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NASA

Technology for Large Space Systems

NASA SP-7046(17)
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A Bibliography with Indexes

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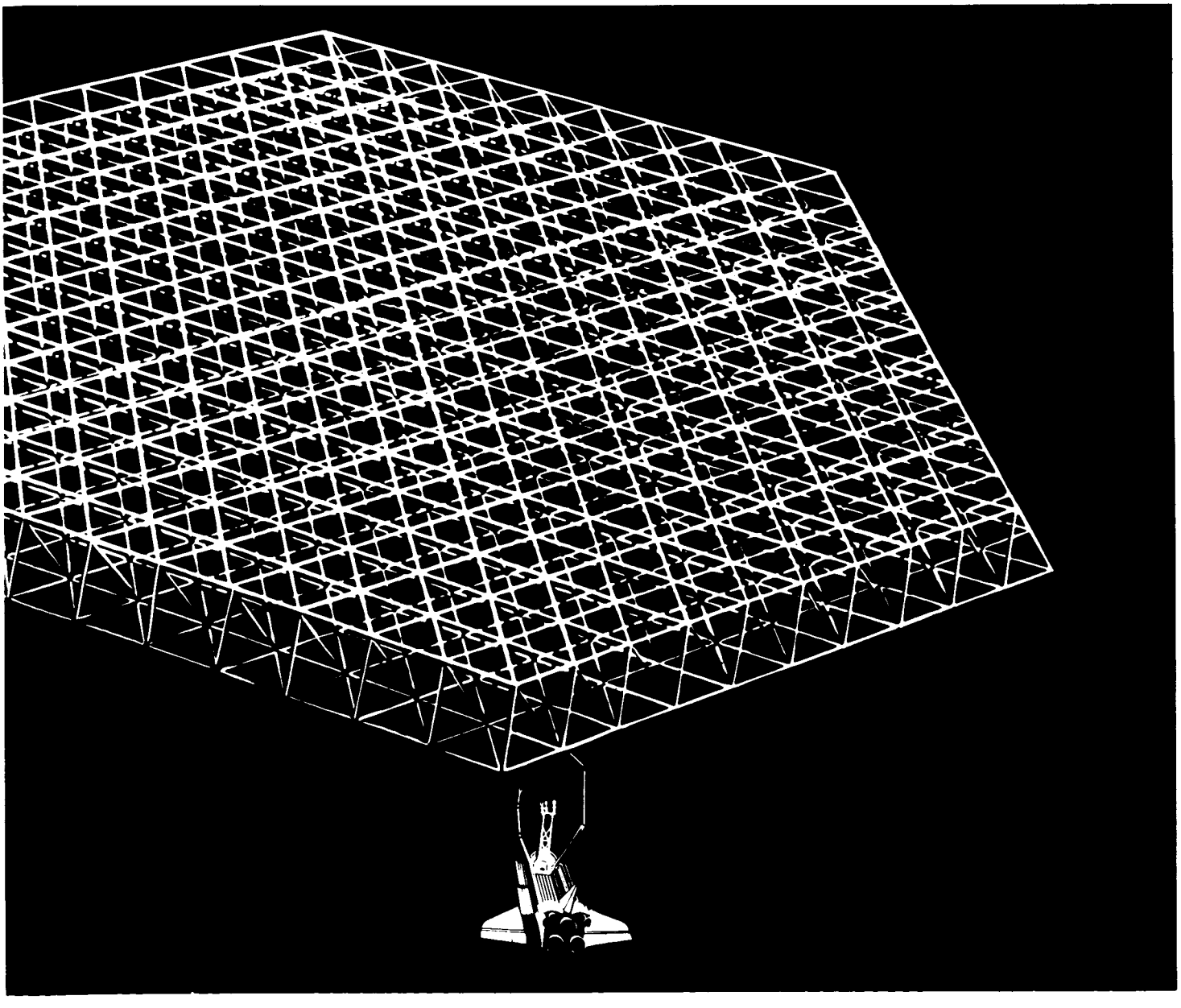

NASA SP-7046(17)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 17

Compiled by
Technical Library Branch
and
Edited by
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Hampton, Virginia

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between January 1 and June 30, 1987 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Division 1987
National Aeronautics and Space Administration
Washington, DC

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A number of words are used, but to best insure that your work is included in the bibliography, use the words *Large Space Structures* somewhere in your title or abstract, or include them as a key word.

This supplement is available from the National Technical Information Service (NTIS), Springfield , Virginia 22161 at the price code A07.

INTRODUCTION

This bibliography is designed to be helpful to the researcher and manager engaged in the developing technology within the discipline areas of the Large Space Systems Technology (LSST). Also, the designers of large space systems for approved missions (in the future) will utilize the technology described in the documents referenced herein.

This literature survey lists 512 reports, articles and other documents announced between January 1, 1987 and June 30, 1987 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA)*.

The coverage includes documents that define specific missions that will require large space structures to achieve their objectives. The methods of integrating advanced technology into system configurations and ascertaining the resulting capabilities is also addressed.

A wide range of structural concepts are identified. These include erectable structures which are earth fabricated and space assembled, deployable antennas which are fabricated, assembled, and packaged on Earth with automatic deployment in space, and space fabricated structures which use pre-processed materials to build the structure in orbit.

The supportive technology that is necessary for full utilization of these concepts is also included. These technologies are identified as analysis and design techniques, structural and thermal analysis, structural dynamics and control, electronics, advanced materials, assembly concepts, and propulsion.

A separate companion document "Space Station Systems Bibliography" (NASA SP-7056) incorporates space station technology not applicable to large space systems. Space station systems technology that is also applicable to large space systems may be documented in both bibliographies.

Robert L. Wright, *Space Systems Division*
Sue K. Seward, *Technical Library Branch*

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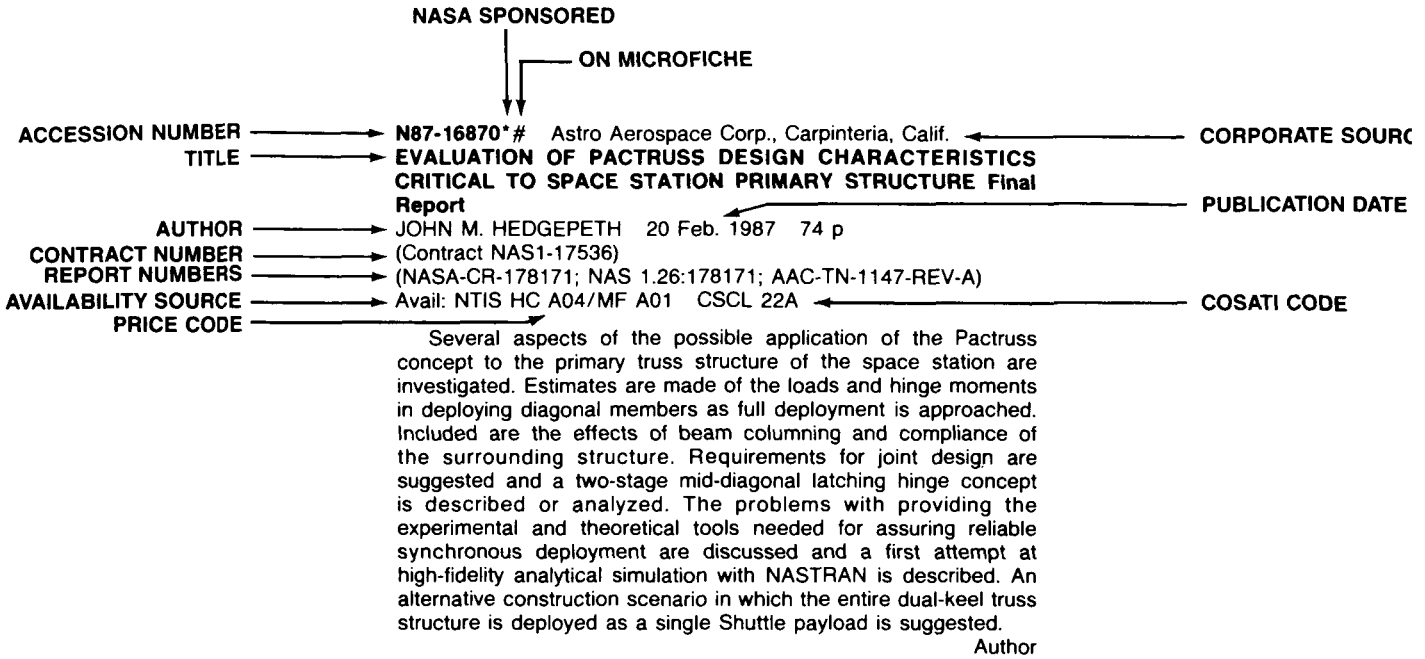
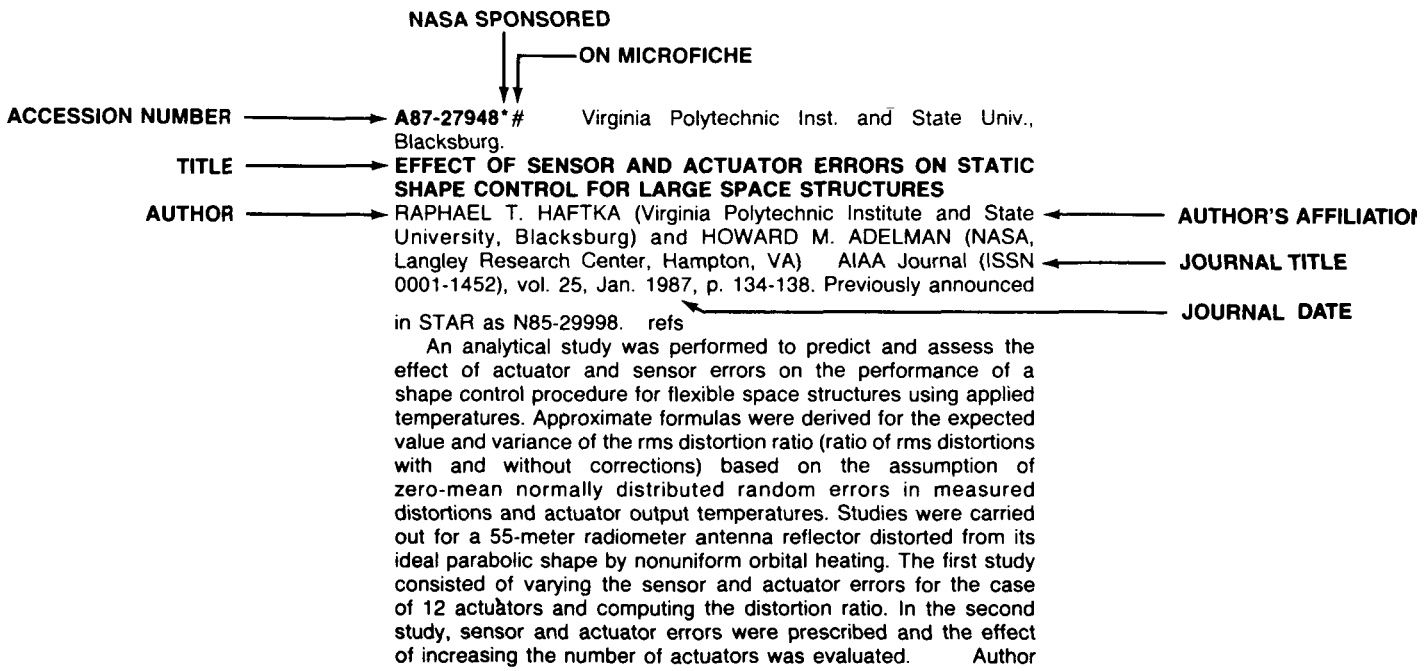


TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 17)

OCTOBER 1987

01

SYSTEMS

Includes mission and program concepts and requirements, focus missions, conceptual studies, technology planning, systems analysis and integration, and flight experiments.

A87-10043* National Aeronautics and Space Administration, Washington, D.C.
TECHNICAL ASPECTS OF THE UNITED STATES SPACE STATION
D. H. HERMAN (NASA, Washington, DC) and D. BRIEHL IN: Space Congress, 23rd, Cocoa Beach, FL, April 22-25, 1986, Proceedings . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1986, p. 7-1 to 7-6.

The design and development of the Space Station are described. The proposed design of the Station is a dual keel configuration which will include manned facilities and unmanned free flying platforms. The Station is to be utilized as a space-based laboratory for basic research and observations, a depot for repair and servicing of spacecraft, a strorage area, and a manufacturing facility. International participation in the Space Station program and technological developments applicable for the Station are discussed. A diagram of the Space Station configuration and a Space Station development schedule are provided. I.F.

A87-12086
ON THE INITIATION OF SPS DEVELOPMENT
K. KURIKI (Tokyo, University, Japan) (University of Tokyo, Institute of Space and Astronautical Science, Space Energy Symposium, 4th, Tokyo, Japan, Mar. 1, 1985) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 4, 1985, p. 315-320.

The concept of finite time availability, a new idea of thermodynamics, is applied to decisions on when the development of the solar power satellite (SPS) should be initiated and how long a lead time should be taken. Admitting the errors in estimation of parameters, an earlier start is concluded to be much safer than a delayed start. Author

A87-14375
GETTING BACK ON TRACK IN SPACE
R. A. LEWIS (Arizona, University, Tucson) and J. S. LEWIS Technology Review (ISSN 0040-1692), vol. 89, Aug.-Sept. 1986, p. 30-40.

The history, current status, and future of the US space program are examined critically from a science perspective. Topics discussed include the early Soviet lead in heavy boosters, the success of the Apollo program, the lack of an Apollo follow-up program, economic and political factors affecting the decision to concentrate NASA efforts on the Space Shuttle (STS), the abandonment of the Saturn boosters and Skylab, the increasing costs of STS, concomitant decreases in overall NASA funding, military demands on STS, and the slow but continuing progress of the Soviet space program. It is argued that space science objectives would have been and will be better served by a diversified program of mainly unmanned missions than by all-purpose (commercial/military/science) programs such as STS and the proposed Space Station. Recommendations for the future include a long-term program to establish a permanent manned station on Mars, reinvestigation of a solar-power-satellite system, transfer of STS operations to an independent agency, longer-term funding of NASA R&D programs by Congress, competitive development of a new lower-cast heavy-lift launcher, more use of military rockets, and international cooperation on large-scale undertakings. T.K.

A87-14969
THE SPACE STATION - UNITED STATES PROPOSAL AND IMPLEMENTATION
E. GALLOWAY Journal of Space Law, vol. 14, no. 1, 1986, p. 14-39. refs

NASA's Space Station program has unique technical characteristics which distinguish it from past international space programs; agreements for its establishment must take these features into account. The engineering calculation of adding modules over time should be matched with legal provisions for jurisdiction and control. Attention is presently given to the legal aspects of launching authority, objects launched into outer space, registration of space objects, peaceful and military purposes, exploration and use of the moon, and relationships with the United Nations specialized agencies and other international organizations. O.C.

A87-15377* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE SPACE STATION PROGRAM
N. W. HINNERS (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Space Station beyond IOC; Proceedings of the Thirty-second Annual International Conference, Los Angeles, CA, November 6, 7, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 11-17.
(AAS PAPER 85-451)

Cost constraints to a large degree control the functionality and form of the IOC of the Space Station. Planning of Station missions must be delayed to retain flexibility, a goal also served by modular development of the Station and by multi-use laboratory modules. Early emphasis on servicing other spacecraft is recommended, as is using available Shuttle flight time for R&D on Space Station technologies and operations. M.S.K.

A87-15380
SPACE STATION EVOLUTION - THE AEROSPACE TECHNOLOGY IMPACT
R. W. HAGER (Boeing Aerospace Co., Seattle, WA) IN: Space Station beyond IOC; Proceedings of the Thirty-second Annual International Conference, Los Angeles, CA, November 6, 7, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 39-43.
(AAS PAPER 85-456)

Space Station-related technologies which will be further developed after IOC are described. The Station IOC may require 90-day resupply missions, each carrying 5000 lb of oxygen, nitrogen and water and picking up waste and delivering food for six astronauts. Logistics requirements will be reduced as the Station evolves into an ecological system within 3-5 percent of complete independence. One standard 43-ft module can hold enough growing plants to supply 2.5 astronauts and transform their wastes. Expert

systems and low-cost, high power sources will be required for production-scale materials processing. M.S.K.

A87-15814#
HUBBLE SPACE TELESCOPE - DAWN OF THE ERA OF SERVICEABLE SPACECRAFT
L. A. WICKMAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 5 p.
(IAF PAPER 86-20)

The Hubble Space Telescope, scheduled for launch in late 1988, is designed to include on-orbit servicing as an integral part of its operational plan. Here, the design philosophy of the Space Telescope and the lessons learned are explored insofar as they can be applied to the design of future serviceable spacecraft. In particular, attention is given to the use of orbital replaceable units, redundancy, environmental considerations, workspace accessibility, and standardization of the design of mechanical fasteners. V.L.

A87-15817*# National Aeronautics and Space Administration, Washington, D.C.
SPACE CONSTRUCTION RESULTS - THE EASE/ACCESS FLIGHT EXPERIMENT
I. BEKEY (NASA, Office of Space Flight, Washington, DC) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 6 p.
(IAF PAPER 86-26)

NASA ground and flight test activities aimed at the development of in-space construction techniques for the assembly of Space-Station-sized structures are described. In particular, attention is given to the EASE and ACCESS flight experiments, the ground and water tank program, and operations in-flight including instrumentations. The baseline experiments demonstrate that erectable structures can be assembled effectively by astronauts in EVA. The average assembly time for a 45-foot truss was 25.5 minutes; the assembly rate was 3.6 struts per minute. V.L.

A87-15818#
THE ESA/MBB UNFURLABLE MESH ANTENNA DEVELOPMENT FOR MOBILE SERVICES
H. KELLERMEIER, H. VORBRUGG (MBB/ERNO, Ottobrunn, West Germany), K. PONTOPPIDAN (TICRA A/S, Copenhagen, Denmark), and D. C. G. EASTON (ESA, European Space Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p. refs
(IAF PAPER 86-27)

The Offset Unfurlable Mesh Antenna (UMA) concept being developed at MBB for communication missions ranging from 850 MHz up to 12 GHz is reviewed with reference to the main stages of the program, its current status, the performance of the UMA concept, and technology demonstration. The design development of the Technology Demonstration Model indicates that this type of reflector can meet the objectives not only in relation to M-SAT requirements but also in relation to other missions. These include meeting the surface tolerance and mesh characteristics required to reduce more stringent side lobe damping requirements and frequency reuse (multibeam capability) for a 5-m C-band Intelsat application and an 8-m L-band multibeam application. V.L.

A87-15904#
COMPACT SPS FOR LUNAR DEVELOPMENT
M. POSPISIL and L. POSPISILOVA IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 6 p. refs
(IAF PAPER 86-156)

The development of compact solar power satellites (SPS) for use on a lunar base is examined. The SPS is to collect solar radiation in space and convert it to a usable form. The compact SPS uses one structure for both the solar radiation reception and transmitting beam emission and it produces a microwave beam of high power density. The proposed requirement and capabilities for a lunar power satellite are discussed. Potential uses for the microwave beam are considered. I.F.

A87-16096*# National Aeronautics and Space Administration, Washington, D.C.
TECHNOLOGIES FOR AFFORDABLE ACCESS TO SPACE
R. S. COLLADAY and S. R. SADIN (NASA, Washington, DC) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p.
(IAF PAPER 86-442)

NASA plans for advanced research and technology programs aimed at reducing operating costs and extending the capability of future space systems are described. The evolution of an almost entirely space-based mode is discussed, including the role of earth launch, servicing, fabrication and assembly and communications. The development of technology for affordable access to space is examined, taking into account progress in the areas of telerobotics, machine autonomy, human autonomy, space-based manufacturing and construction, electric power, and space-based propulsion. C.D.

A87-16105#
MODELING AND SIMULATION OF LARGE SCALE SPACE SYSTEMS STRATEGIC PLANNING IMPLICATIONS
S. NOZETTE, H. DAVIS (Large Scale Programs Institute, Austin, TX), and C. BILBY (Texas, University, Austin) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 6 p. refs
(IAF PAPER 86-453)

A87-16108#
MOON FOR TERRESTRIAL ENERGETICS
M. POSPISIL and L. POSPISILOVA IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 4 p. refs
(IAF PAPER 86-456)

The development of a space energy system for the earth using lunar resources is considered. The resources of the moon and their applications are discussed. The capabilities and costs of a lunar satellite power system and a lunar base are examined. I.F.

A87-16110*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION DESIGN FOR GROWTH
E. B. PRITCHARD (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 9 p.
(IAF PAPER 86-461)

This paper reviews the current status of Space Station planning for growth as the basis of an assessment of potential Space Station evolution directions in the 21st Century to meet the challenges of the report of the U.S. National Commission on space, 'Pioneering the Space Frontier'. Thus future mission requirements are reviewed and assessed. Based on these requirements, evolution scenarios and potential configurations are developed. It is concluded that the Space Station, as a multipurpose facility, should evolve to a capability of 300 kW, crew of 18 and 5 lab modules. Beyond this capability it will be necessary to separate functions and establish two separate Space Stations, one for research and one for operational activities (e.g., transportation node, servicing, etc.). If the U.S. National Commission on space's recommendations are adopted, this separation or 'branching' could occur as early as 2005 to meet the needs of a permanent lunar base. Author

A87-16399
SPACE STATION - NASA'S GREATEST CHALLENGE
T. FURNISS Flight International (ISSN 0015-3710), vol. 130, Aug. 30, 1986, p. 137-140.

An account is given of the progress made by NASA on a Space Station; attention is given to the apportionment of development tasks among NASA facilities and foreign participants in this international project. When completed, the NASA Space Station will encompass four manned modules, of which two will be from the U.S., one from Europe, and the last from Japan. For the first time in any U.S. manned spacecraft, there will be a closed loop environmental control and life support system. O.C.

A87-16930*# National Aeronautics and Space Administration, Washington, D.C.
TELESCIENCE IN ORBIT
D. C. BLACK (NASA, Office of Space Station, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 24, Sept. 1986, p. 44-46.

A promising concept for the scientific use of the NASA Space Station involves attaching payloads to the dual keel truss structure of the manned base, specifically on the upper and lower booms. The lower boom will be primarily employed by the earth observation and space plasma studies community, while the upper boom will be used by astronomers for such instruments as the Solar Optical Telescope and the Astrometric Telescope Facility. The indispensability of a robust Space Shuttle system for these Space Station uses is noted. O.C.

A87-18064*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACECRAFT 2000 - THE CHALLENGE OF THE FUTURE
H. W. BRANDHORST, JR., K. A. FAYMON, and R. W. BERCAW (NASA, Lewis Research Center, Cleveland, OH) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1397-1400.

The need for spacecraft bus technology advances in order to develop the spacecraft for the 21st century is discussed. Consideration is given to the power and electric propulsion systems for mass-limited satellites such as LEO and GEO. The goal of spacecraft bus technology programs is to design a cost-effective spacecraft which operates well in the satellite environment. The possibility of collaboration between government and industry is examined. I.F.

A87-18242
SIMPLEX MAST - AN EXTENDIBLE MAST FOR SPACE APPLICATIONS
K. MIURA, M. NATORI, M. SAKAMAKI (Tokyo, University, Japan), Y. KAKITSUBO, and H. YAHAGI (Japan Aircraft Manufacturing Co., Ltd., Yokohama) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 357-362. refs

A possible concept of an extendible mast for space applications which is called a Simplex Mast is introduced. It consists of continuous longerons, integrated radial spacers and diagonal wires. Model experiments to confirm the effectiveness of the concept is presented, and one of the applications of this mast to a scientific spacecraft is also introduced. Author

A87-18453* National Aeronautics and Space Administration, Washington, D.C.
AN OVERVIEW OF NASA'S PROGRAMS AND PLANS
S. W. KELLER (NASA, Office of Space Science and Applications, Washington, DC) IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 37-44.
(AAS PAPER 85-647)

An overview is given of NASA's technical program offices and their status, recent accomplishments, and plans for the future. Programs covered include the Space Transportation System, TDRS, the Deep Space Network, the various Spacelab missions, the Galileo mission to Jupiter, the Ulysses mission over the poles of the sun, the Hubble Space Telescope, and the Space Station program. D.H.

A87-18508* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEM CONCEPT FOR A MODERATE COST LARGE DEPLOYABLE REFLECTOR (LDR)
P. N. SWANSON, J. B. BRECKINRIDGE, A. DINER, R. E. FREELAND, W. R. IRACE, P. M. MCELROY, A. B. MEINEL, and A. F. TOLIVAR (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Optical Engineering (ISSN 0091-3286), vol. 25, Sept. 1986, p. 1045-1054. NASA-supported research. refs

A study was carried out at JPL during the first quarter of 1985 to develop a system concept for NASA's LDR. Major features of the concept are a four-mirror, two-stage optical system; a lightweight structural composite segmented primary reflector; and a deployable truss backup structure with integral thermal shield. The two-stage optics uses active figure control at the quaternary reflector located at the primary reflector exit pupil, allowing the large primary to be passive. The lightweight composite reflector panels limit the short-wavelength operation to approximately 30 microns but reduce the total primary reflector weight by a factor of 3 to 4 over competing technologies. On-orbit thermal analysis indicates a primary reflector equilibrium temperature of less than 200 K with a maximum gradient of about 5 C across the 20-m aperture. Weight and volume estimates are consistent with a single Shuttle launch, and are based on Space Station assembly and checkout. Author

A87-19789
LARGE INFLATABLE PARABOLIC REFLECTORS IN SPACE
B. AUTHIER and L. HILL (CNRS, Laboratoire d'Astronomie Spatiale, Marseille, France) IN: Instrumentation for submillimeter spectroscopy; Proceedings of the Meeting, Cannes, France, December 5, 6, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 126-132.

