF optical diagnostics allow the velocities, temperatures, concentration fields, and liquid-gas interface deformations to be measured. The modularity of the LSF architecture provides flexibility for technological development and new experimental concepts. C.D.

A91-14158#
SOLAR SAIL ON THE TRACK
JEAN-YVES PRADO, ALAIN PERRET (Union pour la Promotion de la Propulsion Photonique, Toulouse, France), and IGNAZIO OZCARIZ (Comision Vela Solar - Asociacion Ingenieros Aeronauticos, Madrid, Spain) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-496) Copyright
A Spanish association (CVS) in conjunction with the U3P (Union for the Promotion of Photonic Propulsion) is organizing a solar sail race to the moon to be held in 1992, in commemoration of Columbus' discovery of America. This paper describes the objectives of this race, its rules, the design of the vehicle using solar sails, and the technological and educational benefits of the project. B.P.

A91-18070#
EVALUATION OF THE ENDURANCE TEST RESULTS FOR AN ION-ENGINE HOLLOW CATHODE
HIROSHI MURAKAMI and ISAO KUDO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 38, no. 441, 1990, p. 551-558. In Japanese, with abstract in English. refs
Experiments determining the operational life of a hollow cathode, one of the components of the 5-cm diameter mercury propellant ion engine operated on the Japanese Engineering Test Satellite, are presented. Eight-thousand on/off cycle tests were completed and performance mapping was carried out after every 1000th cycle. After the tests, surface analysis of the inner portion of the hollow cathode was carried out using SEM, XMA, and AES. No severe degradation was observed and the operational life was estimated to be about 10,000 hours. The results compare favorably with the 500-hour operational time assigned to the Space Station. B.P.

A91-19325*# Alabama Univ., Huntsville.
RESPONSE OF GRAVITY LEVEL FLUCTUATIONS ON THE GRAVITY PROBE-B SPACECRAFT PROPELLANT SYSTEM
R. J. HUNG, C. C. LEE (Alabama, University, Huntsville), and F. W. LESLIE (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(Contract NAG8-035; NAG8-129; NAGW-812)
(AIAA PAPER 91-0488)
The dynamical behavior of fluids, in particular the effect of surface tension on partially-filled fluids in a rotating dewar under microgravity environment have been investigated. Results show that there is a group of wave trains, both in longitudinal and transverse modes, with various frequencies and wavelengths of slosh waves generated by the restoring force field of gravity jitters and centrifugal forces in this study. The longest wave periods of slosh waves, either the longitudinal or transverse modes, are responsible for the production of wave modes with highest ratio of maximum wave amplitude to wavelength. Also, the lower frequency slosh waves are the wave modes with higher wave energy than that of the higher frequency slosh waves. Author

A91-21509*# Analex Corp., Fairview Park, OH.
THE CRYOGENIC ON-ORBIT LIQUID ANALYTICAL TOOL (COOLANT) - A COMPUTER PROGRAM FOR EVALUATING THE THERMODYNAMIC PERFORMANCE OF ORBITAL CRYOGEN STORAGE FACILITIES
W. J. TAYLOR (Analex Corp., Fairview Park, OH), S. C. HONKONEN, G. E. WILLIAMS, M. W. LIGGETT (General Dynamics Corp., Space Systems Div., San Diego, CA), and S. P. TUCKER (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 15 p. refs
(AIAA PAPER 91-0487) Copyright
The United States plans to establish a permanent manned presence at the Space Station Freedom in low earth orbit (LEO) and then carry out exploration of the solar system from this base. These plans may require orbital cryogenic propellant storage depots. The COOLANT program has been developed to analyze the thermodynamic performance of these depots to support design tradeoff studies. It was developed as part of the Long Term Cryogenic Storage Facility Systems Study for NASA/MSFC. This paper discusses the program structure and capabilities of the COOLANT program. In addition, the results of an analysis of a 200,000 lbm hydrogen/oxygen storage depot tankset using COOLANT are presented. Author

A91-27698
FLUID BEHAVIOR CONSIDERATIONS FOR WASTE MANAGEMENT IN LOW-GRAVITY ENVIRONMENTS
ANTHONY M. WACHINSKI (U.S. Air Force Academy, Colorado Springs, CO) and KURT T. PRESTON (Purdue University, West Lafayette, IN) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1242-1248. refs
Copyright
Design of waste recycling systems for spacecraft requires a knowledge of fluid behavior in microgravity. As gravity is reduced, phenomena usually ignored in the One-G environment of earth can dominate physical or biological processes. This paper provides an explanation of Zero-G, microgravity terminology, and microgravity fluid behavior. Its purpose is to educate civil engineers and waste management professionals on Zero-G basics. Author

A91-28526
SPACE CRYOGENICS WORKSHOP, FRASCATI, ITALY, JULY 18, 19, 1988, PROCEEDINGS
Workshop sponsored by Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative, International Cryogenic Engineering Committee, and Officine Galileo S.p.A. Cryogenics (ISSN 0011-2275), vol. 29, May 1989, 104 p. For individual items see A91-28527 to A91-28542.
Copyright
Papers are presented on cryogenic techniques for large superconducting magnets in space, the superfluid helium on-orbit transfer operations, the critical transport parameters for porous media subjected to counterflow, the pressure drop and the He II

flow through fine mesh screens, and bubble growth in superheated He II. Attention is given to a fluid acquisition system for superfluid He, the design considerations for a micro-g superfluid He fluid acquisition system, state of the art of ISO, an analog multiplexer for cryogenic applications, and a shutter for the Short Wavelength Spectrometer in ISO. Other papers are on new developments with the cryogenic grating drive mechanisms for the ISO spectrometers, the design of cryogenic system for IRTS, a cryogenic vibration test set-up for space qualification, the performance in He II of a centrifugal pump with a jet pump inducer, and carbon-carbon composite as a strong material with low thermal conductivity and thermal contact for rigid optical assemblies at low temperature. I.S.

A91-28528 National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT) OPERATIONS
P. KITTEL (NASA, Ames Research Center, Moffett Field, CA) and M. J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) (Space Cryogenics Workshop, Frascati, Italy, July 18, 19, 1988, Proceedings. A91-28526 11-31) Cryogenics (ISSN 0011-2275), vol. 29, May 1989, p. 493-497. Previously announced in STAR as N88-28084.
Copyright
The in-flight tests and the operational sequences of the Superfluid Helium On-Orbit Transfer (SHOOT) experiment are outlined. These tests include the transfer of superfluid helium at a variety of rates, the transfer into cold and warm receivers, the operation of an extravehicular activity coupling, and tests of a liquid acquisition device. A variety of different types of instrumentation will be required for these tests. These include pressure sensors and liquid flow meters that must operate in liquid helium, accurate thermometry, two types of quantity gauges, and liquid-vapor sensors. Author

A91-28533* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
FLUID ACQUISITION SYSTEM FOR SUPERFLUID HELIUM
M. J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) (Space Cryogenics Workshop, Frascati, Italy, July 18, 19, 1988, Proceedings. A91-28526 11-31) Cryogenics (ISSN 0011-2275), vol. 29, May 1989, p. 517-522. refs
Copyright
To enable the resupply of liquid helium users on orbit, the technology for helium transfer in space is being developed. A key element of the resupply process is the fluid acquisition in the supply dewar; feeding the liquid to the pump. For the Superfluid Helium On-Orbit Transfer (SHOOT) flight experiment a number of fluid acquisition techniques have been examined. Subscale tests performed in one gravity on two of the candidates are described. The hope is that these results may be scaled to much larger systems in low gravity. These two types are a screened channel device and a capillary device. Flow rates versus negative head height are presented. Difficulties with each device and the test environment are explained. Some of the measurements to be made on orbit on the fluid acquisition for SHOOT are described. Author

A91-30655
FAULT PROTECTION ASPECTS OF HEALTH MONITORING FOR SPACE AND SPACE LAUNCH VEHICLES
STEPHEN B. JOHNSON and RON PUENING (Martin Marietta Astronautics Group, Denver, CO) IN: Annual Health Monitoring Conference for Space Propulsion Systems, 2nd, Cincinnati, OH, Nov. 14, 15, 1990, Proceedings. Cincinnati, OH, University of Cincinnati, 1990, p. 562-578.
Copyright
The complementary roles of fault tolerance and health monitoring in the overall design process, particularly as applicable to the vehicle and engine control and health monitoring system design, are discussed. The key role of health monitoring in the achievement of highly reliable systems designs is emphasized, and the role of fault tolerance in the development of a cost-effective health monitoring system is considered. Various fault types are discussed, and reliability requirements for propulsion systems are defined. The issues of quantitative estimates and cost are reviewed. Finally, the impact of fault tolerance on health management system design, fault tolerant avionics for propulsion systems, and propulsion and mechanical system design for fault tolerance are discussed. L.K.S.

N91-10116*# Rockwell International Corp., Downey, CA. Space Transportation Systems Div.
INTEGRATED HYDROGEN/OXYGEN TECHNOLOGY APPLIED TO AUXILIARY PROPULSION SYSTEMS Final Report, Sep. 1990
DAVID L. GERHARDT Oct. 1990 104 p
(Contract NAS3-25643)
(NASA-CR-185289; NAS 1.26:185289) Avail: NTIS HC/MF A06 CSCL 21H
The purpose of the Integrated Hydrogen/Oxygen Technology (IHOT) study was to determine if the vehicle/mission needs and technology of the 1990's support development of an all cryogenic H2/O2 system. In order to accomplish this, IHOT adopted the approach of designing Integrated Auxiliary Propulsion Systems (IAPS) for a representative manned vehicle; the advanced manned launch system. The primary objectives were to develop IAPS concepts which appeared to offer viable alternatives to state-of-the-art (i.e., hypergolic, or earth-storable) APS approaches. The IHOT study resulted in the definition of three APS concepts; two cryogenic IAPS, and a third concept utilizing hypergolic propellants. Author

N91-11031*# Fairchild Technical Support Center, Huntsville, AL.
AUTOMATED FLUID INTERFACE SYSTEM (AFIS) Final Report
Apr. 1990 49 p
(Contract NAS8-37457)
(NASA-CR-183969; NAS 1.26:183969) Avail: NTIS HC/MF A03 CSCL 14B
Automated remote fluid servicing will be necessary for future space missions, as future satellites will be designed for on-orbit consumable replenishment. In order to develop an on-orbit remote servicing capability, a standard interface between a tanker and the receiving satellite is needed. The objective of the Automated Fluid Interface System (AFIS) program is to design, fabricate, and functionally demonstrate compliance with all design requirements for an automated fluid interface system. A description and documentation of the Fairchild AFIS design is provided. Author

N91-11802*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A 10,000-HR LIFE TEST OF AN ENGINEERING MODEL RESISTOJET
RODGER J. SLUTZ Oct. 1990 17 p
(NASA-TM-103216; E-5627; NAS 1.15:103216) Avail: NTIS HC/MF A03 CSCL 21/8
One of the major issues associated with using resistojet thrusters on Space Station Freedom is the long life required. An engineering model resistojet was life-tested to determine if it was capable of meeting that requirement. This thruster, which was designed for 10,000 hr of operation at 2552.4 F (1400 C) or less under cyclical thermal conditions, successfully operated for 10,036 hr at 1836 F (1002 C) while undergoing 141 thermal cycles. Author

N91-12410*# BGB, Inc., Huntsville, AL.
SPACELAB-3 LOW-G ACCELEROMETER DATA FROM THE FLUID EXPERIMENTS SYSTEM (FES)
GARY ARNETT *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 46 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/1
The Fluids Experiment System (FES) flown aboard Spacelab 3 contained a Miniature Electrostatic Accelerometer (MESA). This

accelerometer was purchased from Bell Aerospace, Textron and had three range (auto switching), bidirectional, three orthogonal axis capability. BGB, Inc. is in the process of examining the total mission data from this instrument. From these data, areas of interest are identified and related back to mission events. The basic format of the data for the total mission is root mean square (RMS), with two hours per plot. Author

N91-12743# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
DESIGN, DEVELOPMENT, AND VERIFICATION OF THE EURECA A ORBIT TRANSFER ASSEMBLY (OTA)
H. D. SCHMITZ and R. BRANDT 1990 11 p Previously announced in IAA as A90-42171 Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H., Bremen, Fed. Republic of Germany and ESA/ESTEC, Noordwijk, Netherlands
(MBB-UO-0102-90-PUB; ETN-90-98160) Avail: NTIS HC/MF A03

A description of the pressure regulated monopropellant orbit transfer assembly dealing with the design and development of this complex hydrazine propulsion system is presented. The presentation concentrates on various aspects such as functional design, safety aspects, ground verification, multi-mission aspects, in orbit operation, and ground operations and interfaces. Equipment selection, design and development of major components such as propellant tank and 20 N thruster are presented. The overall system ground acceptance and protoflight qualification tests are described. An outlook with respect to reusability such as flight operation and revalidation of the equipment is presented. ESA

N91-13474*# Spectra Research Systems, Inc., Huntsville, AL. Systems Technology Div.
TELEROBOTIC ON-ORBIT REMOTE FLUID RESUPPLY SYSTEM Final Report, May - Jul. 1989
17 Sep. 1990 79 p
(Contract NAS8-37743)
(NASA-CR-184052; NAS 1.26:184052; SRS/STD-TR90-89)
Avail: NTIS HC/MF A05 CSCL 22/2

The development of a telerobotic on-orbit fluid resupply demonstration system is described. A fluid transfer demonstration system was developed which functionally simulates operations required to remotely transfer fluids (liquids or gases) from a servicing spacecraft to a receiving spacecraft through the use of telerobotic manipulations. The fluid system is representative of systems used by current or planned spacecraft and propulsion stages requiring on-orbit remote resupply. The system was integrated with an existing MSFC remotely controlled manipulator arm to mate/demate couplings for demonstration and evaluation of a complete remotely operated fluid transfer system. Author

N91-14613* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
SYSTEM FOR CONNECTING FLUID COUPLINGS Patent
JOSEPH C. CODY, inventor (to NASA) and PAUL R. MATTHEWS, inventor (to NASA) (Spectra Research Systems, Inc., Huntsville, AL.) 12 Jun. 1990 7 p Filed 29 Feb. 1988
(NASA-CASE-MFS-26042-1-SB; US-PATENT-4,932,688; US-PATENT-APPL-SN-161682; US-PATENT-CLASS-285-82; US-PATENT-CLASS-285-361; INT-PATENT-CLASS-F16L-35/00)
Avail: US Patent and Trademark Office CSCL 13/9

A system for mating fluid transfer couplings is constructed having a male connector which is provided with a pair of opposed rollers mounted to an exterior region thereof. A male half of a fluid transfer coupling is rotatably supported in an opening in an end of the connector and is equipped with an outwardly extending forward portion. The forward portion locks into an engagement and locking region of a female half of the fluid transfer coupling, with female half being rotatably supported in a receptacle. The receptacle has an opening aligned with locking region, with this opening having a pair of concentric, annularly disposed ramps extending around an interior portion of opening. These ramps are inclined toward the interior of the receptacle and are provided with slots through which rollers of the connector pass. After the connector is inserted into the receptacle (engaging forward portion into engagement region), relative rotation between the connector and receptacle causes the rollers to traverse ramps until the rollers abut and are gripped by retainers. This axially forces the forward portion into locked, sealed engagement with the engagement region. Official Gazette of the U.S. Patent and Trademark Office

N91-15275# Microtecnica, Turin (Italy).
MICROGRAVITY TESTS ON SPACELAB WATER AND FREON PUMPS
R. ORLANDO, M. DELFINO, L. TALLONE, and G. PREGNO *In* ESA, International Symposium on Environmental Testing for Space Programmes: Test Facilities and Methods p 443-448 Sep. 1990 Copyright Avail: NTIS HC/MF A23

The requirement of low induced vibration, also referred to as the microgravity requirement, appears in all the current European space programs. But a certain confusion still affects its definition at equipment level and, on the other side, a common agreed standard for its verification is not established yet. The objective of this study is to describe the procedure for the measurement of the vibration transmitted by a generic item to its interface, the test set up and instrumentation proposed for the verification of the requirement for the Columbus and Hermes programs. ESA

N91-15511* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TANK GAUGING APPARATUS AND METHOD Patent
BRIAN G. MORRIS, inventor (to NASA) 18 Sep. 1990 8 p Filed 18 Aug. 1989 Continuation of US-Patent-Appl-SN-217725, filed 11 Jul. 1988
(NASA-CASE-MSC-21059-2; US-PATENT-4,956,996; US-PATENT-APPL-SN-396726; US-PATENT-APPL-SN-217725; US-PATENT-CLASS-73-149; INT-PATENT-CLASS-G01F-17/00)
Avail: US Patent and Trademark Office CSCL 14/2

An apparatus for gauging the amount of liquid in a container of liquid and gas under low or zero gravity net conditions includes an accumulator and appropriate connector apparatus for communicating gas between the accumulator and the container. In one form of the invention, gas is removed from the container and compressed into the accumulator. The pressure and temperature of the fluid in the container is measured before and after removal of the gas; the pressure and temperature of the gas in the accumulator is measured before and after compression of the gas into the accumulator from the container. These pressure and temperature measurements are used to determine the volume of gas in the container, whereby the volume of the liquid in the container can be determined from the difference between the known volume of the container and the volume of gas in the container. Gas from the accumulator may be communicated into the container in a similar process as a verification of the gauging of the liquid volume, or as an independent process for determining the volume of liquid in the container.
Official Gazette of the U.S. Patent and Trademark Office

N91-19317*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CONCEPTUAL STUDY OF ON ORBIT PRODUCTION OF CRYOGENIC PROPELLANTS BY WATER ELECTROLYSIS
MATTHEW E. MORAN 1991 24 p Proposed for presentation at the 27th Joint Propulsion Conference, Sacramento, CA, 24-27 Jul. 1991; cosponsored by AIAA, SAE, ASME, and ASEE
(NASA-TM-103730; E-5964; NAS 1.15:103730) Avail: NTIS HC/MF A03 CSCL 21/9

The feasibility is assessed of producing cryogenic propellants on orbit by water electrolysis in support of NASA's proposed Space Exploration Initiative (SEI) missions. Using this method, water launched into low earth orbit (LEO) would be split into gaseous hydrogen and oxygen by electrolysis in an orbiting propellant processor spacecraft. The resulting gases would then be liquified and stored in cryogenic tanks. Supplying liquid hydrogen and oxygen fuel to space vehicles by this technique has some possible advantages over conventional methods. The potential benefits are derived from the characteristics of water as a payload, and include reduced ground handling and launch risk, denser packaging, and reduced tankage and piping requirements. A conceptual design of a water processor was generated based on related previous studies, and contemporary or near term technologies required. Extensive development efforts would be required to adapt the various subsystems needed for the propellant processor for use in space. Based on the cumulative results, propellant production by on orbit water electrolysis for support of SEI missions is not recommended. Author

N91-19378*# Tennessee Univ., Knoxville. Dept. of Mechanical and Aerospace Engineering.
IN-SPACE EXPERIMENT ON THERMOACOUSTIC CONVECTION HEAT TRANSFER PHENOMENON-EXPERIMENT DEFINITION Final Report
M. PARANG and D. S. CROCKER Feb. 1991 111 p
(Contract NAS3-25359)
(NASA-CR-187070; NAS 1.26:187070) Avail: NTIS HC/MF A06 CSCL 20/4

The definition phase of an in-space experiment in thermoacoustic convection (TAC) heat transfer phenomenon is completed and the results are presented and discussed in some detail. Background information, application and potential importance of TAC in heat transfer processes are discussed with particular focus on application in cryogenic fluid handling and storage in microgravity space environment. Also included are the discussion on TAC space experiment objectives, results of ground support experiments, hardware information, and technical specifications and drawings. The future plans and a schedule for the development of experiment hardware (Phase 1) and flight tests and post-flight analysis (Phase 3/4) are also presented. The specific experimental objectives are rapid heating of a compressible fluid and the measurement of the fluid temperature and pressure and the recording and analysis of the experimental data for the establishment of the importance of TAC heat transfer process. The ground experiments that were completed in support of the experiment definition included fluid temperature measurement by a modified shadowgraph method, surface temperature measurements by thermocouples, and fluid pressure measurements by strain-gage pressure transducers. These experiments verified the feasibility of the TAC in-space experiment, established the relevance and accuracy of the experimental results, and specified the nature of the analysis which will be carried out in the post-flight phase of the report. Author

N91-20664*# Lockheed Engineering and Sciences Co., Houston, TX.
SPACE STATION FREEDOM COUPLING TASKS: AN EVALUATION OF THEIR SPACE OPERATIONAL COMPATIBILITY
CARLOS E. SAMPAIO, JOHN M. BIERSCHWALE, TERENCE F. FLEMING, and MARK A. STUART *In* NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 179-183 Jan. 1991
(Contract NAS9-17900)
Avail: NTIS HC/MF A21 CSCL 22/2

The development of the Space Station Freedom tasks that are compatible with both telerobotic as well as extravehicular activity is a necessary redundancy in order to insure successful day to day operation. One task to be routinely performed aboard Freedom will be the changeout of various quick disconnect fluid connectors. In an attempt to resolve these potentially contradictory issues of compatibility, mock-ups of couplings suitable to both extravehicular as well as telerobotic activity were designed and built. An evaluation performed at the Remote Operator Interaction Laboratory at NASA's Johnson Space Center is discussed, which assessed the prototype couplings as well as three standard coupling designs. Data collected during manual and telerobotic manipulation of the couplings indicated that the custom coupling was in fact shown to be faster to operate and generally preferred over the standard coupling designs. Author

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COMMERCIALIZATION

Use of space stations for large scale commercial operations.