A requirement is noted where large aperture parabolic reflectors are needed for space applications in different wavelength ranges where a high accuracy is required for the reflecting surfaces. It is proposed to get more accurate surfaces by replacing the preformed flexible membranes presently scheduled in the inflatable technology, by elastic disks whose thickness variation along a radius is calculated in order to obtain (after inflation) parabolic caps. To illustrate the method, polyester and polyimide membranes are investigated. If a variable thickness from the center to the edge is obtainable, constructing large aperture parabolic caps by this method appears feasible. The surface accuracy depends mainly on the elastic properties of the material and control of thickness. D.H.

A87-21807* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA GROWTH SPACE STATION MISSIONS AND CANDIDATE NUCLEAR/SOLAR POWER SYSTEMS
JACK A. HELLER and JOSEPH J. NAINIGER (NASA, Lewis Research Center, Cleveland, OH) IN: Space nuclear power systems 1985; Proceedings of the Second Symposium, Albuquerque, NM, Jan. 14-16, 1985. Volume 3 . Malabar, FL, Orbit Book Co., Inc., 1987, p. 47-52. NASA sponsored research.

A brief summary is presented of a NASA study contract and in-house investigation on Growth Space Station missions and appropriate nuclear and solar space electric power systems. By the year 2000 some 300 kWe will be needed for missions and housekeeping power for a 12 to 18 person Station crew. Several Space Station configurations employing nuclear reactor power systems are discussed, including shielding requirements and power transmission schemes. Advantages of reactor power include a greatly simplified Station orientation procedure, greatly reduced occultation of views of the earth and deep space, near elimination of energy storage requirements, and significantly reduced station-keeping propellant mass due to very low drag of the reactor power system. The in-house studies of viable alternative Growth Space Station power systems showed that at 300 kWe a rigid silicon solar cell array with NiCd batteries had the highest specific mass at 275 kg/kWe, with solar Stirling the lowest at 40 kg/kWe.

However, when 10 year propellant mass requirements are factored in, the 300 kWe nuclear Stirling exhibits the lowest total mass. Author

A87-22721#
COST REDUCTION ON LARGE SPACE SYSTEMS THROUGH COMMONALITY
R. D. WAISS (Boeing Aerospace Co., Seattle, WA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0585)

The need for commonality in large space systems is discussed. The basic goal of a commonality program is to reduce total system cost by maximizing the use of standard and common parts, assemblies, subsystems, and/or systems. The application of commonality to the development, production, deployment, and operations of large space structure is examined. The economic benefits of a commonality approach to large space system development are evaluated. Consideration is given to mandated and nonmandate approaches for implementing commonality. I.F.

A87-22751*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE OBSERVATORIES OF THE 21ST CENTURY
M. NEIN, J. HOWELL, S. MORGAN, C. DE SANCTIS (NASA, Marshall Space Flight Center, Huntsville, AL), and D. KOCH (Smithsonian Astrophysical Observatory, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 17 p. refs
(AIAA PAPER 87-0636)

Early in the 21st century, advanced space telescopes will be readied to continue the astronomical observations of the Great Observatories currently under development. This paper describes representative concepts from the very large UV/optical and gamma-ray telescopes under study by NASA, the scientific community, and industry. These studies demonstrate that historical approaches to improving the resolution and sensitivity of space telescopes have reached technology barriers which can only be overcome by innovative solutions to the telescope design. Some of the key technology issues which are guiding the approaches for advanced space telescopes are discussed, and arguments are presented that enabling technology development for these future systems must commence now. Author

A87-22771
SOLAR POWER SATELLITE CONCEPT REVISITED
PETER E. GLASER (Arthur D. Little, Inc., Cambridge, MA) Space Power (ISSN 0883-6272), vol. 6, 1986, p. 157-163. refs

The continued evolution of the solar power satellite (SPS) concept is reviewed. The advances in generic technologies applicable to the SPS resulting from the growth of commercial activities in space, the Space Station program and the strategic defense initiative are highlighted. The growing international literature on the SPS is cited to indicate that this concept continues to receive consideration. Significant developments, including photovoltaic and solar dynamic conversion, space experiments to test performance of critical technologies, power distribution subsystems, automation and teleoperators that are advancing the feasibility of the SPS are discussed. The possibility of a return to the moon and uses of lunar resources for SPS construction are mentioned as examples of space missions that will contribute to the buildup of the industrial infrastructure that can be the foundation for SPS development. Author

A87-24123#
THE INTERNATIONAL SPACE STATION TAKES SHAPE [DIE INTERNATIONALE RAUMSTATION NIMMT GESTALT AN]
SABINE HOLL Luft- und Raumfahrt (ISSN 0173-6264), vol. 7, 3rd Quarter, 1986, p. 76-79. In German.

European technological contributions to the proposed Space Station are reviewed. The Europeans are involved in the design, development, and utilization of such components as a pressurized module, polar platforms, and data processing units. The orbital and terrestrial infrastructure of the Columbus including data processing and telecommunication systems concerned with the coordination of operations on the Station are examined; various applications for the Station are proposed. Consideration is given to the financing of the program, the allocation of costs, the composition of the crew and workload, the allocation of time for use of the Space Station facilities, and technology transfer. I.F.

A87-25752
SPACE STATION - DESIGNING THE FUTURE
ROBERT THOMPSON (McDonnell Douglas Astronautics Co., Saint Louis, MO) IN: Space Tech '86; Proceedings of the International Conference, Geneva, Switzerland, May 14-16, 1986 . London, Online International, Ltd., 1986, p. 9-20.

Requirements for the proposed Space Station, which is to provide permanent life support and housing for an international crew, are examined. The proposed dual-keel design of the Space Station, pressurized cylindrical crew modules, and subsystems (electrical, thermal control, data management, life support control, and propulsion) are described. The Space Station is to be designed to meet users's demands and to be built using a phase development approach. The stages of the phase development are discussed. The basic missions of the Space Station include: (1) science, (2) commercial, (3) technology development, and (4) space operations. Consideration is given to the use of robotic devices on the Station and the development costs. I.F.

A87-25758
THE ROLE OF EXPERT SYSTEMS ON SPACE STATION
D. R. SLOGGETT (Software Sciences, Ltd.; Environmental and Space Systems Group, Farnborough, England) IN: Space Tech '86; Proceedings of the International Conference, Geneva, Switzerland, May 14-16, 1986 . London, Online International, Ltd., 1986, p. 91-107. refs

The planned deployment of the Space Station, and its associated orbital infrastructure, repreents a unique opportunity to evaluate the potential of expert systems to assist in increasing the autonomy, productivity and effectiveness of the Space Station. This paper seeks to address what current technology can provide to achieve this aim, and highlights previous practical examples of Space AI Systems. The paper makes suggestions for practical research programs, that require urgent attention, to pave the way and demonstrate capability in areas of relatively new technology. From this base the paper suggests some practical areas where AI technology can be applied to the Space Station and their resulting benefits. Specific attention is drawn to the application of expert systems to planning and scheduling and the application of expert monitoring systens to assist in fault diagnosis and repair. The paper concludes that urgent attention is required in the area of demonstration programs where low-risk state-of-the-art developments can be undertaken resulting in very real benefits to the Space Station system. Author

A87-25759
SPACE STATION - THE USE OF EXPERT SYSTEMS FOR PLANNING
JENS GULDBERG and JENS LANGELAND (Computer Resources International A/S, Denmark) IN: Space Tech '86; Proceedings of the International Conference, Geneva, Switzerland, May 14-16, 1986 . London, Online International, Ltd., 1986, p. 109-117. refs

Expert systems have been shown to provide useful techniques for handling planning problems related to the operation of complex systems and to system engineering. A brief review of the principle features of such planning systems is used as a reference for a discussion on relevant applications for the Space Station, which include, e.g., mission planning, scheduling of maintenance, software development, payload design, and check-out procedures. Author

A87-27455
RATIONALISING SPACE STATION
TIM FURNISS Space (ISSN 0267-954X), vol. 2, Dec. 1986-Feb. 1987, p. 28-30, 36.

Design and applications requirements which are guiding the definition of the configuration for the manned Space Station (MSS) are summarized. A dual-keel design is necessitated by the need to place the modules at the center of gravity to facilitate micro-g materials processing studies. Solar dynamic generators will replace some of the solar panel capacity to reduce drag on the MSS. Several details of the cabin atmosphere, payload servicing accommodations, closed loop operations, and co-orbiting and polar orbiting platform segments of the MSS are outlined, along with design changes in the aftermath of the Challenger catastrophe. M.S.K.

A87-27605#
FRONT END LOGISTICS INFLUENCE ON SPACE SYSTEM HARDWARE DESIGN
CHARLES O. COOGAN (Acquisition Logistics Engineering, Worthington, OH) IN: Space Logistics Symposium, 1st, Huntsville, AL, Mar. 24-26, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 5-11.
(AIAA PAPER 87-0658)

The application of logistics analysis in systems engineering of designs for future space systems are described. The next phase of space operations, i.e., long-duration large-scale missions, requires operational efficiency and reduced support burdens. Logistics analysis can be applied during the R&D phase of training activities and the definition of space systems maintenance requirements, for projecting the support requirements of production-line space components, for planning launch preparation activities, and for planning space servicing procedures, supplies and support requirements. Components and their lifetimes are considered; the combined subcomponent costs are a major determinant of systems costs, a view complementary to a systems engineering approach. Logistics analysis is useful in the formation of design concepts, and is relatively ineffective if applied during operational phases. M.S.K.

A87-28953
EXTENDING THE SPACE STATION INFRASTRUCTURE
C. M. HEMPSELL (British Aerospace, PLC, Space and Communications Div., Stevenage, England) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 40, Jan. 1987, p. 19-26.

The Space Station program will create an infrastructure of support elements in the space environment. This program has widespread international collaboration producing many different elements, but despite this there remains a potential for expansion of the infrastructure in terms of new locations and the facilities offered. This paper lists 71 possible major systems of which only 21 are currently projected for development. The constraints on further expansion being funding limitations. To allow expansion of the Station beyond the initial operational configuration the paper proposes three approaches: (1) review funding sources, (2) design elements to allow expansion, and (3) introduce multifunction designs. Author

A87-30891
COMMUNICATIONS SPACECRAFT
SAMUEL W. FORDYCE IN: Space science and applications: Progress and potential . New York, IEEE Press, 1986, p. 201-213.

Progress in the designs and performance capabilities of communications satellites is traced from the Echo 1 Al-coated mylar balloon in 1960 to systems planned for the 1990s and beyond. The services allowed with the passive balloon concept were too limited and led to Telstar spacecraft, with 600 voice channels, being placed in elliptical orbits. Geosynchronous communications began in 1963 with the Syncom satellite, which also carried television signals. The evolution of subsequent Intelsat and ANIK satellites is described, as are features of the Marisat, Marecs, and the DBS systems. The near-term capabilities for DBS, advanced communications satellites using TDMA techniques, and mobile communications systems are summarized, along with the NASA ACTS and MSAT-X satellites for exploring the necessary technologies. The roles the Space Station and unmanned GEO platforms will play in future satellite communications are discussed. M.S.K.

A87-31123*# National Aeronautics and Space Administration, Washington, D.C.
NASA'S TECHNOLOGY PLANS - WILL TECHNOLOGY BE READY WHEN WE ARE
RAYMOND S. COLLADAY (NASA, Office of Aeronautics and Space Technology, Washington, DC) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 5 p.
(AIAA PAPER 87-1695)

Recent low NASA science and technology budgets impacted unfavorably on trade balances of aerospace products and lags in several technological areas impinged on other areas already in application which could not be exploited or did not achieve desired performance levels. NASA has formed a Civil Space Technology Initiative, for 1988 start, to foster research on safe and efficient access to space, earth orbiting operations, and science support technologies. R&D programs for fully reusable launch systems, aerobraking concepts, and a multi-arm, highly autonomous capability for space-based remote assembly, repair and servicing of space vehicles are described. Regarding science, emphasis will be placed on large flexible structures and the associated control programs, sensors and data handling and analysis equipment and programs. Finally, technologies common to human activities in regions beyond the Space Station are to be explored in the second phase of the NASA initiative, Pathfinder. M.S.K.

A87-31208#
CLEANING UP OUR SPACE ACT
BRUCE FRISCH Aerospace America (ISSN 0740-722X), vol. 25, Feb. 1987, p. 10, 11.

Space operations have left a significant, and increasing amount, of small debris in orbital slots which are preferred for manned activities. Outgassed material and solid rocket propellant grains can abrade spacecraft windows and degrade optical sensors. A hypervelocity microscopic paint chip once left a 4 mm diam crater in an Orbiter window. Exploding final stages from the Delta and Ariane rockets have left thousands of small pieces in LEO. The number of particles multiplies as collisions occur. NORAD now tracks 6000 pieces of debris in LEO. The problem will be acute for Space Station astronauts in EVA, who will wear new spacesuits with more rigid, impact-resistant parts, and the Space Station, which will have a much larger cross section exposed to, e.g., screws travelling at 10 km/sc. M.S.K.

N87-10170*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SPACE STATION STRUCTURES AND ASSEMBLY VERIFICATION EXPERIMENT, SAVE
R. A. RUSSELL, J. P. RANEY, and L. J. DERYDER Aug. 1986 376 p
(NASA-TM-89004; NAS 1.15:89004) Avail: NTIS HC A17/MF A01 CSCL 22B

The Space Station structure has been baselined to be a 5 M (16.4 ft) erectable truss. This structure will provide the overall framework to attach laboratory modules and other systems, subsystems and utilities. The assembly of this structure represents a formidable EVA challenge. To validate this capability the Space Station Structures/Dynamics Technical Integration Panel (TIP) met to develop the necessary data for an integrated STS structures flight experiment. As a result of this meeting, the Langley Research Center initiated a joint Langley/Boeing Aerospace Company study which supported the structures/dynamics TIP in developing the preliminary definition and design of a 5 M erectable space station truss and the resources required for a proposed flight experiment. The purpose of the study was to: (1) devise methods of truss

assembly by astronauts; (2) define a specific test matrix for dynamic characterization; (3) identify instrumentation and data system requirements; (4) determine the power, propulsion and control requirements for the truss on-orbit for 3 years; (5) study the packaging of the experiment in the orbiter cargo bay; (6) prepare a preliminary cost estimate and schedule for the experiment; and (7) provide a list of potential follow-on experiments using the structure as a free flyer. The results of this three month study are presented. M.G.

N87-10265*# National Aeronautics and Space Administration, Washington, D.C.
LIDAR REMOTE SENSING FROM SPACE: NASA'S PLANS IN THE EARTH SCIENCES
R. J. CURRAN *In* NASA. Langley Research Center 13th International Laser Radar Conference 1 p Aug. 1986
Avail: NTIS HC A15/MF A01 CSCL 20E

A multidisciplinary study of the Earth System to provide a better understanding of the complex interrelated processes involved in the system, the Earth Observing System (EOS), is being developed. Capabilities of the Space Station, both the polar orbiting platform and the lower inclination platforms, will be used to accommodate a number of large active and/or passive sensors. Two lidar instruments being considered as part of the Eos payload are the Lidar Atmospheric Sounder and Altimeter (LASA) and the Laser Atmospheric Wind Sounder (LAWS). The LASA instrument is separable into two portions: the atmospheric sounder component and the retroranging component. The LASA atmospheric sounder will sample the spatial distribution of several atmospheric parameters. The retroranging component will be used to determine the precise three-dimensional position of specifically placed retro-reflectors and to sense how these retro-reflectors change position over monthly to yearly time periods. The LAWS utilizes a lidar system capable of measuring the Doppler shift in the backscattered intensity to determine the wind velocity profile. B.G.

N87-10774# Committee on Appropriations (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Department of Housing and Urban Development-Independent Agencies Appropriation Bill, 1987 p 64-70 1986
Avail: US Capitol, Senate Document Room

The appropriations for research, development, and procurement activities of NASA are discussed. B.G.

N87-10775# Committee on Science and Technology (U.S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, 1987
Washington GPO 1986 37 p An act, H.R. 5495, referred to the Committee on Commerce, Science and Transportation, 99th Congress, 2d Session, 30 Sep. 1986
Avail: US Capitol, House Document Room

Appropriations are discussed for research and development; space flight, control, and data communication; construction of facilities; and research and program management by NASA. B.G.

N87-10919# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. of Aeroelasticity.
EXPERIENCE ON THE OLYMPUS MODAL SURVEY TEST
M. KNORR and A. BERTRAM *In* ESA Proceedings of an International Conference on Spacecraft Structures p 247-252 Apr. 1986
Avail: NTIS HC A19/MF A01

A modal survey test (MST) on two configurations of the large structure test model of the Olympus communications satellite is described: A configuration with the main tanks 2/3 full, the second with empty tanks. The complete MSTs were finished within 4 weeks, including installation and strip down of the test equipment. The spacecraft was mounted on a 40 t seismic block. The satellite is characterized by large dimensions, mass, and complexity. This made it necessary to install a number of exciters and accelerometers at inaccessible structural points several months prior to testing. The test was performed using a computer-supported classical phase resonance method. The day-by-day data transfer via data tape enabled the customer to correlate measured and calculated eigenmodes immediately and to perform orthogonality checks at the end of a working day. ESA

N87-10922# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACECRAFT LOAD, DESIGN AND TEST PHILOSOPHIES
B. K. WADA *In* ESA Proceedings of an International Conference on Spacecraft Structures p 271-276 Apr. 1986
Avail: NTIS HC A19/MF A01

The development of spacecraft loads, design and test philosophies at the Jet Propulsion Laboratory (JPL) during the past 25 years is presented. Examples from the JPL's Viking, Voyager and Galileo spacecraft are used to explain the changes in philosophy necessary to meet the program requirements with a reduction in cost and schedule. Approaches to validate mathematical models of large structures which can't be ground tested as an overall system because of size and/or adverse effects of terrestrial conditions such as gravity are presented. ESA

N87-11640# Committee on Science and Technology (U.S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, 1987
Washington GPO 1986 251 p Report to accompany H.R. 5495 presented by the Committee on Science and Technology to the Committee of the Whole House on the State of the Union, 99th Congress, 2d Session, 16 Sep. 1986
(H-REPT-99-829; GPO-58-629) Avail: US Capitol, House Document Room

Authorization of appropriations to the National Aeronautics and Space Administration for the fiscal year 1987 for research and development; space flight, control, and data analysis; construction of facilities; and research and program management is discussed. B.G.

N87-11641# Committee on Commerce, Science, and Transportation (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION BILL, 1986
1986 26 p A bill, H.R. 5495, referred to the Committee on Science and Technology, 99th Congress, 2d Session, 10 Sep. 1986
(H-REPT-99-829) Avail: US Capitol, House Document Room

Authorized appropriations are summarized for the National Aeronautics and Space Administration for the following: permanently manned space station; space transportation capability development; physics and astronomy; life sciences; planetary exploration; solid earth observations; environmental observations; materials processing in space; communications; information systems; technology utilization; commercial use of space; transatmospheric research and technology; tracking and data advanced systems; space flight, control, and data communication; construction of facilities, including land acquisitions; and research and program management. B.G.

N87-11827*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN, CONSTRUCTION AND UTILIZATION OF A SPACE STATION ASSEMBLED FROM 5-METER ERECTABLE STRUTS
M. M. MIKULAS, JR. and H. G. BUSH Oct. 1986 40 p
(NASA-TM-89043; NAS 1.15:89043) Avail: NTIS HC A03/MF A01 CSCL 22B

Presented are the primary characteristics of the 5-meter erectable truss designated for the space station. The relatively large 5-meter truss dimension was chosen to provide a deep beam for high bending stiffness yet provide convenient mounting locations for space shuttle cargo bay size payloads which are 14.5 ft. (4.4 m) in diameter. Truss nodes and quick-attachment erectable joints

are described which provide for evolutionary three-dimensional growth and for simple maintenance and repair. A mobile remote manipulator system is described which is provided to assist in station construction and maintenance. A discussion is also presented of the construction of the space station and the associated EVA time. Author

N87-12402# Committee on Science and Technology (U.S. House).
HEARINGS BEFORE THE SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY, 99TH CONGRESS, 2ND SESSION, NO. 132, 25, 27 FEBRUARY; 11, 13, 20 MARCH; 9, 10 APRIL, 1986, VOLUME 2
1986 799 p
(GPO-61-777) Avail: US Capitol, House Document Room

The National Aeronautics and Space Administration fiscal year 1987 budget is examined. The impact of the loss of the Challenger and its crew on the space program is assessed. B.G.

N87-12574# Committee on Science and Technology (U.S. House).
NATIONAL COMMISSION ON SPACE REPORT
1986 76 p Hearing before the Subcommittee on Space Science and Applications of the Committee on Science and Technology, 99th Congress, 2d Session, No. 129, 22 Jul. 1986
(GPO-63-143) Avail: Subcommittee on Space Science and Applications

The National Commission on Space was established by Congress in 1984 to formulate a long range agenda for U.S. civilian space activity, so long range goals, opportunities, and policy options could be identified. The process which the Commission followed to arrive at its conclusions, what those conclusions were, as well as the alternatives that were considered are discussed. The objectives and the financial projection requested to achieve them are examined. B.G.

N87-12581*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY FLIGHT DYNAMIC EXPERIMENT
R. W. SCHOCK Washington May 1986 27 p
(NASA-TP-2598; NAS 1.60:2598) Avail: NTIS HC A03/MF A01 CSCL 10A

The purpose of the Solar Array Flight Dynamic Experiment (SAFDE) is to demonstrate the feasibility of on-orbit measurement and ground processing of large space structures dynamic characteristics. Test definition or verification provides the dynamic characteristic accuracy required for control systems use. An illumination/measurement system was developed to fly on space shuttle flight STS-31D. The system was designed to dynamically evaluate a large solar array called the Solar Array Flight Experiment (SAFE) that had been scheduled for this flight. The SAFDE system consisted of a set of laser diode illuminators, retroreflective targets, an intelligent star tracker receiver and the associated equipment to power, condition, and record the results. In six tests on STS-41D, data was successfully acquired from 18 retroreflector targets and ground processed, post flight, to define the solar array's dynamic characteristic. The flight experiment proved the viability of on-orbit test definition of large space structures dynamic characteristics. Future large space structures controllability should be greatly enhanced by this capability. Author

N87-15898# National Academy of Public Administration, Washington, D. C.
NASA: THE VISION AND THE REALITY
ERASMUS H. KLOMAN Oct. 1985 66 p
(OP-5) Avail: NTIS HC A04/MF A01

The complex of aspirations and national priorities lying behind the original vision of the civilian space program and how that program has fared in the real world of politics centering on Washington were explored. The programmatic evolution of NASA and some of the key administrative and management concepts developed to govern the operation of the agency were examined. In gathering information, both former and present NASA officials were interviewed as well as knowledgable individuals outside the agency. B.G.

N87-15908# Committee on Appropriations (U.S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Department of Housing and Urban Development, and Certain Independent Agencies Appropriations for Fiscal Year 1987, Part 2 p 985-1065 1986
Avail: Subcommittee of the Committee on Appropriations

The budget request, along with its necessary revisions, will assist in the initiation of procurement for a replacement orbiter and inertial upper-stage airborne support equipment. Also included are funds to augment activities directed toward resolution of space shuttle sytem anomalies and initiation of development of the Space Station. B.G.

N87-16018*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
FLIGHT DYNAMICS LABORATORY OVERVIEW
THADDEUS SANDFORD *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 41-65 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

The Flight Dynamics Laboratory (FDL) is one of four Air Force Wright Aeronautical Laboratories (AFWAL) and part of the Aeronautical Systems Division located at Wright-Patterson AFB, Ohio. The FDL is responsible for the planning and execution of research and development programs in the areas of structures and dynamics, flight controls, vehicle equipment/subsystems, and aeromechanics. Some of the areas being researched in the four FDL divisions are as follows: large space structures (LSS) materials and controls; advanced cockpit designs; bird-strike-tolerant windshields; and hypersonic interceptor system studies. Two of the FDL divisions are actively involved in programs that deal directly with LSS control/structures interaction: the Flight Controls Division and the Structures and Dynamics Division. Author

N87-16022*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF THE LENS ANTENNA DEPLOYMENT DEMONSTRATION (LADD) SHUTTLE-ATTACHED FLIGHT EXPERIMENT
H. HILL, D. JOHNSTON, and H. FRAUENBERGER (Grumman Aerospace Corp., Bethpage, N.Y.) *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 125-144 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 20N

The primary objective of the LADD Program is to develop a technology demonstration test article that can be used for both ground and flight tests to demonstrate the structural and mechanical feasibility and reliability of the single-axis roll-out space based radar (SBR) approach. As designed, the LADD will essentially be a generic strucutural experiment which incorporates all critical technology elements of the operational satellite and is applicable to a number of future antenna systems. However, to fully determine its design integrity for meeting the lens flatness and constant geometry requirements in a zero g environment under extreme thermal conditions, the LADD must be space flight tested. By accurately surveying the structure under varying conditions the membrane tolerance-holding capabilities of the structure will be demonstrated. The flight test will provide data to verify analytical tools used to predict thermal and structural behavior. Most important, the experiment will provide an initial indication of structural damping in a zero g vacuum environment. The recently completed Solar Array Flight Experiment (SAFE) showed orbital damping greater than that experienced during ground testing. From the experience and the information obtained from LADD it is hoped that designs can be confidently extrapolated to operational satellites with apertures in the 20 m by 60 m size range. Author

N87-16029*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COFS 1 RESEARCH OVERVIEW
G. C. HORNER *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 233-251 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22A

The Control of Flexible Structures (COFS) program is divided into three areas of research. These three areas are controls/structures analysis development, ground test experiments, and in-space experiments. The ground test experiments are intended to validate analyses and to confirm through hardware tests our technical readiness to successfully fly the Mast hardware. There is this close relation to the results of ground tests and analytical predictions that must be understood before flight experiments may be attempted. Details relative to each program area are given. Author

N87-16030*# Harris Corp., Palm Bay, Fla.
DESCRIPTION OF THE MAST FLIGHT SYSTEM
RONALD C. TALCOTT and JOHN W. SHIPLEY *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 253-263 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22A

The Mast Flight System is composed of several subsystems. Primary among these is the Deployable Mast Subsystem (DMS) which consists of a beam assembly and an associated mechanism for deploying and retracting the beam. The beam assembly is a joint dominated graphite epoxy and titanium truss as is expected of future large space structures. Integral to the beam assembly are actuators, sensors and associated electronics which are available for excitation and damping as desired by the experimenter. The beam structural characteristics can also be modified as desired by the experimenter using the Parameter Modification Device installed at the end of the beam. Data measured on the beam by the sensors and commands to the actuators are transmitted along the beam digitally at 150 Hz using a standard 1553 type bus. The Modular Distributed Information Sybsystem (MDIS) computer functions as bus master and ensures that all experimental data is saved for future analysis. The MDIS computer also performs a safing function to prevent inadvertent overexcitation of the beam. Finally, the Excitation and Damping Subsystem (EDS) computer is available to the experimenter for implementation of control algorithms or any other numerical operations as desired. Data from all system sensors can be accessed by the EDS computer. Author

N87-16033*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MAST FLIGHT SYSTEM OPERATIONS
M. LARRY BRUMFIELD *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 299-317 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 20K

The integration process of the MAST flight system is surveyed. Insight is given into the planned orbital experiment process. The data flow necessary to support the flight operation is outlined. Author

N87-16034*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COFS 1 GUEST INVESTIGATOR PROGRAM
ANTHONY FONTANA and ROBERT L. WRIGHT *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 319-325 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22A

The process for selecting guest investigators for participation in the Control of Flexible Structures (COFS)-1 program is described. Contracts and grants will be awarded in late CY87. A straw-man list of types of experiments and a distribution of the experiments has been defined to initiate definition of an experiments package which supports development and validation of control structures interaction technology. A schedule of guest investigator participation has been developed. Author

N87-16323*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
EXTENDABLE RETRACTABLE TELESCOPIC MAST FOR DEPLOYABLE STRUCTURES
M. SCHMID and M. AGUIRRE (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* NASA. Lewis Research Center The 20th Aerospace Mechanics Symposium p 13-29 May 1986
Avail: NTIS HC A14/MF A01 CSCL 22B

The Extendable and Retractable Mast (ERM) which is presently developed by Dornier in the frame of an ESA-contract, will be used to deploy and retract large foldable structures. The design is based on a telescopic carbon-fiber structure with high stiffness, strength and pointing accuracy. To verify the chosen design, a breadboard model of an ERM was built and tested under thermal vacuum (TV)-conditions. It is planned as a follow-on development to manufacture and test an Engineering Model Mast. The Engineering Model will be used to establish the basis for an ERM-family covering a wide range of requirements. Author

N87-16848*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESCRIPTION OF THE SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) FACILITY
JEFFREY P. WILLIAMS and ROSEMARY A. RALLO (Purdue Univ., West Lafayette, Ind.) Jan. 1987 45 p
(NASA-TM-89057; NAS 1.15:89057) Avail: NTIS HC A03/MF A01 CSCL 01C

A laboratory facility for the study of control laws for large flexible spacecraft is described. The facility fulfills the requirements of the Spacecraft Control Laboratory Experiment (SCOLE) design challenge for laboratory experiments, which will allow slew maneuvers and pointing operations. The structural apparatus is described in detail sufficient for modelling purposes. The sensor and actuator types and characteristics are described so that identification and control algorithms may be designed. The control implementation computer and real-time subroutines are also described. Author

N87-16927# Contraves Corp., Zurich (Switzerland). Space Dept.
DEVELOPMENT OF A 2.8 M OFFSET ANTENNA REFLECTOR USING INFLATABLE, SPACE-RIGIDIZED STRUCTURES TECHNOLOGY
M. C. BERNASCONI *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 31-37 Aug. 1986
Avail: NTIS HC A12/MF A01

Results of the mechanical tests of an offset reflector structure, based on the technology of chemically-rigidized membranes are presented. Folding, stowage, and deployment tests confirm the high packaging efficiency, as well as the controllability of the inflation process. Geometric measurements at different manufacturing stages were used to assess the quality of the surface; the typical surface deviation obtained is 0.9 mm rms. Folding and cure processes have a negligible impact on reflector quality. The packaging and deployment procedures were verified by a depolyment test in vacuum. ESA

N87-16928# Toshiba Research and Development Center, Kawasaki (Japan). Space Program Div.
STUDY ON SOLID SURFACE, DEPLOYABLE ANTENNA REFLECTOR
Y. TSUTSUMI, A. KASAHARA, Y. HISADA (National Space Development Agency, Ibaraki, Japan), and Y. ITOH *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 41-45 Aug. 1986
Avail: NTIS HC A12/MF A01

A study was carried out on the precision-contour solid surface, deployable reflector in the 20 to 30 GHz, center-fed Cassegrain antenna to be mounted on data relay and tracking satellites. Reflector sizes are 1.8 m stowed diameter and 5 m deployed diameter. As a solid surface deployable reflector to satisfy the

above requirements, two kinds of deployment concepts were developed. Based on the kinematic analysis results, preliminary design was carried out and a partial model was built to confirm the deployment kinematics. Deployment test results, using a partial model, show that two deployment concepts can be applied to the solid surface deployable reflector satisfying the requirements of a large ratio of deployed/stowed dimensions. ESA

N87-16933# Nippon Telegraph and Telephone Public Corp., Yokosuka (Japan).
DEVELOPMENT OF 30/20 GHZ SATELLITE ANTENNA STRUCTURES
M. MINOMO and T. YASAKA *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 85-90 Aug. 1986
Avail: NTIS HC A12/MF A01

An antenna structural design for a large capacity communication satellite using 13 beams in the 30/20GHz frequency bands is discussed. This design is to be utilized in developing a more cost effective domestic satellite communication system for Japan. This system requires 2 high precision deployable antennas with projected aperture diameters of 3.5m at 20GHz and 2.5m at 30GHz. The in-orbit demonstration will use the ETS-6 satellite. Based on experience in the development of spaceborne antennas for 30/20GHz bands (e.g., for the CS-2 and CS-3 satellites) activities in structural design of high precision deployable antennas show the truss reflector structure is promising for achieving required structural properties. ESA

N87-16935# Construcciones Aeronauticas S.A., Madrid (Spain). Space Div.
CONSTRUCCIONES AERONAUTICAS S.A. (CASA) LARGE REFLECTOR ANTENNA
J. ESCOBAR *In* ESA Proceedings of the Second ESA Workhop on Mechanical Technology for Antennas p 97-102 Aug. 1986 (Contract ESA-5277/82-NL-PP)
Avail: NTIS HC A12/MF A01

The development of a 11/14 GHz large reflector assembly is reviewed. Investigations on CFRP properties, their design and calculation methods, the development of the associated software, the gathering of a data base from tests at component level, and basic studies on the general configuration of antennas are outlined. A demonstration model to resolve the technological problems related with the design, manufacture and test of a large reflector was built. ESA

N87-16939# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DEVELOPMENT STATUS OF THE ERS-1 SAR ANTENNA
R. WAGNER, H. J. LUHMANN, R. SIPPEL, and M. WESTPHAL *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 131-137 Aug. 1986
Avail: NTIS HC A12/MF A01

A 10 m x 1 m planar array antenna for the ERS-1 satellite is described. It features metallized CFRP waveguides as radiating elements and feeding network components, CFRP sandwich reinforcements of the mechanical panels, a deployable truss structure, and mechanism for launch fixation, release, and deployment. Mechanical design of the antenna structure towards satisfactory dynamic properties in launch configuration within the narrow constraints of mass, volume, and mechanical loads; structural analysis of the stowed and deployment antenna, to determine dynamic properties, internal loads, and deformations; and design of the hold down and release mechanism arrangement of six hinged clamps for launch fixation, to be released via a system of springs and cables by a pyrotechnic device, are reviewed. ESA

N87-17152*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
FEATURES AND TECHNOLOGIES OF ERS-1 (ESA) AND X-SAR ANTENNAS
R. SCHUESSLER and R. WAGNER *In* JPL The Second Spaceborne Imaging Radar Symposium p 125-129 1 Dec. 1986
Avail: NTIS HC A10/MF A01 CSCL 09C

Features and technologies of planar waveguide array antennas developed for spaceborne microwave sensors are described. Such antennas are made from carbon fiber reinforced plastic (CFRP) employing special manufacturing and metallization techniques to achieve satisfactory electrical properties. Mechanical design enables deployable antenna structures necessary for satellite applications (e.g., ESA ERS-1). The slotted waveguide concept provides high aperture efficiency, good beamshaping capabilities, and low losses. These CFRP waveguide antennas feature low mass, high accuracy and stiffness, and can be operated within wide temperature ranges. Author

N87-17571*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE LARGE DEPLOYABLE REFLECTOR: A NASA SUBMILLIMETER-INFRARED ORBITING OBSERVATORY
PAUL N. SWANSON *In* ESA Proceedings of an ESA Workshop on a Spaceborne Submillimeter Astronomy Mission. A Cornerstone of the ESA Long Term Science Program p 265-276 Aug. 1986
Avail: NTIS HC A14/MF A01

The Large Deployable Reflector (LDR) concept is outlined. The LDR telescope is based on a 20-m diameter reflector. The primary mirror is a filled aperture made up of 84 hexagonal panels, each 2 m edge-to-edge. The panels are based on lightweight structural composite materials. The optical configuration is a four mirror two stage system. The primary mirror is passive. The active optical elements for figure control are at the quaternary mirror. The primary mirror panels are supported by a deployable PAC truss backup structure at the vertices of each hexagon. The four focal plane instruments covering the range of 30 to 1000 microns are located near the vertex of the primary mirror. Some instruments will be cooled with stored cryogens to liquid helium temperatures, others to liquid nitrogen temperatures. The spacecraft functions will be located in a resource module behind the primary mirror. The LDR will be transferred to orbit by the space transportation system and assembled and tested at the space station. It will then be boosted to an orbit of greater than or = 700 km as a free flyer. ESA

N87-17746*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MANNED MARS MISSION EARTH-TO-ORBIT (ETO) DELIVERY AND ORBIT ASSEMBLY OF THE MANNED MARS VEHICLE
B. BARISA and G. SOLMON *In its* Manned Mars Missions. Working Group Papers, Volume 1, Section 1-4 p 306-315 May 1986
Avail: NTIS HC A22/MF A01 CSCL 22A

The initial concepts developed for the in-orbit assembly of a Manned Mars Vehicle and for the Earth-to-Orbit (ETO) delivery of the required hardware and propellant are presented. Two (2) Mars vehicle concepts (all-propulsive and all-aerobrake) and two (2) ETO Vehicle concepts were investigated. Both Mars Vehicle concepts are described in Reference 1, and both ETO Vehicle concepts are described in Reference 2. The all-aerobrake configuration reduces the number of launches and time required to deliver the necessary hardware/propellent to orbit. Use of the larger of the 2 ETO Vehicles (HLLV) further reduces the number of launches and delivery time; however, this option requires a completely new vehicle and supporting facilities. Author

N87-17799*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
BUDGET AVAILABILITY
KELLEY J. CYR *In* NASA. Marshall Space Flight Center Manned Mars Mission. Working Group Papers, V. 2, Sect. 5, App. p 929-935 May 1986
Avail: NTIS HC A24/MF A01 CSCL 05C

A forecast of the total NASA budget required to achieve a manned mission to Mars at around the end of this century is described. A methodology is presented for projecting the major components of the NASA budget, including the NASA base, space flight, space station, Shuttle Derived Launch Vehicle, and the Manned Mars Mission. The NASA base, including administrative expenses, construction of facilities and research and development other than manned flight, is assumed to level off at the present (1985) level and remain constant at approximately $3.5 billion (constant fiscal year 1985 dollars). The budget for space flight, which consists of Shuttle research and development, operations, and tracking and data acquisition costs, is projected to decrease from approximately $4 billion in 1985 to just under $2.5 billion by 1989 and then level off. Planning profiles for three major programs are constructed: a permanently manned space station; a Shuttle Derived Vehicle; and a Manned Mars Mission. It is concluded that all of the programs can be conducted by the year 2002 with a 3 percent real growth rate in the NASA budget. Author

N87-17836*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE SCOLE DESIGN CHALLENGE
LARRY TAYLOR and A. V. BALAKRISHNAN (California Univ., Los Angeles) *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 385-412 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

An NASA program is discussed which was initiated to make direct comparisons of control laws for, first, a mathematical problem, than an experimental test article is being assembled under the cognizance of the Spacecraft Control Branch. The physical apparatus will consist of a softly supported dynamic model of an antenna attached to the Shuttle by a flexible beam. The control objective will include the task of directing the line of sight of the Shuttle/antenna configuration toward a fixed target, under conditions of noisy data, limited control authority and random disturbances. A workshop will be planned to discuss and compare results of the design challange. Author

N87-17837*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESCRIPTION OF THE SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) FACILITY
JEFFREY P. WILLIAMS and ROSEMARY A. RALLO *In its* Proceedings of the 3rd Annual SCOLE Workshop p 413-458 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

A laboratory facility for the study of control laws for large flexible spacecraft is described. The facility fulfills the requirements of the Spacecraft Control Laboratory Experiment (SCOLE) design challenge for a laboratory experiment, which will allow slew maneuvers and pointing operations. The structural apparatus is described in detail sufficient for modelling purposes. The sensor and actuator types and characteristics are described so that identification and control algorithms may be designed. The control implementation computer and real-time subroutines are also described. Author

N87-17846# Lawrence Livermore National Lab., Calif.
PRELIMINARY FINDINGS FOR INTEGRATED MODELING AND SIMULATION OF DIRECTED ENERGY WEAPONS
K. D. PIMENTEL, D. T. GAVEL, and J. W. ROBLEE 22 May 1986 8 p Presented at the 2nd European Simulation Congress, Antwerp, Belgium, 9 Sep. 1986
(Contract W-7405-ENG-48)
(DE86-011636; UCRL-93765; CONF-8609113-1) Avail: NTIS HC A02/MF A01

A preliminary study was recently completed at Lawrence Livermore National Laboratory of the issues important to the integrated modeling and simulation of future directed energy weapon (DEW) space platforms. The preliminary study comprised three parts: (1) a preliminary survey of existing computer codes used for integrated modeling and simulation; (2) work by a multidisciplinary team on a simple optical beam expander model to motivate cooperation in the three technical areas of space structures, optics, and control systems; and (3) identifying needs in integrated modeling and simulation for DEW systems. Results of this study indicate that much of the technology for end-to-end modeling and simulation of DEW space platforms may be in hand today. However, there may be critical needs in certain modeling and simulation areas, particularly in the package integration and computer/human interface areas, that are beyond the current state of the art to meet required levels of performance. DOE

N87-19310*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE LARGE DEPLOYABLE REFLECTOR (LDR) REPORT OF THE SCIENCE COORDINATION GROUP
1 Oct. 1986 109 p
(Contract NAS7-918)
(NASA-CR-180235; JPL-PUB-86-46; NAS 1.26:180235) Avail: NTIS HC A06/MF A01 CSCL 03A

The Large Deployable Reflector (LDR) is a telescope designed to carry out high-angular resolution, high-sensitivity observations at far-infrared and submillimeter wavelengths. The scientific rationale for the LDR is discussed in light of the recent Infrared Astronomical Satellite (IRAS) and Kuiper Airborne Observatory (KAO) results and the several new ground-based observatories planned for the late 1980s. The importance of high sensitivity and high angular resolution observations from space in the submillimeter region is stressed. The scientific and technical problems of using the LDR in a light bucket mode at approx. less than 5 microns and in designing the LDR as an unfilled aperture with subarcsecond resolution are also discussed. The need for an aperture as large as 20 m is established, along with the requirements of beam-shape stability, spatial chopping, thermal control, and surface figure stability. The instrument complement required to cover the wavelength-spectral resolution region of interest to the LDR is defined. Author

N87-20064*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE INTERACTION OF SMALL AND LARGE SPACECRAFT WITH THEIR ENVIRONMENT
URI SAMIR (Michigan Univ., Ann Arbor) and NOBIE H. STONE *In* JPL, Space Technology Plasma Issues in 2001 p 69-91 1 Oct. 1986 Prepared in cooperation with Tel-Aviv Univ., Israel
Avail: NTIS HC A20/MF A01 CSCL 20I

The most significant results from small scientific satellites and from the space shuttle mission STS-3 regarding body-plasma interactions are presented and discussed. The causes for the above information being meager and fragmentary are given. The research avenues to be followed in the future in order to correct this situation are mentioned, including practical ways to achieve this goal. Author

02

ANALYSIS AND DESIGN TECHNIQUES

Includes interactive techniques, computerized technology design and development programs, dynamic analysis techniques, environmental modeling, thermal modeling, and math modeling.

A87-10092
SPACE VEHICLE DESIGN [CONCEPTION DES VEHICULES SPATIAUX]
D. MARTY (CNES, Direction des Lanceurs, Evry, France) Paris, Masson, 1986, 666 p. In French. refs

A general overview of the main problems encountered in space vehicle design is presented in order to provide simple methods for the working out of preliminary projects, the comparison of architectures, and the verification of the feasibility of new systems. The discussion on satellites includes such topics as earth escape conditions, theoretical and real movement, orbit plane correction, and thermal control. Interplanetary vehicles are discussed with examinations of the influence sphere and orbit transfers. The performance, separation and jettisoning, and aerodynamics of conventional space launchers are then considered. Problems relating to reusable launch vehicles, ballistic missiles, the reentry body, and the Space Station are also discussed. Finally, a general discussion of the avionics, propulsion, and structural technology common to all space vehicles is presented, including instrumentation, energy sources, launcher guidance and attitude control, rocket engine thrust, and combustion. Also considered are propellants, engine characteristics, advanced propulsive systems, and structural materials and manufacturing. R.R.

A87-15196
EQUIPMENT DESIGNS FOR SPACE STATION EVA EXAMINED
Aerospace Engineering (ISSN 0736-2536), vol. 6, Aug. 1986, p. 11-14.

A survey of projected Space Station operational requirements has revealed that EVA is called for in 193 missions. A group of EVA suit requirements has been derived, and three generic EVA suit architectures, characterized as 'soft', 'hybrid' and 'hard', have been evaluated against these requirements. Study results indicate that the hard suit concept is the most promising of the three configurations. O.C.

A87-15819#
S BAND 3.5-M-DIAMETER FAN RIB TYPE DEPLOYABLE MESH ANTENNA FOR SATELLITE USE
T. ITANAMI, M. MINOMO, and I. OHTOMO (Nippon Telegraph and Telephone Public Corp., Electrical Communications Laboratories, Yokosuka, Japan) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p. refs
(IAF PAPER 86-28)

A design is presented for a satellite-borne S-band fan rib type deployable mesh antenna for the Japanese maritime satellite communication system. The system proposed here uses an offset Cassegrain antenna with a main reflector focal length of 2.5 m, a subreflector focal length of 450 mm, and a subreflector eccentricity of 2.5. The subreflector angular aperture, as determined by the current distribution method, is 48 degrees, which is about 40 percent larger than the aperture determined by geometrical optics without allowance for the finite aperture edge. The design provides a beam edge gain of more than 31 dB. Details of the structural, electrical, and thermal design of the antenna are examined. V.L.

A87-15893#
SOLAR ARRAY MECHANISMS FOR INDIAN SATELLITES, APPLE, IRS AND INSAT-IITS
S. DAS (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India) and I. SELVARAJ (Indian Space Research Organization, Satellite Centre, Bangalore, India) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 12 p.
(IAF PAPER 86-142)

Large-area rigid panel deployable and trackable solar arrays are widely used in the present day operational satellites. Three solar array mechanisms of this type for Indian spacecrafts are described, one of which has already undergone flight verification. The other two mechanisms are of higher complexity and are being readied for launch in the immediate future, as essential for providing the country's space services in communication and remote sensing fields. The design approach, test program and implications of test modeling towards achieving the design goal are discussed. Performance characteristics of the solar array mechanisms achieved after flight verification and qualification tests are also highlighted in the paper. Author

A87-17146#
HOPE FOR SIMULATING FLEXIBLE SPACECRAFT
R. GLUCK (TRW, Inc., Space and Technology Group, Redondo Beach, CA) Aerospace America (ISSN 0740-722X), vol. 24, Nov. 1986, p. 40-44.

The application of a custom architectured parallel processing system (CAPPS) to the simulation of a large angle maneuver of the Space Shuttle's remote manipulator system and power extension package, and to the despinning of a whirling flexible beam by torques are described. The CAPPS is fully digital and utilizes a large number of high-speed computational units (CUs); the design and operation of the system's CUs are examined. The system software consists of programs for: (1) deriving the equations of motion, (2) converting the equations to machine language for execution, and (3) of special algorithms for efficient parallel processing. Potential applications for CAPPS are discussed. I.F.

A87-21257#
SPACE STATION THRILLERS UNFOLD AT DRAPER LAB
DON EYLES (Charles Stark Draper Laboratory, Inc., Cambridge, MA) Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1986, p. 38-41.

The operational capabilities of a computer-graphics system designed for aiding operations in space (e.g., the recovery of a troubled spacecraft) are described. The visualization system will let the astronaut place his eye at any point of space and simulate space operations. The system will first create a dynamic scene based on the vectors and transformations that specify the real-world interrelationships between spacecraft and other objects. It then allows a number of points of view to be chosen within the overall scene. I.S.

A87-22363#
OPTIMAL STRUCTURAL DESIGN WITH CONTROL GAIN NORM CONSTRAINT
N. S. KHOT, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), H. OZ (Ohio State University, Columbus), R. V. GRANDHI (Wright State University, Dayton, OH), and F. E. EASTEP (Dayton, University, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 11 p. refs
(AIAA PAPER 87-0019)

A structure/control system optimization problem has been formulated with constraints on the closed-loop eigenvalue distribution, structural frequencies and the minimum Frobenious norm of the required control gains. A simultaneous optimization is suggested, where at each iteration control objective function is minimized first with the closed-loop eigenvalue constraints; and then structural optimization is performed to satisfy the constraints on the optimal control gain norm and structural frequencies. The feasibility of the approach is demonstrated on a 2-Bar truss structure. For each locally optimal design, response simulations

were done and control efforts were observed. Qualitative aspects of the optimal designs are also included. Author

A87-25978
ARCHITECTURE AND DESIGN PROCESS FOR COMPLEX SYSTEMS: SPACE STATION - A CASE STUDY
RICHARD T. LUKE (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: Aerospace Applications Conference, Steamboat Springs, CO, Feb. 1-8, 1986, Digest . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, 16 p.

The system architecture and design (A&D) process involves the identification of a set of mission objectives and the definition of detailed block diagrams for each element of a system that can accomplish said objectives. Attention is presently given to the distinct phases of A&D, drawing upon examples from recent NASA Space Station activities in general and the Station's communications system in particular; a specific segment of the communications system is presented to illustrate the application of the complete A&D process. It is noted that the risk associated with early freezing of baseline designs can be minimized by involving representatives from subsequent design phases in preceding ones. O.C.

A87-27617#
USE OF SUPPORT SIMULATION MODELING TECHNIQUES IN THE DEVELOPMENT OF LOGISTICS SUPPORT CONCEPTS FOR SDI ORBITAL PLATFORMS AND CONSTELLATIONS
RICHARD FLOWERREE, SCOTT BENSON, and MARK MCCRAY (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Space Logistics Symposium, 1st, Huntsville, AL, Mar. 24-26, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 103-115.
(AIAA PAPER 87-0690)

Simulation modeling techniques being applied to explore logistics support systems for SDI orbital platforms are described. The studies are targeted at optimizing the systems/subsystems redundancy levels, defining constellation servicing schedules, identifying appropriate man-tended servicing missions, and quantifying the reusable and consumable components necessary for ensuring a given level of system availability. Consideration is also being given to robotics in on-orbit maintenance, constellation regrouping/reconfiguration after engagement, and the ground-based support services necessary for given levels of space systems deployment and availability. War-game, design synthesis and space transportation models being used in the studies are summarized. Sample results are provided from the SAGITTAR experiment, a simulation of the fuel, orbital replacement units, and other consumables needed for a platform. M.S.K.