A91-10131*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION FREEDOM COMMERCIAL INFRASTRUCTURE
KEVIN BARQUINERO (NASA, Office of Space Flight, Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p.
(AIAA PAPER 90-3760) Copyright

Several approaches to initiating the provision of the Space Station Freedom (SSF) commercial infrastructure are discussed, including proposals from the private sector, the commercial development of infrastructure, and the commercial operation of infrastructure. Specific options for SSF commercial infrastructure which are currently being studied by NASA are described. One candidate for commercial service is the supplemental power for SSF beyond the Assembly Complete phase. The methods which a company could use in providing supplemental power are discussed, with special attention given to the use of solar dynamic power elements attached ot the SSF evolution structure. Another option under evaluation is commercial provision of SSF logistics services using ELVs. I.S.

A91-10906#
SPACE-BASED MANUFACTURING
R. O. NEWLON (Product Development Technology Corp., Littleton, CO) IN: Space Logistics Symposium, 3rd, Colorado Springs, CO, Apr. 30-May 2, 1990, Proceedings. Huntsville, AL, Society of Logistics Engineers, 1990, 11 p. refs

The paper discusses the logistics involved in establishing and operating microgravity, low earth orbit, commercial manufacturing facilities. The operational system requirements are developed leading to derived functional requirements. Technological constraints are included to limit the requirements to practical system implementations. Functional partitioning separates the ground-based functions from space-based functions. An architecture that meets the operational and derived requirements is developed and used as the basis for functional analysis and preliminary system design considerations. The resulting space-based manufacturing method is expected to produce the lowest life-cycle cost products when compared to existing industrial proposed methods including the methods that involve Space Stations. Author

A91-14113*# National Aeronautics and Space Administration, Washington, DC.
ECONOMIC CONSEQUENCES OF COMMERCIAL SPACE OPERATIONS
BARBARA A. STONE (NASA, Office of Commercial Programs, Washington, DC) and PETER W. WOOD IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 15 p.
(IAF PAPER 90-609) Copyright

The potential economic benefits generated from increased industry involvement and investment in space activities and the subsequent cost implications are discussed. A historical overview of commercial industry involvement in space is given and sources of new economic growth in space are discussed. These include communications satellites, small satellites, positioning and navigation services, space transportation and infrastructure, remote sensing, and materials processing in space such as the manufacturing of protein crystals and zeolites. Macroeconomic trends and principles such as limits on technology trade, eased restrictions on international joint ventures, foreign investments in U.S. firms, and increased foreign competition are discussed. Earth observations and mapping are considered. Opportunities for private sector involvement in building space infrastructure and space transportation are highlighted. L.K.S.

A91-14115#
AN ANALYSIS ON SPACE COMMERCIALIZATION IN JAPAN
YOSHIKI MORINO and FUMIO KODAMA (Science and Technology Agency, Tokyo, Japan) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p.
(IAF PAPER 90-614) Copyright

In the 1980s, the world space industry has reached a new level of space commercialization, from which self-supporting mechanisms of the free market economy could be activated and human activities in space could be accelerated. From this point of view, it seems very important to investigate the possible contribution of Japanese industry, which has shown unique technological characteristics in the world economy. An effort is made to find a possible role for Japanese industries in the future expansion of world space commercialization. By looking into varied activities of the Japanese space industry, promising possibilities were found for Japanese companies to formulate new design and development philosophies for space technology by drawing on their unique expertise in civil technology. Author

A91-14118#
COMMERCIALIZATION STRATEGIES FOR SPACE POWER TECHNOLOGY
FRANK E. LITTLE and MIKE O. KENNEDY (Texas A & M University, College Station) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 14 p.
(IAF PAPER 90-617)

An example of a strategy for the commercialization of space power technology is presented. The systems by which power can be delivered from an orbiting space station to one or more spacecraft include tethers that transfer energy between space vehicles at distances less than 1 km, transmission of energy at microwave or submillimeter wavelengths for distances less than 1000 km, and laser transmission. The use of tethers is limited by mission and distance considerations, while energy conversion technologies and laser transmissions are not mature enough to be practical. However, recent advancements in microwave technologies indicate that the development of a commercial intraspace microwave transmission system is both achievable and practical in this decade. A marketing strategy for such a system is proposed. R.E.P.

A91-14140#
COMMERCIAL SPACE ACTIVITIES VERSUS OUTER SPACE AS THE PROVINCE OF ALL MANKIND? - AN ASSESSMENT OF THE INFLUENCE OF ARTICLE I PARA. 1 OF THE OUTER SPACE TREATY ON COMMERCIAL SPACE ACTIVITIES
STEPHAN HOBE IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p. refs
(IAF PAPER ST-90-007) Copyright

The current status of space law which requires equal participation of all countries in commercial space activities is assessed. The distribution of utilization rights in GEO is examined, and the utilization regime for the moon and other celestial bodies is reviewed. The impact of this space law on current commercial space activities is addressed. C.D.

A91-27657* General Electric Co., Philadelphia, PA.
SPACE STATION FREEDOM ATTACHED PAYLOADS AND COMMERCIALIZATION
N. FURIO, B. PYFER, R. B. SMITH, JR., S. R. HUNT (General Electric Co., Astro-Space Div., King of Prussia, PA), and D. SUDDETH (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 831-841.
(Contract NAS5-32000)
Copyright

NASA's Space Station Freedom (SSF) attaches external payloads to its main truss structure via Attached Payload Accommodation Equipment (APAE); this equipment also provides access to such SSF resources as electrical power, command/control, and data handling. In orbit, APAE payloads are installed and maintained by a teleoperated robot or by an astronaut in EVA. Commercialization of EPAE will be accomplished by private companies concerned with the development of materials processing, earth resources and ocean resources monitoring, telecommunications, and industrial services. Attention is given to APAE user-integration activity. O.C.

A91-27668
AUTOMATED MANUFACTURING IN PLATFORM-BASED ORBITAL SYSTEMS (APROPOS)
ELMAR DEGENHART, JUERGEN GEISSINGER (Fraunhofer-Institut fuer Produktionstechnik und Automatisierung, Stuttgart, Federal Republic of Germany), and ARWED H. EXNER (Deutsche Agentur fuer Raumfahrtangelegenheiten GmbH, Bonn, Federal Republic of Germany) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 946-959. refs
Copyright

An orbiting manufacturing system has been conceptually defined for production of high pressure/temperature gas turbine blades, in order to verify the technical feasibility of orbiting automation and robotics based on highly standardized components which will minimize complexity while maximizing task flexibility. The 'skin technology' envisioned for turbine blade production allows the remelting and controlled solidification of preformed eutectic refractory alloy blanks; the production of some 2000 blades over the course of a 90-day mission is envisioned. The manufacturing platform maximizes modular distribution possibilities and a functionally segregated infrastructure. O.C.

N91-12404*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
IMPLICATIONS OF ACCELERATION ENVIRONMENTS ON SCALING MATERIALS PROCESSING IN SPACE TO PRODUCTION
KEN DEMEL *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 34 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/1

Some considerations regarding materials processing in space are covered from a commercial perspective. Key areas include power, proprietary data, operational requirements (including logistics), and also the center of gravity location, and control of that location with respect to materials processing payloads. Author

N91-12731# INTOSPACE G.m.b.H., Hanover (Germany, F.R.).
INDUSTRIAL AND SCIENTIFIC APPLICATION OF SPACE TRAVEL [INDUSTRIELLE UND WISSENSCHAFTLICHE NUTZUNG DER RAUMFART]
JUERGEN VONDERLIPPE *In* Deutscher Industrie- und Handelstag, Space Travel Economics: Prospects for a Greater Participation of German Companies in Space Travel Research p 97-101 1989 In GERMAN
Avail: NTIS HC/MF A11

The importance of weightlessness as an industrial application is outlined. A medium size company, whose task is to foster weightlessness application in the industry is presented. Using as an example the COSIMA mission, the company marketing strategy is explained. ESA

N91-13051*# Research Inst. for Advanced Computer Science, Moffett Field, CA.
SPACE AND BIOTECHNOLOGY: AN INDUSTRY PROFILE
RICHARD S. JOHNSTON, DAVID J. NORTON, and BALDWIN H. TOM Nov. 1988 93 p
(Contract NCC9-16)
(NASA-CR-187034; NAS 1.26:187034) Avail: NTIS HC/MF A05 CSCL 06/3

The results of a study conducted by the Center for Space and Advanced Technology (CSAT) for NASA-JSC are presented. The objectives were to determine the interests and attitudes of the U.S. biotechnology industry toward space biotechnology and to prepare a concise review of the current activities of the biotechnology industry. In order to accomplish these objectives, two primary actions were taken. First, a questionnaire was designed, reviewed, and distributed to U.S. biotechnology companies. Second, reviews of the various biotechnology fields were prepared in several aspects of the industry. For each review, leading figures in the field were asked to prepare a brief review pointing out key trends and current industry technical problems. The result is a readable narrative of the biotechnology industry which will provide space scientists and engineers valuable clues as to where the space environment can be explored to advance the U.S. biotechnology industry. Author

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EXPERIMENTS

Design and description of experiments to be performed or managed from the space station.

A91-10058#
MECHANICAL DESIGN AND SIMULATION OF A MICROGRAVITY ISOLATION MOUNT FOR COLUMBUS
R. G. OWEN, D. I. JONES, A. R. OWENS (University of Wales, Bangor), and A. A. ROBINSON (ESTEC, Noordwijk, Netherlands) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p. refs
(Contract ESA-7637/88)
(AIAA PAPER 90-3628) Copyright

A Microgravity Isolation Mount (MGIM) designed to provide active vibration isolation for microgravity payloads is described. The required microgravity level is achieved by adopting a noncontact strategy, whereby the payload floats inside its enclosure and its position is controlled by magnetic actuators. The design concentrates on the requirements of materials science payloads, and provides a detailed description of the locking mechanisms used to release and capture the payload during micrigravity periods. A nonlinear model used to simulate payload release shows that a successful release depends upon the severity of the input vibration level. Author

A91-10066*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EARTH SCIENCE AND APPLICATIONS ATTACHED PAYLOADS ON SPACE STATION
THOMAS G. WICKS and RALPH R. ARNOLD (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p. refs
(AIAA PAPER 90-3640) Copyright

This paper describes the Office of Space Science and Applications' process for Attached Payloads on Space Station Freedom from development through on-orbit operations. Its primary objectives are to detail the sequential steps of the attached payload methodology by tracing in particular the selected Earth Science and Applications' payloads through this flow and relate the integral role of Marshall Space Flight Center's Science Utilization Management function of integration and operations. Author

A91-10217*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
LIFESAT - A SATELLITE FOR BIOLOGICAL RESEARCH
EMILY MOREY-HOLTON, RODNEY W. BALLARD (NASA, Ames Research Center, Moffett Field, CA), LEONARD F. CIPRIANO, and PHILIP DAVIES (Lockheed Engineering and Sciences Co., Moffett Field, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 12 p. refs
(AIAA PAPER 90-3888) Copyright

The Lifesat program, which provides for the development and operation of an unmanned, free-flying, recoverable, reusable satellite for microgravity biological research, is briefly reviewed. The payload modules will support research in radiation biology, general biology, and biomedical disciplines. The Lifesat will be capable of long-duration flights of up to 60 days and will be able to fly directly into trapped radiation belts and in circular or eccentric polar orbits. The Lifesat will also serve as a testbed for Space Station Freedom experiments. V.L.

A91-10218*# National Aeronautics and Space Administration, Washington, DC.
BIOLOGICAL RESEARCH ON SPACE STATION FREEDOM
L. P. CHAMBERS (NASA, Life Sciences Div., Washington, DC), P. D. STABEKIS, and R. C. TEETER (Lockheed Engineering and Sciences Co., Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p. refs
(AIAA PAPER 90-3889) Copyright

The paper discusses laboratory capabilities of the SSF which permit long-term, systematic investigations into the effects of the space environment, particularly the effect of microgravity, on a range of biological specimens. The ability to manipulate gravity levels between 0 and 2.0 g makes it possible to examine gravitational effects along a continuum. Space centrifuge research is expected to lead to practical applications in areas such as aging, treating malfunctions of the body regulatory and defense mechanisms, improving agricultural production, and extending human performance. B.P.

A91-10219*# State Univ. of New York, Stony Brook.
BIOLOGICAL RESEARCH ON A SPACE STATION
A. D. KRIKORIAN (New York, State University, Stony Brook) and CATHERINE C. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 6 p. refs
(AIAA PAPER 90-3890) Copyright

A Space Station can provide reliable, long duration access to ug environments for basic and applied biological research. The uniqueness of access to near-weightless environments to probe fundamental questions of significance to gravitational and Space biologists can be exploited from many vantage points. Access to centrifuge facilities that can provide 1 g and hypo-g controls will permit identification of gravity-dependent or primary effects. Understanding secondary effects of the ug environment as well will allow a fuller exploitation of the Space environment. Author

A91-10400* Stanford Univ., CA.
THE ADVANCED SOLAR OBSERVATORY
ARTHUR B. C. WALKER, JR. (Stanford University, CA), WAYNE BAILEY (Teledyne Brown Engineering, Huntsville, AL), EDWARD L. CHUPP (New Hampshire, University, Durham), HUGH S. HUDSON (California, University, La Jolla), RONALD MOORE, WILLIAM ROBERTS, RICHARD B. HOOVER (NASA, Marshall Space Flight Center, Huntsville, AL) et al. Optical Engineering (ISSN 0091-3286), vol. 29, Oct. 1990, p. 1306-1318. refs
Copyright

A conceptual plan for the development of a comprehensive long duration solar space observatory, The Advanced Solar Observatory (ASO) is described. The ASO is intended to provide solar astronomers with the observational power necessary to address fundamental problems relating to the solar convection zone and activity cycle; the thermal and nonthermal processes that control the transport of energy, mass, and magnetic flux in the solar atmosphere; the generation of the solar wind; and the dynamics of the inner heliosphere. The ASO concept encompasses three proposed Space Station-based instrument ensembles: (1) the High Resolution Telescope Cluster, which includes far ultraviolet, extreme ultraviolet, and X-ray telescopes; (2) the Pinhole/Occulter Facility, which includes Fourier transform and coded aperture hard X-ray and gamma ray telescopes and occulted ultraviolet and visible light coronagraphs; and (3) the High Energy Facility, which contains neutron, gamma ray, and low frequency radio spectrometers. Two other facilities, the Orbiting Solar Laboratory, and a package of Global Dynamics Instrumentation, will, with the Space Station ensembles, form a comprehensive capability for solar physics. The scientific program of the ASO, current instrument concepts for the Space Station based ASO instrument ensembles, and plans for their accommodation on the Space Station are described. Author

A91-13726*# National Aeronautics and Space Administration, Washington, DC.

IN-SPACE TECHNOLOGY EXPERIMENTS - PREREQUISITE FOR MISSIONS OF THE FUTURE

LEONARD A. HARRIS, 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, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 12 p.
(IAF PAPER 90-001)

Experience with the Shuttle and free-flying satellites as technology test beds has shown the feasibility and desirability of using space assets as facilities for technology development. Thus, with the arrival of the Space Station Freedom era, technologists will be ready for an accessible engineering facility in space, particularly to support technology development for manned space exploration. As the 21st century is approached, virtually every flight to the Space Station Freedom will carry one or more research, technology and engineering experiments. The experiments planned will utilize both the pressurized volume and the external attachment facilities. A unique class of experiments will use the Space Station itself as an experimental test bed. Based upon recent examination of possible Space Station assembly sequences, technology payloads may utilize upwards of 20 percent of available resources. Author

A91-13805#

INTERNATIONAL SPACE PROJECT OF THE EARTH REMOTE SENSING 'PRIRODA'

N. A. ARMAND and B. G. KUTUZA (AN SSSR, Institut Radiotekhniki i Elektroniki, Moscow, USSR) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-103)

The international space project Priroda, designed for developing earth remote sensing programs is discussed with special attention given to the specific remote sensing module which will be joined to the orbital station Mir. The module will contain instruments for remote sensing of the environment, including a microwave radiometric system Ikar, an IR spectroradimetric system Istok-1, a television camera, an oceanic radioaltimeter, a SYR, a data-acquisition system for collecting information from geographical platforms, and equipment for measuring ozone and aerosol concentration profiles. The characteristics of these instruments are presented together with a diagram of the module. I.S.

A91-13958#

MICROGRAVITY ENVIRONMENT DYNAMIC DISTURBANCES

D. EILERS, B. KOTZIAS (MBB/ERNO, Bremen, Federal Republic of Germany), S. PORTIGLIOTTI (Aeritalia S.p.A., Turin, Italy), and H. STARK (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p. Research supported by ESA.
(IAF PAPER 90-345) Copyright

A computational model for the prediction of dynamic disturbances to spacecraft in the microgravity environment is described. The computational model consists of three major elements, each of which stands for a response prediction in a dedicated frequency band which overlaps that of the others. One model element uses a multibody dynamic algorithm to describe the accelerated motions of the flexible spacecraft closed loop control. The second is a finite-element model for a broader low-frequency structural dynamics calculation. The third is a high-frequency structure dynamics prediction model using test data from components and structure transfer functions. The outputs of the individual model elements are processes by a superposition progam, resulting in an acceleration response spectrum over the 0.1-1000 Hz frequency range. C.D.

A91-13959#

IN ORBIT TECHNOLOGY EXPERIMENTS

HARTMUT JANCZIKOWSKI and HEINZ J. SPRENGER (Intospace GmbH, Hanover, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p.
(IAF PAPER 90-346) Copyright

Two planned in-orbit Soviet technology experiments are briefly discussed which will be relevant to improvement of contruction, maintenance, and repair of space infrastructure. One experiment will study the influence of a six-month exposure to the outer space environment on optical fibers. The second experiment will investigate the soldering of electronic equipment using an automated laser. The characteristics of the reentry capsules used for the experiment are outlined. C.D.

A91-13964

MICROGRAVITY QUALITY ANALYSIS GUIDELINES FOR AUTOMATED ORBITAL SYSTEMS

WALTER E. KNABE (MBB/ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-355)

The microgravity disturbance characteristics of the automation and robotics elements of automated orbital systems designed and/or used as facilities for microgravity experimentation and processing are discussed. The compatibility of disturbances from these sources with existing microgravity qualilty requirements is examined using a transfer function approach. The results demonstrate semiquantitatively the need and usefulness of analyzing the microgravity disturbances induced by automation and robotics components in orbital systems and to assess the effect of these disturbances on the overall microgravity quality of automated systems. Guidelines are provided for performing these tasks within the framework of an existing global microgravity model. C.D.