A87-28552
COMPARISON OF MULTIPLE INPUT RANDOM AND SINE EXCITATION METHODS FOR AEROSPACE STRUCTURES
DAVID L. HUNT (SDRC, Inc., San Diego, CA), BRUCE WENDLER, and SAM SOULE (TRW, Inc., Federal Systems Div., Redondo Beach, CA) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 1 . Schenectady, NY, Union College, 1986, p. 563-571.

The results of modal tests on a communication-satellite structure are reported, comparing the effectiveness of methods employing sine-dwell and multiple-input random-burst (MIRB) excitation. The data are presented in graphs, tables, and matrices and briefly characterized. MIRB excitation is shown to give mode shapes of quality equal to those obtained with sine-dwell excitation and to require significantly less testing and setup time. It is concluded that MIRB is the method of choice for lightly damped structures with moderate mode density and coupling, whereas sine-dwell excitation is preferable for verification testing or when modal-response/force-level changes are being investigated. T.K.

A87-31121#
SOFTWARE ARCHITECTURE FOR MANUFACTURING AND SPACE ROBOTICS
J. S. ALBUS, R. LUMIA, and H. MCCAIN (NBS, Robot Systems Div., Gaithersburg, MD) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 11 p. refs
(AIAA PAPER 87-1687)

A hierarchical architecture is described which supports Space Station telerobots in a variety of modes. The system is divided into three hierarchies: task decomposition, world model, and sensor processing. Goals at each level of the task decomposition hierarchy are divided both spatially and temporally into simpler commands for the next lower level. This decomposition is repeated until, at the lowest level, the drive signals to the robot actuators are generated. To accomplish its goals, task decomposition modules must often use information stored in the world model. The purpose of the sensory system is to update the world model as rapidly as possible to keep the model in registration with the physical world. This paper describes the architecture of the entire control system hierarchy and how it can be applied to space telerobot applications. Author

N87-10418 Iowa State Univ. of Science and Technology, Ames.
APPLICATION OF GRAPH THEORY TO THE NONLINEAR ANALYSIS OF LARGE SPACE STRUCTURES Ph.D. Thesis
M. I. HINDAWY 1986 100 p
Avail: Univ. Microfilms Order No. DA8615055

A new graph representation of nonlinear large space structures is introduced. During the loading process the structural graph changes its levels as the nonlinear regions in the large space structure change configuration. This variable structured graph is used to order the nodes and members of the discretized nonlinear structural model. A new algorithm is used to change the established order of the nonlinear model and updates the condensed nonlinear stiffness matrix equation for the structure. In addition to accounting for structural nonlinearities the algorithm can take into consideration plastic hinge formation and fracture of members in large space structures. Dissert. Abstr.

N87-10894# Engineering System International, Rungis (France).
EQUIVALENT CONTINUUM ANALYSES OF LARGE SPACE TRUSSES
E. HAUG, P. DOWLATYARI, and J. DUBOIS *In* ESA Proceedings of an International Conference on Spacecraft Structures p 57-65 Apr. 1986
(Contract ESTEC-5209/82-NL-PB(SC))
Avail: NTIS HC A19/MF A01

The techniques of discrete field methods, conventional equivalent continua, and micropolar equivalent continua are introduced, and their usefulness for the calculation of large space structures and their ease of numerical implementation are assessed. An example of a large space truss was run on the computer, using the full model, and several equivalent continuum finite element models. The full and equivalent continuum models of the chosen realistic sample space truss are loaded statically with mechanical load cases characteristic of orbital transfer conditions and with thermal gradients which might arise in operating conditions. Dynamic behavior is studied by extracting vibration frequencies and mode shapes. Results suggest that it is better to channel development efforts into an integrated sandwich finite element, uniting anisotropic membrane skins and an anisotropic brick or thick shell core into one element. This type of element is likely to be useful as an equivalent continuum finite element for most practical space trusses. ESA

N87-11761*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

IDEAS: A MULTIDISCIPLINARY COMPUTER-AIDED CONCEPTUAL DESIGN SYSTEM FOR SPACECRAFT

M. J. FEREBEE, JR. *In its* Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 21 p 1984

Avail: NTIS HC A22/MF A01 CSCL 22B

During the conceptual development of advanced aerospace vehicles, many compromises must be considered to balance economy and performance of the total system. Subsystem tradeoffs may need to be made in order to satisfy system-sensitive attributes. Due to the increasingly complex nature of aerospace systems, these trade studies have become more difficult and time-consuming to complete and involve interactions of ever-larger numbers of subsystems, components, and performance parameters. The current advances of computer-aided synthesis, modeling and analysis techniques have greatly helped in the evaluation of competing design concepts. Langley Research Center's Space Systems Division is currently engaged in trade studies for a variety of systems which include advanced ground-launched space transportation systems, space-based orbital transfer vehicles, large space antenna concepts and space stations. The need for engineering analysis tools to aid in the rapid synthesis and evaluation of spacecraft has led to the development of the Interactive Design and Evaluation of Advanced Spacecraft (IDEAS) computer-aided design system. The ADEAS system has been used to perform trade studies of competing technologies and requirements in order to pinpoint possible beneficial areas for research and development. IDEAS is presented as a multidisciplinary tool for the analysis of advanced space systems. Capabilities range from model generation and structural and thermal analysis to subsystem synthesis and performance analysis.

Author

N87-11762*# TRW Defense and Space Systems Group, Redondo Beach, Calif.

MICROCOMPUTER DESIGN AND ANALYSIS OF THE CABLE CATENARY LARGE SPACE ANTENNA SYSTEM

W. AKLE *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 14 p 1984

Avail: NTIS HC A22/MF A01 CSCL 20K

The use of microcomputers in the design of a cable catenary large space antenna system is discussed. The development of a system design capability, data base utilization, systems integration, program structure and logic, and integrated graphics output are discussed.

R.J.F.

N87-13626# MATRA Espace, Toulouse (France).

STUDY OF FREQUENCY SELECTIVE SYSTEMS. PART 1: PRELIMINARY INVESTMENTS ON SHAPES AND LATTICES; SOFTWARE DEVELOPMENTS. PART 2: INTERFACING OF POLITECNICO FSS PROGRAMS WITH MATRA REFLECTOR ANTENNA SOFTWARE. PART 3: APPLICATION TO MACS PHASE 2 TX ANTENNA (MATRA)

P. G. MANTICA, R. TASCONE, R. ORTA, and R. ZICH Paris, France ESA Dec. 1985 230 p Prepared in cooperation with Politechnico di Torino, Italy, and Satcom International, Toulouse, France

(Contract ESA-5279/82-F-RD(SC))

(ANT/NTEA/04.85; DE/GE/006.85; ESA-CR(P)-2271; ETN-86-98140) Avail: NTIS HC A11/MF A01

The impact of frequency selective surfaces (FSS) on an offset Cassegrain satellite antenna comprising one solid main reflector, two dichroic subreflectors, and the feed clusters was assessed. Patch shapes and lattices were studied in order to develop FSS software. The FSS programs were interfaced with reflector antenna software. The complete package was applied to the MACS phase 2 TX antenna. Results show that the software can analyze any common FSS configuration with all necessary details: single or multigrid periodic structures (conductive patches) inserted in a sandwich of dielectric layers. The link with reflector antenna software allows an accurate prediction of overall antenna performance. Analysis reveals cross-polarization limitations in offset configuration, and phase shifts in dual-grid configuration with a wide range of incidence angles. This leads to a depointing of the beam radiated by the antenna. To compensate, two solutions appear feasible: either repoint the whole antenna, or vary the spacing between the two grids with respect to the incidence angles.

ESA

N87-14059*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE IDENTIFICATION OF A DISTRIBUTED PARAMETER MODEL FOR A FLEXIBLE STRUCTURE

H. T. BANKS (Brown Univ., Providence, R. I.), S. S. GATES (Draper (Charles Stark) Lab., Inc., Cambridge, Mass.), I. G. ROSEN (University of Southern California, Los Angeles.), and Y. WANG Oct. 1986 44 p

(Contract NAS1-17070; NAS1-18107; NAG1-517; NSF MCS-85-04316; AF-AFOSR-84-0398; AF-AFOSR-84-0393)

(NASA-CR-178199; ICASE-86-71; NAS 1.26:178199) Avail: NTIS HC A03/MF A01 CSCL 72B

A computational method is developed for the estimation of parameters in a distributed model for a flexible structure. The structure we consider (part of the RPL experiment) consists of a cantilevered beam with a thruster and linear accelerometer at the free end. The thruster is fed by a pressurized hose whose horizontal motion effects the transverse vibration of the beam. The Euler-Bernoulli theory is used to model the vibration of the beam and treat the hose-thruster assembly as a lumped or point mass-dashpot-spring system at the tip. Using measurements of linear acceleration at the tip, it is estimated that the parameters (mass, stiffness, damping) and a Voight-Kelvin viscoelastic structural damping parameter for the beam using a least squares fit to the data. Spline based approximations to the hybrid (coupled ordinary and partial differential equations) system are considered; theoretical convergence results and numerical studies with both simulation and actual experimental data obtained from the structure are presented and discussed.

Author

N87-14370# Air Force Academy, Colo.

MMU (MANNED MANEUVERING UNIT) TASK SIMULATOR Final Report, Jun. 1985 - Jan. 1986

S. ALFANO 15 Jan. 1986 80 p

(AD-A169552; USAFA-TR-86-2) Avail: NTIS HC A05/MF A01 CSCL 22A

Described are simplified mathematical models of the Manned Maneuvering Unit (MMU) used in the USAFA Proximity Operations Simulator for the VAX 11/780 and the Evans and Sutherland PS 300 computers. This simulator serves as a learning aid for cadets studying orbital dynamics and MMU mission planning and as a research platform for the Department of Astronautics. The Manned Maneuvering Unit (MMU) Proximity Operations Simulator is a nine degrees-of-freedom trajectory integrator (six degrees of freedom for the MMU and three degrees of freedom for the target) which generates digital and graphical data to describe relative motion of the MMU and a free-flying target. This motion is obtained by applying the Clohessy-Wiltshire equations for terminal rendezvous/docking with the Earth modeled as a uniform sphere and aerodynamic forces ignored. MMU position relative to target is computed by a first-order Euler integrator which uses quaternions to define the rotational state. The target is modeled as a Space Transportation System (STS) Orbiter. The MMU is treated as a rigid body whose mass properties (gross wt., moments and products of inertia, and center of gravity location) are set within the porgram and remain constant.

GRA

N87-16042*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTER-AIDED DESIGN AND DISTRIBUTED SYSTEM TECHNOLOGY DEVELOPMENT FOR LARGE SPACE STRUCTURES
ERNEST S. ARMSTRONG and SURESH M. JOSHI *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 441-456 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

Proposed large space structures have many characteristics that make them difficult to analyze and control. They are highly flexible, with components mathematically modeled by partial differential equations or very large systems of ordinary differential equations. They have many resonant frequencies, typically low and closely spaced. Natural damping may be low and/or improperly modeled. Coupled with stringent operational requirements of orientation, shape control, and vibration suppression, and the inability to perform adequate ground testing, these characteristics present an unconventional identification and control design problem to the systems theorist. Some of the research underway within Langley's Spacecraft Control Branch, Guidance and Control Division aimed at developing theory and algorithms to treat large space structures systems identification and control problems is described. The research areas to be considered are computer-aided design algorithms, and systems identification and control of distributed systems. Author

N87-16058# American Society of Civil Engineers, New York.
IDENTIFICATION OF LARGE SPACE STRUCTURES ON ORBIT Final Report, Sep. 1985 - Aug. 1986
EUGENE DENMAN, TIMOTHY HASSELMAN, C. T. SUN, JER-NAN JUANG, and JOHN JUNKINS Sep. 1986 356 p
(Contract F04611-85-C-0092)
(AD-A173756; AFRPL-TR-86-054) Avail: NTIS HC A16/MF A01 CSCL 22A

The aspects of state of the practice modeling and identification of large space structures are discussed in this report. Methods of modeling a structures as well as identification procedures are presented along with data acquisition and processing requirements. Recommendations for developing algorithms for the task of space structure identification are given. GRA

N87-16322*# Messerschmitt-Boelkow-Blohm/Entwicklungspring Nord, Bremen (West Germany).
DESIGN AND DEVELOPMENT OF A TELESCOPIC AXIAL BOOM
ROLAND FELKAI *In* NASA. Lewis Research Center The 20th Aerospace Mechanics Symposium p 1-12 May 1986
Avail: NTIS HC A14/MF A01 CSCL 22B

A special telescopic boom has been design-optimized, developed and qualified to carry an S-band antenna for the German Telecommunication Satellite is discussed. The design driver requirements, the alternatives investigated, the final technical solution, the tests performed, and special problem areas encountered during its development are discussed. Author

N87-16925# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
EXPERIENCE GAINED BY SECTOR MODEL TESTING OF AN UNFURLABLE MESH/RIB ANTENNA
H. HEINZE, H. HERBIG, and H. VORBRUGG *In* ESA Proceedings of the Second ESA Workhop on Mechanical Technology for Antennas p 17-22 Aug. 1986
(Contract ESTEC-5206/82-NL-PB(SC))
Avail: NTIS HC A12/MF A01

An unfurlable offset mesh antenna for communication satellite applications in the range 850 MHz to 12 GHz was designed. The reflector design concept should cover aperture diameters from 3.2 (12 GHz) to 12 m (850 MHz) with surface errors between 0.1 mm and 1.4 mm RMS. This versatility is met by a radial rib concept where foldable main ribs and intermediate ribs tension a gold plated molybdenum mesh to the required surface contour. The accuracy is varied by applying a different number of ribs (e.g., 16 for 850 MHz or 30 for 12 GHz) and mesh fastening points (so-called stand-offs). Tests with a two rib test model prove that the deployment and retraction system is reliable and that the mesh provides the required reflector surface. The configuration of the mesh is suitable in a range of frequencies up to 12 GHz. With the right mesh tension there are no passive intermodulation products. ESA

N87-16934# Spar Aerospace Ltd., Ste-Anne-de-Bellevue (Quebec).
DESIGN OF A LOW DISTORTION SHARED APERTURE REFLECTOR
L. DONATO and V. K. JHA *In* ESA Proceedings of the Second ESA Workhop on Mechanical Technology for Antennas p 91-96 Aug. 1986
(Contract CAN-DEPT-COMM-21ST-36100-3-031)
Avail: NTIS HC A12/MF A01

A design concept for a low thermal distortion dual gridded shared aperture reflector for satellite antennas is proposed. Low distortion characteristics result in improved on-orbit gain performance of the antenna system. The absence of an intercostal structure between reflectors improves electrical cross polar and gain performance. A finite difference model to predict temperatures of the reflector assembly was generated. From the temperature profiles a finite element model was used to evaluate the distortions of the parabolic surfaces. From the distorted best fit surfaces, pointing errors, defocussing, and rms deviation from the best fit parabola were evaluated and compared to thermal distortions of previous designs. The results show a significant improvement. ESA

N87-17828*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FINITE ELEMENT MODEL OF SCOLE LABORATORY CONFIGURATION
BETH LEE, JEFFREY P. WILLIAMS, and DEAN SPARKS *In its* Proceedings of the 3rd Annual SCOLE Workshop p 149-162 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

The Spacecraft Control Laboratory Experiment (SCOLE) is defined by element properties: material constants; mast, reflector, rigid links as beam elements; cable as bar element; and space shuttle as very stiff beam. Two boundary conditions are modeled: suspended (6 degrees of freedom for all joints except the top of the cable) and cantilevered cables (shuttle platform fixed in all degrees of freedon). Calculations include stiffness and mass matrices, initial stresses, static displacements and reactions, and eigensolutions. B.G.

N87-20066*# Systems Science and Software, La Jolla, Calif.
A UNIFIED APPROACH TO COMPUTER ANALYSIS AND MODELING OF SPACECRAFT ENVIRONMENTAL INTERACTIONS
I. KATZ, M. J. MANDELL, and J. J. CASSIDY *In* JPL, Space Technology Plasma Issues in 2001 p 113-125 1 Oct. 1986
Avail: NTIS HC A20/MF A01 CSCL 22B

A new, coordinated, unified approach to the development of spacecraft plasma interaction models is proposed. The objective is to eliminate the unnecessary duplicative work in order to allow researchers to concentrate on the scientific aspects. By streamlining the developmental process, the interchange between theories and experimentalists is enhanced, and the transfer of technology to the spacecraft engineering community is faster. This approach is called the UNIfied Spacecraft Interaction Model (UNISIM). UNISIM is a coordinated system of software, hardware, and specifications. It is a tool for modeling and analyzing spacecraft interactions. It will be used to design experiments, to interpret results of experiments, and to aid in future spacecraft design. It breaks a Spacecraft Ineraction analysis into several modules. Each module will perform an analysis for some physical process, using phenomenology and algorithms which are well documented and have been subject to review. This system and its characteristics are discussed. E.R.

03

STRUCTURAL CONCEPTS

Includes erectable structures (joints, struts, and columns), deployable platforms and booms, solar sail, deployable reflectors, space fabrication techniques, and protrusion processing.

A87-11842* Lockheed Missiles and Space Co., Sunnyvale, Calif.
DEVELOPMENT OF SPACE STATION STRUT DESIGN
R. R. JOHNSON, R. M. BLUCK, A. M. C. HOLMES, and M. H. KURAL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) SAMPE Quarterly (ISSN 0036-0821), vol. 17, July 1986, p. 1-9.
(Contract NAS1-17660)

Candidate Space Station struts exhibiting high stiffness (38-40 msi modulus of elasticity) were manufactured and experimentally evaluated. One and two inch diameter aluminum-clad evaluation specimens were manufactured using a unique dry fiber resin injection process. Preliminary tests were performed on strut elements having 80 percent high-modulus graphite epoxy and 20 percent aluminum. Performed tests included modulus of elasticity, thermal cycling, and coefficient of thermal expansion. The paper describes the design approach, including an analytical assessment of strut thermal deformation behavior. The major thrust of this paper is the manufacturing process which produces aluminum-clad struts with precisely controlled properties which can be fine-tuned after fabrication. An impact test and evaluation procedure for evaluating toughness is described. Author

A87-15929#
A NEW STRUCTURE TOWARD HIGH PRECISION LARGE ANTENNA
T. YASAKA, M. MINOMO, and K. OHATA (Nippon Telegraph and Telephone Public Corp., Electrical Communications Laboratories, Yokosuka, Japan) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 10 p.
(IAF PAPER 86-201)

A new structure for a large precision antenna is considered, and the concept is demonstrated. This structure copes with the problems related to distortion assessment with increasing flexibility under 1 G, and to thermal deformation suppression over large areas with limited structural mass and volume. In the structure, near-zero truss elements are assembled to a base structure from which a thin paraboloidal shell is supported by a number of support elements with adjustment capability. The structural model of the truss-shell reflectors were fabricated, and tests showed that they possessed the desired structural properties. C.D.

A87-15930*# Astro Aerospace Corp., Carpinteria, Calif.
STRUCTURAL CONCEPTS FOR LARGE SOLAR CONCENTRATORS
J. M. HEDGEPETH (Astro Aerospace Corp., Carpinteria, CA) and R. K. MILLER (Southern California, University, Los Angeles, CA) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 11 p. refs
(Contract NAS1-17536)
(IAF PAPER 86-202)

Solar collectors for space use are examined, including both early designs and current concepts. In particular, attention is given to stiff sandwich panels and aluminum dishes as well as inflated and umbrella-type membrane configurations. The Sunflower concentrator is described as an example of a high-efficiency collector. It is concluded that stiff reflector panels are most likely to provide the long-term consistent accuracy necessary for low-orbit operation. A new configuration consisting of a Pactruss backup structure, with identical panels installed after deployment in space, is presented. It is estimated that concentration ratios in excess of 2000 can be achieved with this concept. V.L.

A87-15933#
DEVELOPMENT OF A 'HINGELESS MAST' AND ITS APPLICATIONS
T. KITAMURA, K. OKAZAKI, S. SATO (Japan Aircraft Manufacturing Co., Ltd., Yokohama), M.. NATORI, K. MIURA (Tokyo, University, Japan) et al. IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 7 p. refs
(IAF PAPER 86-205)

An evaluation is made of the design features and space applications of an extendible mast whose stowage mode involves very compact helical geometry coiling. This 'Hingeless Mast' concept yields structural accuracy and weight properties that are judged superior to those of the more conventional 'simplex' mast, and is composed of flexible longerons, integral radial spacers, and triangulating wires. O.C.

A87-15934#
CONCEPT OF TENSION ACTIVATED CABLE LATTICE ANTENNA
K. MIURA (Tokyo, University, Japan) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 10 p.
(IAF PAPER 86-206)

A new concept of a three-dimensional, integrated cable lattice system which can meet a variety of requirements concerning facet sizing and arrangement is presented. The geometric modelling of the lattice, the boundary restraints, the reflector surface deviation, and the electromagnetic behavior of the tension truss antenna are discussed. The primary feature of the antenna is that its shape is uniquely determined by the member lengths and their arrangement, and not by the equilibrium of forces. C.D.

A87-16145#
OPTIMIZATION OF A TRUSS MEMBER
D. S. LEONARD (Iowa State University of Science and Technology, Ames) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p. refs
(IAF PAPER ST-86-17)

The present study involves the determination of the shape of a truss-type pin jointed member for which the buckling strength to weight ratio is maximized. From an analytical study using the ANSYS finite element code it was determined that a hollow cylindrical shell with varying cross section should be used. To keep the weight of the member to a minimum, an open lattice construction was chosen. For the lattice structure, an additional advantage was attained by using uniaxial graphite-epoxy material in the design. Author

A87-18243
2D-ARRAY MISSION - TWO-DIMENSIONALLY DEPLOYABLE SOLAR CELL ARRAY MISSION
K. MIURA, A. USHIROKAWA, M. NATORI, and M. SAKAMAKI (Tokyo, University, Japan) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 363-368.

The main purposes of the 2D-Array mission are the verification in space of the effectiveness of tension-stabilized large space structures which are absolutely necessary for future space development of solar power generation using large thin solar cells. The array consists of a large area of solar-cell blanket and a circumferential rim made of several extendible masts which supports the blanket through tension wires and fixtures. The blanket is deployed and stowed through the two-dimensional deployment of a plane surface. Author

A87-18321
TRUNCATION ERROR ESTIMATION OF A SPACECRAFT MODEL WITH A FLEXIBLE APPENDAGE
T. KAI and Y. OHKAMI (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 957-962. refs

A mathematical model expanded with constrained and unconstrained modes is presented for a control experimental model which is composed of a rigid part and an elastic part and is freely rotatable around one axis. Frequency response functions of the angle of rotation with respect to the control torque about the axis are derived. Zeros and poles of these functions are calculated and the differences between the two mode systems are shown for several inertial ratios of the rigid part to the elastic part. Author

A87-18489
ON THE ORBITER BASED DEPLOYMENT OF FLEXIBLE MEMBERS
A. K. MISRA, D. M. XU (McGill University, Montreal, Canada), V. J. MODI (British Columbia, University, Vancouver, Canada; Tokyo, University, Japan), and A. M. IBRAHIM IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 601-616. refs
(Contract NSERC-67-1547)
(AAS PAPER 85-673)

Using relatively general formulation procedures, the paper attempts to study complex interactions between deployment, attitude dynamics and flexural rigidity for two distinct configurations representing deployment of beam and tether type appendages from the Orbiter. The study suggests that under critical combinations of parameters the systems can become unstable. The results have some relevance to the next generation of communications satellites with large flexible beam type booms and solar panels as well as deployment and retrieval of tethered subsatellite systems. Author

A87-18495
OPTIMAL CONTROL OF COMPONENT DEPLOYMENT FOR THE SPACE RADIOTELESCOPE SYSTEM
W. STUIVER (Hawaii, University, Honolulu) IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 679-684.
(AAS PAPER 85-683)

Earlier work (Stuiver et al., 1981, and Stuiver, 1985) on the construction and deployment of a very large space-based radiotelescope for SET1 is extended. The configuration would consist of a self-contained, fully automated antenna system made up of free-floating components. The large spherical reflecting receiver dish would be backed up by an even larger, nominally planar, shield to block electromagnetic radiation. It has been postulated that because of their high area-to-mass ratios the dish and shield would be fabricated at or near GEO altitude and moved by solar sailing to the point of operation. D.H.

A87-20148
BEHAVIOURAL ANALYSIS OF ADHESIVE-BONDED STRUCTURAL JOINTS IN SPACE VEHICLES
J.-P. MAIGRET and M. MARTIN (Aerospatiele, Saint-Medard-en-Jalles, France) International Journal of Adhesion and Adhesives (ISSN 0143-7496), vol. 6, Oct. 1986, p. 189-198. refs.