A91-13973#

QSAM - A MEASUREMENT SYSTEM TO DETECT QUASI-STEADY ACCELERATIONS ABOARD A SPACECRAFT

H. HAMACHER, R. JILG, and B. FEUERBACHER (DLR, Cologne, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. refs
(IAF PAPER 90-377) Copyright

The QSAM (Quasi-Steady Acceleration Measurement) system is an instrument especially developed to detect selectively a spacecraft's low-frequency acceleration under microgravity free of any bias or noise. The QSAM principle is briefly addressed here along with the QSAM hardware design and data processing system. The dominating low-frequency accelerations and uncertainties of a purely analytic characterization based on orbit and attitude data are also pointed out. C.D.

A91-13975#

HIGH TEMPERATURE FURNACE DEVELOPMENTS FOR MICROGRAVITY APPLICATIONS

D. VALENTIAN, A. DHENAUT, and C. CORDELLE (SEP, Vernon, France) IAF, International Astronautical Congress, 41st, Dresden,

Federal Republic of Germany, Oct. 6-12, 1990. 12 p.
(Contract CNES-87-502000; ESA-7337/87/NL/PB)
(IAF PAPER 90-379) Copyright

This paper describes the development of two different 2000 C space furnaces: one uses a Sepcarb carbon/carbon diffusion and operates under vacuum, the second one is fully metallic. The results of tests of these furnaces showed that both can be built with power less than 1 kW and very good thermal stability. The lifetime of these furnaces is compatible with the foreseen requirements of Columbus payloads and operations under vacuum. The paper discusses the particular merits of each of the furnaces. I.S.

A91-13991*# National Aeronautics and Space Administration, Washington, DC.

VIBRATION ENVIRONMENT - ACCELERATION MAPPING STRATEGY AND MICROGRAVITY REQUIREMENTS FOR SPACELAB AND SPACE STATION

GARY L. MARTIN (NASA, Microgravity Science and Applications Div., Washington, DC), CHARLES R. BAUGHER (NASA, Marshall Space Flight Center, Huntsville, AL), and RICHARD DELOMBARD (NASA, Lewis Research Center, Cleveland, OH) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p.
(IAF PAPER 90-350) Copyright

In order to define the acceleration requirements for future Shuttle and Space Station Freedom payloads, methods and hardware characterizing accelerations on microgravity experiment carriers are discussed. The different aspects of the acceleration environment and the acceptable disturbance levels are identified. The space acceleration measurement system features an adjustable bandwidth, wide dynamic range, data storage, and ability to be easily reconfigured and is expected to fly on the Spacelab Life Sciences-1. The acceleration characterization and analysis project describes the Shuttle acceleration environment and disturbance mechanisms, and facilitates the implementation of the microgravity research program. B.P.

A91-13992#

CHARACTERIZATION OF THE MIR SPACE STATION AS A PROTEIN CRYSTAL GROWTH ENVIRONMENT

A. P. ARROTT, R. L. RENSHAW, V. NIJHAWAN (Payload Systems, Inc., Cambridge, MA), G. K. FARBER (Pennsylvania State University, University Park), B. L. STODDARD (California, University, Berkeley) et al. IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-356) Copyright

Payload Systems Inc. has completed 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 conducive 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. Author

A91-13997*# National Aeronautics and Space Administration, Washington, DC.

MICROGRAVITY SCIENCE AND APPLICATIONS OVERVIEW - RESEARCH, FACILITY AND INSTRUMENTATION DEVELOPMENT, SPACE STATION FREEDOM OPERATIONS AND UTILIZATION PLANNING

M. E. KICZA (NASA, Microgravity Science and Applications Div., Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p.
(IAF PAPER 90-370) Copyright

An overview is provided of NASA's Microgravity Science and Applications Program, with emphasis on plans for evolution to the Space Station. The Microgravity Science and Applications Division program consists of two major parts including the ground-based research program and the flight program. Transition to flight experiment status may occur only after the ground-based research and testing demonstrates sufficient technical maturity to assure that scientific objectives can be met in space with a high degree of success. Program strategy calls for a transition to the Space Station Freedom before the end of the century. In this connection, six multi-user facilities are planned to be phased into operation aboard the Space Station over an extended time frame. It is projected that the design of these facilities will evolve based on experience with precursor experiment hardware designed and operated on Skylab and other carriers. L.K.S.

A91-14010#

NUMERICAL SIMULATION OF CONTROLLED DIRECTIONAL SOLIDIFICATION UNDER MICROGRAVITY CONDITIONS

S. HOLL, D. ROOS, and J. WEIN (M.A.N. Technologie GmbH, Munich, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 8 p. Research supported by BMFT and DARA GmbH. refs
(IAF PAPER 90-399) Copyright

This paper despresents two computer-based simulation models of controlled directional solidification in microgravity. The two models were applied to simulate solidification experiments run aboard sounding rockets and Spacelab. The results gained so far in the context of Texus, FSLP, D1, and D2 experiments, highlight their simulation-supported preparation and evaluation. Possibilities of enhancing the efficiency of preindustrial research in the Columbus era through the incorporation of suitable simulation methods and tools are discussed. I.S.

A91-14073#

THE DEVELOPMENT OF ADVANCED CENTRIFUGES FOR SPACE BIOLOGY EXPERIMENTS

G. TRAXLER and K. SPERKER (Oesterreichische Raumfahrt- und Systemtechnik Gesellschaft mbH, Vienna, Austria) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 5 p. Research supported by ESA.
(IAF PAPER 90-550) Copyright

Advanced centrifuges for space biology will render possible long term experiments with biological samples for determining gravity threshold effects as well as serving as 1 g reference experiments. The development of such systems is driven by the requirements for a very low microgravity disturbance and for providing a maximal experimental area being exposed to a gravity field with the least possible gradient. Design concepts are presented for large diameter centrifuges, comprising also tethered systems, as well as for a 650 mm diameter centrifuge with a capability for automatic sample transfer from and onto a spinning rotor, respectively. A breadboard model of the latter one has been developed and is being used for the demonstration and verification of the design in critical technology areas. Author

A91-14967*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

EVOLUTION OF SPACELAB PAYLOAD OPERATIONS TO SPACE STATION FREEDOM

H. GOLDEN (NASA, Marshall Space Flight Center, Huntsville, AL) and E. L. SAENGER (McDonnell Douglas Space Systems Co., Huntsville, AL) AIAA and NASA, International Symposium on Space Information Systems, 2nd, Pasadena, CA, Sept. 17-19, 1990. 11 p.
(AIAA PAPER 90-5044) Copyright

NASA's Office of Space Science and Applications is actively involved in the development of operational concepts and data infrastructures which will be integrated to maximize the effectiveness of Space Station Freedom (SSF) payloads. Spacelab is noted to furnish an excellent 'experience base' for SFF activities. The SSF operations/data systems will be adaptable with respect to changes in payload manifests, in facility/apparatus complexity, and in implementing technologies; they will also be capable of flexibly accommodating the expanding needs of a highly variegated community of scientific users. Flowcharts are presented for the SSF payload operations concept, its flight operational data flows, and a data-flow growth concept. O.C.

A91-15773* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

TROPICAL RAIN MAPPING RADAR ON THE SPACE STATION

EASTWOOD IM and FUK LI (JPL, Pasadena, CA) IN: Quantitative remote sensing: An economic tool for the Nineties; Proceedings of IGARSS '89 and Canadian Symposium on Remote Sensing, 12th, Vancouver, Canada, July 10-14, 1989. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1989, p. 1485-1490. refs

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The conceptual design for a tropical rain mapping radar for flight on the manned Space Station is discussed. In this design the radar utilizes a narrow, dual-frequency (9.7 GHz and 24.1 GHz) beam, electronically scanned antenna to achieve high spatial (4 km) and vertical (250 m) resolutions and a relatively large (800 km) cross-track swath. An adaptive scan strategy will be used for better utilization of radar energy and dwell time. Such a system can detect precipitation at rates of up to 100 mm/hr with accuracies of roughly 15 percent. With the proposed space-time sampling strategy, the monthly averaged rainfall rate can be estimated to within 8 percent, which is essential for many climatological studies. I.E.

A91-16002

THE HIGH RESOLUTION IMAGING SPECTROMETER (HIRIS) FACILITY INSTRUMENT FOR THE FIRST POLAR ORBITING PLATFORM

ALEXANDER F. H. GOETZ (Colorado, University, Boulder) IN: Quantitative remote sensing: An economic tool for the Nineties; Proceedings of IGARSS '89 and Canadian Symposium on Remote Sensing, 12th, Vancouver, Canada, July 10-14, 1989. Volume 5. New York, Institute of Electrical and Electronics Engineers, 1989, p. 2922-2924. refs

Copyright

The High-Resolution Imaging Spectrometer (HIRIS) is designed to acquire images in 192 spectral bands simultaneously in the 0.4-2.5-micron wavelength region. HIRIS is a targeting rather than a continuous-acquisition instrument and obtains high spatial and spectral resolution images in a 24-km swath with a 30-m GIFOV in vertical viewing. Two-axis pointing is proposed which will allow image acquisition at -30 deg +52 deg down-track and + or - 26 deg cross-track. The raw data rate of the instrument is 405 Mb/s. The high spectral resolution will make it possible to directly identify surficial materials such as rocks, soils, and suspended matter in water, and HIRIS opens up the possibility of studying biogeochemical processes in vegetation canopies. I.E.

A91-16849

MICROGRAVITY AND JAPAN

TANYA SIENKO Space (ISSN 0267-954X), vol. 6, Nov.-Dec. 1990, p. 36-38, 40.

Copyright

Japan's use of the microgravity environment is discussed. Research primarily focuses on the processing of inorganic materials such as semiconductors and metals. Research options on earth include drop shafts and drop towers, sounding rockets, and experimental jet aircraft. Japan has recently opened a Microgravity Research Center in Hokkaido with an underground drop tower 730 m deep, allowing 10 seconds in freefall with a payload of up to a ton. Japan's sounding rockets include the TT-500AA and the TR-IA which allow up to six minutes in microgravity; a new NASDA rocket will increase payload to 1.5 tonnes. Microgravity experiments on crystallization and high-temperature superconductors were conducted by the Japanese in early 1991. The efforts of Japan's Space Technology Corporation (STC) appear to be geared toward chip manufacture. Proposed Japanese experiments using the International Microgravity Laboratory and the mission of the Space Flyer Unit, Japan's first space platform, and the JEM are discussed. L.K.S.

A91-16912#

HIGH ACCURACY LABORATORY TESTS ON AN ORBITAL-MICROGRAVITY-SENSOR-SYSTEM

D. K. JOOS and W. HUNSAENGER (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, Federal Republic of Germany) IN: Symposium Gyro Technology 1989, Stuttgart, Federal Republic of Germany, Sept. 19, 20, 1989, Proceedings. Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1989, p. 13.0-13.20.

ESA's Eureca orbital platform will measure residual acceleration disturbances with a microgravity measurement system whose calibration entails tests to a 10 to the -6th g accuracy. This calibration problem is approached by determining the residual deterministic errors in the test equipment by means of an extended error model; these errors are subsequently eliminated from the measurement data by software, concurrently with the actual testing process. Accuracies greater than 1 micro-g have been established, and further gains may be achieved through the application of correlation techniques and digital filters to reduce test equipment seismic background noise. O.C.

A91-17007

STABILIZATION OF THE POSITION OF A CHARGED BODY IN SPACE BY AN ELECTRIC FIELD [STABILIZATSIIA POLOZHENIIA ZARIAZHENNOGO TELA V PROSTRANSTVE ELEKTRICHESKIM POLEM]

S. N. IVASHEVSKII, V. M. LYKOSOV, A. A. MALYKH, and P. P. SMYSHLIAEV IN: Dynamics of control systems. Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1989, p. 73-75. In Russian.

Copyright

The feasibility of stabilizing the position of a charged spherical body in space by means of an electric field in the absence of gravity is examined theoretically. In the case of a quasi-steady electric field, a condition is derived which relates the charge, mass, and radius of the body and the frequency of the electric field at which the averaged potential energy can have local minima. The results are of in interst in connection with the carrying out of space manufacturing experiments. B.J.

A91-18727* National Aeronautics and Space Administration, Washington, DC.

UNITED STATES MICROGRAVITY PROGRAMS

RICHARD H. OTT and ROBERT S. SOKOLOWSKI (NASA, Washington, DC) (ZARM, MBB-ERNO, OHB-System, et al., International Microgravity Congress, 1st, Bremen, Federal Republic of Germany, Sept. 24-26, 1990) Microgravity Science and Technology (ISSN 0938-0108), vol. 3, Dec. 1990, p. 132-137.

Copyright

The U.S. Microgravity Program encompasses research initiatives of the NASA Office of Space Science and Applications and Office of Commercial Programs. NASA involvement in space missions extends to the U.S Microgravity Laboratory, the International Microgravity Laboratory, the Space Life Sciences Mission, and planned activities aboard the Japanese and German Spacelab missions. Flight programs under the aegis of NASA's Centers for the Commercial Development of Space will employ the Space Shuttle-based Commercial Middeck Augmentation Module and the Suborbital and Orbital Expendable Launch Vehicles. The projected Space Station will include a significant microgravity program. O.C.

A91-19155#

PROGRAMMATIC OVERVIEW OF THE ESA MICROGRAVITY PROGRAMME

G. SEIBERT (ESA, Paris, France) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 17 p.

(AIAA PAPER 91-0139) Copyright

An overview is presented of European activities in the various 'microgravity' research disciplines including materials sciences, fluid science, and life sciences. Research objectives of microgravity disciplines are stated and a short summary of results thus far obtained describe the activities of ESA's ongoing microgravity program including the mission opportunities and the experimental equipment to be flown. Plans for future continuation of the program into the Space Station era are considered. Microgravity research carriers and facilities including short duration carriers such as aircraft and sounding rockets, Spacelab, the European Retrievable Carrier Spacecraft, and the future Columbus Attached Laboratory is described. Research facilities for Spacelab are discussed including the ESA biorack, a multi-purpose facility for experiments in cell biology and radiation biophysics; the ESA anthrorack; the Advanced Fluid Physics Module; the Critical Point Facility; The Bubble, Drop, and Particle Unit; and the Advanced Gradient Heating Facility. L.K.S.

A91-19228*# Houston Univ., TX.
SPACE VACUUM PROCESSING
A. IGNATIEV, H. D. SHIH, M. DANIELS (Houston, University, TX), R. SEGA (NASA, Johnson Space Center, Houston, TX), and T. BONNER (Space Industries, Inc., Webster, TX) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 6 p. refs
(Contract NAGW-977)
(AIAA PAPER 91-0310) Copyright

The unique ultra-vacuum environment of low-earth orbit space is to be utilized for vacuum processing of advanced semiconductor and superconductor materials through epitaxial thin-film growth. The quality of semiconductor single crystal (epitaxial) thin-films can be significantly enhanced in the space ultra-vacuum through the reduction of impurities. This will be accomplished by the development of the free-flying Wake Shield Facility presently being built by the Space Vacuum Epitaxy Center in conjunction with industry and NASA under a low-cost, short time commercial approach to space hardware development. Author

A91-19246*# Alabama Univ., Huntsville.
CROSS-CORRELATION ANALYSIS OF ON-ORBIT RESIDUAL ACCELERATIONS IN SPACELAB
MELISSA J. B. ROGERS and J. IWAN D. ALEXANDER (Alabama, University, Huntsville) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 7 p. refs
(Contract NAG8-759)
(AIAA PAPER 91-0348) Copyright

To characterize the low-gravity environment within orbiting space laboratories, researchers are operating sensitive accelerometer systems. Transient accelerations recorded in spacecraft can have magnitudes up to 0.01 g over a wide range of frequencies. These accelerations have components in the 0.001-100-Hz range no greater in magnitude than 0.001 g. Some experiments can be sensitive to such accelerations, so investigators are interested in identifying causal relationships between accelerations and experimental results. Here, two forms of synthetic experiment data created using Spacelab 3 accelerometer data are evaluated using cross-correlation analysis. The results show that the use of cross-correlation techniques is appropriate, for specific experiment classes, for assessing relationships between both transient and oscillatory residual accelerations and experimental results recorded in a low-gravity environment. Author

A91-21376#
JAPANESE MICROGRAVITY SCIENCE ACTIVITIES
YOSHINORI FUJIMORI (NASDA, Space Experiment Group, Tokyo, Japan) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 14 p.
(AIAA PAPER 91-0142) Copyright

The plans of the Japanese space experiments aboard the Shuttle and the Space Station are discussed. The First Material Processing Test is discussed, noting that it consists of two major disciplines, material and life sciences. The experiments scheduled to take place will investigate the effects of microgravity on the synthesis of new materials: alloys, composites, semiconductors, and inorganic or organic crystals. Other experiments will investigate the effect of weightlessness and intense space radiation on the cells of both animals and humans. A number of these experiments are listed. The International Microgravity Laboratory, a NASA program in which U.S. scientists can utilize the hardwares provided by Non-U.S. agencies, is discussed. The Space Station Program is also discussed including the current preparation for research aboard the JEM, the equipment required for initial operations capability, and the generic technologies which enable the users in the Space Station to carry out experiments. L.K.S.

A91-21377#
MICROGRAVITY SCIENCE ISSUES FOR THE NINETIES
ROBERT J. NAUMANN (Alabama, University, Huntsville) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p. refs
(AIAA PAPER 91-0143) Copyright

Several issues confronting the NASA microgravity science and application program in the fields of biotechnology, electronic materials, metals and alloys, and nonmetallic systems are discussed. It is recommended that NASA consider a dedicated man-tended, free-flying spacecraft as the first element of the Space Station that can accommodate those microgravity experiments which require a long-duration high-quality microgravity environment with no direct crew involvement during their operation. This module should remain as a free flyer to maintain the capability of conducting long-duration experiments with extremely low acceleration background. Y.P.Q.

A91-21614*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
A PREVIEW OF A MICROGRAVITY LASER LIGHT SCATTERING INSTRUMENT
W. V. MEYER (NASA, Lewis Research Center, Cleveland, OH) and R. R. ANSARI (Case Western Reserve University, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 8 p. refs
(AIAA PAPER 91-0779) Copyright

The development of a versatile, miniature, modular light scattering instrument to be used in microgravity is described. The instrument will measure microscopic particles in the size range of thirty angstroms to above three microns. This modular instrument permits several configurations, each optimized for a particular experiment. In particular, a multiangle instrument will probably be mounted in a rack in the Space Shuttle and on the Space Station. It is possible that a Space Shuttle glove-box and a lap-top computer containing a correlator card can be used to perform a number of experiments and to demonstrate the technology needed for more elaborate investigations. Y.P.Q.

A91-23210
COLUMBUS PROJECT TELESCOPE
PETER STRITTMATTER (Steward Observatory, Tucson, AZ) IN: Advanced technology optical telescopes IV; Proceedings of the Meeting, Tucson, AZ, Feb. 12-16, 1990. Part 1. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 71-84. refs
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The design for the Columbus binocular telescope has been completed and the project is now proceeding to the construction phase. The two 8-m f/1.2 borosilicate honeycomb mirrors will give an effective collecting area of 11.3 m and a baseline of 22 m for interferometry. The optics are supported on an exceedingly compact and rigid 'C-ring' mount with a lowest eigenfrequency of around 10 Hz. The system will be housed in a corotating enclosure and will be located on Mt. Graham in southeastern Arizona. Instrumentation priorities have been established for the telescope and conceptual designs are now under development. Author

A91-23211
OPTICAL DESIGN, ERROR BUDGET AND SPECIFICATIONS FOR THE COLUMBUS PROJECT TELESCOPE

J. M. HILL (Steward Observatory, Tucson, AZ) IN: Advanced technology optical telescopes IV; Proceedings of the Meeting, Tucson, AZ, Feb. 12-16, 1990. Part 1. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 86-107. refs
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The Columbus Project's double 8-m diameter binocular (11.3-m aperture) telescope optical configuration encompasses (1) two Cassegrain foci at f/5.4 that are optimized for wide-field optical observations, (2) an additional two Cassegrain foci at f/15 which are optimized for the thermal IR, (3) a combined f/33 focus optimized for interferometry, and (4) several additional stations derived from either the folding or redirection of the first three types. Attention is presently given to the telescope's error budget, whose goal is the achievement of a wavefront structure function equivalent to images of 0.23 arcsec FWHM; the wavefront of the combined telescope, atmosphere, and instrumentation should be equivalent to a detected image of 0.34 arcsec FWHM. O.C.

A91-23222
A SPACE SCHMIDT IMAGING TELESCOPE - OPTICAL CONCEPT AND ASTROPHYSICAL OBJECTIVES
GEORGE R. CARRUTHERS (U.S. Navy, E. O. Hulburt Center for Space Research, Washington, DC), JACQUELINE FISCHER (U.S. Navy, Naval Research Laboratory, Washington, DC), JAMES D. WRAY (Sci-Tech Astronomical Research, Foresthill, CA), DANIEL J. SCHROEDER (Beloit College, WI), ROBERT W. O'CONNELL (Virginia, University, Charlottesville) et al. IN: Advanced technology optical telescopes IV; Proceedings of the Meeting, Tucson, AZ, Feb. 12-16, 1990. Part 1. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 215-236. refs
Copyright

The design concept of a wide-field astronomical imaging telescope for use as a payload on an unmanned space platform, a Space Station attached payload, or a Delta-class Explorer is described. The instrument is based on a space Schmidt telescope concept studied by NASA and ESA (1979) for Spacelab missions. The astrophysical objectives include all-sky surveys in the UV and NIR ranges. Objects of interest include very hot and very cool stars and the interstellar medium. The UV range is inaccessible from the ground, and large-area surveys and sensitive imagery of diffuse sources are impractical with current or planned UV space telescopes. The NIR range is severely compromised in ground-based observations, particularly of diffuse sources, by airglow emissions, and no wide-field NIR space telescopes are currently approved for flight. Author

A91-23288
DESIGN STRATEGIES FOR VERY LARGE TELESCOPES
WARREN DAVISON (Steward Observatory, Tucson, AZ) IN: Advanced technology optical telescopes IV; Proceedings of the Meeting, Tucson, AZ, Feb. 12-16, 1990. Part 2. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1990, p. 878-883. refs
Copyright

The reasons are presented for the high performance of the Columbus Project Telescope whose design is based on two short focal mirrors, large drive and support radii, and a short load path to the ground. The radius squared is argued to be the most important tool for the inprovement of performance in the large optical telescopes, since the stiffness of the mechanics is proportional to the radius at which they act squared. The six Columbus telescope finite element models show that optimization of a structure depends more on the initial conditions (radius squared) than the truss shape or elements. It is concluded that future exploitation of radius squared could lead to higher performance for the very large telescope. A.B.

A91-26816* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CALIBRATION AND OPERATION OF A LARGE SPACE-BASED OPTICAL INTERFEROMETER
R. A. LASKIN, W. G. BRECKENRIDGE, M. SHAO, and D. C. REDDING (JPL, Pasadena, CA) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 233-252. refs
(AAS PAPER 90-040) Copyright

The on-orbit calibration of the optics, structure, and control systems of the CSI Focus Mission Interferometer (FMI) is described. The calibration involves the estimation and propagation of both positional and rotational parameters and the propagation of both positional and rotational parameters at the nanometer/nanoradian level. It is shown that, given a nanometer class metrology system to monitor positional changes of critical optical elements, this calibration procedure should enable the FMI to perform 50 picoradian astrometry. The same Kalman filter that implements the initializing calibration of the interferometer baselines and internal pathlengths will also participate in the astrometric measurements of stellar positions. B.J.

A91-26819* Ball Aerospace Systems Div., Boulder, CO.
STRUCTURAL CONTROL SENSORS FOR CASES
HUGH W. DAVIS (Ball Aerospace Systems Group, Boulder, CO), JOHN P. SHARKEY, and CONNIE K. CARRINGTON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 305-328.
(AAS PAPER 90-044) Copyright

The Remote Attitude Measurement Sensor (RAMS) is currently baselined to meet two important sensor needs for CASES (Control, Astrophysics and Structures Experiment in Space). First, as a tip displacement sensor, RAMS is designed to provide accurate knowledge of the position and orientation of the boom tip assembly. Secondly, as a boom motion tracker, it is designed to monitor 43 reflective targets which are distributed along the length of the boom and provide displacment information for post facto processing. The design and operation of RAMS as these two types of sesnors are described, and attention is given to how RAMS interfaces with the CASES closed-loop control system and how systems identification is accommodated. B.J.

A91-26832 Massachusetts Inst. of Tech., Cambridge.
MIT-NASA/KSC SPACE LIFE SCIENCE EXPERIMENTS - A TELESCIENCE TESTBED
CHARLES M. OMAN (MIT, Cambridge, MA), BYRON K. LICHTENBERG (Payload Systems, Inc., Cambridge, MA), RICHARD L. FISER, and DEBORAH S. VORDERMARK (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Guidance and control 1990; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, Feb. 3-7, 1990. San Diego, CA, Univelt, Inc., 1990, p. 575-589. MIT-supported research. refs
(Contract NAGW-1092)
(AAS PAPER 90-002) Copyright

Experiments performed at MIT to better define Space Station information system telescience requirements for effective remote coaching of astronauts by principal investigators (PI) on the ground are described. The experiments were conducted via satellite video, data, and voice links to surrogate crewmembers working in a laboratory at NASA's Kennedy Space Center. Teams of two PIs and two crewmembers performed two different space life sciences experiments. During 19 three-hour interactive sessions, a variety of test conditions were explored. Since bit rate limits are necessarily imposed on Space Station video experiments surveillance video was varied down to 50 Kb/s and the effectiveness of PI controlled frame rate, resolution, grey scale, and color decimation was investigated. It is concluded that remote coaching by voice works and that dedicated crew-PI voice loops would be of great value on the Space Station. L.K.S.

A91-27690* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LARGE SPACE SYSTEMS IN GLOBAL CHANGE MITIGATION
LYLE M. JENKINS (NASA, Johnson Space Center, Houston, TX) IN: Engineering, construction, and operations in space II;

Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 1169-1174. refs
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The monitoring from space of such processes as the greenhouse effect and depletion of the ozone layer is discussed, as well as possibilities for active intervention in them, using space systems. Possibilities include the use of the Solar Power Satellite to reduce dependence on the burning of fossil fuels, dispersal of materials to neutralize chemicals responsible for ozone depletion, and measures to reduce the impact of local disasters, both natural and man-made. A.F.S.

A91-28428
THE AUTOMATED SPACE OBSERVATORY
PETER L. MANLY Journal of Practical Applications in Space (ISSN 1046-8757), vol. 1, Spring 1990, p. 23-28. refs
Copyright

A description is given of the Automated Photoelectric Telescope (APT), a small telescope guided by a computer. The telescope is given a list of stars to observe and performs the observations automatically, compiling the data for transmission to the astronomer at the end of the night. A proposal which has been made to NASA is described, according to which four unattended automated telescopes will be attached to Space Station Freedom. The telescopes would each be about a half meter in aperture, and would use off-the-shelf commercially available technology. It is pointed out that an automated space telescope would not require many of the advance systems developed for other free-flying space telescopes as it needs no active guidance system, since it could obtain information as to the orientation of the Space Station from a real-time link with the station's computers. L.K.S.

A91-28527* California Univ., Berkeley.
CRYOGENIC TECHNIQUES FOR LARGE SUPERCONDUCTING MAGNETS IN SPACE
M. A. GREEN (California, University, Berkeley) (Space Cryogenics Workshop, Frascati, Italy, July 18, 19, 1988, Proceedings. A91-28526 11-31) Cryogenics (ISSN 0011-2275), vol. 29, May 1989, p. 484-492. NASA-supported research. Previously announced in STAR as N89-27455. refs
(Contract DE-AC03-76SF-00098)
Copyright

A large superconducting magnet is proposed for use in a particle astrophysics experiment, ASTROMAG, which is to be mounted on the United States Space Station. This experiment will have a two-coil superconducting magnet with coils which are 1.3 to 1.7 meters in diameter. The two-coil magnet will have zero net magnetic dipole moment. The field 15 meters from the magnet will approach earth's field in low earth orbit. The issue of high Tc superconductor will be discussed in the paper. The reasons for using conventional niobium-titanium superconductor cooled with superfluid helium will be presented. Since the purpose of the magnet is to do particle astrophysics, the superconducting coils must be located close to the charged particle detectors. The trade off between the particle physics possible and the cryogenic insulation around the coils is discussed. As a result, the ASTROMAG magnet coils will be operated outside of the superfluid helium storage tank. The fountain effect pumping system which will be used to cool the coil is described in the report. Two methods for extending the operating life of the superfluid helium dewar are discussed. These include: operation with a third shield cooled to 90 K with a sterling cycle cryocooler, and a hybrid cryogenic system where there are three hydrogen-cooled shields and cryostat support heat intercept points. Author

A91-28964
SUBMILLIMETER OBSERVATIONS FROM SPACE - A SPACE STATION SUBMILLIMETER FACILITY (SSSF)
K. W. WEILER, K. J. JOHNSTON, R. M. BEVILACQUA, P. R. SCHWARTZ (U.S. Navy, Naval Research Laboratory, Washington, DC), J. P. HACKET (Com Dev, Ltd., Cambridge, Canada) et al. Astrophysics and Space Science (ISSN 0004-640X), vol. 175, no. 2, Jan. 1991, p. 311-333. refs
Copyright

The large manned Space Station will provide, for the first time, a permanent structure in space with a size sufficient to carry a high-resolution high-sensitivity synthesis interferometer operating at submillimeter wavelengths. This paper discusses the many possibilities for astrophysical investigations at submillimeter wavelengths and describes the instrument designed to carry these observations. Attention is also given to data handling in space and on the ground. I.S.

A91-29442
MICROGRAVITY QUALITY PROVIDED BY DIFFERENT FLIGHT OPPORTUNITIES
H. STARK (ESTEC, Noordwijk, Netherlands), C. STAVRINIDIS, D. EILERS, and E. HORNUNG (International Microgravity Congress, 1st, Bremen, Federal Republic of Germany, Sept. 24-26, 1990) Microgravity Science and Technology (ISSN 0938-0108), vol. 3, Feb. 1991, p. 191-203. refs
Copyright

An overview of the microgravity environment of short and longer duration test and flight installations for European users is presented. Those installations include drop towers, parabolic flights, sounding rockets, heavy launchers, Shuttle/Spacelab missions, the Eureca Free Flyer, the Space Station Freedom/Columbus Attached Laboratory, and the Columbus Free Flying Laboratory. The results of on-orbit microgravity/acceleration measurements from Shuttle/Spacelab flights were compared with the natural and induced perturbations and disturbance source forcing functions. Test results of the spacecraft structure dynamics transfer functions are analyzed. Eureca design with respect to maintaining a specific requirement for the micro-g environment is described. The micro-g specifications for the Columbus Free Flying Laboratory and the Columbus Attached Laboratory have been compared with performance analysis result predictions and various technology tasks. O.G.

A91-29553
A SOLAR INTERFEROMETRIC MISSION FOR ULTRAHIGH RESOLUTION IMAGING AND SPECTROSCOPY - SIMURIS
L. DAME (ONERA, Chatillon; CNRS, Service d'Aeronomie, Verrieres-le-Buisson, France), L. ACTON, M. BRUNER (Lockheed Research Laboratories, Palo Alto, CA), P. CONNES (CNRS, Service d'Aeronomie, Verrieres-le-Buisson, France), T. CORNWELL (National Radio Astronomy Observatory, Socorro, NM) et al. (Solar corona and solar wind; Proceedings of Symposium 9 of the 28th COSPAR Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A91-29501 11-92) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 1, 1991, p. 383-386. refs
Copyright

SIMURIS is an interferometric investigation of the very fine structure of the solar atmosphere from the photosphere to the corona. It was proposed to ESA/1/, November 30, 1989, for the Next Medium Size Mission - M2, and accepted in February 1990 for an Assessment Study in the context of the Space Station. The main scientific objectives are outlined, and the ambitious model payload featuring the Solar Ultraviolet Network (SUN), a 2 m long monolithic array of 4 telescopes of 20 cm, and the Imaging Fourier Transform Spectrometer (IFTS), an UV and Visible Imaging Fourier Transform Spectrometer coupled to a 40-cm-diameter Gregory, are described. Author

A91-29554
THE IMAGING FOURIER TRANSFORM SPECTROMETER FOR THE SIMURIS MISSION
B. H. FOING (ESTEC, Noordwijk, Netherlands; CNRS, Institut d'Astrophysique Spatiale, Verrieres-le-Buisson, France), L. DAME (ONERA, Chatillon, France), A. P. THORNE (Imperial College of Science, Technology, and Medicine, London, England), and P. LEMAIRE (CNRS, Service d'Aeronomie, Verrieres-le-Buisson, France) (Solar corona and solar wind; Proceedings of Symposium 9 of the 28th COSPAR Plenary Meeting, The Hague, Netherlands,

June 25-July 6, 1990. A91-29501 11-92) Advances in Space Research (ISSN 0273-1177), vol. 11, no. 1, 1991, p. 387-390. refs

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The Solar Interferometric Mission for Ultrahigh Resolution *Imaging and Spectroscopy* (SIMURIS) is an *interferometric* investigation in space at ultraviolet and visible wavelengths aimed at reconnaissance of solar features at angular scales from 0.3 to 0.01 arcsec. The Imaging Fourier Transform Spectrometer (IFTS) is, with the Solar Ultraviolet Network (SUN), one of the core instruments of the proposed SIMURIS mission. It consists of a 40-cm Gregory telescope feeding a double grating pre-dispersive spectrometer before entering a Fourier transform spectrometer for a field of 10 x 10 sq arcsec at 0.3 arcsec resolution. The SIMURIS/IFTS requires upgrading of existing FTS down to 120 nm, with imaging capabilities. There are also demanding constraints on the real time processing, and the subsequent important data rate, and requirements on an upgraded instrument pointing system (IPS), within the resources and capabilities of the Space Station. Author

A91-29713*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

FLIGHT PAYLOADS ENVIRONMENTAL APPROACH

JOHN W. SCHLUE (JPL, Pasadena, CA) IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 157-161.

The Earth Observing System (EOS) and Space Station (SS) attached payload instruments to be developed by JPL will have a consistent implied level of reliability confidence based on the application of product assurance requirements. An important subset of these requirements is a set of detailed environmental design and test requirements. These requirements have a sound technical defense, are unambiguous in their level of detail, provide rational risk management as a function of payload classification, and are rigorously enforced with a comprehensive waiver process imposed on planned deviations. Author

A91-29725

HOW TO SUCCEED IN BUSINESS WITHOUT REALLY FLYING

FRANK KUZNIK Air and Space (ISSN 0886-2257), vol. 6, Apr.-May 1991, p. 70-74.

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This review describes the conception and design of the Spacehab module positioned in the Space Shuttles cargo bay that can be used as a pressurized laboratory for industrial experiments. The crew is able to handle the experiments by floating out of the middeck of the spacecraft and entering the laboratory through a connecting tunnel. Commercial experiments to be conducted focus on the areas of crystal growth, robotics, materials development, and pharmaceuticals. Depending on locker configuration, the module can transport two to three dozen experiments per flight. The complexities of forming the commercial enterprise to work with NASA for conducting commercial programs in space are described. R.E.P.

A91-30088

THE CASES FLIGHT EXPERIMENT - AN OVERVIEW

JOHN R. SESAK and J. MEL WALDMAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: 1990 American Control Conference, 9th, San Diego, CA, May 23-25, 1990, Proceedings. Vol. 1. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 878-882.

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An overview of the control astrophysics and structures experiment in space (CASES) is provided. The overview includes pertinent CSI (control structures interaction) issues. The CASES program provides a unique opportunity to integrate slewing, pointing, vibration, and shape control in a single control subsystem. The integration of these major subsystems with overlapping bandwidths represents a major CSI step beyond vibration control. The parameter modification system figures in the quasistatic shape control subsystem. The integration of these major subsystems stems directly from realistic requirements imposed by the astrophysics experiment. The CASES baseline consists of a configuration packaged into five modules, the astrophysics module, the propulsion module, the boom module, the astrophysics *electronics module, and the control and data handling electronics* module. Each is briefly described. I.E.

A91-30211

STRATEGIES FOR CONTROLLING A MICROGRAVITY ISOLATION MOUNT

D. I. JONES (North Wales, University College, Bangor, Wales) *IN: 1990 American Control Conference, 9th, San Diego, CA, May* 23-25, 1990, Proceedings. Vol. 3. Piscataway, NJ, Institute of Electrical and Electronics Engineers, 1990, p. 2601-2606. refs

(Contract ESTEC-7637/88)

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A description is given of the concept of an active vibration isolation system called a microgravity isolation mount (MGIM) for use onboard orbiting spacecraft. The purpose of the mount is to reduce to an acceptable level the residual accelerations experienced by sensitive experimental payloads due to vibrational disturbances within the spacecraft environment. The advantages and drawbacks of introducing an umbilical to carry electrical power and cooling water between the fixed and free part of the mount are discussed. The interaction between this design factor and the selection of the control technique is considered. Three different techniques for controlling the mount are compared, involving, respectively, feedback of relative displacement measurements only, feedback of payload acceleration, and direct control of umbilical extension. The tradeoffs between the three methods are described. I.E.

A91-30667* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.

DEVELOPMENT OF EXPERIMENTAL FACILITIES FOR PROCESSING METALLIC CRYSTALS IN ORBIT

BILL J. DUNCAN (NASA, Marshall Space Flight Center; Sverdrup Technology, Inc., Huntsville, AL) IN: TABES 90 - Annual Technical and Business Exhibition and Symposium, 6th, Huntsville, AL, May 15, 16, 1990, Submitted Papers. Huntsville, AL, Huntsville Association of Technical Societies, 1990, p. 206-211. refs

(TABES PAPER 90-1804) Copyright

This paper discusses the evolution, current status, and planning for facilities to exploit the microgravity environment of earth orbit in applied metallic materials science. Space-Shuttle based facilities and some precursor flight programs are reviewed. Current facility development programs and planned Space Station furnace capabilities are described. The reduced gravity levels available in earth orbit allow the processing of metallic materials without the disturbing influence of gravitationally induced thermal convection, stratification due to density differences in sample components, or the effects of hydrostatic pressure. Author

N91-12401*# National Aeronautics and Space Administration. *Marshall Space Flight Center, Huntsville, AL.*

MEASUREMENT AND CHARACTERIZATION OF THE ACCELERATION ENVIRONMENT ON BOARD THE SPACE STATION

CHARLES R. BAUGHER, ed. Washington Aug. 1990 669 p

Workshop held in Guntersville, AL, 11-14 Aug. 1986; sponsored by Teledyne Brown Engineering

(Contract NAS8-36122)

(NASA-CP-3088; M-639; NAS 1.55:3088) Avail: NTIS HC/MF A99 CSCL 03/1

This workshop provides a comprehensive overview of the work and status of each of these areas to provide a basis for establishing a systematic approach to the challenge of avoiding these difficulties during the Space Station era of materials experimentation. The discussions were arranged in the order of: the scientific understanding of the requirements for a micro-gravity environment, a history of acceleration measurements on spacecraft, the state of accelerometer technology, and the current understanding of the predicted Space Station environment.