In space structures, the design of adhesive-bonded joints generally involves a very low safety ratio. This requires careful choice of the criteria applied to account for external factors (mechanical, static and dynamic, and thermal effects). The situation is complicated by the behavior of the materials involved, particularly composites, which undergo large distortions, and whose fracture criteria depend on load cycles. In addition, polymerization effects in joints between different materials, such as metals and composites, must also be taken into account. In this paper a calculation tool is presented for bonded structures, and procedures for the accurate determination of the mechanical properties of adhesive materials are given. Author

A87-22395#
OPTIMIZATION OF A TRUSS MEMBER
DANIEL SHANE LEONARD (Iowa State University of Science and Technology, Ames) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. refs
(AIAA PAPER 87-0073)

In designing large space structures for space application, weight must be minimized. Such large structures are envisioned as an assembly of pin jointed truss-type members designed to withstand predetermined compressive and tensile loads. Since buckling is of primary concern it is desirable to maximize the buckling strength to weight ratio for such members. The present study involves the determination of the shape of a truss-type pin jointed member for which the buckling strength to weight ratio is maximized. From an analytical study using the ANSYS finite element code it was determined that a hollow cylindrical shell with varying cross section should be used. To keep the weight of the member to a minimum, an open lattice construction was chosen. For the lattice structure, an additional advantage was attained by using uniaxial graphite-epoxy material in the design. Once designed the optimal truss member was laid up over a plaster mandrel, intertwining the axial and ring elements. A finite elements analysis was then completed for the truss member for comparison with the experimental outcome. Author

A87-28882* Cincinnati Univ., Ohio.
SHEAR DEFORMATION PLATE CONTINUA OF LARGE DOUBLE LAYERED SPACE STRUCTURES
MOHAMED SAMIR HEFZY and ADNAN H. NAYFEH (Cincinnati, University, OH) International Journal of Solids and Structures (ISSN 0020-7683), vol. 22, no. 12, 1986, p. 1455-1469. refs
(Contract NSG-1185)

A simple method is presented to model large rigid-jointed lattice structures as continuous elastic media with couple stresses using energy equivalence. In the analysis, the transition from the discrete system to the continuous media is achieved by expanding the displacements and the rotations of the nodal points in a Taylor series about a suitable chosen origin. The strain energy of the continuous media with couple stresses is then specialized to obtain shear deformation plate continua. Equivalent continua for single layered grids, double layered grids, and three-dimensional lattices are then obtained. Author

A87-31175#
OPTIMIZATION OF EQUIVALENT PERIODIC TRUSS STRUCTURES
M. LAJCZOK (Martin Marietta Corp., Denver, CO) AIAA Journal (ISSN 0001-1452), vol. 25, March 1987, p. 502-504.

Equivalent modeling is presently used in conjunction with simple calculations to optimize a struss structure of cantilever type having ten bays. This approach, which deepens insight into the relative performance of tubular member and solid member truss structures could be extended to more complex structures, given sufficient care in the selection of equivalent models. Attention is given to a comparison of the Bernoulli-Euler and Timoshenko beam approaches. O.C.

N87-10923# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT OF DEPLOYABLE TRUSS CONCEPT FOR SPACE STATION
H. S. GREENBERG (Rockwell International Corp., Downey, Calif.) and E. E. ENGLER *In* ESA Proceedings of an International Conference on Spacecraft Structures p 277-282 Apr. 1986
Avail: NTIS HC A19/MF A01

A single-fold, automatically deployable and retractable, square-shaped truss concept that is a candidate for the strongback of NASA's Space Station was developed. Compact stowage within

a square-shaped housing is achieved by using folded longerons and telescoping diagonal members. Deployment or retraction is accomplished, bay by bay, in a controlled manner with root strength maintained at all times. Control is accomplished by motor-driven jack-screws operated by a controller. Power, data, and fluid utility lines can be integrated onto trays that unfold with the truss. To verify performance a kinematically representative ground test article version is used. ESA

N87-10927# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France).
DEVELOPMENT OF A LIGHTENED STRUCTURE FOR THE GSR3 SOLAR GENERATOR [DEVELOPPEMENT D'UNE STRUCTURE ALLEGEE DE GENERATEUR SOLAIRE GSR3]
A. PLAGNE and J. P. REAU *In* ESA Proceedings of an International Conference on Spacecraft Structures p 299-304 Apr. 1986 In FRENCH
Avail: NTIS HC A19/MF A01

Weight reduction techniques employed in the GSR3 solar generator (35W/kg end of life) are described. The surface mass of the structure is 900 to 1050 g/sqm depending on the degree of optimization of stacking points. The structure is highly versatile, and can be used fully or partly deployed. Carbon fiber composite was chosen to meet weight and sizing constraints. ESA

N87-14366*# Harris Corp., Melbourne, Fla.
DEVELOPMENT OF THE 15 METER DIAMETER HOOP COLUMN ANTENNA Final Report
Washington NASA Dec. 1986 161 p
(Contract NAS1-15763)
(NASA-CR-4038; NAS 1.26:4038) Avail: NTIS HC A08/MF A01 CSCL 22B

The building of a deployable 15-meter engineering model of the 100 meter antenna based on the point-design of an earlier task of this contract, complete with an RF-capable surface is described. The 15 meter diameter was selected so that the model could be tested in existing manufacturing, near-field RF, thermal vacuum, and structural dynamics facilities. The antenna was designed with four offset paraboloidal reflector surfaces with a focal length of 366.85 in and a primary surface accuracy goal of .069 in rms. Surface adjustment capability was provided by manually resetting the length of 96 surface control cords which emanated from the lower column extremity. A detailed description of the 15-meter Hoop/Column Antenna, major subassemblies, and a history of its fabrication, assembly, deployment testing, and verification measurements are given. The deviation for one aperture surface (except the outboard extremity) was measured after adjustments in follow-on tests at the Martin Marietta Near-field Facility to be .061 in; thus the primary surface goal was achieved. Author

N87-14373* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
FOLDABLE SELF-ERECTING JOINT Patent
T. E. PELISCHEK, inventor (to NASA) 7 Oct. 1986 8 p Filed 9 Mar. 1984 Supersedes N84-32424 (22 - 22, p 3542)
(NASA-CASE-MSC-20635-1; US-PATENT-4,615,637; US-PATENT-APPL-SN-588039; US-PATENT-CLASS-403-85; US-PATENT-CLASS-403-102; US-PATENT-CLASS-403-119; US-PATENT-CLASS-403-146; US-PATENT-CLASS-403-163; US-PATENT-CLASS-16-294; US-PATENT-CLASS-16-370) Avail: US Patent and Trademark Office CSCL 22B

The invention relates to a foldable self erecting joint which may be used to deploy the tetratruss frame of the proposed shuttle launched triangular space station. The frame must be folded into the payload bay of the space shuttle orbiter. To deploy the frame the tubes are automatically unfolded and once in position should remain safely. A pair of hinged, tubular members in which the hinging is located at corresponding portions of the members are used. The opposite edge portions are connected by spring-based toggle links which in the unfolded position of the members are nested against one of the members in substantial alignment and over-center for securely locking the joint in the unfolded position. Official Gazette of the US Patent and Trademark Office

N87-16031*# Harris Corp., Palm Bay, Fla.
MAST FLIGHT SYSTEM BEAM STRUCTURE AND BEAM STRUCTURAL PERFORMANCE
DAVID C. LENZI and JOHN W. SHIPLEY *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 265-279 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 20K

An overall understanding of the beam assembly and data with which potential experimenters can begin to conduct analyses relevant to their experiments is given. Data is given on the beam structural concept, the tip remote station layout, the intermediate remote station layout with and without actuators, beam element materials, equivalent beam characteristics, beam element properties, remote station mass properties, and MAST Flight System modal characteristics. R.J.F.

N87-16055# McIntosh Structural Dynamics, Inc., Palo Alto, Calif.
INVESTIGATION OF INTERACTIVE STRUCTURAL AND CONTROLLER SYNTHESIS FOR LARGE SPACECRAFT Final Report, 1 Mar. 1984 - 30 Oct. 1985
SAMUEL C. MCINTOSH, JR. and MICHEL A. FLOYD 22 Jan. 1986 45 p Prepared in cooperation with Integrated Systems, Inc.
(Contract F49620-84-C-0025)
(AD-A172811; TR-86-1; AFOSR-86-0900TR) Avail: NTIS HC A03/MF A01 CSCL 22B

A technique is developed for least-weight optimal design of a tubular-truss space structure, subject to constraints on its natural frequencies and its open-loop disturbance-rejection properties. The disturbance-rejection properties of the structure are measured by disturbance-to-regulated-variable grammians. It is shown how this technique can be embedded in a model-reduction scheme based on internal balancing. Examples treated include a simple dumbell model and csdl model no. 1. Author (GRA)

N87-16870*# Astro Aerospace Corp., Carpinteria, Calif.
EVALUATION OF PACTRUSS DESIGN CHARACTERISTICS CRITICAL TO SPACE STATION PRIMARY STRUCTURE Final Report
JOHN M. HEDGEPETH 20 Feb. 1987 74 p
(Contract NAS1-17536)
(NASA-CR-178171; NAS 1.26:178171; AAC-TN-1147-REV-A)
Avail: NTIS HC A04/MF A01 CSCL 22A

Several aspects of the possible application of the Pactruss concept to the primary truss structure of the space station are investigated. Estimates are made of the loads and hinge moments in deploying diagonal members as full deployment is approached. Included are the effects of beam columning and compliance of the surrounding structure. Requirements for joint design are suggested and a two-stage mid-diagonal latching hinge concept is described or analyzed. The problems with providing the experimental and theoretical tools needed for assuring reliable synchronous deployment are discussed and a first attempt at high-fidelity analytical simulation with NASTRAN is described. An alternative construction scenario in which the entire dual-keel truss structure is deployed as a single Shuttle payload is suggested. Author

N87-16931# Turin Univ. (Italy). Dipt. di Elettronica.
DIELECTRIC SUPPORT STRUCTURES FOR SPACECRAFT ANTENNA FEEDS
R. D. GRAGLIA, M. OREFICE, U. PONZI (Rome Univ., Italy), and S. SGUBINI *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 63-71 Aug. 1986
Avail: NTIS HC A12/MF A01

Analysis and design criteria for radio frequency transparent towers, to be used as support structures of feeds or subreflector in spacecraft reflector antennas are discussed. Candidate materials are fiber reinforced plastics, in particular those with good

mechanical and dielectric properties, as aramid fiber (Kevlar). The electromagnetic analysis is performed by subdividing the structure in simple members (planes, cylinders, etc.) and considering each individual contribution to the scattering. Typical structures for offset and symmetrical configurations were considered, and design criteria are given. ESA

N87-16938# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
GIOTTO SPACECRAFT HIGH GAIN ANTENNA MECHANICAL DESIGN AND DEVELOPMENT
R. HALM, F. FELICI, H. J. SCHOEDEL (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany), and H. RAUPP *In its* Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas (date) p 123-126 Aug. 1986
Avail: NTIS HC A12/MF A01

The development approach of the Giotto spacecraft high gain antenna structure is presented. The antenna structure consists of a dynamically and statically balanced offset parabolic reflector and a tripod support structure for the S/X-band feed. The reflector dish is a sandwich construction having CFRP face sheets employing ultra high module fibers bonded to an aluminum honeycomb core. The tripod is designed to provide the required eigenfrequencies by stiff profiles made of CFRP. ESA

04

STRUCTURAL AND THERMAL ANALYSIS

Includes structural analysis and design, thermal analysis and design, analysis and design techniques, and thermal control systems.

A87-15197
CONTROLLING WASTE HEAT IN MILITARY SPACECRAFT
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, Aug. 1986, p. 23-29.

The purpose of a spacecraft thermal management system (TMS) is to gather waste heat and reject it from the vehicle; attention is presently given to the anticipated compounding of already severe military space platform TMS requirements by the incorporation of a high pulsed power heat rejection capability. An evaluation is conducted of several TMS configurations that appear promising; the capillary pumped-loop type being noteworthy. Also noted are radiator systems and TMSs incorporating heat storage media. O.C.

A87-15936#
NONLINEAR EFFECTS IN THERMAL CONDUCTION PROBLEMS OF LARGE SPACE STRUCTURES
P. SANTINI (Roma, Universita, Rome, Italy) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 12 p.
(IAF PAPER 86-208)

Some of the most important nonlinearities affecting the thermal behavior of space structures are considered and discussed. The basic equations for a single member are written, and the complete system in steady condition is described. Several methods of numerical solutions are considered (successive approximations; artificial unsteady; Newton Raphson), and the relevant relative merits are analyzed. Typical examples on a simple structure are carried out, and final conclusions are drawn. Author

A87-15939#
STRESS AND DEFORMATION ANALYSIS OF THERMALLY LOADED LIGHT WEIGHT COMPOSITE STRUCTURES
K. PFEIFER and J. BODE (Messerschmitt-Boelkow-Blohm GmbH, Muenich, West Germany) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 16 p.
(IAF PAPER 86-212)

The effect of thermally induced deformations and stresses on the dimensional stability of fiber composite structures is discussed with particular reference to the reflector shells of a space antenna consisting of two Kevlar/Nomex sandwich shells approximately 1100 mm in diameter, their edges connected by a Kevlar/glass ring. The rear shell is fixed at the satellite by a conical carbon fiber composite cylinder and stiffened by four Kevlar/Nomex ribs. A finite-element model is used to determine the contour changes due to different Young's moduli and thermal expansion coefficients of the core. V.L.

A87-18266
THE INFLUENCE OF INTERSTITIAL MEDIA ON SPACECRAFT THERMAL CONTROL
L. S. FLETCHER (Texas A & M University, College Station) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 527-532. refs

Thermal control is of significant importance in the design and operation of most aerospace systems. The importance of thermal protection systems and the concern for energy efficiency suggest the need for more reliable knowledge of energy transfer across metallic junctions with and without interstitial media. This paper discusses recent investigations of thermal contact conductance involving both gaseous and nongaseous interstitial media in terms of thermal enhancement and thermal isolation characteristics. Author

A87-18273
DEGRADATION OF SPACECRAFT THERMAL SHIELD MATERIALS BY IRRADIATION OF ENERGETIC PARTICLES
M. KOITABASHI, S. SHIMOJI, T. IMAMURA, J. ENOMOTO (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan), H. KIMURA (Mitsubishi Electric Corp., Kamakura Works, Japan) et al. IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 577-582. refs

For studying the effect of the space radiation environment on silver-teflon and aluminized kapton films, the irradiations of electrons and of protons simultaneously with ultraviolet rays were performed on these films in a high vacuum condition. The solar absorptance, thermal emittance, tensile strength, and elongation rate were measured. Silver-teflon was degraded more than aluminumized kapton. The electron irradiation affected mostly the mechanical property, while the proton irradiation affected the thermooptical property. The electron irradiation created many more small molecules in the teflon film than the proton irradiation, and the double bonds between carbon atoms increased with the fluences. Author

A87-18487* Virginia Polytechnic Inst. and State Univ., Blacksburg.
PARAMETER IDENTIFICATION IN DISTRIBUTED SPACECRAFT STRUCTURES
L. MEIROVITCH and M. A. NORRIS (Virginia Polytechnic Institute and State University, Blacksburg) IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 573-586. refs
(Contract NAG1-225)
(AAS PAPER 85-670)

This paper develops a new technique for the identification of parameters in distributed systems. The technique is based on the finite element method. An an illustration, the method is applied to

the identification of the mass and stiffness distributions of a space structure, simulated by a nonuniform free-free beam. Author

A87-18940*# California Univ., Los Angeles.
ALTERNATIVE APPROXIMATION CONCEPTS FOR SPACE FRAME SYNTHESIS
R. V. LUST and L. A. SCHMIT (California, University, Los Angeles) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 333-348) AIAA Journal (ISSN 0001-1452), vol. 24, Oct. 1986, p. 1676-1684. Previously cited in issue 13, p. 1853, Accession no. A85-30265. refs
(Contract NSG-1490)

A87-20082#
EFFECTS OF THERMAL CYCLING ON THE MECHANICAL AND PHYSICAL PROPERTIES OF A SPACE QUALIFIED EPOXY ADHESIVE
J. A. SANBORN and D. E. MOREL, JR. (Harris Corp., Government Systems Sector, Melbourne, FL) IN: Reinforced Plastics/Composites Institute, Annual Conference, 41st, Atlanta, GA, January 27-31, 1986, Preprint . Lancaster, PA, Technomic Publishing Co., 1986, 5 p.

Structural adhesives used for space applications must be able to survive large temperature fluctuations while maintaining their mechanical strength. This paper describes a series of experiments performed to document property degradation of EA 956 epoxy due to temperature extremes experienced in the orbital environment. Testing included tension, lap shear, coefficient of thermal expansion (CTE) and differential scanning calorimetry (DSC). CTE data indicate that the exact value of strength decrease depends strongly on temperature; three distinct regions are observed when sample strain is plotted as a function of temperature with the CTE increasing with increasing temperature. DSC traces on as cast and thermally cycled samples show that thermal cycling produces a change in the physical structure of the resin resulting in a significant increase in the glass transition temperature of the network. Author

A87-20247
AN EXPLICIT EXPRESSION FOR THE TANGENT-STIFFNESS OF A FINITELY DEFORMED 3-D BEAM AND ITS USE IN THE ANALYSIS OF SPACE FRAMES
K. KONDOH, K. TANAKA, and S. N. ATLURI (Georgia Institute of Technology, Atlanta) Computers and Structures (ISSN 0045-7949), vol. 24, no. 2, 1986, p. 253-271. refs
(Contract F33615-83-K-3205; AF-AFOSR-84-0020A)

Simplified procedures for finite-deformation analyses of space frames, using one beam element to model each member of the frame, are presented. Each element can undergo three-dimensional, arbitrarily large, rigid motions as well as moderately large nonrigid rotations. Each element can withstand three moments and three forces. The nonlinear bending-stretching coupling in each element is accounted for. By obtaining exact solutions to the approximate governing differential equations, an explicit expression for the tangent-stiffness matrix of each element, valid at any stage during a wide range of finite deformations, is derived. An arc-length method is used to incrementally compute the large-deformation behavior of space frames. Author

A87-22814
EFFICIENT OPTIMIZATION OF SPACE TRUSSES
HOJJAT ADELI (Ohio State University, Columbus) and OSAMA KAMAL Computers and Structures (ISSN 0045-7949), vol. 24, no. 3, 1986, p. 501-511. refs

An efficient and robust algorithm is developed for minimum weight design of space trusses with fixed geometry employing the general geometric programming (GGP) technique. The nonlinear programming (NLP) problem is formulated based on the virtual work method of structural analysis. The objective function is linear, subjected to linear size and stress constraints and nonlinear displacement constraints. Based on an arbitrary starting point, the signomials are condensed into posynomials and subsequently into monomials. Next, the monomials are linearized through logarithmic transformation. The resulting linear programming (LP) problem is solved iteratively using a dual simplex algorithm until the optimal feasible solution eventually coincides with a local optimum of the approximated problem. This solution point is then used to formulate a new approximated problem and the same procedure is automatically repeated until the solution of the original problem is found. Five examples are presented to illustrate the application of the algorithm presented in this paper. Author

A87-25687*# Old Dominion Univ., Norfolk, Va.
FINITE-ELEMENT THERMAL-STRUCTURAL ANALYSES OF A CABLE-STIFFENED ORBITING ANTENNA
EARL A. THORTON, PRAMOTE DECHAUMPHAI (Old Dominion University, Norfolk, VA), and AJAY E. PANDEY (Virginia Polytechnic Institute and State University, Blacksburg) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 1, p. 308-315) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Nov.-Dec. 1986, p. 620-624. USAF-NASA-supported research. Previously cited in issue 13, p. 1894, Accession no. A85-30262. refs

A87-28577
SUBSTRUCTURE COUPLING OF ANALYTICAL AND TEST MODELS FOR AN EXPERIMENTAL STRUCTURE
FRANCOIS CHARRON, VIRENDRA K. JHA, HELENE LAPIERRE, STEPHEN J. SOROCKY (Spar Aerospace, Ltd., Toronto, Canada), and FRANK R. VIGNERON (CDG, Communications Research Centre, Ottawa, Canada) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 2 . Schenectady, NY, Union College, 1986, p. 1463-1470. refs

Substructure coupling as a means of synthesizing the structural model for a large structure is demonstrated. An experimental satellite structure consisting of two substructures was built and tested. Substructure experimental and analytical models were generated and coupled by using SYSTAN software. The synthesized results were compared with the NASTRAN and test results of the complete structure. Results showed that modes of the coupled structure sensitive to clamped boundary conditions between substructures were better synthesized by using analytical substructure models, while those sensitive to certain asymmetries in substructure material properties were synthesized by using the test derived model for the substructure. Author

A87-30296#
BUCKLING AND NONLINEAR RESPONSE OF IMPERFECT THREE-LEGGED TRUSS COLUMNS
DOV ELYADA (Raphael Armament Development Authority, Haifa, Israel) and CHARLES D. BABCOCK (California Institute of Technology, Pasadena) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 495-501) AIAA Journal (ISSN 0001-1452), vol. 25, Feb. 1987, p. 324-330. Research supported by the California Institute of Technology. Previously cited in issue 18, p. 2656, Accession no. A86-38854. refs

A87-31213#
THERMAL CONTROL SYSTEMS FOR SPACECRAFT INSTRUMENTATION
G. P. PETERSON (Texas A & M University, College Station) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Jan.-Feb. 1987, p. 7-13. Previously cited in issue 14, p. 1982, Accession no. A83-32736. refs

A87-31225*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACECRAFT STRUCTURAL MODEL IMPROVEMENT BY MODAL TEST RESULTS
J.-C. CHEN, L. F. PERETTI, and J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 478-489) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Jan.-Feb. 1987, p. 90-94. Previously cited in issue 13, p. 1847, Accession no. A84-31737. refs
(Contract NAS7-918)

N87-10406*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
A TAYLOR-GALERKIN FINITE ELEMENT ALGORITHM FOR TRANSIENT NONLINEAR THERMAL-STRUCTURAL ANALYSIS
Progress Report, period ending 1 Jan. 1986
E. A. THORNTON and P. DECHAUMPHAI Apr. 1986 12 p Previously announced in IAA as A86-38823
(Contract NSG-1321)
(NASA-CR-177064; NAS 1.26:177064) Avail: NTIS HC A02/MF A01 CSCL 20K

A Taylor-Galerkin finite element method for solving large, nonlinear thermal-structural problems is presented. The algorithm is formulated for coupled transient and uncoupled quasistatic thermal-structural problems. Vectorizing strategies ensure computational efficiency. Two applications demonstrate the validity of the approach for analyzing transient and quasistatic thermal-structural problems. Author

N87-10890# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Mechanical Systems Div.
DESIGN AND VERIFICATION ACTIVITIES AND REQUIREMENTS FOR SPACECRAFT STRUCTURES
C. STAVRINIDIS *In* ESA Proceedings of an International Conference on Spacecraft Structures p 27-33 Apr. 1986
Avail: NTIS HC A19/MF A01

The scope and associated cost related with spacecraft structures design and verification are discussed. These depend on such factors as the geometrical dimensions of the spacecraft, weight criticality and the degree of dynamic interaction of the spacecraft with the launch vehicle. For large complex spacecraft which often have significant dynamic interaction with the launch vehicle, structural design and verification usually require a combination of analysis, development testing, and qualification testing. ESA

N87-10895# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Structural Mechanics.
ANALYSIS OF LONG THIN-WALLED TUBES
B. GEIER and A. K. RATH (Indian Space Research Organization, Trivandrum) *In* ESA Proceedings of an International Conference on Spacecraft Structures p 67-72 Apr. 1986
Avail: NTIS HC A19/MF A01

Analysis of thin walled composite tubes for large space structures under buckling loads is discussed. Material law, nonlinear theory of anisotropic shells, computation of fundamental states, and computation of buckling loads are considered. ESA

N87-10907# Centre National d'Etudes Spatiales, Toulouse (France).
PREDICTION AND CORRELATION OF STRUCTURAL RESPONSE IN ACOUSTIC CHAMBERS [PREVISION ET CORRELATION DE LA REPONSE DE STRUCTURES EN CHAMBRE ACOUSTIQUE]
F. MERCIER and H. DEFOSSE *In* ESA Proceedings of an International Conference on Spacecraft Structures p 151-156 Apr. 1986 In FRENCH
Avail: NTIS HC A19/MF A01

Vibro-acoustic prediction methods in random noise used for acoustic coupling analysis of large satellites are described. The first method is for low frequencies, using modal superposition. The second is a high frequency method using a statistical energy method via a comparison of calculations and tests of a honeycomb panel. Using both methods, the response throughout the entire acoustic frequency range can be calculated. ESA

N87-10910# Technische Hochschule, Aachen (West Germany). Inst. fuer Leichtbau.
TRANSIENT EXTERNAL LOADS OR INTERFACE FORCES RECONSTRUCTED FROM STRUCTURAL RESPONSE MEASUREMENTS
H. OERY, H. GLASER, and D. HOLZDEPPE *In* ESA Proceedings of an International Conference on Spacecraft Structures p 171-177 Apr. 1986 Sponsored by Deutsche Forschungsgemeinschaft and MBB GmbH
Avail: NTIS HC A19/MF A01

The procedure for the reconstruction of transient forcing functions based on measured structural responses during former flights is described, i.e., the inverse problem of the dynamic response is investigated. The method is developed on the basis of the combination and inversion of the phase-plane-method, which delivers modal responses and the Williams method, which separates the pure dynamic and the quasistatic parts of structural responses. Criteria influencing the reconstruction of the impulsive active load and its time-history are discussed. For a spacecraft transported by a launcher the interface motion time-history must be defined. ESA