N91-12403*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
DESIRABLE LIMITS OF ACCELERATIVE FORCES IN A SPACE-BASED MATERIALS PROCESSING FACILITY
ROBERT J. NAUMANN *In its* Measurement and Characterization of the Acceleration Environment on Board the Space Station 18 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

There are three categories of accelerations to be encountered on orbiting spacecraft: (1) quasi-steady accelerations, caused by atmospheric drag or by gravity gradients, 10(exp -6) to 10(exp -7) g sub o; (2) transient accelerations, caused by movements of the astronauts, mass translocations, landing and departure of other spacecraft, etc.; and (3) oscillary accelerations, caused by running machinery (fans, pumps, generators). Steady accelerations cause continuing displacements; transients cause time-limited displacements. The important aspect is the area under the acceleration curve, measured over a certain time interval. Note that this quantity is not equivalent to a velocity because of friction effects. Transient motions are probably less important than steady accelerations because they only produce constant displacements. If the accelerative forces were not equal and opposite, the displacement would increase with time. A steady acceleration will produce an increasing velocity of a particle, but eventually an equilibrium value will be reached where drag and acceleration forces are equal. From then on, the velocity will remain constant, and the displacement will increase linearly with time. Author

N91-12405*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ACCELERATION EFFECTS OBSERVED IN OPTICAL DATA TAKEN IN SPACELAB 3 FES
JAMES TROLINGER, RAVINDRA LAL (Alabama A & M Univ., Huntsville.), and RUDY RUFF *In its* Measurement and Characterization of the Acceleration Environment on Board the Space Station 25 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 20/6

Optical instrumentation in the Fluids Experiment System (FES) is briefly described. Samples of the data produced by the schlieren and holography systems during the Spacelab 3 flight are then presented with some of the holographic interferometry data being presented for the first time. Acceleration effects that can be observed in these data are discussed and the potential for using them as a basis for measurement is explored. This includes the tracking of deliberately introduced tracer particles and density gradients in the FES, the analysis of the existing concentration gradients, and a new fiber optic G-meter concept. Finally, some of the plans for acceleration measurement in the upcoming International Microgravity-1/FES are described. Author

N91-12406*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MICROGRAVITY AND ITS EFFECTS ON RESIDUAL MOTIONS IN FLUIDS
J. IWAN D. ALEXANDER and CHARLES A. LUNDQUIST (Alabama Univ., Huntsville.) *In its* Measurement and Characterization of the Acceleration Environment on Board the Space Station 11 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/1

The primary reason for conducting many materials science experiments in space is to minimize or eliminate undesirable effects that might result owing to convective motions in fluids that are driven by buoyancy effects. Of particular concern are the low frequency accelerations caused by the Earth's gravity gradient field, spacecraft attitude motions, and atmospheric drag. In order to gain a limited understanding of the effects of these accelerations, researchers calculated the Stokes' motion of a spherical particle in a fluid for various types of spacecraft attitudes. Researchers assessed the effect of slowly rotating the experimental system relative to the spacecraft in order to reduce the rate at which the particles accumulate against the container wall. Author

N91-12407*# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
THE MICROGRAVITY ENVIRONMENT OF THE D1 MISSION
H. HAMACHER, U. MERBOLD (European Space Agency, Paris, France), and R. JILG *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 24 p Aug. 1990 Previously announced in IAA as A87-15978
Avail: NTIS HC/MF A99 CSCL 22/1

Some characteristic features and results of D1 microgravity measurements are discussed as performed in the Material Science Double Rack (MSDR) and the Materials Science Double Rack for Experiment Modules and Apparatus (MEDEA). Starting with a brief review of the main potential disturbances, the payload aspects of interest to the analysis and the accelerometer measuring systems are described. The microgravity data are analyzed with respect to selected mission events such as thruster firings for attitude control, operations of Spacelab experiment facilities, vestibular experiments and crew activities. The origins are divided into orbit, vehicle, and experiment induced perturbations. It has been found that the microgravity-environment is dictated mainly by payload-induced perturbations. To reduce the microgravity-level, the design of some experiment facilities has to be improved by minimizing the number of moving parts, decoupling of disturbing units from experiment facilities, by taking damping measures, etc. In addition, strongly disturbing experiments and very sensitive investigations should be performed in separate mission phases. Author

N91-12409*# Draper (Charles Stark) Lab., Inc., Cambridge, MA.
PREDICTION AND RECONSTRUCTION OF ON-ORBIT ACCELERATION
EDWARD BERGMANN *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 16 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/1

As the number of acceleration sensitive experiments to be carried on each Shuttle or Space Station mission increases, the requirement for either low-g environment or for accelerometry at each experiment location also increases. Preflight planning of such experiments in the past has not always included detailed analyses of the acceleration environment at the experiment location that had a serious impact on the experiment. Careful modeling of the mission activities and their effect on the experiment in many cases would have been beneficial to these experiments. In some cases, the experiment was not comprised, but insufficient instrumentation was available onboard to directly measure accelerations at the experiment location. The type of preflight modeling available to assist in experiment design and mission integration is described, as well as the use of that tool postflight to enhance flight data when sensors are not ideally suited to experiment analysis. Examples of recent shuttle flight experiments are presented. Author

N91-12411*# Teledyne Brown Engineering, Huntsville, AL.
MSL-2 ACCELEROMETER DATA RESULTS
FRED HENDERSON *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 29 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

The Materials Science Laboratory-2 (MSL-2) mission flew the Marshall Space Flight Center-developed Linear Triaxial Accelerometer (LTA) on the Space Transportation System (STS) 61-C Shuttle mission launched January 21, 1986. Flight data were analyzed to verify the quietness of the MSL carrier and to characterize the acceleration environment for future MSL users. The MSL was found to introduce no significant experiment acceleration; and the effects of crew treadmill exercise, Orbiter vernier engine firings, and other routine flight occurrences were established. The LTA was found to be well suited for measuring nominal to very quiet STS acceleration levels at frequencies below

50 Hz. Special processing was used to examine the low-frequency spectrum and to establish the effective rms amplitude associated with dominant frequencies. Author

N91-12412*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MECHANICAL ISOLATION FOR GRAVITY GRADIOMETERS
DAVID SONNABEND *In* NASA, Marshall Space Flight Center, *Measurement and Characterization of the Acceleration Environment on Board the Space Station* 12 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

In principle, gravity gradiometers are immune to the effects of acceleration and vibrations. In real instruments, scale factor errors and structural compliance lead to undesired instrument outputs. Described here are the instruments and the fundamental sources of the problems, a calculation of the magnitude of the effects, a demonstration of the need for isolation in the Shuttle (indeed, almost any spacecraft), and the Jet Propulsion Laboratory eddy current isolation technique and its current development status. Author

N91-12413*# Textron Bell Aerospace Co., Belmont, CA.
THE MESA ACCELEROMETER FOR SPACE APPLICATION
WILLIAM G. LANGE and ROBERT W. DIETRICH *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 28 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

An electrostatically suspended proof mass in the Miniature Electrostatic Accelerometer (MESA) is used to measure acceleration in the submicro-g range. Since no fixed mechanical suspension (such as springs or strings) is used, the constrainment scaling can be changed electrically after being placed in orbit. A single proof mass can sense accelerations in three axes simultaneously. It can survive high-g pyrotechnic-generated shocks and launch environments while unpowered. Author

N91-12414*# Payload Systems, Inc., Wellesley, MA.
A NEW ACCELEROMETER RECORDING SYSTEM FOR SHUTTLE USE
BYRON LICHTENBERG *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 18 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

Microgravity investigators are interested in enhancing the capabilities and improving the information return from accelerometers used in microgravity research. In addition to improving the accelerometer sensor, efforts should be directed towards using recent advances in microprocessor technology and system design techniques to improve sensor calibration and temperature compensation, online data display and analysis, and data reduction and information storage. Results from the above areas of investigation should be combined in an integrated design for a spaceflight microgravity accelerometer package. Author

N91-12415*# Honeywell, Inc., Minneapolis, MN. Systems and *Research Center.*
NEW ACCELEROMETERS UNDER DEVELOPMENT
JERRY WALD and M. TEHRANI *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 20 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

The commercial viability of the Space Station requires that it provide a micro-g, or submicro-g environment to users. This represents significant improvement over existing systems. Attainment of the lowest micro-g levels requires isolation systems. Passive and active systems have been evaluated. Best performance is achieved using active approaches where accelerometer sensors close feedback loops. Two emerging accelerometer technologies are presented that have promise for meeting performance goals while achieving reductions of package size, weight, and power. The technologies addressed are Honeywell's design concept for an optical cavity locking accelerometer and the recent development of an integrated-silicon accelerometer for government applications. Author

N91-12416*# Maryland Univ., College Park.
SUPERCONDUCTING SIX-AXIS ACCELEROMETER
H. J. PAIK *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 14 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

A new superconducting accelerometer, capable of measuring both linear and angular accelerations, is under development at the University of Maryland. A single superconducting proof mass is magnetically levitated against gravity or any other proof force. Its relative positions and orientations with respect to the platform are monitored by six superconducting inductance bridges sharing a single amplifier, called the Superconducting Quantum Interference Device (SQUID). The six degrees of freedom, the three linear acceleration components and the three angular acceleration components, of the platform are measured simultaneously. In order to improve the linearity and the dynamic range of the instrument, the demodulated outputs of the SQUID are fed back to appropriate levitation coils so that the proof mass remains at the null position for all six inductance bridges. The expected intrinsic noise of the instrument is 4 x 10(exp -12)m s(exp -2) Hz(exp -1/2) for linear acceleration and 3 x 10(exp -11) rad s(exp -2) Hz(exp -1/2) for angular acceleration in 1-g environment. In 0-g, the linear acceleration sensitivity of the superconducting accelerometer could be improved by two orders of magnitude. The design and the operating principle of a laboratory prototype of the new instrument is discussed. Author

N91-12417*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PRESENTATION ON A SPACE ACCELERATION MEASUREMENT SYSTEM (SAMS)
THEODORE L. CHASE *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 20 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

The primary objective of the Space Acceleration Measurement Systems (SAMS) project is to provide an acceleration measurement system capable of serving a wide variety of space experiments. The design of the system being developed under this project takes into consideration requirements for experiments located in the middeck, in the orbiter bay, and in Spacelab. In addition to measuring, conditioning, and recording accelerations, the system will be capable of performing complex calculations and interactive control. The main components consist of a remote triaxial optical storage device. In operation, the triaxial sensor head produces output signals in response to acceleration inputs. These signals are preamplified, filtered and converted into digital data which is then transferred to optical memory. The system design is modular, facilitating both software and hardware upgrading as technology advances. Two complete acceleration measurement flight systems will be build and tested under this project. Author

N91-12418*# *Teledyne Geotechnical, Dallas, TX.*
ACQUISITION AND ANALYSIS OF ACCELEROMETER DATA
KEITH R. VERGES *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 32 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

Acceleration data reduction must be undertaken with a complete understanding of the physical process, the means by which the data are acquired, and finally, the calculations necessary to put the data into a meaningful format. Discussed here are the acceleration sensor requirements dictated by the measurements desired. Sensor noise, dynamic range, and linearity will be determined from the physical parameters of the experiment. The digitizer requirements are discussed. Here the system from sensor to digital storage medium will be integrated, and rules of thumb for experiment duration, filter response, and number of bits are explained. Data reduction techniques after storage are also discussed. Time domain operations including decimating, digital filtering, and averaging are covered, as well as frequency domain methods, including windowing and the difference between power and amplitude spectra, and simple noise determination via coherence analysis. Finally, an example experiment using the Teledyne Geotech Model 44000 Seismometer to measure from 1 Hz to 10(exp -6) Hz is discussed. The sensor, data acquisition system, and example spectra are presented. Author

N91-12419*# Applied Technology Associates, Inc., Albuquerque, NM.
CHARACTERIZING PERFORMANCE OF ULTRA-SENSITIVE ACCELEROMETERS
HENRY SEBESTA *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 27 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

An overview is given of methodology and test results pertaining to the characterization of ultra sensitive accelerometers. Two issues are of primary concern. The terminology ultra sensitive accelerometer is used to imply instruments whose noise floors and resolution are at the state of the art. Hence, the typical approach of verifying an instrument's performance by measuring it with a yet higher quality instrument (or standard) is not practical. Secondly, it is difficult to find or create an environment with sufficiently low background acceleration. The typical laboratory acceleration levels will be at several orders of magnitude above the noise floor of the most sensitive accelerometers. Furthermore, this background must be treated as unknown since the best instrument available is the one to be tested. A test methodology was developed in which two or more like instruments are subjected to the same but unknown background acceleration. Appropriately selected spectral analysis techniques were used to separate the sensors' output spectra into coherent components and incoherent components. The coherent part corresponds to the background acceleration being measured by the sensors being tested. The incoherent part is attributed to sensor noise and data acquisition and processing noise. The method works well for estimating noise floors that are 40 to 50 dB below the motion applied to the test accelerometers. The accelerometers being tested are intended for use as feedback sensors in a system to actively stabilize an inertial guidance component test platform. Author

N91-12422*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
LOW-G PAYLOAD PLACEMENT CONSTRAINTS FOR SPACE STATION
ANITA S. CARPENTER and STANLEY N. CARROLL *In its* Measurement and Characterization of the Acceleration Environment on Board the Space Station 14 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Payloads onboard the Space Station will be subjected to a steady state acceleration level dominated by gravity gradient and aerodynamic drag forces. The g-level due to gravity gradient forces depends on the payload location relative to the center of mass, whereas the g-level due to aerodynamic drag may be assumed nearly constant throughout the Space Station. The vector of acceleration due to aerodynamic drag can always be broken down into three orthogonal components, in the direction opposite to the velocity vector, along the local vertical, and perpendicular to the orbit plane. It will be shown that the gravity gradient term has two components, which are orthogonal to one another. One component is along the local vertical and the other is perpendicular to the orbit plane. Thus, the combination of all components form an orthogonal triad of vectors. Addressed here are the payload location constraints to satisfy the requirements of 1 micro-g. The permissible locations are within an open-ended tube having an elliptical cross section, which is aligned with the velocity vector and centered on the system center of mass. Author

N91-12426*# Sundstrand Data Control, Inc., Redmond, WA.
NOISE POWER SPECTRAL DENSITY OF THE SUNDSTRAND QA-2000 ACCELEROMETER
REX PETERS, DAVID GRINDELAND, and CHARLES R. BAUGHER, ed. (National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.) *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 6 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

There are no good data on low frequency (less than 0.1 Hz) power spectral density (PSD) for the Q-Flex accelerometer. However, some preliminary stability measurements were made over periods of 12 to 24 hours and demonstrated stability less than 0.5 micro-g over greater than 12 hours. The test data appear to contain significant contributions from temperature variations at that level, so the true sensor contribution may be less than that. If what was seen could be construed as a true random process, it would correspond to about 0.1 micro-g rms over a bandwidth from 10(exp -5) Hz to about 1 Hz. Other studies of low frequency PSD in flexure accelerometers have indicated that material aging effects tend to approximate a first order Markhov process. If we combine such a model with the spectrum obtained at higher frequencies, it suggests the spectrum shown here as a conservative estimate of Q-Flex noise performance. Author

N91-12427*# Teledyne Brown Engineering, Huntsville, AL.
THE PERFECTLY IDEAL ACCELEROMETER
ERNST STUHLINGER *In* NASA, Marshall Space Flight Center, Measurement and Characterization of the Acceleration Environment on Board the Space Station 20 p Aug. 1990
Avail: NTIS HC/MF A99 CSCL 14/2

Given here is a condensed version of the results and conclusions that developed during the Workshop. Upper limits of residual accelerations that can be tolerated during materials processes, presented as acceptable and as desirable limits, are shown. Designs and capabilities of various accelerometers, and their inherent problems, are compared. Results of acceleration measurements on Spacelab flights are summarized, and expected acceleration levels on the Space Station under various conditions are estimated. Author

N91-12744# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
MISSION CHARACTERISTICS AND MICROGRAVITY ENVIRONMENT OF THE COLUMBUS FREE FLYING LABORATORY
WIELFRIED WOEHLKE and JENS ROHLFSEN 1909 12 p Presented at the 39th Raumfahrt-Kongress, HOG, Garmisch-Partenkirchen, Fed. Republic of Germany, 28 Jun. - 1 Jul. 1990 Prepared in cooperation with Erno Raumfahrttechnik G.m.b.H., Bremen, Fed. Republic of Germany
(MBB-UO-0105-90-PUB; OTN-030787; ETN-90-98161) Avail: NTIS HC/MF A03

The orbital mission and the low frequency microgravity environment of the Free Flyer are described. This includes mission scenarios, propellant and microgravity budgeting, orbit altitude strategies, rendezvous and berthing of the Free Flyer with Space Station Freedom, and the low frequency acceleration levels at the module to payload rack interface. The potential use of the Free Flyer for carrying out experiments and processes in very low microgravity environments is investigated. ESA

N91-13575*# National Aeronautics and Space Administration, Washington, DC.
MICROGRAVITY STRATEGIC PLAN, 1990
1990 26 p
(NASA-TM-103448; NAS 1.15:103448) Avail: NTIS HC/MF A03 CSCL 22/1

The mission of the NASA Microgravity program is to utilize the unique characteristics of the space environment, primarily the near absence of gravity, to understand the role of gravity in materials processing, and to demonstrate the feasibility of space production of improved materials that have high technological, and possible commercial, utility. The following five goals for the Microgravity Program are discussed: (1) Develop a comprehensive research program in fundamental sciences, materials science, and biotechnology for the purpose of attaining a structured understanding of gravity dependent physical phenomena in both Earth and non-Earth environments; (2) Foster the growth of interdisciplinary research community to conduct research in the space environment; (3) Encourage international cooperation for the purpose of conducting research in the space environment; (4) Utilize a permanently manned, multi-facility national microgravity laboratory in low-Earth orbit to provide a long-duration, stable microgravity environment; (5) Promote industrial applications of space research for the development of new, commercially viable products, services, and markets resulting from research in the space environment. Y.S.

N91-14725*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
EXOBIOLOGY IN EARTH ORBIT: THE RESULTS OF SCIENCE WORKSHOPS HELD AT NASA, AMES RESEARCH CENTER
D. DEFREES, ed., D. BROWNLEE, ed., J. TARTER, ed., D. USHER, ed., W. IRVINE, ed., and H. KLEIN, ed. 1989 142 p Original contains color illustrations
(NASA-SP-500; NAS 1.21:500) Avail: NTIS HC/MF A07; also available SOD HC $6.50 as 033-000-01057-5; 5 functional color pages CSCL 06/3

The Workshops on Exobiology in Earth Orbit were held to explore concepts for orbital experiments of exobiological interest and make recommendations on which classes of experiments should be carried out. Various observational and experimental opportunities in Earth orbit are described including those associated with the Space Shuttle laboratories, spacecraft deployed from the Space Shuttle and expendable launch vehicles, the Space Station, and lunar bases. Specific science issues and technology needs are summarized. Finally, a list of recommended experiments in the areas of observational exobiology, cosmic dust collection, and in situ experiments is presented. M.G.