N87-10911# Kassel Univ. (West Germany).
STRUCTURAL SYSTEM IDENTIFICATION USING SINGLE AND MULTIAXIAL VIBRATION TEST DATA
M. LINK *In* ESA Proceedings of an International Conference on Spacecraft Structures p 179-184 Apr. 1986
Avail: NTIS HC A19/MF A01

A method allowing for the verification of the mathematical model of a structure in terms of its modal data and in terms of its physical mass, stiffness, and damping matrix is presented. Single and multiaxial shaking table excitation and the effect of incomplete excitation and response data, i.e., the effect that only a limited number of modes may be excited are stressed. The numerical results of a study using a mathematical spacecraft model for simulating test data from shaking table excitation are presented. ESA

N87-10912# Spar Aerospace Ltd., Ste-Anne-de-Bellevue (Quebec).
DEMONSTRATION OF MODAL SYNTHESIS ON AN EXPERIMENTAL STRUCTURE AND ITS APPLICATION TO LARGE SPACECRAFT
F. CHARRON, V. L. JHA, H. LAPIERRE, S. J. SOROCKY, and F. R. VIGNERON (Department of Communications, Ottawa, Ontario) *In* ESA Proceedings of an International Conference on Spacecraft Structures p 185-190 Apr. 1986
Avail: NTIS HC A19/MF A01

A substructural coupling method is demonstrated on an experimental structure. This method is used to compute the modal parameters of the structure. The substructures are defined using the modal parameters (natural frequencies, mode shapes and modal masses) measured from a modal survey or computed from a finite element model. Application of substructure coupling methods to large spacecraft is described. Results show

inaccuracies (error in the natural frequency computation, inability to compute some modes) for the system results. ESA

N87-10917# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
INITIAL RESULTS FROM MULTIAXES TRANSIENT TESTING
K. ECKHARDT *In* ESA Proceedings of an International Conference on Spacecraft Structures p 233-239 Apr. 1986
Avail: NTIS HC A19/MF A01

The qualification testing of spacecraft structures is considered and a methodology in which the various verification steps merge to a series of closely coordinated experimental and analytical activities is proposed. The concept means introducing multiaxes transient testing using hydraulic vibration systems for earthquake simulation to replace conventional single-axes sine testing on electrodynamic shakers. The idea is to cope with large flexible spacecraft structures and to realize a more realistic simulation of loads by imposing transient base excitation with up to six degrees of freedom simultaneously in order to achieve the correct load vector (phase information). It is demonstrated that the required environment can be simulated with sufficient accuracy. Results of the comparison of detailed test responses with applicable responses measured in a shaker test using only axial transient input are presented. ESA

N87-10924# Saab-Scania, Linkoping (Sweden).
TELE-X ANTENNA MODULE STRUCTURE QUALIFICATION PROGRAM
T. ANDERSSON *In* ESA Proceedings of an International Conference on Spacecraft Structures p 283-288 Apr. 1986
Avail: NTIS HC A19/MF A01

The qualification program for the TELE-X Spacecraft Antenna Module Structure is presented. The CFRP structure is adapted to a Cassegrain system with extreme thermal stability requirements. Requirements constraining the design and the qualification program to verify the structure ability to meet these requirements are described. Analysis models used and experience from test predictions and model correlations are presented. ESA

N87-10926# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LOADS ANALYSIS FOR THE GALILEO SPACECRAFT
M. TRUBERT *In* ESA Proceedings of an International Conference on Spacecraft Structures p 293-298 Apr. 1986
Avail: NTIS HC A19/MF A01

The loads analysis for the design of the Galileo structure was done by combining the transient analysis method with methods aimed at reducing cost and schedule impact while increasing confidence in the estimation of the loads. The preliminary sizing was done by the mass acceleration curve. The loads iterations were done by the generalized shock spectra method. Only a few critical subsystems required a coupled transient analysis to show positive margins. Dynamic coupling between the launch vehicle and the spacecraft was done by analytically removing and adding a spacecraft to a given launch vehicle at the modal level, without re-solving the eigenvalue problem. The modal response resulting from the dynamic coupling between the launch vehicle and the spacecraft was used only for the 28 Galileo modes below 40 Hz. In the absence of definition of the Shuttle/Centaur model and the forcing functions above 40 Hz, the mass acceleration curve was used to generate modal bounds between 40 and 80 Hz. ESA

N87-10928# Royal Netherlands Aircraft Factories Fokker, Amsterdam. Space Div.
ENGINEERING AND SOFTWARE INTERFACING FOR THERMAL, STRUCTURAL AND ATTITUDE CONTROL RELATED WITH SPACECRAFT
J. J. WIJKER, H. GEYSELAERS, and A. C. M. VANSWIETEN *In* ESA Proceedings of an International Conference on Spacecraft Structures p 305-313 Apr. 1986
(Contract ESTEC-5158/82-NL-PB(SC))
Avail: NTIS HC A19/MF A01

The engineering and software interfaces between the finite element package ASKA, the dynamic and control analysis package DCAP, and the thermal analysis program SINDA are presented. The engineering background of interface programs IFDCAP and SINAS is discussed. ESA

N87-11832# British Aerospace Public Ltd. Co., Bristol (England). Space and Communications Div.
A STUDY OF LARGE SPACE STRUCTURES
N. FOSTER 5 Jul. 1982 45 p
(LR46869; ETN-86-97949) Avail: NTIS HC A03/MF A01

The structural design requirements for a large space structure are identified. The preferred structural model is the tetrahedral truss, capable of being deployed automatically or constructed using the Shuttle remote manipulator system. Preliminary analysis was performed to show how such a structure could be modelled to determine the structural characteristics. Aspects for investigation of the structural modelling are identified, including joint stiffness, thermal stability, manufacturing tolerances, deployment dynamics and dynamic interaction. ESA

N87-11966*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMAL ANALYSIS OF RADIOMETER CONTAINERS FOR THE 122M HOOP COLUMN ANTENNA CONCEPT
L. A. DILLON-TOWNES Sep. 1986 54 p
(NASA-TM-89026; NAS 1.15:89026) Avail: NTIS HC A04/MF A01 CSCL 20D

A thermal analysis was conducted for the 122 Meter Hoop Column Antenna (HCA) Radiometer electronic package containers. The HCA radiometer containers were modeled using the computer aided graphics program, ANVIL 4000, and thermally simulated using two thermal programs, TRASYS and MITAS. The results of the analysis provided relationships between the absorptance-emittance ratio and the average surface temperature of the orbiting radiometer containers. These relationships can be used to specify the surface properties, absorptance and reflectance, of the radiometer containers. This is an initial effort in determining the passive thermal protection needs for the 122 m HCA radiometer containers. Several recommendations are provided which expand this effort so specific passive and active thermal protection systems can be defined and designed. Author

N87-12596# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
COMPARISON OF METHODS FOR THE CALCULATION OF THERMAL CONTACT RESISTANCE OF THE FIRST BRAZILIAN SATELLITE M.S. Thesis, 6 Dec. 1985 [COMPARACAO DE METODOS PARA O CALCULO DA RESISTENCIA TERMICA DE CONTATOS DO PRIMEIRO SATELITE BRASILEIRO]
M. B. H. MANTELLI Apr. 1986 105 p In PORTUGUESE; ENGLISH summary
(INPE-3864-TDL/217) Avail: NTIS HC A06/MF A01

A comparative study of the methods developed for the calculation of thermal contact resistance between two surfaces submitted to a perpendicular heat flux is presented. Several factors affecting this resistance are analyzed and a brief historical review of the works in this field is made, spotting the methods of interest for spacial applications. These are compared to experimental data so as to establish the most proper method for the couplings of the first Brazilian satellite. Author

N87-13484# Engineering System International, Rungis (France).
APPLICATION OF DYNAMIC ELEMENTS AND CONTINUUM METHODS TO LARGE SPACE STRUCTURES, VOLUME 1 Final Report
A. BOSSAVIT, J. CLINCKEMAILLIE, E. HAUG, J. DUBOIS, DOWLATYARI, and Y. OUALI Paris, France ESA Dec. 1985 214 p
(Contract ESTEC-5209/82-NL-PB(SC))
(ED/82-362/RD-VOL-1; ESA-CR(P)-2217-VOL-1; ETN-86-98150)
Avail: Issuing Activity

Methods for the analysis of complex and large structures are reviewed. Classical numerical approaches are analyzed (Ritz methods, weighted residuals, boundary integrals) and substitute continuum and reduction methods are considered. The continuum methods are evaluated for application to a large space truss. It is concluded that lower order continua (for example: equivalent finite elements) form a sufficiently accurate basis for practical representations of large space trusses. Improved equivalent finite elements are identified and are recommended. ESA

N87-15264# Texas A&M Univ., College Station. Mechanics and Materials Center.
A MODEL FOR PREDICTING THERMOMECHANICAL RESPONSE OF LARGE SPACE STRUCTURES Final Technical Report, Apr. 1983 - May 1986
D. H. ALLEN and W. E. HAISLER Jul. 1986 286 p
(Contract F49620-83-C-0067)
(AD-A172966; MM-4875-86-16; AFOSR-86-0884TR) Avail: NTIS HC A13/MF A01 CSCL 13M

A report on predictions of the thermomechanical response of large space structures contains the following: Summary of Completed Research, Literature Survey, Selection of Constitutive Equations, Coupled Energy Balance Law, Space Structural Response Algorithms, Model Results for Large Space Structures; Publications List; A Prediction of Heat Generation in a Thermoviscoplastic Uniaxial Bar, An Efficient and Accurate Alternative to Subincrementation for Elastic Plastic Analysis by the Finite Element Method, Predicted Axial Temperature Gradient in A Viscoplastic Uniaxial Bar Due to Thermomechanical Coupling, Predicted Temperature Field in a Thermomechanically Heated Viscoplastic Space Truss Structure, Effect of Degradation of Material Properties on the Dynamic Response of Large Space Structures, A Fractographic Study of Damage Mechanisms in Short-Fiber Metal Matrix Composites, Analytical and Numerical Solution of a Time Dependent Thermoviscoplastic Problem in Mechanics, A Finite Element Model for the Thermoelastic Analysis of Large Composite Space Structures, and Predicted Dynamic Response of a Composite Beam with Load History Dependent and Spatially Variable Damage. GRA

N87-16021*# General Dynamics Corp., San Diego, Calif. Space Systems Div.
DEPLOYABLE TRUSS STRUCTURE ADVANCED TECHNOLOGY
J. E. DYER and M. P. DUDECK *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 111-124 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

The 5-meter technology antenna program demonstrated the overall feasibility of integrating a mesh reflector surface with a deployable truss structure to achieve a precision surface contour compatible with future, high-performance antenna requirements. Specifically, the program demonstrated: the feasibility of fabricating a precision, edge-mounted, deployable, tetrahedral truss structure; the feasibility of adjusting a truss-supported mesh reflector contour to a surface error less than 10 mils rms; and good RF test performance, which correlated well with analytical predictions. Further analysis and testing (including flight testing) programs are needed to fully verify all the technology issues, including structural dynamics, thermodynamics, control, and on-orbit RF performance, which are associated with large, deployable, truss antenna structures. Author

N87-16937# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. des Systems Balistiques et Spatiaux.
STRUCTURAL ANALYSIS, MANUFACTURING AND DEVELOPMENT STATUS OF LARGE POLARIZATION SENSITIVE DUAL-GRIDDED REFLECTORS
J. D. LEFEBVRE *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 111-121 Aug. 1986
Avail: NTIS HC A12/MF A01

The design of a 2.5 m diameter dual-gridded reflector assembly including the dynamic, static, thermal, and thermoelastic analyses is presented. The reflectors consist of two Kevlar sandwich shells, each being fitted with a grid of copper wires, and stiffened on the back by a system of Kevlar webs and struts. Mechanical and RF test results, performed on earlier developed reflector assemblies (1.4 m and 1.8 m) demonstrate the validity of the design. ESA

N87-16948# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Mechanical Systems Div.
ENGINEERING AND SOFTWARE INTERFACING FOR THERMAL, STRUCTURAL AND DYNAMIC CONTROL RELATED WITH SPACECRAFT ACTIVITIES
C. STAVRINIDIS, M. KLEIN, and J. WIJKER (Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost) *In its* Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 219-225 Aug. 1986
(Contract ESTEC-5158/82-NL-PB(SC))
Avail: NTIS HC A12/MF A01

Engineering practices and information needed by the different spacecraft disciplines, and the possibilities of coupling thermal, structural, and attitude control analysis programs are discussed. Implementation of identified and developed methods for specific interfaces is described. Engineering and software interfaces between the finite element package ASKA and the dynamic control analysis package DCAP, and between the thermal analysis program SINDA and the finite element package ASKA are presented. The software for the corresponding interface programs are identified as IFDCAP and SINAS. ESA

N87-16949# Liege Univ. (Belgium).
THE EXTENDABLE REFRACTABLE MAST (ERM) THERMAL ANALYSIS: A HEAT RADIATION CASE STUDY VIA THE FINITE ELEMENT METHOD
M. HOGGE, J. P. COBUT, J. FAGNOUL, E. STENNE, and P. M. LEONARD *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 227-235 Aug. 1986
Avail: NTIS HC A12/MF A01

A heat radiation finite element procedure was developed for the thermal analysis of an extendable retractable mast (ERM) for space shuttle solar arrays and antennas. Thermal loading of the mast is mainly by radiation, and such heat inputs are barely treated in a comprehensive way in finite element computer programs: radiative heat exchanges are defined in terms of surfaces whereas finite element models deal with nodal unknowns located at the boundary of the radiant areas. A procedure which enables an automatic translation of surface data into nodal inputs via specialized surface elements was developed and may be used along with standard codes for angle factors determination. The effectiveness of the method is demonstrated on ERM thermal models. ESA

N87-16952# Rome Univ. (Italy). Dipt. Aerospaziale.
THERMOMECHANICAL CHARACTERISTICS OF DICHROIC SUBREFLECTORS
C. ARDUINI, R. BARBONI, A. CASTELLANI, U. PONZI, and S. SGUBINI *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 255-260 Aug. 1986
Avail: NTIS HC A12/MF A01

Temperature, stress, and deformation aspects of Kevlar composite dichroic reflectors were studied. Criteria to guarantee that thermal displacements do not exceed any maximum value in the direction normal to the middle surface were derived. The skin

of the sandwich was checked for thermal buckling to find a criterion for safe sizing. Different cases of Sun illumination and transient conditions were analyzed to determine the maximum gradient inside the structure. The structural analysis was carried out via finite elements. The type of finite element and the number of grid nodes were a compromise between the modeling requirements and the large number of cases which result from the structural concepts, design requirements, heating conditions, type of constraints, and materials properties. Thermostructural results are presented. ESA

N87-16956*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
SYSTEM ENGINEERING STUDY OF ELECTRODYNAMIC TETHER AS A SPACEBORNE GENERATOR AND RADIATOR OF ELECTROMAGNETIC WAVES IN THE ULF/ELF FREQUENCY BAND Final Report
ROBERT D. ESTES Feb. 1987 117 p
(Contract NAG8-551)
(NASA-CR-180156; NAS 1.26:180156) Avail: NTIS HC A06/MF A01 CSCL 20N

An electrodynamic tether deployed from a satellite in low-Earth orbit can perform, if properly instrumented, as a partially self-powered generator of electromagnetic waves in the ULF/ELF band, potentially at power levels high enough to be of practical use. Two basic problems are examined. The first is that of the level of wave power that the system can be expected to generate in the ULF/ELF radiation band. The second major question is whether an electrodynamic tethered satellite system for transmitting waves can be made partially self-powering so that power requirements for drag compensation can be met within economical constraints of mass, cost, and complexity. The theoretical developments and the system applications study are presented. The basic design criteria, the drag-compensation method, the effects on the propagation paths from orbit to Earth surface of high-altitude nuclear debris patches, and the estimate of masses and sizes are covered. An outline of recommended analytical work, to be performed as a follow-on to the present study, is contained. B.G.

N87-17783*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MARS LANDING MISSION: A STRUCTURAL APPROACH
STAN FULLER *In its* Manned Mars Mission. Working Group Papers, V. 2, Sect. 5, App. p 733-744 May 1986
Avail: NTIS HC A24/MF A01 CSCL 22A

A Mars landing mission in 2000 presents a structural challenge. Earlier studies have indicated that a Mars landing was then feasible using current structural techniques. Since these earlier studies, technology advances were made to enhance the capability. Lighter and stronger materials, large structures programs, and supercomputers now exist and even greater advances are expected. The feasibility of a Mars landing does not depend on the structure. If the space travelers can withstand the trip, the necessary structures can be provided to deliver them. If artificial gravity is required the structure can also provide for it. The structural challenge is to provide structural designs that are lightweight with high reliability. In order to do this advanced technology must be utilized to the fullest on all structural elements. Author

N87-17826*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
MODELING AND IDENTIFICATION OF SCOLE
L. MEIROVITCH and M. A. NORRIS *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 109-120 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

Vector differential equations for distributed structures; discretization (in space) of distributed structures; and parameter identification for the Spacecraft Control Laboratory Experiment (SCOLE) are examined. B.G.

N87-19442# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
SENSORS FOR A SYSTEM TO CONTROL THE LIQUID FLOW INTO AN EVAPORATION COLD PLATE OF A TWO-PHASE HEAT TRANSPORT SYSTEM FOR LARGE SPACECRAFT
A. A. M. DELIL 4 Jan. 1986 89 p
(Contract NIVR-1073)
(NLR-TR-86001-U; B8679797; ETN-87-99281) Avail: NTIS HC A05/MF A01

Two-phase flow sensors to control liquid flow rates in the Columbus space platform thermal busses were assessed. The hollow core coaxial capacitor concept looks very promising for annular flow and to a lesser extent also for homogeneous flow. Its disadvantage is the extra flow resistance introduced by the gage. The axial capacitor gage is the simplest one. It adds no flow resistance since the electrodes are arranged flush with the flow line wall. Its sensitivity for void fraction variations is better than the corresponding sensitivity of the hollow core coaxial capacitor. A disadvantage is the inability to accurately and sensitively measure in the case of nonannular flow patterns or low void fraction mixtures. Both disadvantages are not very severe. Only in homogeneous flow, the sonic velocity concept offers an alternative to the hollow core coaxial capacitor. The velocity of sound concept is a little more sensitive for the temperature fluctuations since the velocity of sound depends more strongly on the temperature than the permittivity does. ESA

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STRUCTURAL DYNAMICS AND CONTROL

Includes modeling, systems identification, attitude and control techniques and systems, surface accuracy measurement and control techniques and systems, sensors, and actuators.

A87-10901
VIBRATION DATA REDUCTION FOR DESIGN, ANALYSIS AND TESTING OF SPACECRAFT
P. S. NAIR, M. SAMBASIVA RAO (Indian Space Research Organization, Satellite Centre, Bangalore, India), and S. DURVASULA (Indian Institute of Science, Bangalore, India) IN: Finite elements in computational mechanics - FEICOM '85; Proceedings of the International Conference, Bombay, India, December 2-6, 1985. Volume 2 . Oxford, Pergamon Press, 1985, p. 677-688. refs

Techniques for reducing the vibrational data produced by current FEM programs for large spacecraft structures are developed analytically and demonstrated. It is shown that the dynamical behavior of a structure can be understood by deriving the modal effective mass, the effective inertance or flexibility, and the energy distribution from the FEM data, processes involving relatively small computational effort. Numerical results for two sample problems (a simple cantilever beam and the APPLE spacecraft - mounted between Meteosat and CAT as in the Ariane composite payload stack) are presented in tables and graphs and briefly characterized. The reduction techniques are shown to be quite effective in sorting the FEM data for interpretation by the designer. T.K.

A87-11159
THE TIDAL VELOCITY FIELD IN THE LOCAL SUPERCLUSTER
P. B. LILJE (Cambridge University, England), A. YAHIL (Cambridge University, England; New York, State University, Stony Brook), and B. J. T. JONES (Nordisk Institut for Teoretisk Atomfysik, Copenhagen, Denmark) Astrophysical Journal, Part 1 (ISSN 0004-637X), vol. 307, Aug. 1, 1986, p. 91-96. SERC-supported research. refs
(Contract DE-AC02-80ER-10719)

In addition to the usual Virgocentric infall velocities, a significant quadrupolar tidal velocity field has been detected in the Local Supercluster, due to the density structure outside it. This tidal

field is not caused by a single external structure, but the Hydra-Centaurus supercluster appears to be a major contributor, since the eigenvector associated with the largest positive eigenvalue of the quadrupole points in its direction. At the distance of the Virgo Cluster the eigenvalues of the tidal field are about 200 km/s, but the component in the direction of Virgo is only 46 + or - 70. The determination of the cosmological density parameter from the Virgocentric infall is therefore little affected by the addition of the tidal field. The residual random ('thermal') velocity of the Local Group relative to its nearest neighbors is 72 + or - 37 km/s, which is not statistically significant. Author

A87-12139
STABILIZATION OF A CLASS OF HYBRID SYSTEMS ARISING IN FLEXIBLE SPACECRAFT
S. K. BISWAS (Ottawa, University, Canada) and N. U. AHMED Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 50, July 1986, p. 83-108. refs
(Contract NSERC-A-7109)

Consideration is given to the problem of rigorous modeling of flexible spacecraft and their stabilization. It is shown that the dynamics of the flexible spacecraft can be described by a coupled system of ordinary differential equations and partial differential equations (hybrid system). Liapunov's approach is used to prove the stabilizability of the system. Simple feedback controls are suggested for stabilization of flexible spacecraft. Author

A87-13317* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FAILURE-ACCOMMODATING CONTROL OF LARGE FLEXIBLE SPACECRAFT
S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 156-161. refs

This paper considers the problem of designing failure-accommodating controllers for large flexible spacecraft when there are sector-type nonlinearities in the loops. It is proved that an LQG-type controller can be made failure tolerant by inserting appropriate gains in the actuator paths and state estimator residual paths. For the state feedback case, when the actuators are saturating type, it is proved that there exists a finite region of attraction, which is invariant in the presence of these gains. Another class of controllers, which employs collocated sensors and actuators is presented, and is shown to have excellent failure-accommodation properties in addition to its robustness properties. Author

A87-13392
A LABORATORY EXPERIMENT IN CONTROL/STRUCTURE INTERACTION
J. A. BOSSI and J.-W. TSOU (Washington, University, Seattle) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1034-1038. Research supported by Boeing Aerospace Co.

A laboratory simulation having the characteristics of a flexible spacecraft (i.e. multiple, coupled rigid-body and flexible modes) is described. Initial test results utilizing the simulator as a test bed for multivariable control law designs are presented. Author

A87-13393
SLEW MANEUVER CONTROL OF THE SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE)
Y. P. KAKAD (North Carolina, University, Charlotte) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1039-1044. refs

In this paper, the dynamics and control of the NASA-Spacecraft Control Laboratory Experiment (SCOLE) test article slew maneuver are developed. The slew maneuver is specified about any arbitrary axis of the spacecraft, and it is considered that the spacecraft undergoes nonlinear rigid-body motion and linear elastic motion. Author

A87-13394* Ohio State Univ., Columbus.
DECENTRALIZED CONTROL EXPERIMENTS ON NASA'S FLEXIBLE GRID
U. OZGUNER, S. YURKOWICH, J. MARTIN, III, and F. AL-ABBASS (Ohio State University, Columbus) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1045-1051. Research supported by Ohio State University. refs
(Contract NASA ORDER L-91188-B)

Methods arising from the area of decentralized control are emerging for analysis and control synthesis for large flexible structures. In this paper the control strategy involves a decentralized model reference adaptive approach using a variable structure control. Local models are formulated based on desired damping and response time in a model-following scheme for various modal configurations. Variable structure controllers are then designed employing co-located angular rate and position feedback. In this scheme local control forces the system to move on a local sliding mode in some local error space. An important feature of this approach is that the local subsystem is made insensitive to dynamical interactions with other subsystems once the sliding surface is reached. Experiments based on the above have been performed for NASA's flexible grid experimental apparatus. The grid is designed to admit appreciable low-frequency structural dynamics, and allows for implementation of distributed computing components, inertial sensors, and actuation devices. A finite-element analysis of the grid provides the model for control system design and simulation; results of several simulations are reported on here, and a discussion of application experiments on the apparatus is presented. Author

A87-13395* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DESIGN OF ROBUST FAILURE DETECTION FILTERS
A. M. SAN MARTIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and W. E. VANDER VELDE (MIT, Cambridge, MA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings, Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1052-1059. refs
(Contract NAG1-126)

An essential aspect of the design of control systems for large, flexible spacecraft is fault tolerance. Because it is anticipated that a large number of sensors and actuators will be required to realize good control over these assemblies, the detection and isolation of component failures cannot be based on direct comparisons among replicated components. Instead, the notion of 'analytic redundancy' must be employed for the FDI function. Unfortunately this makes the FDI function sensitive to modeling errors which are certain to exist in the large space structure problem due to model truncation and parameter uncertainty. This paper addresses the robustness to model error of one method of FDI residual generation - the failure detection filter. Initial designs were found to be extremely sensitive to modeling error. The sources of this sensitivity are analyzed and modifications to the design are suggested. The improved filter is shown to have much better visibility of the failure signatures relative to the background due to modeling error. Author

A87-13431* Illinois Univ., Urbana.
AUTOMATIC DECOUPLING OF FLEXIBLE SPACECRAFT SLEWING MANEUVERS
T. A. W. DWYER, III (Illinois, University, Urbana) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1529-1534. refs
(Contract NSF ECS-85-16445; NAG1-436)

The capability for large angle slewing maneuvers with very demanding pointing accuracy and tracking speed is increasingly

required for space-based systems. This is particularly the case for space-based directed energy beam pointing. A method is thus proposed in this paper for commanding general pointing and tracking maneuvers with automatic correction for slew-excited structural deformations. All existing rigid body multiaxial slewing algorithms and flexible body vibration damping algorithms can then be used simultaneously, without design iterations. In particular, an example is given of a retargeting maneuver with specified line-of-sight settling time and no torque saturation. Author

A87-13433* Vigyan Research Associates, Inc., Hampton, Va.
NONLINEAR ATTITUDE CONTROL OF ELASTIC SPACECRAFT-ANTENNA SYSTEM
S. N. SINGH (Vigyan Research Associates, Inc., Hampton, VA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1539-1544. refs
(Contract NAS1-17919)

An approach to large angle rotational maneuvers of a spacecraft-beam-tip body (an antenna or a reflector) configuration based on nonlinear invertibility and linear feedback stabilization is presented. A control law u sub d is derived to obtain independent decoupled control of attitude angles, lateral elastic deflections, slopes due to bending and angular deflection due to torsion at the tip of the beam using torquers and force actuators. For the stabilization of the elastic oscillations, a linear feedback control law, u sub s, is obtained based on a linearized model about the terminal state augmented with a servo-compensator. Simulation results obtained for single axis control, for simplicity, show that large slewing and elastic mode stabilization can be accomplished in spite of uncertainty in the system using the total control u = u sub d + u sub s. Author

A87-13437
POINTING, CONTROL, AND STABILIZATION OF SOLAR DYNAMIC SYSTEM ON A SPACE STATION
E. T. FALANGAS and H. H. WOO (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1563-1571.