N91-15206# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SOME ASPECTS OF EUROPEAN MICROGRAVITY UTILISATION
PETER BEHRMANN *In its* Some Papers from the Seminar Mirando al Espacio p 73-79 Jun. 1990
Copyright Avail: NTIS HC/MF A05; EPD, ESTEC, Noordwijk, Netherlands, HC 30 Dutch guilders

ESA structures involved in microgravity and the fields of microgravity research are discussed. Research areas include crystal growth, fluid sciences, containerless processing and protein crystallization. Flight opportunities and examples of microgravity hardware are examined. ESA

N91-15941*# Lockheed Missiles and Space Co., Sunnyvale, CA.
WORKSTATIONS AND GLOVEBOXES FOR SPACE STATION
MARIA JUNGE *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 19 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

Lockheed Missiles and Space Company is responsible for designing, developing, and building the Life Sciences Glovebox, the Laboratory Sciences Workbench, and the Maintenance Workstation plus 16 other pieces of equipment for the U.S. Laboratory Module of the Space Station Freedom. The Laboratory Sciences Workbench and the Maintenance Workstation were functionally combined into a double structure to save weight and volume which are important commodities on the Space Station Freedom. The total volume of these items is approximately 180 cubic feet. These workstations and the glovebox will be delivered to NASA in 1994 and will be launched in 1995. The very long lifetime of 30 years presents numerous technical challenges in the areas of design and reliability. The equipment must be easy to use by international crew members and also easy to maintain on-orbit. For example, seals must be capable of on-orbit changeout and reverification. The stringent contamination requirements established for Space Station Freedom equipment also complicate the zero gravity glovebox design. The current contamination control system for the Life Sciences Glovebox and the Maintenance Workstation is presented. The requirement for the Life Sciences Glovebox to safely contain toxic, reactive, and radioactive materials presents challenges. Trade studies, CAD simulation techniques and design challenges are discussed to illustrate the current baseline conceptual designs. Areas which need input from the user community are identified. Author

N91-15942*# Teledyne Brown Engineering, Huntsville, AL.
THE MATERIALS PROCESSING SCIENCES GLOVEBOX
LARRY TRAWEEK *In* NASA, Marshall Space Flight Center, Space Station Freedom Toxic and Reactive Materials Handling 20 p Jul. 1990
Avail: NTIS HC/MF A99 CSCL 22/2

The Materials Processing Sciences Glovebox is a rack mounted workstation which allows on orbit sample preparation and characterization of specimens from various experiment facilities. It provides an isolated safe, clean, and sterile environment for the crew member to work with potentially hazardous materials. It has to handle a range of chemicals broader than even PMMS. The theme is that the Space Station Laboratory experiment preparation and characterization operations provide the fundamental glovebox design characteristics. Glovebox subsystem concepts and how internal material handling operations affect the design are discussed. Author

N91-16350*# *Case Western Reserve Univ., Cleveland, OH.*
DEVELOPMENT OF A VERSATILE LASER LIGHT SCATTERING INSTRUMENT Final Report
WILLIAM V. MEYER and RAFAT R. ANSARI Oct. 1990 25 p
(Contract NCC3-74)
(NASA-CR-182474; NAS 1.26:182474) Avail: NTIS HC/MF A03 CSCL 20/5

A versatile laser light scattering (LLS) instrument is developed for use in microgravity to measure microscopic particles of 30 A to above 3 microns. Since it is an optical technique, LLS does not affect the sample being studied. A LLS instrument built from modules allows several configurations, each optimized for a particular experiment. The multiangle LLS instrument can be mounted in the rack in the Space Shuttle and on Space Station Freedom. It is possible that a Space Shuttle glove-box and a lap-top computer containing a correlator card can be used to perform a number of experiments and to demonstrate the technology needed for more elaborate investigations. This offers simple means of flying a great number of experiments without the additional requirements of full-scale flight hardware experiments. Y.S.

N91-16813*# Wisconsin Univ., Madison. Applied Superconductivity Center.
ASTROMAG COIL COOLING STUDY
BEN-ZION MAYTAL (Technion - Israel Inst. of Tech., Haifa.) and STEVEN W. VANSCIVER Dec. 1990 127 p
(Contract NAG5-1417)
(NASA-CR-187768; NAS 1.26:187768) Avail: NTIS HC/MF A07 CSCL 20/12

ASTROMAG is a planned particle astrophysics magnetic facility. Basically it is a large magnetic spectrometer outside the Earth's atmosphere for an extended period of time in orbit on a space station. A definition team summarized its scientific objectives assumably related to fundamental questions of astrophysics, cosmology, and elementary particle physics. Since magnetic induction of about 7 Tesla is desired, it is planned to be a superconducting magnet cooled to liquid helium 2 temperatures. The general structure of ASTROMAG is based on: (1) two superconducting magnetic coils, (2) dewar of liquid helium 2 to provide cooling capability for the magnets; (3) instrumentation, matter-anti matter spectrometer (MAS) and cosmic ray isotope spectrometer (CRIS); and (4) interfaces to the shuttle and space station. Many configurations of the superconducting magnets and the dewar were proposed and evaluated, since those are the heart of the ASTROMAG. Baseline of the magnet configuration and cryostat as presented in the phase A study and the one kept in mind while doing the present study are presented. ASTROMAG's development schedule reflects the plan of launching to the space station in 1995. Author

N91-17718*# Science Applications International Corp., McLean, VA. Lab. for Atmospheric and Space Sciences.
MEASUREMENT REALITIES OF CURRENT COLLECTION IN DYNAMIC SPACE PLASMA ENVIRONMENTS
EDWARD P. SZUSZCZEWICZ *In* NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 88-124 Dec. 1990
Avail: NTIS HC/MF A16 CSCL 20/9

Theories which describe currents collected by conducting and non-conducting bodies immersed in plasmas have many of their concepts based upon the fundamentals of sheath-potential distributions and charged-particle behavior in superimposed electric and magnetic fields. Those current-collecting bodies (or electrodes) may be Langmuir probes, electric field detectors, aperture plates on ion mass spectrometers and retarding potential analyzers, or spacecraft and their rigid and tethered appendages. Often the models are incomplete in representing the conditions under which the current-voltage characteristics of the electrode and its system are to be measured. In such cases, the experimenter must carefully take into account magnetic field effects and particle anisotropies, perturbations caused by the current collection process itself and contamination on electrode surfaces, the complexities of non-Maxwellian plasma distributions, and the temporal variability of the local plasma density, temperature, composition and fields. This set of variables is by no means all-inclusive, but it represents a collection of circumstances guaranteed to accompany experiments involving energetic particle beams, plasma discharges, chemical releases, wave injection and various events of controlled and uncontrolled spacecraft charging. Here, an attempt is made to synopsize these diagnostic challenges and frame them within a perspective that focuses on the physics under investigation and the requirements on the parameters to be measured. Examples include laboratory and spaceborne applications, with specific interest in dynamic and unstable plasma environments. Author

N91-17883*# National Aeronautics and Space Administration, Washington, DC.
THE ASTROPHYSICS PROGRAM AT THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
C. J. PELLERIN *In* ESA, Evolution in Astrophysics: IUE Astronomy in the Era of New Space Missions p 175-182 Aug. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders CSCL 03/2

Three broad themes characterize the goals of the Astrophysics Division at NASA. These are obtaining an understanding of the origin and evolution of the universe, the fundamental laws of physics, and the birth and evolutionary cycle of galaxies, stars, planets and life. These goals are pursued through contemporaneous observations across the electromagnetic spectrum with high sensitivity and resolution. The strategy to accomplish these goals is fourfold: the establishment of long term space based observatories implemented through the Great Observatories program; attainment of crucial bridging and supporting measurements visa missions of intermediate and small scope conducted within the Explorer, Spacelab, and Space Station Attached Payload Programs; enhancement of scientific access to results of space based research activities through an integrated data system; and development and maintenance of the scientific/technical base for space astrophysics programs through the research and analysis and suborbital programs. The near term activities supporting the first two objectives are discussed. ESA

N91-19324*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF A VIBRATION ISOLATION PROTOTYPE SYSTEM FOR MICROGRAVITY SPACE EXPERIMENTS
KIRK A. LOGSDON, CARLOS M. GRODSINSKY, and GERALD V. BROWN 1990 8 p Presented at the 28th Plenary Meeting of the Committee on Space Research, The Hague, Netherlands, 25 Jun. - 6 Jul. 1990; cosponsored by COSPAR, ESA, and NASDA
(NASA-TM-103664; E-5871; NAS 1.15:103664) Avail: NTIS HC/MF A02 CSCL 13/2

The presence of small levels of low-frequency accelerations on the space shuttle orbiters has degraded the microgravity environment for the science community. Growing concern about this microgravity environment has generated interest in systems that can isolate microgravity science experiments from vibrations. This interest has resulted primarily in studies of isolation systems with active methods of compensation. The development of a magnetically suspended, six-degree-of-freedom active vibration isolation prototype system capable of providing the needed compensation to the orbital environment is presented. A design for the magnetic actuators is described, and the control law for the prototype system that gives a nonintrusive inertial isolation response to the system is also described. Relative and inertial sensors are used to provide an inertial reference for isolating the payload. Author

N91-19566*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CENTRIFUGE FACILITY CONCEPTUAL SYSTEM STUDY. VOLUME 1: FACILITY OVERVIEW AND HABITATS
ROBERT SYNNESTVEDT, ed. Oct. 1990 352 p
(NASA-TM-102860-VOL-1; A-90268-VOL-1; NAS 1.15:102860-VOL-1) Avail: NTIS HC/MF A16 CSCL 06/3

The results are presented for a NASA Phase 1 study conducted from mid 1987 through mid 1989 at Ames Research Center. The Centrifuge Facility is the major element of the biological research facility for the implementation of NASA's Life Science Research Program on Space Station Freedom using non-human specimens (such as small primates, rodents, plants, insects, cell tissues). Five systems are described which comprise the Facility: habitats, holding units, centrifuge, glovebox, and service unit. Volume 1 presents a facility overview and describes the habitats - modular units which house living specimens. Author

N91-19609# Deutsche Forschungsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.). Microgravity User Support Center.
TOOLS FOR THE PREPARATION, PERFORMANCE AND EVALUATION OF LIFE SCIENCES EXPERIMENTS
DITTMAR PADEKEN, MARIANNE SCHUBER, and DIETER SEIBT *In* ESA, Fourth European Symposium on Life Sciences Research in Space p 171-174 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

Life sciences experiments in the field of microgravity research need extensive preparation, performance, and evaluation. Infrastructure for the preparation of experiments covering the disciplines of the human physiology with ESA Anthrorack and gravitational biology and biological processing techniques with the German payload Biolabor is given. A survey of the available multipurpose ground infrastructure for Spacelab missions and for the preparation of Columbus user support was built up. The possible application spectrum for life sciences ground facilities is described. The application field of an information system developed for microgravity research (ARIADNE) is shown. ESA

N91-19658# Eidgenoessische Technische Hochschule, Zurich (Switzerland). Space Biology Group.
BIOLAB ON COLUMBUS: A FACILITY FOR BASIC SCIENCE AND BIOTECHNOLOGY
AUGUSTO COGOLI *In* ESA, Fourth European Symposium on

Life Sciences Research in Space p 441-444 Nov. 1990
Copyright Avail: NTIS HC/MF A25; EPD, ESTEC, Noordwijk, Netherlands, HC 80 Dutch guilders

The status of the planning of multiuser facilities to be installed in the Columbus Attached Laboratory and the Columbus Free Flying Laboratory is presented. An international team of European scientists carried out a phase A study in 1988 to define the scientific objectives of Biolab, the biological multiuser facility for the Columbus Attached Laboratory. Two industrial phase A studies, performed in 1989, demonstrated the feasibility of the concept. Another scientific study for Biolab on the Columbus Free Flying Laboratory was completed in May 1990. ESA

N91-20717*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MICROGRAVITY CURSOR CONTROL DEVICE EVALUATION FOR SPACE STATION FREEDOM WORKSTATIONS
SUSAN ADAM, KRITINA L. HOLDEN, DOUGLAS GILLAN (Lockheed Engineering and Sciences Co., Houston, TX.), and MARIANNE RUDISILL *In its* Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 582-587 Jan. 1991
Avail: NTIS HC/MF A14 CSCL 22/2

This research addressed direct manipulation interface (curser-controlled device) usability in microgravity. The data discussed are from KC-135 flights. This included pointing and dragging movements over a variety of angles and distances. Detailed error and completion time data provided researchers with information regarding cursor control shape, selection button arrangement, sensitivity, selection modes, and considerations for future research. Author

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PLATFORMS & TETHERS

Descriptions and requirements of independent experimental platforms or missions using tethers aboard space stations.

A91-10011#
THE EXPLORER PLATFORM
RANDY SIMPSON (Fairchild Space Co., Germantown, MD) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 6 p.
(AIAA PAPER 90-3543) Copyright

This paper describes the Explorer Platform, which is a cost-effective reusable space platform designed to support a multitude of scientific payloads which will be shuttled to it from earth by the STS, while remaining on orbit for at least 10 years. The Explorer Platform, which is presently entering the integration and test phase at the NASA Goddard Space Flight Center, is planned for launching on a Delta launch vehicle in September 1991, carrying the Extreme Ultraviolet Explorer as an initial payload; this will be followed by the X-Ray Timing Explorer and the Lyman Far Ultraviolet Spectroscopic Explorer. These missions will use the existing space asset and will not require a spacecraft bus, allowing resources to be used primarily for payload development. During the 10 years of its projected life, the Explorer Platform will support additional missions, increasing its cost effectiveness. I.S.

A91-10065*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE GEO PLATFORM
R. J. KOCZOR (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 7 p. refs
(AIAA PAPER 90-3639) Copyright

NASA plans for a Geostationary Earth Observatory (GEO) platform meant to operate in conjunction with the polar orbiting Earth Observing System (EOS) are discussed. The scientific goals of the GEO platform are summarized, and the facility's instruments are examined, including the microwave precipitation radiometer, atmospheric profiler, earth processes spectrometer, advanced lightning mapper, high resolution earth processes imager, operational instrument suite, solar constant and spectrum monitors, earth climate sensor, and trace gas imager. The GEO system to provide data and information to users is addressed. C.D.

A91-10333*# Massachusetts Inst. of Tech., Cambridge.
ROLE OF CURRENT DRIVEN INSTABILITIES IN THE OPERATION OF PLASMA CONTACTORS USED WITH ELECTRODYNAMIC TETHERS
A. GIOULEKAS and D. E. HASTINGS (MIT, Cambridge, MA) Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 559-566. refs
(Contract NAG3-681)
Copyright

The collection of current to an electrodynamic tether in low LEO is enhanced by a plasma cloud surrounding the anode (called a plasma contactor). The main mechanism by which this is achieved is the scattering, perpendicular to the lines of the magnetic field, of the electrons which enter the plasma cloud. The scattering may be a result of the interaction between the electrons and unstable EM waves, one example being lower-hybrid waves. The boundaries of instability are found for the lower-hybrid waves in a parametric study where, for the cases of Ar and NH_3 clouds, the density, the ratio of electron to ion temperature, and the composition of the electron population, are varied. The main conclusion is that the lower-hybrid waves will be confined to the outer regions of the cloud and have the right properties to scatter electrons. Author

A91-12923*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE EOS POLAR PLATFORM
GERALD SOFFEN (NASA, Goddard Space Flight Center, Greenbelt, MD) and MITCHELL K. HOBISH (Research and Data Systems Corp., Greenbelt, MD) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-28, 1990. 16 p. refs
(AIAA PAPER 90-3638) Copyright

An overview of NASA's Earth Observing System (EOS) is presented. The EOS will be part of the Mission to Planet Earth that will include a series of flight and scientific experiments. The initial polar-orbiting platform, EOS-A, will carry a suite of instruments designed to examine earth system processes at and near the planet's surface, and the interactions between various subsystems. Some of the instruments that will provide specialized data for geologists, meteorologists, biochemists, biologists, and physicists are described. Thus, EOS will provide an opportunity for technologists and scientists to examine the earth to a level of detail not previously attainable. R.E.P.

A91-13779#
THE COLUMBUS FREE FLYING LABORATORY
JOACHIM GUELPEN (MBB/ERNO, Bremen, Federal Republic of Germany) and JOCHEN GRAF (ESTEC, Noordwijk, Netherlands) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 10 p.
(IAF PAPER 90-070) Copyright

An overview of the Columbus man-tended Free Flyer (FF) is presented. The design evolution of the FF is reviewed, and the resources which it offers to the user community are outlined. The operational scenario and orbital strategy for the FF are summarized. The FF pressurized module, resource module, and subsystem characteristics are examined. Increases in the technological capabilities of the FF that are required are discussed. C.D.

A91-15590
THE TECHNOLOGICAL CHALLENGE OF FUTURE SPACE RADAR SYSTEMS
HANS MARTIN BRAUN, GERHARD HANS RAUSCH, and HELMUT

KAPPEL (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Quantitative remote sensing: An economic tool for the Nineties; Proceedings of IGARSS '89 and Canadian Symposium on Remote Sensing, 12th, Vancouver, Canada, July 10-14, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1989, p. 566-569.
Copyright

Demanding user requirements on operational space radars to be flown on the forthcoming polar platforms, which call for a further increases in technological capabilities, are discussed. Technological requirements for future civil space radar programs are examined, present developments within the key technology areas are presented, and recommendations on the most important areas of investigations in the near future are given. This review is based on the European and German programs of earth observation and basic technology research. I.E.

A91-15591
MULTIMISSION CAPABILITY OF THE EUROPEAN POLAR PLATFORM
R. BENZ, G. GEBAUER, F. TANNER (Dornier GmbH, Friedrichshafen, Federal Republic of Germany), and E. ZEIS (ESTEC, Noordwijk, Netherlands) IN: Quantitative remote sensing: An economic tool for the Nineties; Proceedings of IGARSS '89 and Canadian Symposium on Remote Sensing, 12th, Vancouver, Canada, July 10-14, 1989. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1989, p. 570-574. Research supported by ESA.
Copyright

A multimission and program aspect study has been performed for the two European Polar Platform (EPP) concepts currently under study in the Columbus program. Various potential payload complements, comprising in total more than 25 different instruments, have been accommodated in order to prove the multimission capability of both EPPs, making use of commonality to the other Columbus elements or to the SPOT program. The payload complements comprise (1) an operational instrument package for meteorological applications, (2) core-facility instruments for earth observation, and (3) announcement-of-opportunity and space science-instruments. Both EPP concepts accommodate the required payload complements. Different payload module capabilities, as well as the different flight orientation of both platforms and dissimilar payload accommodation principles, resulted in two distinct payload module solutions. I.E.

A91-17924
STABILIZATION OF TETHERED SATELLITES DURING STATION KEEPING
DER-CHERNG LIAW and EYAD H. ABED (Maryland, University, College Park) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. 35, Nov. 1990, p. 1186-1196. Research supported by the TRW Foundation. refs
(Contract AF-AFOSR-90-0015; NSF CDR-88-03012; NSF ECS-86-57561)
Copyright

After deriving a set of dynamic equations governing the dynamics of a tethered satellite system (TSS), stabilizing tension-control laws are derived in feedback form. The tether is assumed to be rigid and massless, and the equations of motion are derived using the system Lagrangian. It is observed that, to stabilize the system, tools from stability analysis of critical nonlinear systems must be applied. Tools related to the Hopf bifurcation theorem are used in the construction of the stabilizing control laws, which may be taken purely linear. Simulations illustrate the nature of the conclusions and show that nonlinear terms in the feedback can be used to significantly improve the transient response. I.E.

A91-21522*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
USES OF TETHERED ATMOSPHERIC RESEARCH PROBES
RICHARD DELOACH (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 10 p. refs
(AIAA PAPER 91-0533)

In situ measurements in the lower thermosphere are rare because of the difficulty of reaching these altitudes with conventional instrument platforms. The emerging technology of tethered satellites as a means to probe these altitudes from above has matured to the point that a flight program is planned to verify the operational performance of a low-cost deployer mechanism for tethered satellites, and to demonstrate a basic understanding of the dynamics of tethered satellite deployment. With such operational developments at hand, it is appropriate to review some of the potential applications of tethered measurement platforms for acquiring in situ data in the upper atmosphere. This paper focuses on downward-deployed tethered satellite measurements of interest to atmospheric scientists and to hypersonic aerodynamicists, and discusses ways in which this technology may be able to support selected long-range research programs currently in progress or in various stages of pre-flight development. The intent is to illustrate for the potential user community some of the unique advantages of tethered measurement platform technology now under development, and to stimulate creative thinking about ways in which this new capability may be used in support of future research programs. Author

A91-22192#
THE COLUMBUS FREE-FLYING LABORATORY - A STEPPING STONE TOWARDS EUROPEAN AUTONOMY
J. COLLET (ESA, Directorate for Space Station and Microgravity, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 64, Nov. 1990, p. 28-32.
Copyright

The main objectives of the Columbus Program include the development of further European capabilities in manned space flight. The Columbus Program includes the Columbus Attached Laboratory, the Columbus Free-Flying Laboratory, and the Columbus Polar Platform. The need for a manned orbital infrastructure is discussed, with emphasis on commercial microgravity activities. Details of the Columbus Free-Flying Laboratory are presented. It is designed to accommodate the material-science, fluid-physics, and life-sciences research domains. A 6.2-m-long pressurized module of 4.5-m diameter can accommodate payloads equivalent to 16 single racks, and a replaceable resource module propvides 20 kW of power and a data-transmission capacity (downlink) of 100 Mbit/s. The role of Columbus in an autonomous scenario is discussed. L.K.S.