This paper presents the design and analysis of a drive system to soft couple the solar dynamic (SD) power systems from interaction with the structure of a single keel Space Station. The drive system features a low bandwidth controller that attenuates the dominant transverse boom torsional mode. The objective is to present some preliminary results. The pointing of the massive SD system is sensitive to induced disturbance forces. Minimizing the effects of these disturbances on SD pointing is essential in achieving desired pointing accuracy. An integral loop is included to attenuate low frequency disturbances. Beside the integration of the two controllers, the viable concept presented in this paper utilizes sun sensors mounted outboard of the alpha joint on the left and right transverse booms. Tracking error is minimized by using the pointing error from the sun in the control logic for alpha drive slewing. The system is capable of achieving good stability robustness, performance, and acceptable disturbance rejection. Author

A87-13458* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VIBRATION SUPPRESSION OF PLANAR TRUSS STRUCTURES UTILIZING UNIFORM DAMPING CONTROL
G. C. ANDERSEN (NASA, Langley Research Center, Hampton, VA) and L. M. SILVERBERG (North Carolina State University, Raleigh) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 2040-2047. refs

A variety of methods has been devised for vibrational control of a structure using both passive and active controls. Presented in this paper is a relatively new method for vibration suppression, uniform damping control. This method consists of implementing a control law which tends to dampen each vibrational mode of the structure at the same desirable exponential rate. The unique aspects of this method are that the control law is not explicitly dependent on the structural stiffness, the control forces are directly proportional to the distribution of the structural mass, and the control law is natural and decentralized. The control law was applied to a flexible planar truss structure and the various aspects of implementation of the control law examined are: actuator/sensor number, placement, and the impact of the actuator/sensor number and placement on the necessary control 'power' requirements such as peak power loads, total power requirements, etc. Also examined are the effects of using a limited number of active members in terms of the vibrational performance when compared with the 'ideal' distributed control law. Author

A87-13494* Colorado State Univ., Fort Collins.
NONLINEAR INTERFACES FOR ACCELERATION-COMMANDED CONTROL OF SPACECRAFT AND MANIPULATORS
T. A. W. DWYER, III, G. K. F. LEE, and N. CHEN (Colorado State University, Fort Collins) IN: Applied numerical modeling . San Diego, CA, Univelt, Inc., 1986, p. 517-522. refs
(Contract NSF ECS-83-04968; NAG1-436; F49620-83-K-0032)

Nominal command generation in real time for the control of manipulators or of maneuvering spacecraft is hampered by the nonlinearity of the equations of motion. Likewise the real time tracking of a computed nominal trajectory in the presence of disturbances requires the computation of time-varying Jacobians of the motion. An alternative approach is the formulation of acceleration-commanded control laws in appropriately chosen generalized advantageous to design dedicated circuit interfaces to perform the required transformation. It is also possible to guarantee that actuator and sensor saturation limits are not exceeded, by means of feedback-biased circuits that implement automatic overload limitation of acceleration commands. Recent developments following this 'hardware computation' point of view will be discussed. Author

A87-14074*# Howard Univ., Washington, D. C.
THE DYNAMICS AND CONTROL OF A SPACE PLATFORM CONNECTED TO A TETHERED SUBSATELLITE
R. FAN (Howard University, Washington, DC; Beijing Institute of Control Engineering, People's Republic of China) and P. M. BAINUM (Howard University, Washington, DC) NASA, AIAA, and PSN, International Conference on Tethers in Space, Arlington, VA, Sept. 17-19, 1986, Paper. 19 p. Research supported by the Ministry of Astronautics of the People's Republic of China, Howard University, and NASA. refs

A mathematical model of the open and closed loop dynamics of a space tethered-platform-subsatellite system (TPS) is developed. The TPS consists of a rigid platform from which an (assumed massless) tether is deploying a subsatellite from an attachment point which is offset from the mass center of the platform. Control is provided by modulation of the tension level in the tether and by momentum-type platform-mounted devices. Control-law gains are obtained based on linear quadratic regulator techniques. Typical transient responses are presented. Author

A87-14941
ELF GENERATION IN THE LOWER IONOSPHERE VIA COLLISIONAL PARAMETRIC DECAY
K. KO, C. R. MENYUK (Science Applications International Corp., McLean, VA), A. REIMAN (Princeton University, NJ), V. TRIPATHI (Indian Institute of Technology, New Delhi, India), P. PALMADESSO (U.S. Navy, Naval Research Laboratory, Washington, DC) et al. Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Sept. 1, 1986, p. 10097-10107. refs
(Contract N00014-82-M-0133)

Generation of ELF waves by stimulated parametric coupling of two HF waves in the lower ionosphere is considered. In this region the nonlinear force is dominated by the thermal rather than the ponderomotive nonlinearity. It is shown that this results in lowering the pump threshold for complete decay by more than an order of magnitude while achieving efficiencies in excess of those expected

on the basis of the Manley-Rowe relations. The lower-frequency mode excited for E region altitudes is the helicon mode, which continues to frequencies below the ion cyclotron frequency because ion-neutral collisions freeze the ion motion. The application of these results to ELF generation in the lower ionosphere, including power estimates for a proof of principle experiment, is discussed.
Author

A87-15450
FLEXIBILITY CONTROL OF SOLAR ARRAYS BASED ON STATE ESTIMATION BY KALMAN FILTERING
T. FUKUDA, Y. KURIBAYASHI, H. HOSOKAI (Tokyo Science University, Japan), and N. YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) IN: Theoretical and applied mechanics. Volume 34 - Proceedings of the Thirty-fourth Japan National Congress for Applied Mechanics, Tokyo, Japan, December 11, 12, 1984 . Tokyo/New York, University of Tokyo Press/Columbia University Press, 1986, p. 405-411. refs

The problem dealt with here is how to estimate and control the vibrational modes of flexible booms of solar arrays even in large angle attitude maneuvers. The boom is controlled as a distributed parameter system, the dynamics of which is developed in the manner of the unconstrained mode. Differential solar cell sensors are used to measure vibrations of the boom, but the sensor outputs are contaminated by noises. Therefore, the Kalman filtering method is employed to estimate states based on the dynamics in the above. Then all estimated states are fed back to control the whole system, and an optimal control strategy is employed so that the control performance can be improved.
Author

A87-15931*# Massachusetts Inst. of Tech., Cambridge.
A PROCEDURE FOR CALCULATING THE DAMPING IN MULTI-ELEMENT SPACE STRUCTURES
E. F. CRAWLEY and K. J. ODONNELL (MIT, Cambridge, MA) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 10 p. refs
(Contract NAGW-21)
(IAF PAPER 86-203)

A procedure for analyzing the damping in a multielement space structure connected by joints is described, in which distributed material damping and discrete nonlinear joint properties are incorporated into a linear analysis. The procedure involves four steps: (1) creation of a linear undamped finite element model; (2) experimental measurements of the transient response of a truss member in free fall tests to obtain material damping properties; with these properties incorporated into a linear damped finite element model of the structure; (3) the identification of the nonlinear joint properties using the force-state mapping technique; and (4) linearization of the identified nonlinear components, which are then incorporated into the linear damped model to create the linearized damped finite element model. I.S.

A87-15932#
IMPROVING THE ACTIVE VIBRATIONAL CONTROL OF LARGE SPACE STRUCTURES THROUGH STRUCTURAL MODIFICATIONS
F. E. EASTEP (Dayton, University, OH), N. S. KHOT (USAF, Wright Aeronautical Laboratories, Wright Patterson AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 9 p. refs
(IAF PAPER 86-204)

Structural and control system design methods for large space structures are presently integrated in order to reduce structural response to the disturbances encountered. The design scheme formulation is obtained by means of the structural modification of a nominal finite element model that is optimally controlled by a linear regulator, in order to increase the active modal damping factor beyond that of the nominal structure. Because an optimal active control method is employed, the sensitivity of the Riccati matrix to structural modifications is obtained. The algorithm's application is illustrated by structural modification of a nominal model with different constraints on the closed loop eigenvalues.
O.C.

A87-15957#
DYNAMICS FORMULATION AND SIMULATION OF MULTI-BODY SPACE STRUCTURES
Y. OHKAMI, O. OKAMOTO, T. KIDA, I. YAMAGUCHI, and K. MATSUMOTO (National Aerospace Laboratory, Chofu, Japan) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p. refs
(IAF PAPER 86-238)

A matrix approach to dynamics formulation and simulation of complex space structures is outlined. This approach can treat spacecraft dynamics consisting of an arbitrary number of rigid bodies connected by an arbitrary number of hinges in a complex system configuration. The constraints on the hinges connecting these bodies can be free, kinetic, kinematic, or any combination of these. The characteristic features of this method make it compatible with a general-purpose computer program system.
C.D.

A87-15963*# Howard Univ., Washington, D. C.
SYNTHESIS OF CONTROL LAWS FOR OPTIMALLY DESIGNED LARGE SPACE STRUCTURES
K. SATYANARAYANA and P. M. BAINUM (Howard University, Washington, DC) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 9 p. Research supported by Howard University and NASA. refs
(IAF PAPER 86-246)

In this study, the vibration control of large space structures using the linear quadratic regulator technique is investigated. Emphasis is made on the control of both optimally designed structures and also the original (uniform) structures using the cantilever beam as an example. The open loop and closed loop eigenvalues are compared and the transient responses are obtained to determine the effectiveness of the control system design. Author

A87-16187* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ON-ORBIT SYSTEMS IDENTIFICATION OF FLEXIBLE SPACECRAFT
L. W. TAYLOR, JR. (NASA, Langley Research Center, Hampton, VA) IN: Identification and system parameter estimation 1985; Proceedings of the Seventh Symposium, York, England, July 3-7, 1985. Volume 1 . Oxford and New York, Pergamon Press, 1985, p. 511-516. refs

The process of on-orbit systems identification of flexible spacecraft is examined in terms of the difficulties that are expected because of the potentially unmanageable number of unknown model parameters due to the very high order system models involved. A Jordon block canonical form and global model parameters are used to reduce the number of unknown parameters to manageable numbers. A Bayesian approach is discussed which enables the merging of theoretical models with ground or on-orbit test results by using Unconditional Maximum Likelihood Parameter Estimation. A Modified Newton-Raphson technique is proposed for determining the model parameter estimates and an expected fit error criterion is recommended for the determination of the model structure and order reduction. Author

A87-17760#
MODELING AND SIMULATION OF SPACECRAFT SOLAR ARRAY DEPLOYMENT
B. WIE, N. FURUMOTO, A. K. BANERJEE, and P. M. BARBA (Ford Aerospace and Communications Corp., Palo Alto, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 593-598. Previously cited in issue 23, p. 3428, Accession no. A86-47923. refs

A87-17761*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SLEWING CONTROL EXPERIMENT FOR FLEXIBLE STRUCTURES
J.-N. JUANG, L. G. HORTA (NASA, Langley Research Center, Hampton, VA), and H. H. ROBERTSHAW (Virginia Polytechnic Institute and State University, Blacksburg) (Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985, p. 547-570) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Sept.-Oct. 1986, p. 599-607. Previously cited in issue 18, p. 2614, Accession no. A86-39509. refs

A87-18241
A BASIC STUDY FOR DIVIDED MODAL SURVEY OF FUTURE LARGE SPACECRAFT
H. MITSUMA (National Space Development Agency of Japan, Tsukuba Space Center, Sakura), K. SHIRAKI (National Space Development Agency of Japan, Tokyo), F. KUWAO, T. TAKAHASHI, S. SEKIMOTO (Toshiba Corp., Kawasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 351-355. refs

A modal-survey procedure for use in the dynamic design of large spacecraft is described and demonstrated. The large spacecraft is divided into a number of modules; the modules are subjected to single-point-excitation tests; and the results are combined using SABBA, a coupling-analysis software package. The validity of the approach is confirmed in computations on several spacecraft configurations. T.K.

A87-18320
ATTITUDE CONTROL EXPERIMENT FOR FLEXIBLE SPACECRAFT
K. YAMADA, T. KASHIWASE, M. INOUE, and K. TSUCHIYA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1986, p. 951-956.

An attitude control problem for a flexible spacecraft with noncolocated sensor and actuator is considered. The plant dynamics has become a nonminimum phase system, and both the classical control theory and the modern control theory are applied to the controller design. Because the phase of the first vibration mode is opposite to that of the rigid body mode, the controller designed by the classical control theory becomes a nonminimum phase system as a necessary consequence. The designed controllers are verified by physical experiments as well as numerical simulations and these results show the good performance of the controllers. Author

A87-18322
NUMERICAL AND EXPERIMENTAL EVALUATION OF POLES AND SYSTEM ZEROS FOR LARGE FLEXIBLE SPACE STRUCTURES
Y. OHKAMI, O. OKAMOTO, S. YOSHIMURA, T. KIDA, I. YAMAGUCHI (National Aerospace Laboratory, Chofu, Japan) et al. IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 963-968. refs

As a preliminary study on LSS attitude and figure/shape controller design, poles and zeros are evaluated numerically and experimentally for a simple flexible space structure model. The model under consideration consists of a rigid primary body and a flexible appendage attached rigidly to the primary body, and a single-degree-of-freedom control moment gyro (CMG) on board as an actuator. The transfer function of the system is derived analytically, and open-loop responses are experimentally examined under the impulsive disturbance to the appendage. The results of the experiments show that the first vibration mode of the appendage and the interacted rotational motion of the primary body are damped in a short time. Author

A87-18323
LOCAL OUTPUT-FEEDBACK CONTROL FOR LARGE FLEXIBLE SPACE STRUCTURES
T. KIDA, I. YAMAGUCHI, and Y. OHKAMI (National Aerospace Laboratory, Chofu, Japan) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 969-974. refs

This paper discusses the possibility of applying decentralized local control techniques to the LSS attitude/shape control problems. The proposed controller is implemented by feeding back only the local outputs and their feedback gains are designed based on the decomposed small-size subsystems. The preliminary results obtained are both on its stability properties and the estimation of its convergence speeds. A simple numerical example is introduced to illustrate the design procedures and the obtained results. Author

A87-18324
DYNAMICS OF THE ORBITER BASED FLEXIBLE MEMBERS
V. J. MODI (British Columbia, University, Vancouver, Canada) and A. M. IBRAHIM IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 975-984. refs
(Contract NSERC-A-2181; NSERC-G-0662)

The paper studies libration/vibration interaction dynamics associated with the proposed NASA/Lockheed Solar Array Flight Experiment. Results suggest substantial influence of the inertia parameter, flexural rigidity of the appendages, orbit eccentricity, deployment velocity, initial conditions, etc. on the system response. This would indicate additional demand on the orbiter's control system during construction of space-platforms. Author

A87-18490
LARGE-ANGLE SLEWING OF FLEXIBLE SPACECRAFT
H. SOGA, K. HIRAKO (Toshiba Corp., Kawasaki, Japan), Y. OHKAMI, T. KIDA, and I. YAMAGUCHI (National Aerospace Laboratory, Chofu, Japan) IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 617-630.
(AAS PAPER 85-674)

A sub-optimal slewing control method is proposed for dealing with the slewing maneuver problem of a flexible spacecraft. The rigid body mode is controlled by an open-loop optimal controller of a design suitable for the optimal control approach such as the maximum principle. The elastic bending modes are regulated to nominal undeformed states by the optimal LQ regulator. The control law is obtained easily and can be realized in an on-board controller. The system is expected to be robust with regard to parameter errors and disturbances. Feasibility has been demonstrated through ground-based hardware experiments using a flexible spacecraft model mounted on a single-axis air-bearing table. D.H.

A87-22364*# Flight Mechanics and Control, Inc., Hampton, Va.
DYNAMIC ANALYSIS OF SATELLITES WITH DEPLOYABLE HINGED APPENDAGES
KEVIN F. OAKES (Flight Mechanics and Control, Inc., Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 13 p. Research sponsored by Old Dominion University. refs
(Contract NGR-47-003-052)
(AIAA PAPER 87-0020)

The nonlinear equations of motion determining the planar dynamical behavior of an orbiting satellite deploying both one and two rigid appendages have been formulated using Lagrange's equations. The analysis accounts for large angle rotations, Coriolis effects, and the gravitational gradient, and the resulting coupled governing equations are integrated numerically. The analysis is applied to the Space Shuttle based deployment of rigid truss-like members, and results show that spacecraft inertia parameters, appendage mass and length, deployment velocity, and initial conditions all influence the system response. It is found that the

resulting librational movement is related to the size of the deployment payload, and that gravitational forces lead to vehicle stabilization. R.R.

A87-22396#
VIBRATION CONTROL OF NONLINEAR FLEXIBLE STRUCTURES
IRA R. ASTRACHAN and RICHARD J. FOURNIER AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p. NSF-supported research.
(AIAA PAPER 87-0074)

A simple yet effective method for controlling the undesired vibration of a nonlinear flexible structure is presented. The control system will detect anomalous motion, calculate the necessary restoring force, and implement that restoring force at the optimum time. The active vibration control system will keep the motion of the structure below a predetermined threshold during continuous excitation and significantly reduce the damping time required to recover from single random disturbances. The effectiveness of the control strategy is demonstrated through actual testing on a structural model. Author

A87-22462*# Cambridge Research Associates, Mass.
FREQUENCY-SHAPED LARGE-ANGLE MANEUVERS
HON M. CHUN, JAMES D. TURNER (Cambridge Research Associates, MA), and JES-NAN JUANG (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 17 p. refs
(AIAA PAPER 87-0174)

The paper considers the problem of maneuvering a flexible spacecraft through large angles in finite time. The basic control problem is divided into two parts. The first part consists of generating a frequency-shaped open-loop solution for the nonlinear rigid body as the nominal solution. The resulting two-point boundary-value problem is solved by introducing a continuation method for altering the mass distribution and boundary conditions for the spacecraft. For the second part, a feedback control is designed by linearizing the flexible body response about several points along the rigid body nominal solution. The perturbation gains are designed by using a frequency-shaped cost functional approach. The gains are linearly interpolated to produce smooth control time-histories as the linear piecewise constant plant models change during the maneuver. Author

A87-22831
RESPONSE OF DISCRETIZED STRUCTURES WITH ELASTO-PLASTIC DEFORMATION TO NON-STATIONARY RANDOM EXCITATION
C. W. S. TO (Calgary, University, Alberta, Canada) Journal of Sound and Vibration (ISSN 0022-4650), vol. 110, Nov. 8, 1986, p. 463-470. NSERC-supported research. refs

A formulation, within the framework of the finite element method, for the analysis of the responses of symmetric and asymmetric nonlinear structures, involving elasto-plastic deformation, subjected to nonstationary random excitation represented as a product of an arbitrary time modulating function and a stationary process, not necessarily white in nature, is proposed in this paper. A numerical strategy for implementing the proposed formulation is also included. Application of the method is made for the determination of the time-dependent variance of the response of a quarter-scale physical model of a class of mast antenna structures. Computed results are included and discussed. Author

A87-23212#
ON THE DYNAMICS OF FLEXIBLE BEAMS UNDER LARGE OVERALL MOTIONS - THE PLANE CASE. I, II
J. C. SIMO (Stanford University, CA) and L. VU-QUOC (California, University, Berkeley) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 53, Dec. 1986, p. 849-863. refs
(Contract AF-AFOSR-83-0361)
(ASME PAPER 86-WA/APM-41)

A new approach to the dynamics of a plane beam under large overall motions is presented which uses the fully nonlinear plane beam theory to account for finite rotations as well as finite strains. The expression of the inertial terms is obtained in the equations of motions simply as mass times acceleration. The inherent nonlinear character of the problem is transferred to the stiffness part of the equations of motion, resulting in equations of motion arising typically in nonlinear structural dynamics. It is shown that the dynamics of flexible beams under large overall motions can be analyzed in any existing nonlinear finite element program. Numerical examples that involve finite vibrations coupled with large overall motions and demonstrate the capability of the present formulation for handling multibody dynamics are presented. C.D.

A87-23213#
FREE ROTATION OF AN ELASTIC ROD WITH AN END MASS
C. Y. WANG (Michigan State University, East Lansing) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 53, Dec. 1986, p. 864-868.

This paper models a rotating space satellite with a long flexible antenna. Large deformations of the elastic rod are caused by the centrifugal forces. Bifurcation analysis shows the effect of end mass on the critical rotation speeds above which sinuous equilibrium configurations occur. The nonlinear governing equations are then integrated numerically. A class of solutions with a looped configuration is found whose existence requires a certain minimum total energy and minimum angular momentum. Catastrophic changes are possible. Author

A87-23986#
WAVE-ABSORBING CONTROLLERS FOR A FLEXIBLE BEAM
A. H. VON FLOTOW and B. SCHAEFER (DFVLR, Oberpfaffenhofen, West Germany) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 443-452) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 673-680. Previously cited in issue 22, p. 3238, Accession no. A85-45924. refs

A87-23989*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SEQUENTIAL LINEAR OPTIMIZATION APPROACH FOR CONTROLLER DESIGN
LUCAS G. HORTA, JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA), and JOHN L. JUNKINS (Texas A & M University, College Station) (Guidance, Navigation and Control Conference, Snowmass, CO, Aug. 19-21, 1985, Technical Papers, p. 725-731) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 699-703. Previously cited in issue 22, p. 3239, Accession no. A85-45953. refs

A87-23995#
EFFICIENT MODAL ANALYSIS OF DAMPED LARGE SPACE STRUCTURES
TREVOR WILLIAMS (Kingston Polytechnic, Kingston-upon-Thames, England) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Nov.-Dec. 1986, p. 722-724. SERC-supported research. refs

A novel eigenstructure perturbation technique that is valid for general feedback and minimizes numerical difficulties through the exclusive use of unitary transformations is presented. It is noted that these complex matrices (or their real subclass, the orthogonal matrices) are basic to nearly all numerically reliable algorithms developed in control theory. The method directly yields the order

of error anticipated in its eigenvalue and eigenvector estimates. O.C.