A91-23738#
STOCHASTIC ATTITUDE CONTROL FOR AN ORBITING TETHERED PLATFORM SUBSATELLITE SYSTEM DURING STATION KEEPING
J. BAI (Beijing Institute of Astronautical Systems Engineering, People's Republic of China), P. M. BAINUM (Howard University, Washington, DC), and F. RUYING (Beijing Institute of Control Engineering, People's Republic of China) IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 225-244. Research supported by the Institute of Astronautical Systems Engineering of China and Howard University. refs

The stochastic attitude control for an orbiting Tethered-Platform-Subsatellite system during station keeping is investigated using an optimal control law based on linear quadratic regulator techniques and the estimate based on linear continuous Kalman filter theory. The numerical simulations show that by using the estimate of the state variables (instead of their measurement) for control law implementation it is possible to achieve satisfactory transient responses during the station keeping phase. Author

A91-23740#
EXPERIMENTAL DEMONSTRATION OF OFFSET CONTROL WITH AN APPLICATION TO THE TETHERED PAYLOAD
V. J. MODI, P. K. LAKSHMANAN, A. K. MISRA, R. J. PICHA, S.

CHAN (British Columbia, University, Vancouver, Canada) et al. IN: Dynamics and control of large structures; Proceedings of the Seventh VPI&SU Symposium, Blacksburg, VA, May 8-10, 1989. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1989, p. 261-282. Research supported by NSERC. refs

Using a ground based experimental facility, the paper demonstrates validity of the mathematical model aimed at studying offset control of an orbiting platform supported tethered satellite system. The mathematical model for the system is discussed first and some representative control data presented. This is followed by a description of the ground based experimental simulation involving controller, actuator and sensors used in the test program. Results confirm effectiveness of the offset control strategy during both the stationkeeping and retrieval phases. Author

A91-25747*# National Aeronautics and Space Administration, Washington, DC.
TETHERED AEROTHERMODYNAMIC RESEARCH FOR HYPERSONIC WAVERIDERS
JOHN L. ANDERSON (NASA, Washington, DC) IN: International Hypersonic Waverider Symposium, 1st, College Park, MD, Oct. 17-19, 1990, Proceedings. College Park, MD, University of Maryland, 1990, 16 p. refs

This paper describes the concept of a space-tethered atmospheric system, a hybrid craft consisting of an orbiting spacecraft and a downward-deployed aerodynamically-configured satellite. Such a system could conduct both hypersonic aerothermodynamics research and atmospheric science research in the outer atmosphere (about 150-90 km). Descriptions of specific space-tethered atmospheric systems, scheduled tether flight validation experiments, and a development strategy for a three-phased aerothermodynamics research capability culminating in a 'flying wind tunnel' are provided. Author

A91-26631
CONTROL OF AN ORBITING PLATFORM SUPPORTED TETHERED SATELLITE SYSTEM
P. K. LAKSHMANAN, V. J. MODI (British Columbia, University, Vancouver, Canada), and A. K. MISRA (McGill University, Montreal, Canada) IN: Automatic control in aerospace; IFAC Symposium, Tsukuba, Japan, July 17-21, 1989, Selected Papers. Oxford, England and New York, Pergamon Press, 1990, p. 185-190. refs
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The present mathematical model of Tethered Satellite System (TSS) dynamics, where the system encompasses a plate-type space station from which a tether-supported subsatellite is deployed and retrieved, is used to analyze the rigid-body dynamics of the tether, subsatellite, and space station, accounting for the tether mass as well as a three-dimensional offset of its attachment point. Attention is given to three different control strategies, respectively, thrusters, tether-line tension, and motion of the attachment offset, in order to achieve control of the system when it is subject to relatively large initial disturbances. While tension control yields the most prompt damping, offset control is most energy-efficient. A thruster-offset hybrid controller is most efficient for disturbance-damping. O.C.

A91-27354* National Aeronautics and Space Administration, Washington, DC.
SPACE-TETHERED ATMOSPHERIC SYSTEMS
J. L. ANDERSON (NASA, Office of Aeronautics, Washington, DC) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 44, March 1991, p. 103-110. refs
Copyright

This paper describes the concept of a space-tethered atmospheric system, a hybrid craft consisting of an orbiting spacecraft and a downward-deployed aerodynamically-configured satellite. Such a system could conduct hypersonic aerothermodynamics and atmospheric science research in the lower thermosphere (150-90 km). Descriptions of specific tethered atmospheric systems, scheduled tether flight validation experiments, candidate research topics and envisioned capabilities and benefits are provided. Author

A91-27411#
ATTITUDE DETERMINATION AND CONTROL FOR THE MULTI-MISSION SPACE PAYLOAD PLATFORM (SPP)
CHARLES A. BENET and JOHN B. STETSON, JR. (General Electric Co., Astro-Space Div., Princeton, NJ) IN: Annual AIAA/Utah State University Conference on Small Satellites, 4th, Logan, UT, Aug. 27-30, 1990, Proceedings. Vol. 2. Logan, UT, Utah State University, 1990, 20 p.

A general purpose SPP has been designed to support a range of payloads that may be used for scientific, surveillance, communication, or meteorological research. This platform has a common core bus weighing 130 kg that is available in both spin-stabilized and three-axis stabilized configurations that allows up to a 300 kg, 260 Watt payload to be injected directly into a low altitude elliptical or circular orbit. An onboard hydrazine propulsion system can be used to attain, correct, and/or maintain higher altitude orbits. A flexible attitude determination and control system (ADACS) has been incorporated such that only a minimum number of changes are necessary for different missions. The ADACS includes simultaneous attitude and momentum control utilizing the vehicle bias momentum together with magnetic torquers and a solar array orientation control system. R.E.P.

A91-29772#
THREE-DIMENSIONAL VIBRATIONS OF TETHERED SATELLITE SYSTEMS
MONICA PASCA, MARCELLO PIGNATARO (Roma I, Universita, Rome, Italy), and ANGELO LUONGO (L'Aquila, Universita, Italy) (International Conference on Tethers in Space - Toward Flight, 3rd, San Francisco, CA, May 17-19, 1989, Collection of Papers and Abstracts, p. 153-161) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 312-320. Previously cited in issue 17, p. 2591, Accession no. A89-40199. refs
Copyright

A91-29792#
FEEDBACK TETHER DEPLOYMENT AND RETRIEVAL
SRINIVAS R. VADALI (Texas A & M University, College Station) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 469, 470. Texas Advanced Research and Technology Program-supported research. refs
Copyright

A modified Liapunov control law is considered with a view to eliminating terminal oscillations during space tether deployment and retrieval operations. It is shown that rapid tether retrieval is possible if moderate pitch-angle excursion of the tether is allowed during the intermediate phase of retrieval, as well as by setting a positive target pitch angle; this will in addition ensure that tension is always positive. In all cases, the pitch angle can be controlled to the desired equilibrium point. O.C.

A91-29793#
MISSION FUNCTION CONTROL OF TETHERED SUBSATELLITE DEPLOYMENT/RETRIEVAL - IN-PLANE AND OUT-OF-PLANE MOTION
HIRONORI FUJII, KENJI UCHIYAMA, and KENTAROH KOKUBUN (Tokyo Metropolitan Institute of Technology, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 14, Mar.-Apr. 1991, p. 471-473.
Copyright

The control problem posed by tethered satellite deployment and retrieval is presently treated by means of the mission function control. Numerical simulation results indicate that mission function controllability is effective in the case of a subsatellite that is connected to a main body via a tether which swings with both in-plane and out-of-plane motions. The algorithm's performance is demonstrably adequate when the three-dimensional motion of the tethered subsatellite is analytically taken into account. O.C.

A91-30795#
THE ERS-1 SPACECRAFT AND ITS PAYLOAD
R. FRANCIS, G. GRAF, P. G. EDWARDS, M. MCCAIG, C.

MCCARTHY (ESTEC, Noordwijk, Netherlands) et al. ESA Bulletin (ISSN 0376-4265), no. 65, Feb. 1991, p. 26-48.
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The design and operation of the ESA terrestrial remote-sensing satellite ERS-1 are described and illustrated with extensive diagrams, drawings, and photographs. Consideration is given to the 780-km 98.5-deg orbit, the spacecraft platform (based on the SPOT platform), attitude and orbit control, the payload electronics module and antenna support structure, the onboard command and control systems, the on-orbit deployment of the antennas and solar panels, and the data-handling and telemetry systems. The payload comprises the Active Microwave Instrument (image and wave-mode SAR and wind scatterometer), the Radar Altimeter, the Along-Track Scanning Radiometer and Microwave Sounder, the Laser Retro-Reflector, and the Precise Range and Range-rate Equipment. The history of the ERS-1 development and testing phases, covering the period 1984-1990, is briefly reviewed. D.G.

A91-32114#
ON THE CONTROL OF TETHERED SATELLITE SYSTEMS
V. J. MODI, P. K. LAKSHMANAN, and A. K. MISRA (British Columbia, University, Vancouver, Canada) IN: AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 32nd, Baltimore, MD, Apr. 8-10, 1991, Technical Papers. Pt. 4. Washington, DC, American Institute of Aeronautics and Astronautics, 1991, p. 2865-2876. Centers of Excellence Program-supported research. refs
(Contract NSERC-A-2181)
(AIAA PAPER 91-1002) Copyright

A mathematical model is proposed for studying the dynamics of the Tethered Satellite System (TSS) consisting of a plate-type Space Station from which a tether supported subsatellite is deployed or retrieved. The rigid body dynamics of the tether, subsatellite and Space Station are analyzed accounting for the mass of the tether as well as a three-dimensional offset of its point of attachment. Controllability of the linearized equations is established numerically and a comparative study of three different control strategies conducted. The strategies employ thrusters, tension in the tether line or motion of the offset of the attachment to achieve control of the system subjected to relatively large initial disturbances. Results suggest that, in the stationkeeping mode, the tension control strategy damps a given disturbance in the shortest time, however, at an expense of the energy. On the other hand, the offset control proves to be the most efficient in terms of energy consumption, but now the response to disturbance persists over a longer duration. In addition, the performance of the thruster control, tension control, and offset control strategies, as well as their combinations are analyzed during retrieval of the tether. Results suggest that the thruster-offset hybrid controller is the most effective in damping given disturbances. Author

N91-10098*# George Washington Univ., Hampton, VA.
FIRST EVALUATION OF THE MAIN PARAMETERS IN THE DYNAMICS OF THE SMALL EXPENDABLE DEPLOYER SYSTEM (SEDS) FOR A TETHERED SATELLITE Contractor Report, 4 Aug. - 2 Sep. 1988
LUIGI DELUCA Washington NASA Oct. 1990 18 p
(Contract NAS1-18458)
(NASA-CR-4319; NAS 1.26:4319) Avail: NTIS HC/MF A03 CSCL 22B

The dynamics of the motion of the Small Expendable Deployer System (SEDS) is studied by using a simplified model in which no external forces (except the gravity gradient field) are applied on the tethered body and the tether is assumed massless. The dynamics of SEDS operation is modeled as a sequence of two phases: the deployment phase and the swing phase. For the first one the velocity dependent forces are found to force the tether forward from the local vertical. When the deployment ends, Coriolis effects vanish and the swing phase begins, which is characterized by a wide free libration. The time duration as well as velocity, acceleration and tension of the tethered body are estimated for both deployment and swing phases. Author

N91-11045 Stanford Univ., CA.
ATTITUDE CONTROL OF TETHERED SATELLITES Ph.D. Thesis
XIAOHUA HE 1990 164 p
Avail: Univ. Microfilms Order No. DA9024330

Methods of attitude control of tethered satellites are presented. The main effort is focused on the case of a tethered space observatory that requires high pointing accuracy. A tethered satellite is connected to a parent spacecraft by a long tether. The gravity gradient caused tension in the tether passively provides satellite attitude stability about two axes. However, active attitude control is necessary for high accuracy pointing and new control methods are required since conventional methods are not efficient due to the tether tension. With a movable tether attachment point on a tethered satellite, active control torques can be produced about two axes by varying the offset of tether tension vector from the satellite's center of mass. For the third axis, parallel to the tension vector, the control torque can be provided by momentum devices. No mass ejection is needed. Tether dynamics especially damping properties have significant effects on the satellite's pointing accuracy, which are studied with a flexible continuum model. Dynamic equations are solved analytically with approximations. Various damping mechanisms are analyzed including viscous, structural, and linear friction damping. Ground test results are extrapolated to predict space behavior of tethers of much different sizes. Methods are developed to enhance damping. Numerical simulations of kinetic isolation tether experiment (KITE), an orbital flight experiment being designed to demonstrate the new attitude control methods, show the pointing accuracy of one arcsecond. Dissert. Abstr.

N91-11046 Stanford Univ., CA.
PRECISION TETHERED SATELLITE ATTITUDE CONTROL Ph.D. Thesis
ROBERT JOHN KLINE-SCHODER 1990 144 p
Avail: Univ. Microfilms Order No. DA9024338

Tethered spacecraft possess unique dynamic characteristics which make them advantageous for certain classes of experiments. In practice, all satellites have some requirement on the attitude control of the spacecraft, and tethered satellites are no exception. It has previously been shown that conventional means of performing attitude control for tethered satellites are insufficient for any mission with pointing requirements more stringent than about 1 deg. Herein, theoretical development is examined of both a large angle slew and long term, precision pointing control algorithm for tethered satellites, and the simulation of the Kinetic Isolation Tether Experiment (KITE) mission in an Earth laboratory environment. To that end, a scaled, 1-D, air bearing supported laboratory simulator of the KITE satellite configuration was constructed and is described in detail. The system equations are derived and a suitable control law is described. The precision control algorithm consists of a Linear Quadratic Gaussian, full state feedback control law in conjunction with a multivariable Kalman filter. The control algorithm has been shown to regulate the vehicle orientation to within 0.60 arcsec RMS. In addition, a tether dynamics simulator was constructed in order to implement the natural dynamic behavior of a 2 km long tether in the earth laboratory environment. The tether simulator is used to test the ability of the control algorithm to regulate the air-bearing vehicle orientation in the presence of variations in the tether tension magnitude and direction. Dissert. Abstr.

N91-15201# European Space Agency. ESRIN, Frascati (Italy).
THE ERS-1 AND THE POLAR PLATFORM: PRESENT AND FUTURE OF THE OBSERVATION OF THE EARTH AND THE EUROPEAN SPACE AGENCY [EL ERS-1 Y LA PLATAFORMA POLAR: PRESENTE Y FUTURO DE LA OBSERVACION DE LA TIERRA EN LA AGENCIA ESPACIAL EUROPEA]
EVANGELINA ORIOLPIBERNAT *In its* Some Papers from the Seminar Mirando al Espacio p 39-48 Jun. 1990 In SPANISH
Copyright Avail: NTIS HC/MF A05; EPD, ESTEC, Noordwijk, Netherlands, HC 30 Dutch guilders

The satellite is to be launched by the end of 1990. It has onboard instruments active in the microwave spectra band to provide information independent of meteorological conditions. It will yield oceanographic data as well as high resolution images of coastal areas, ice, and soil. The polar platform is the continuation of the ERS series and its organization is dependent on the information collected from present experience. ESA

N91-18183 Princeton Univ., NJ.
THE CONTROLLED RETRIEVAL OF A TETHERED SATELLITE Ph.D. Thesis
ALEXANDER HERMANN BOSCHITSCH 1990 177 p
Avail: Univ. Microfilms Order No. DA9027540

There is much interest in the dynamics and control of tethers for space applications. The control of a tethered subsatellite during the inherently unstable retrieval process poses one of the greater challenges in this area. The dynamics and control of tethered subsatellite retrieval are studied in order to find ways of attenuating the rigid body motions. An idealized model incorporating a variable length, massive, flexible, and entensible tether, is first defined and the extended Hamilton's Principle used to obtain the governing partial differential equations of motion. The reduced rigid body equations are then derived and used in addressing two fundamental questions regarding the deterministic subsatellite retrieval problem: (1) Can acceptable rigid body motions be produced using retrieval rate as the only control, which is addressed by formulating and numerically solving a nonlinear trajectory optimization problem using a conjugate gradient algorithm. (2) Can one produce acceptable rigid body motions during retrieval using a controller designed via linear quadratic feedback theory, addressed by extending by the out-of-plane motion and also retaining the time varying nature of the linearized tether equation. A key determinant for both controllers and their behaviors is the cost function on which they are based. Dissert. Abstr.

21

TRANSPORTATION NODE

Use of the space station as a node for the launching, assembly or support of lunar or other exploratory missions.

A91-10087#
SPACE STATION FREEDOM: LAUNCH PAD TO THE PLANETS - A LOOK AT ON-ORBIT PROCESSING
RICK VARGO (McDonnell Douglas Space Systems Co., Cocoa Beach, FL) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 9 p.
(AIAA PAPER 90-3676) Copyright

The Space Exploration Initiative (SEI) vehicles envisioned to fulfill the national goals of a manned lunar outpost and of human exploration of Mars will require on-orbit assembly, refurbishment, checkout, and launch. On-orbit processing requirements for these vehicles must be identified to determine facility and resource impacts to Space Station Freedom (SSF). This paper describes a methodology to apply Kennedy Space Center (KSC) space vehicle processing experience to determine the tasks, flows, and resources necessary to process SEI vehicles at SSF. Results provided in this paper include assembly analyses for Phobos and Mars vehicles and a lunar vehicle refurbishment analysis. In addition, a concept for facility accommodations at SSF is defined. Author

A91-10091*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
LONG DURATION MISSION SUPPORT OPERATIONS CONCEPTS
T. W. EGGLESTON (NASA, Johnson Space Center, Houston, TX) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p. refs
(AIAA PAPER 90-3682) Copyright

It is suggested that the system operations will be one of the most expensive parts of the Mars mission, and that, in order to reduce their cost, they should be considered during the conceptual phase of the Space Exploration Initiative (SEI) program. System operations of Space Station Freedom, Lunar outpost, and Mars Rover Sample Return are examined in order to develop a similar concept for the manned Mars mission. Factors that have to be taken into account include: (1) psychological stresses caused by long periods of isolation; (2) the effects of boredom; (3) the necessity of onboard training to maintain a high level of crew skills; and (4) the 40-min time delays between issuing and receiving a command, which make real-time flight control inoperative and require long-term decisions to be made by the ground support. B.P.

A91-10128*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION ACCOMMODATION OF THE SPACE EXPLORATION INITIATIVE
PETER AHLF, LEWIS PEACH (NASA, Washington, DC), and VELIMIR MAKSIMOVIC (BDM International, Inc., Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3756) Copyright

It is pointed out that Space Station Freedom (SSF) will support the transportation, research, and development requirements of the Space Exploration Initiative through augmentation of its resources and initial capabilities. These augmentations include providing facilities for lunar and Mars vehicle testing, processing, and servicing; providing laboratories and equipment for such enabling research as micrógravity countermeasures development; and providing for the additional crew that will be required to carry out these duties. It is noted that the best way to facilitate these augmentations is to ensure 'design-for-growth' capabilities by incorporating necessary design features in the baseline program. The critical items to be accommodated in the baseline design include provisions for future increased power-generation capability, the ability to add nodes and modules, and the ability to expand the truss structure to accommodate new facilities. The SSF program must also address the effect on nonexploration users (e.g., NASA experimenters, commercial users, university investigators, and international partners of the U.S.) of SSF facilities. B.J.

A91-10129*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONCURRENT RESEARCH ON THE SPACE STATION TRANSPORTATION NODE
B. D. MEREDITH (NASA, Langley Research Center, Hampton, VA) and K. LEATH (McDonnell Douglas Space Systems Co., Rockville, MD) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 8 p. refs
(AIAA PAPER 90-3757) Copyright

The feasibility of integrating scientific research on Space Station Freedom (SSF) with concurrent lunar-vehicle assembly and servicing operations associated with the support of Space Exploration Initiative (SEI) is investigated. The SSF, SEI, and lunar-vehicle user resource requirements are reviewed, and a station configuration is derived which can accommodate a significant percentage of user requirements while supporting the lunar transport vehicle (LTV) processing operations. The derived station configuration will require several augmentations to the baseline configuration. Most notably, the SSF power generation will be increased by an addition of six solar dynamic arrays, crew support will be increased by adding two habitation modules, and more payloads will be accomodated by adding dual keels. I.S.

A91-10130*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STATION FREEDOM FLIGHT OPERATIONS IN SUPPORT OF EXPLORATION MISSIONS
KAREN D. BRENDER (NASA, Langley Research Center, Hampton, VA) and CHARLES P. LLEWELLYN (Analytical Mechanics Associates, Inc., Hampton, VA) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 13

p. refs
(Contract NAS1-18246)
(AIAA PAPER 90-3758) Copyright

The operational requirements on Space Station Freedom (SSF) for supporting the Lunar Phase of the Space Exploration Initiative (SEI) are examined, and a concept is developed for carrying out these operations. Attention is given to the types of events and tasks that must be performed on the SSF to process the lunar vehicles, as well as to resources required for the SSF and the methods of meeting the operational requirements of the lunar missions. Critical technology areas and needs that must be addressed to enable lunar missions are also discussed. I.S.

A91-10157*# National Aeronautics and Space Administration, Washington, DC.

TECHNOLOGY AND MARS EXPLORATION

JOHN C. MANKINS (NASA, Washington, DC) and CORINNE M. BUONI (Science Applications International Corp., Washington, DC) AIAA, Space Programs and Technologies Conference, Huntsville, AL, Sept. 25-27, 1990. 10 p.
(AIAA PAPER 90-3797) Copyright

The currently envisioned technology needs of the Space Exploration Initiative are surveyed. Earth-to-orbit transportation technology requirements are summarized. Space transportation needs regarding aerobraking, space-based engines, autonomous landing, autonomous rendezvous and docking, vehicle structures and cryogenic tankage, artificial gravity, nuclear propulsion, nuclear thermal propulsion, and nuclear electric propulsion. For in-space operations, cryogenic fluid systems, in-space assembly and construction, and vehicle processing and servicing are addressed. For surface operations on the moon and Mars, space nuclear power, resource utilization, planetary rovers, surface solar power, and surface habitats and construction are discussed. Regenerative life support, radiation protection, extravehicle activity, are considered along with factors pertaining to scientific activity in space and information systems and communications. C.D.

A91-13754#

KEY ELEMENTS AND TECHNOLOGIES FOR LUNAR AND MARS APPLICATIONS IN THE FRAME OF POST-COLUMBUS MANNED EUROPEAN SCENARIOS

U. APEL (MBB/ERNO, Bremen, Federal Republic of Germany) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 9 p. refs
(IAF PAPER 90-034) Copyright

The key elements common to a number of different scenarios for returning to the moon and progressing further to Mars are considered. The possible evolution of these concepts from elements existing or under development, such as the Columbus elements, are discussed. The technology testbed function of the European Columbus infrastructure with respect to lunar and Mars missions and applications is described. Key technologies include closed loop ECLSS, advanced photovoltaic conversion and energy storage, zero-G and low-G chemical processing techniques, cryogenic propellant storage and transfer, advanced reusable thermal shielding, and real-time image processing. L.K.S.

A91-13891#

THE STARLIGHT FUSION PROPULSION CONCEPT

R. A. BOND, V. THOMPSON, A. BOND, L. ALLEN (Culham Laboratory, Abingdon, England), and L. W. HOBBS (British Aerospace /Space Systems/, Ltd., Stevenage, England) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 11 p.
(IAF PAPER 90-233) Copyright

This report describes the results of a preliminary study of a nuclear fusion rocket engine based on the tokamak magnetic confinement concept. The requirements were based on near term missions, such as Space Station to cis-Lunar and Mars transfer/return operations, and the use of near-term earth launcher systems for the installment of hardware into low earth orbit. The engine uses a fusion reactor to heat a propellant, such as hydrogen, to high temperature and then expands it through a nozzle to produce thrust. The nuclear fuel is deuterium plus tritium which is stored on board. Author

A91-14016*# National Aeronautics and Space Administration, Washington, DC.

AN ODYSSEY FOR THE TURN OF THE MILLENNIA

DOUGLAS A. O'HANDLEY and ARNOLD D. ALDRICH (NASA, Office of Aeronautics, Exploration and Technology, Washington, DC) IAF, International Astronautical Congress, 41st, Dresden, Federal Republic of Germany, Oct. 6-12, 1990. 6 p.
(IAF PAPER 90-412) Copyright

The paper discusses one of the goals of the U.S. national space policy, i.e., to expand human presence and activity beyond earth orbit into the solar system. Journeys to the Moon and Mars, involving Space Station Freedom and robotic spacecraft, require advances in technology and opportunities for international cooperation are substantual. Two or more significantly different reference mission architectures are planned to be developed and United States astronauts are expected to land on Mars before 2019. Ideas and technologies which may benefit the Space Exploration Initiative are channeled to a program, called 'Outreach Program', to be later assessed by the Synthesis Group, an organization of senior U.S. specialists. B.P.

A91-21462*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.

NASA EVOLUTION OF EXPLORATION ARCHITECTURES

BARNEY B. ROBERTS (NASA, Johnson Space Center, Houston, TX) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 41 p.
(AIAA PAPER 91-0325) Copyright

A series of charts and diagrams is used to provide a detailed overview of the evolution of NASA space exploration architectures. The pre-Apollo programs including the Werner von Braun feasibility study are discussed and the evolution of the Apollo program itself is treated in detail. The post-Apollo era is reviewed and attention is given to the resurgence of strategic planning exemplified by both ad hoc and formal efforts at planning. Results of NASA's study of the main elements of the Space Exploration Initiative which examined technical scenarios, science opportunities, required technologies, international considerations, institutional strengths and needs, and resource estimates are presented. The 90-day study concludes that, among other things, major investments in challenging technologies are required, the scientific opportunities provided by the program are considerable, current launch capabilities are inadequate, and Space Station Freedom is essential. L.K.S.

A91-21464#

HUMAN PLANETARY EXPLORATION STRATEGY FEATURING HIGHLY DECOUPLED ELEMENTS AND CONSERVATIVE PRACTICES

BENTON C. CLARK (Martin Marietta Corp., Astronautics Group, Denver, CO) AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 13 p.
(AIAA PAPER 91-0328) Copyright

Mission designs which are fundamentally in accordance with a lowest common denominator approach as well as more ambitious enhancements to the core design are discussed. This approach is based upon a modular vehicle design which is straightforwardly assembled by docking maneuvers and intra-vehicular outfitting. An overall strategy for parallel development of transportation vehicles and associated capabilities for human travel to Mars and the moon is presented which accomodates the desired characteristics. It is noted that this strategy builds upon and emulates the proven success of the Apollo Program strategies including the division of the mission into discrete, self-contained elements with 'clean' interfaces; the incorporation of conservative design using redundancy and independent fall-back modes; and the parallel developments of hardware elements. L.K.S.

A91-27613
AN INFRASTRUCTURE FOR EARLY LUNAR DEVELOPMENT
BRAND NORMAN GRIFFIN (Boeing Co., Huntsville, AL) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 1. New York, American Society of Civil Engineers, 1990, p. 389-398.
Copyright

A complete earth/lunar infrastructure is presented. All phases necessary to support a return mission to the moon and achieve permanent occupancy are described. This paper offers design concepts and supporting rationale for a low-risk, low-cost program based on existing technologies and use of the proven Shuttle system. At the heart of the infrastructure is the Shuttle cargo bay and its payload retention system. The payload sizing and method of structural support is used as a standard throughout the infrastructure, ensuring compatibility and simplifying user operations. Horizontal integration and handling on earth and the moon represents a substantial cost avoidance through use of existing Shuttle systems and minimal lunar ground support equipment. Author

A91-27662* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
TECHNOLOGY NEEDS DEVELOPMENT AND ORBITAL SUPPORT REQUIREMENTS FOR MANNED LUNAR AND MARS MISSIONS
KAREN D. BRENDER (NASA, Langley Research Center, Hampton, VA) and CHARLES P. LLEWELLYN IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 884-894.
Copyright

This paper presents an overview of the critical technology needs and the Space Station Freedom focused support requirements for the Office of Exploration's manned lunar and Mars missions. The emphasis is on e directed at the technology needs associated with the low earth orbit (LEO) transportation node assembly and vehicle processing functions required by the lunar Mars mission flight elements. The key technology areas identified as crucial to support the LEO node function include in-space assembly and construction, in-space vehicle processing and refurbishment, space storable cryogenics, and autonomous rendezvous and docking. Author

A91-27663* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LOW EARTH ORBIT INFRASTRUCTURE TO ACCOMMODATE MANNED LUNAR MISSIONS
WILLIAM M. CIRILLO, PATRICK A. TROUTMAN, KAREN D. BRENDER (NASA, Langley Research Center, Hampton, VA), ERIC L. DAHLSTROM, J. KIRK AYERS (Lockheed Engineering and Sciences Co., Houston, TX), and LAURA M. WATERS IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 895-904.
Copyright

In order to establish bases on the lunar and Mars surfaces, a significant amount of orbital infrastructure including assembly platforms, cryogenic fluids depots, and Space Station Freedom, will be required in LEO. These facilities will be required to perform a myriad of functions ranging from orbital demonstration of advanced technology systems and establishment of life science capabilities to servicing and refurbishment of reusable lunar transfer vehicles. This paper addresses the requirements levied on these facilities and provides an overview of potetial LEO infrastructure elements that satisfy various advanced manned missions. Of key importance to the success of the manned lunar mission are (1) the evolutionary growth of Space Station Freedom to serve as a transportation node and (2) the development of a Shuttle-derived launch vehicle to deliver mission elements to LEO. Author

A91-27664* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPACE TRANSPORTATION NODE - THE ATRIUM FACILITY
KRISS J. KENNEDY (NASA, Johnson Space Center, Houston, TX) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 905-916. refs
Copyright

A conceptual design for a space transportation node is presented with a view to the fulfilment of assembly platform support requirements associated with a lunar transportation system. This 'Atrium Facility', which will support lunar base activities before, during, and after the lunar base buildup phase, encompasses a central assembly area surrounded by hangars and workstation platforms; six permanent crewmembers will be supported, as well as four to six transient lunar and Space Shuttle crewmembers. The Atrium Facility dry mass of nearly 320,000 kg excludes cryogenic propellant stowage and the traslunar vehicle envisioned for transportation. O.C.

A91-27667
MALEO: MODULAR ASSEMBLY IN LOW EARTH ORBIT - AN ALTERNATE STRATEGY FOR LUNAR BASE DEPLOYMENT
MADHU THANGAVELU (Southern California, University, Los Angeles, CA) IN: Engineering, construction, and operations in space II; Proceedings of Space 90, the Second International Conference, Albuquerque, NM, Apr. 22-26, 1990. Vol. 2. New York, American Society of Civil Engineers, 1990, p. 936-945. refs
Copyright

In the Modular Assembly in LEO (MALEO) strategy for construction of an initial lunar-habitation operational capability, separate lunar base components are assembled in LEO into a complete system and transported to the lunar surface, where operational habitation can proceed immediately upon touchdown. Among the major operational advantages of such a procedure over the piecemeal launch to lunar landing, followed by robotic assembly, are the safer LEO EVA environment, the ease of LEO replacement of parts, the preclusion of contamination of MALEO critical components by lunar soil, the reduction of precursor missions, and the obviation of power-frugal initial operations on the lunar surface. O.C.

A91-29028
SEA DRAGON IN THE MANNED MARS MISSION
R. C. TRUAX Journal of Practical Applications in Space (ISSN 1046-8757), vol. 2, Fall 1990, p. 1-18.
Copyright

It is suggested that design principles for low-cost launch vehicles developed during the study of the Sea Dragon 25 years ago are still valid. The main characteristics of the Sea Dragon and the Shuttle are compared. The Sea Dragon is considered to be capable of satisfying all the major space missions from the economic standpoint, including the Strategic Defense Initiative, the manned Space Station, the orbiting solar power station, a manned lunar base, and the manned misssion to Mars. O.G.

A91-30663* McDonnell-Douglas Space Systems Co., Rockville, MD.
THE ROLE OF SPACE STATION FREEDOM IN THE HUMAN EXPLORATION INITIATIVE
P. R. AHLF, R. J. SAUCILLO (McDonnell Douglas Space Systems Co., Rockville, MD), B. D. MEREDITH, and L. L. PEACH (NASA, Washington, DC) IN: TABES 90 - Annual Technical and Business Exhibition and Symposium, 6th, Huntsville, AL, May 15, 16, 1990, Submitted Papers. Huntsville, AL, Huntsville Association of Technical Societies, 1990, p. 129-134.
(TABES PAPER 90-1306) Copyright

Exploration accommodation requirements for Space Station Freedom (SSF) and mission-supporting capabilities have been studied. For supporting the Human Exploration Initiative (HEI), SSF will accommodate two functions with augmentations to the baseline Assembly Complete configuration. First, it will be an earth-orbiting

transportation node providing facilities and resources (crew, power, communications) for space vehicle assembly, testing, processing and postflight servicing. Second, it will be an in-space laboratory for science research and technology development. The evolutionary design of SSF will allow the on-orbit addition of pressurized laboratory and habitation modules, power generation equipment, truss structure, and unpressurized vehicle processing platforms.
O.G.

N91-18133*# Houston Univ., TX. Coll. of Architecture.
SPACEPORT AURORA: AN ORBITING TRANSPORTATION NODE
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 69-78 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/2

With recent announcements of the development of permanently staffed facilities on the Moon and Mars, the national space plan is in need of an infrastructure system for transportation and maintenance. A project team at the University of Houston College of Architecture and the Sasakawa International Center for Space Architecture, recently examined components for a low Earth orbit (LEO) transportation node that supports a lunar build-up scenario. Areas of investigation included identifying transportation node functions, identifying existing space systems and subsystems, analyzing variable orbits, determining logistics strategies for maintenance, and investigating assured crew return systems. The information resulted in a requirements definition document, from which the team then addressed conceptual designs for a LEO transportation node. The primary design drivers included: orbital stability, maximizing human performance and safety, vehicle maintainability, and modularity within existing space infrastructure. For orbital stability, the power tower configuration provides a gravity gradient stabilized facility and serves as the backbone for the various facility components. To maximize human performance, human comfort is stressed through zoning of living and working activities, maintaining a consistent local vertical orientation, providing crew interaction and viewing areas and providing crew return vehicles. Vehicle maintainability is accomplished through dual hangars, dual work cupolas, work modules, telerobotics and a fuel depot. Modularity is incorporated using Space Station Freedom module diameter, Space Station Freedom standard racks, and interchangeable interior partitions. It is intended that the final design be flexible and adaptable to provide a facility prototype that can service multiple mission profiles using modular space systems.
Author

N91-18138*# Maryland Univ., College Park.
PROJECT EXODUS
In USRA, Proceedings of the 6th Annual Summer Conference: NASA/USRA University Advanced Design Program p 105-110 Nov. 1990
Avail: NTIS HC/MF A14 CSCL 22/1

Project Exodus is an in-depth study to identify and address the basic problems of a manned mission to Mars. The most important problems concern propulsion, life support, structure, trajectory, and finance. Exodus will employ a passenger ship, cargo ship, and landing craft for the journey to Mars. These three major components of the mission design are discussed separately. Within each component the design characteristics of structures, trajectory, and propulsion are addressed. The design characteristics of life support are mentioned only in those sections requiring it. Author

N91-18173*# National Aeronautics and Space Administration, Washington, DC.
BEYOND EARTH'S BOUNDARIES: HUMAN EXPLORATION OF THE SOLAR SYSTEM IN THE 21ST CENTURY Annual Report, 1988
1991 51 p
(NASA-TM-103383; NAS 1.15:103383) Avail: NTIS HC/MF A04 CSCL 22/1

This is an annual report describing work accomplished in developing the knowledge base that will permit informed recommendations and decisions concerning national space policy and the goal of human expansion into the solar system. The following topics are presented: (1) pathways to human exploration; (2) human exploration case studies; (3) case study results and assessment; (4) exploration program implementation strategy; (5) approach to international cooperation; (6) recommendations; and (7) future horizons.
K.S.

N91-18200# Technische Univ., Munich (Germany, F.R.). Lehrstuhl fuer Raumfahrttechnik.
THE SPACE STATION AS A STATION FOR INTERPLANETARY MISSIONS Ph.D. Thesis [DIE RAUMSIMULATION ALS BAHNHOF FUER INTERPLANETARE MISSIONEN]
MICHAEL H. OBERSTEINER 1989 109 p In GERMAN
(ETN-91-98799) Avail: NTIS HC/MF A06

The take off orbit and its consequences on orbit mechanics and mission planning are examined. Based on an idealized preliminary investigation, orbit computation is realized and evaluated for Earth Mars orbits. The developed algorithm includes complex conical sections, impulse Hohmann transfer stations, Lambert problem and parameter optimization. Growth factors are to be included for the Space Station, in the next interplanetary missions.
ESA

LARGE SPACE STRUCTURES AND SYSTEMS IN THE SPACE STATION ERA / *A Bibliography (Supplement 03)*

DECEMBER 1991

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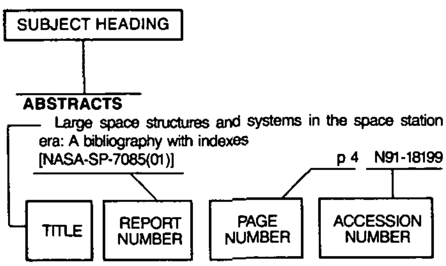

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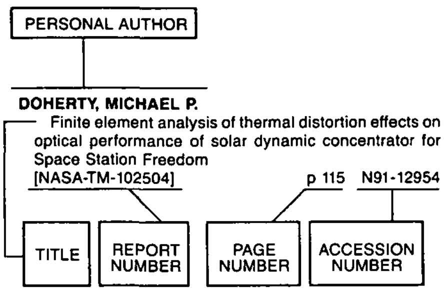

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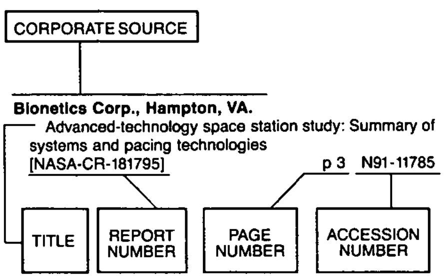

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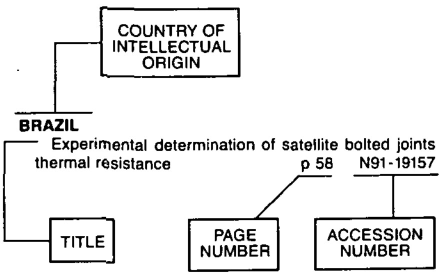

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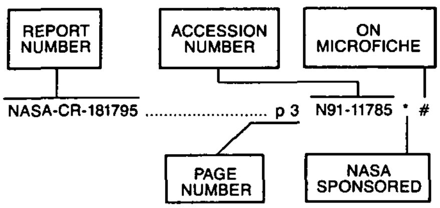

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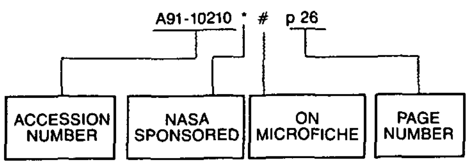

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