A87-24049* Vigyan Research Associates, Inc., Hampton, Va.
NONLINEAR ATTITUDE CONTROL OF FLEXIBLE SPACECRAFT UNDER DISTURBANCE TORQUE
SAHJENDRA N. SINGH (Vigyan Research Associates, Inc., Hampton, VA) Acta Astronautica (ISSN 0094-5765), vol. 13, Aug. 1986, p. 507-514. refs
(Contract NAS1-17919)

A control law for large-angle single-axis rotational maneuvers of a spacecraft-beam-tip body (an antenna or a reflector) configuration is presented. It is assumed that an unknown but bounded disturbance torque is acting on the spacecraft. A model reference adaptive torque control law is derived for the slewing of the space vehicle. This controller includes a dynamic system in the feedback path and requires only attitude angle and rate of the space vehicle for feedback. For damping out the elastic motion excited by the slewing maneuver, a stabilizer is designed assuming that a torquer and a force actuator are available at the tip body. The stabilizer uses only the flexible modes for the synthesis of the control law. Simulation results are presented to show that fast, large-angle rotational maneuvers can be performed using the adaptive controller and the stabilizer in spite of the presence of continuously acting unknown torque on the spacecraft. Author

A87-24552
MODAL CONTROL OF TRAVELING WAVES IN FLEXIBLE STRUCTURES
L. MEIROVITCH and J. K. BENNIGHOF (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Sound and Vibration (ISSN 0022-460X), vol. 111, Nov. 22, 1986, p. 131-144.
(Contract AF-AFOSR-83-0017)

This paper is concerned with the control of a traveling wave in a structure by the independent modal-space control method. It is demonstrated that the control forces tend to concentrate in the immediate vicinity of the disturbance, and there are virtually no control forces acting at any point of the structure before the arrival of the disturbance. Two numerical examples are included, one for a string in transverse vibration and one for a beam in bending. Satisfactory control was achieved in spite of the fact that only a finite number of modes was retained for control. Author

A87-24902#
DECENTRALIZED CONTROL OF MULTI-BODY SPACECRAFT - A NUMERICAL EXPERIMENT
R. G. MELTON (Pennsylvania State University, University Park) and M. A. THAMES (General Electric Co., Astro Space Div., Valley Forge, PA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. refs
(AIAA PAPER 87-0018)

This paper presents the results of numerical studies on the use of decentralized configuration control of spacecraft that can be modelled as tree topologies of rigid bodies with non-rigid connections. The decentralized scheme consists of each body having an autonomous controller that uses state information of that body and the adjacent body that is closer to the tree root. It is proposed that such a control structure would have several benefits of large modular spacecraft. The results indicate good performance, even for simple position and rate feedback loops in each body, leading to the suggestion that a rigorous stability analysis be undertaken to demonstrate the applicability of this control to a wider variety of spacecraft configurations. Author

A87-25680#
EXPERIMENTAL CHARACTERIZATION OF PASSIVELY DAMPED JOINTS FOR SPACE STRUCTURES
JACKY PRUCZ (West Virginia University, Morgantown), A. D. REDDY, L. W. REHFIELD (Georgia Institute of Technology, Atlanta), and R. W. TRUDELL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Nov.-Dec. 1986, p. 568-575. refs
(Contract F49620-83-C-0017)

An innovative means to enhance the inherent damping in structures is provided by the designed-in incorporation of viscoelastic materials in joints. The damping and stiffness properties of such joints have been experimentally evaluated at room temperature and low frequencies on representative specimens. The test data show that proper design configurations can yield significant damping benefits without unacceptable stiffness penalties. Three different test methods and a new data reduction procedure have been utilized in the experimental program. Two of the three methods are new. A simplified steady-state technique and a sine-pulse propagation approach have been developed and applied in this research. The results show relatively low data scatter from repeated measurement sets, and there is good agreement among the different test methods. Author

A87-27449
ON THE STABILITY OF MULTIPLE PARAMETER TIME-VARYING DYNAMIC SYSTEMS
MEHDI AHMADIAN (Clemson University, SC) International Journal of Non-Linear Mechanics (ISSN 0020-7462), vol. 21, no. 6, 1986, p. 483-488. refs

A technique is presented for determining the stability of lumped-parameter, time-varying, dynamic systems with aperiodic coefficients. An 'energy like' function is used to develop stability conditions which are direct in terms of the coefficient matrices. The significance of what is presented here is twofold. First, it gives stability conditions applicable to systems which are not necessarily periodic. Second, it allows for a systematic categorization of the effects of the parameter changes on system response and stability, in order to provide a better understanding of the behavior of this class of dynamic systems as they arise in various areas of engineering. Author

A87-27948*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
EFFECT OF SENSOR AND ACTUATOR ERRORS ON STATIC SHAPE CONTROL FOR LARGE SPACE STRUCTURES
RAPHAEL T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg) and HOWARD M. ADELMAN (NASA, Langley Research Center, Hampton, VA) AIAA Journal (ISSN 0001-1452), vol. 25, Jan. 1987, p. 134-138. Previously announced in STAR as N85-29998. refs

An analytical study was performed to predict and assess the effect of actuator and sensor errors on the performance of a shape control procedure for flexible space structures using applied temperatures. Approximate formulas were derived for the expected value and variance of the rms distortion ratio (ratio of rms distortions with and without corrections) based on the assumption of zero-mean normally distributed random errors in measured distortions and actuator output temperatures. Studies were carried out for a 55-meter radiometer antenna reflector distorted from its ideal parabolic shape by nonuniform orbital heating. The first study consisted of varying the sensor and actuator errors for the case of 12 actuators and computing the distortion ratio. In the second study, sensor and actuator errors were prescribed and the effect of increasing the number of actuators was evaluated. Author

A87-28537
MODAL SPACE DESIGN FOR ACTIVE VIBRATION CONTROL OF LARGE FLEXIBLE STRUCTURES
HAGOP V. PANOSSIAN (HR Textron, Inc., Valencia, CA) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 1 . Schenectady, NY, Union College, 1986, p. 167-170. refs

Modal space design and control for stochastic linear systems is considered herein. Uncertainties in the frequencies, damping ratios, and mode shapes are assumed and the system dynamics is formulated in a stochastic model. The theory of eigensystem assignment is then treated for the above mentioned model under complete controllability and observability assumptions. Moreover, direct output feedback control is achieved under minimum mean square error between the desired and actual eigensystems. Author

A87-28544
MODAL ANALYSIS TECHNIQUE USED IN GERMANY FOR AEROSPACE STRUCTURES
N. NIEDBAL (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 1 . Schenectady, NY, Union College, 1986, p. 378-385. refs

Modal-survey testing is an increasingly common part of the qualification procedure for aerospace structures, since it offers an experimental verification of normal mode parameters determined by dynamic finite-element analysis. Moreover, it permits identification of structural damping, knowledge of which is essential for reliable flight-load calculations for space structures. A state of the art of modern modal-survey testing is given here, covering the phase-resonance method and various phase-separation methods. The use of modal-survey results in the dynamic qualification of aerospace structures is discussed, emphasising the correlation of analytical and experimental modal data. This aspect has attracted growing interest in recent years, due to the obvious need for convenient tools that allow finite-element models to be updated with measured modal data. Author

A87-28558
IDENTIFICATION, APPLICATIONS, AND DYNAMIC ANALYSIS OF NONLINEAR SPACECRAFT COMPONENTS
INGO KOLSCH and HORST BAIER (Dornier System GmbH, Friedrichshafen, West Germany) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 1 . Schenectady, NY, Union College, 1986, p. 720-729. refs

Techniques for the dynamical analysis of spacecraft structures with nonlinear components are discussed, considering both undesirable nonlinearities (such as joint stiffness and bearing play) and designed nonlinearities (such as dampers and shock absorbers to isolate delicate equipment from launch or on-orbit accelerations). The sine-vibration testing, harmonic-balance analysis, and Fourier-approximation analysis (to account for quasi-static accelerations) of an actuator-bearing/solar-panel assembly for the TV-Sat/TDF-1 communication satellite are described and illustrated with graphs and diagrams. Good agreement between model predictions and test measurements is demonstrated, and problems in determining the stiffness coefficients and evaluating the damping are indicated. T.K.

A87-28569
COMPUTATION OF TOTAL RESPONSE MODE SHAPES USING TUNED FREQUENCY RESPONSE FUNCTIONS
RALPH BRILLHART and DAVID L. HUNT (SDRC, Inc., San Diego, CA) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 2 . Schenectady, NY, Union College, 1986, p. 1228-1236. refs

A new approach called Move Response on Trace allows rapid computation of mode frequencies and shapes immediately following data acquisition. The technique is applicable to multiple-input modal tests in which frequency response functions are obtained. When this technique was applied to an aerospace structure, the results compared well with the polyreference approach, yielding results in considerably less time with less user interaction. Author

A87-28578
TRANSIENT MODAL TUNING
G. DUDLEY SHEPARD (Lowell, University, MA) IN: International Modal Analysis Conference, 4th, Los Angeles, CA, Feb. 3-6, 1986, Proceedings. Volume 2 . Schenectady, NY, Union College, 1986, p. 1482-1486.

Transient modal tuning for system identification in space is considered, and the advantages of using the impulse response of a complex structural mode (where the damping properties of the system are not proportional to the mass or stiffness properties) as an input to selectively enhance that mode is demonstrated. Excitation transients are designed which will most efficiently concentrate energy in a selected bandwidth and yield a high percentage of the desired mode response relative to undesired modal responses. It is noted that because spatial tuning in space is likely to be inefficient, transient modal tuning must largely rely on temporal tuning. R.R.

A87-29368
THE DYNAMICAL QUALIFICATION OF PRESENT AND FUTURE SPACECRAFT STRUCTURES [DIE DYNAMISCHE QUALIFIKATION HEUTIGER UND ZUKUENFTIGER RAUMFAHRTSTRUKTUREN]
AXEL BERTRAM, HORST HUENERS, and WERNER SACHS (DFVLR, Institut fuer Aeroelastic, Goettingen, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), Nov. 1986, p. 56-61. In German.

The dynamical design-verification procedures employed by the DFVLR Institut fuer Aeroelastik for spacecraft development are discussed, with a focus on the performance and analysis of modal survey tests. The mobile static-vibration-test facility and the modal-analysis programs for the Olympus platform, the Ariane-4 payload shroud, and the ESA Simple and Complex Models (hypothetical spacecraft designed to test the accuracy of modal-synthesis techniques) are described and illustrated with drawings, diagrams, and photographs. In the latter tests, modal synthesis is found to be a very useful design tool, but one requiring considerable experience on the part of the designer. The need for improved model-updating strategies and for new test concepts to simulate flight loads and analyze subassemblies is indicated. T.K.

A87-30294*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
AN ANALYTICAL AND EXPERIMENTAL STUDY OF A CONTROL SYSTEM'S SENSITIVITY TO STRUCTURAL MODIFICATIONS
RAPHAEL T. HAFTKA, ZORAN N. MARTINOVIC, WILLIAM L. HALLAUER, JR., and GEORGE SCHAMEL (Virginia Polytechnic Institute and State University, Blacksburg) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 2, p. 642-650) AIAA Journal (ISSN 0001-1452), vol. 25, Feb. 1987, p. 310-315. Previously cited in issue 13, p. 1855, Accession no. A85-30393. refs
(Contract NAG1-224)

A87-30545
A FOUR NODE MARGUERRE ELEMENT FOR NON-LINEAR SHELL ANALYSIS
PHILIPPE JETTEUR and FRANCOIS FREY (Lausanne, Ecole Polytechnique Federale, Switzerland) Engineering Computations (ISSN 0264-4401), vol. 3, Dec. 1986, p. 276-282. refs
(Contract SNSF-2,353,0,84)

A nonlinear shallow thin shell element is described. The element is a curved quadrilateral one with corner nodes only. At each node, six degrees of freedom (i.e., three translations and three rotations) make the element easy to connect to space beams, stiffeners or intersecting shells. The curvature is dealt with by Marguerre's theory. Membrane bending coupling is present at the element level and improves the element behavior, especially in nonlinear analysis. The element converges to the deep shell

solution. The sixth degree of freedom is a true one, which can be assimilated to the in-plane rotation. The present paper describes how overstiffness due to membrane locking on the one hand and to the sixth degree of freedom on the other hand can be corrected without making use of numerical adjusted factors. The behavior of this new element is analyzed in linear and nonlinear static and dynamic tests. Author

A87-31095*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
GROUND FACILITY FOR LARGE SPACE STRUCTURES DYNAMICS AND CONTROL VERIFICATION
HENRY WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) International Test and Evaluation Association, Symposium, Huntsville, AL, Sept. 30-Oct. 2, 1986, Paper. 20 p.

NASA Marshall Space Flight Center has developed a facility in which closed loop control of Large Space Structures (LSS) can be demonstrated and verified. The main objective of the facility is to verify LSS control system techniques so that on-orbit performance can be ensured. The facility consists of an LSS test article or payload which is connected to a 3-axis angular pointing mount assembly that provides control torque commands. The angular pointing mount assembly is attached to a base excitation system which will simulate disturbances most likely to occur for Orbiter and DOD payloads. The control computer contains the calibration software, the reference systems, the alignment procedures, the telemetry software, and the control algorithms. The total system is suspended in such a fashion that the LSS test article has the characteristics common to all LSS. Author

N87-10138 Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
PARAMETER OPTIMIZATION AND ATTITUDE STABILIZATION OF A FLEXIBLE SPACECRAFT
D. C. CEBALLOS *In* CNES Proceedings of an International Conference on Space Dynamics for Geostationary Satellites p 405-412 1986
Avail: CEPADUES-Editions, 111 rue Nicolas-Vauquelin, 31100 Toulouse, France

The synthesis and analysis of a control law for a flexible spacecraft are described. The control law is considered a simple proportional, integral, and derivative law together with a second order structural filter. Parameter optimization is applied for finding the controller parameters, to optimize behavior when applied to the high order model. Frequency and Laplace domain analysis which indicate the satisfactory behavior of the proposed controller are shown. ESA

N87-10172*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechancis.
IDENTIFICATION AND CONTROL OF STRUCTURES IN SPACE Progress Report, 1 Jul. - 31 Dec. 1985
L. MEIROVITCH 1985 42 p
(Contract NAG1-225)
(NASA-CR-179811; NAS 1.26:179811) Avail: NTIS HC A03/MF A01 CSCL 22B

Work during the period July 1 - December 31, 1985, has concentrated on the application of the equations derived in the preceding period to the maneuvering and vibration suppression of the Spacecraft Control Laboratory Experiment (SCOLE) model. Two different situations have been considered: (1) a space environment and (2) a laboratory environment. This report covers the first case and consists of a paper entitled Maneuvering and Vibration Control of Flexible Spacecraft, presented at the Workshop on Structural Dynamics and Control Interaction of Flexible Structures, Marshall Space flight Center, Huntsville, AL, April 22 to 24, 1986. The second case will be covered in the report for the next period. Author

N87-10891# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ON OPTIMAL PASSIVE AND ACTIVE CONTROL OF PRECISION SPACECRAFT STRUCTURES
H. BAIER *In* ESA Proceedings of an International Conference on Spacecraft Structures p 35-39 Apr. 1986
Avail: NTIS HC A19/MF A01

The application of structural optimization and control methods for precision spacecraft structures is discussed. The necessity of proper decomposition into subproblems is emphasized. The shape adjustment and control of an antenna reflector is considered and results are presented. In the dynamic regime, active isolation is applied for a sensitive payload and the benefit of such an approach is outlined. For passive design purposes a control forces approach which is numerically efficient but does not necessarily lead to an optimum is used. ESA

N87-10896# Texas Univ., Austin.
A STUDY OF NODAL COUPLING METHODS
R. R. CRAIG *In* ESA Proceedings of an International Conference on Spacecraft Structures p 75-80 Apr. 1986
Avail: NTIS HC A19/MF A01

Component mode synthesis time-domain methods for undamped structures are introduced. Component normal modes with fixed or free boundaries, constraint modes, and inertia-relief attachment modes are described. An inertia attachment mode is defined. System eigensolutions based on various component mode sets are compared. Work on the application of attachment modes to modal control of flexible structures is noted. ESA

N87-10897# Intespace, Toulouse (France).
EFFECTIVE MODAL PARAMETERS AND TRUNCATION EFFECTS IN STRUCTURAL DYNAMICS [PARAMETRES MODAUX EFFECTIFS ET EFFETS DE TRONCATURE EN DYNAMIQUE DES STRUCTURES]
A. GIRARD and J. F. IMBERT *In* ESA Proceedings of an International Conference on Spacecraft Structures p 81-86 Apr. 1986 In FRENCH
Avail: NTIS HC A19/MF A01

Modal superposition techniques used to calculate the low frequency response of structures are discussed. A unified approach to the effective modal parameters method of interpreting eigenmodes is outlined. These parameters obey summation rules to reconstruct the corresponding static properties, enabling truncation effects to be estimated in terms of residual parameters representing the global contribution of higher modes. This reveals the role of flexibility, mass, transmissibility, and effective strains. ESA

N87-10898# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DAMPING REPRESENTATION RELATED TO SPACECRAFT STRUCTURAL DESIGN
E. HILBRANDT *In* ESA Proceedings of an International Conference on Spacecraft Structures p 87-92 Apr. 1986
Avail: NTIS HC A19/MF A01

Analysis methods for damping representation and damping prediction and design measures to enhance damping properties of space structures are reviewed. Isolation (filtering) absorption, and discrete and continuous dampers (damping layers) are discussed. Test results on beam and plate structures are compared to analytical models. It is shown that a design for damping concepts in spacecraft structures may significantly reduce the response levels and thus have a beneficial effect on equipment design. ESA

N87-10901# Rome Univ. (Italy).
COMPUTATIONAL METHODS IN ELASTIC PERIODIC STRUCTURES ANALYSES
F. GRAZIANI and S. SGUBINI *In* ESA Proceedings of an International Conference on Spacecraft Structures p 109-112 Apr. 1986
Avail: NTIS HC A19/MF A01

A method for decomposing an eigenvalue problem of N-bays dimensions into N problems of 1-bay dimensions is indicated. The results provide a contribution to obtain a recursive relationship in evaluating the eigenvalue equation and in computing the eigenvalues for axisymmetric and linear periodic structures. ESA

N87-10903# Footscray Inst. of Tech. (Australia).
ON A SIMPLE VIBRATION CONTROL DESIGN FOR LARGE SPACE STRUCTURE MODELS WITH UNCERTAIN PARAMETERS
R. LICATA *In* ESA Proceedings of an International Conference on Spacecraft Structures p 119-124 Apr. 1986
Avail: NTIS HC A19/MF A01

The presence of unavoidable modeling errors and sizeable uncertainty in parameters of a reduced-order model of a large flexible space structure is addressed in relation to the controller design problem. Due mainly to limitations placed by on-board computers (which cause on-line adaptive or self-tuning control schemes to become unrealizable on flexible spacecraft) a controller design solution in the form of a simple to implement time-invariant feedback, obtained by considering constant and with known statistics the uncertain model parameters, is presented. The proposed stochastic optimal control scheme, more insensitive to parameter variation and spillover effects compared with that obtained by deterministic approach, may be used in the design of local or global controllers of a flexible spacecraft structure. ESA

N87-10904# London Univ. (England). Queen Mary Coll.
THE EFFECT OF THE NON-UNIFORM STRESS DISTRIBUTION IN THE BLANKETS OF SINGLE AND TWIN BOOM SOLAR ARRAY PANELS UPON THEIR MODAL CHARACTERISTICS
J. R. WRIGHT *In* ESA Proceedings of an International Conference on Spacecraft Structures p 125-130 Apr. 1986
Avail: NTIS HC A19/MF A01

The modal behavior of deployed flexible solar arrays of the single boom fold-out and twin boom roll-out types was studied with simple theoretical model configurations. The effect of the nonuniform stress distribution in the array blanket arising from flexible end members was investigated for out-of-plane/bending modes. It is found that the string-like modes important for control are hardly affected so a uniform tension analysis is adequate. However, other modes needed for response behavior are affected, particularly for the single boom array where buckling can occur. It is also found that bending stiffness in the blanket needs to be included to lead to a unique and complete set of array modes if uniform tension is assumed. ESA

N87-10915# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
A REVIEW OF TIME DOMAIN MODAL TEST METHODS AND APPLICATIONS
S. R. IBRAHIM *In* ESA Proceedings of an International Conference on Spacecraft Structures p 205-211 Apr. 1986
Avail: NTIS HC A19/MF A01

Time domain modal testing techniques based on direct use of a structure's free decay time response functions are reviewed. They are economical and powerful tools for in-space, or in-orbit, identification of space structures. Even though meritorious in laboratory controlled modal tests, these techniques possess unique and useful qualities when the only available responses are those obtained while the structure is in operation or use. Application to solar array orbital dynamics is described. ESA

N87-10925# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Group.
INFLUENCE OF FIBER ORIENTATION AND BOUNDARY CONDITIONS ON THE DYNAMIC BEHAVIOR OF A CYLINDRICALLY TELESCOPING SOLAR ARRAY (INTELSAT 6)
E. D. SACH, H. J. HUETTMANN, and E. FRITSCHE *In* ESA Proceedings of an International Conference on Spacecraft Structures p 289-292 Apr. 1986
Avail: NTIS HC A19/MF A01

To meet the strong frequency requirements in stowed configuration of the INTELSAT 6 solar array (2 central telescoping cylinders in sandwich design, the face sheets of which are made of aramid fiber fabric and carbon fiber fabric) analyses were performed to show the influence of fiber orientations, number of layers and stiffener rings and boundary conditions on the dynamic behavior. The investigations show that each reinforcement measure is effective only in a very limited range. To fulfill the frequency requirement with a minimum structural mass, a combination of several reinforcements is necessary. ESA

N87-10938# Societe Bertin et Cie, Plaisir (France).
DYNAMICS OF FLEXIBLE MECHANISMS [DYNAMIQUE DE MECANISMES FLEXIBLES]
G. GALLAY, F. GIRARD, and J. M. AUCLAIR *In* ESA Proceedings of an International Conference on Spacecraft Structures p 381-386 Apr. 1986 In FRENCH
Avail: NTIS HC A19/MF A01

A method for the automatic generation of the equations of motion of complex flexible mechanical systems such as large space structures is presented. The equations are derived using the method of virtual work of Kane (1901). The rigid body kinematics treatment uses relative coordinates. A model synthesis method is added to handle the problem of a deformable solid body. The method minimizes the number of equations, while being able to cope with complex topologies (closed chains). ESA

N87-10957# Groningen Rijksuniversiteit (Netherlands). Dept. of Mathematics.
LARGE FLEXIBLE SPACE STRUCTURES: SOME SIMPLE MODELS
J. BONTSEMA 1986 27 p
(TW-269; B8666169; ETN-86-98503) Avail: NTIS HC A03/MF A01

Simple models of large flexible space structures are used to study the effect of flexibility and damping. The models are a one dimensional flexible beam (Euler-Bernouilli) and two flexible beams connected through a central disk, where for simplicity it is assumed that the thickness of the disk in the direction of the beams is zero. Partial differential equations are derived for these structures and it is proved that the equations are well posed. Equations for the eigenfrequencies and eigenmodes of the structures are given and the controls and observations are discussed. As an example for finite dimensional control design the method of Curtain (1983) is discussed. ESA

N87-11765*# Engineering Mechanics Association, Inc., Palo Verde, Calif.
COMPONENT TESTING FOR DYNAMIC MODEL VERIFICATION
T. K. HASSELMAN and J. D. CHROSTOWSKI *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 15 p 1984
Avail: NTIS HC A22/MF A01 CSCL 01A

Dynamic model verification is the process whereby an analytical model of a dynamic system is compared with experimental data, adjusted if necessary to bring it into agreement with the data, and then qualified for future use in predicting system response in a different dynamic environment. These are various ways to conduct model verification. The approach taken here employs Bayesian statistical parameter estimation. Unlike curve fitting, whose objective is to minimize the difference between some analytical function and a given quantity of test data (or curve), Bayesian

estimation attempts also to minimize the difference between the parameter values of that funciton (the model) and their initial estimates, in a least squares sense. The objectives of dynamic model verification, therefore, are to produce a model which: (1) is in agreement with test data; (2) will assist in the interpretation of test data; (3) can be used to help verify a design; (4) will reliably predict performance; and (5) in the case of space structures, will facilitate dynamic control. Author

N87-11766*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
DUAL STRUCTURAL-CONTROL OPTIMIZATION OF LARGE SPACE STRUCTURES
A. MESSAC and J. TURNER *In* NASA. Langley Research Center Recent Experiences in Multidisciplinary Analysis and Optimization, Part 2 28 p 1984
Avail: NTIS HC A22/MF A01 CSCL 22B

A new approach is proposed for solving dual structural-control optimization problems for high-order flexible space structures where reduced-order structural models are employed. For a given initial structural dessign, a quadratic control cost is minimized subject to a constant-mass constraint. The sensitivity of the optimal control cost with respect to the stuctural design variables is then determined and used to obtain successive structural redesigns using a contrained gradient optimization algorithm. This process is repeated until the constrained control cost sensitivity becomes negligible. A numerical example is presented which demonstrates that this new approach effectively addresses the problem of dual optimization for potentially very high-order structures. Author

N87-11829# State Univ. of New York, Buffalo. Dept. of Mechanical and Aerospace Engineering.
QUALITATIVE RESULTS FOR DISTRIBUTED SYSTEMS WITH DISCRETE AND STIFFNESS WITH APPLICATION TO CONTROL Final Report, 1 Jul. 1982 - 30 Jun. 1985
D. J. INMAN 26 Aug. 1985 215 p
(Contract AF-AFOSR-0242-82)
(AD-A168622; AFOSR-86-0286TR) Avail: NTIS HC A10/MF A01 CSCL 22B

Distributed parameter models of large flexible space structures subject to various control techniques have been studied. The main thrust has been to develop qualitative results which are independent of truncation of discretization approaches by treating the fully distributed model. Emphasis has been on controlling the transient response of non-conservative linear partial differential equation models of such structures subject to a few point actuators. Inequalities have been developed between the stiffness and damping operators which when satisfied guarantee that the response of a self-adjoint system will be uniformly exponentially stable. In addition, it has been shown that the inequalities insure that finite dimensional versions of the control problem converge to an optimal control of the fully distributed system subject to compact feedback as the number of modes in the finite model increases. The inequality developed constitutes a generalization of the concept of underdamping normally used with single degree of freedom systems and provides a physical interpretation of the result. GRA

N87-11834# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (West Germany).
LARGE WHEEL ACTUATORS DEFINITION STUDY Final Report
H. HEIMEL and H. H. SCHULZ Paris ESA Dec. 1985 243 p
(Contract ESTEC-5907/84-NL-AN(SC))
(TELDIX-15-020-880; ESA-CR(P)-2265; ETN-86-98144) Avail: NTIS HC A11/MF A01

Large momentum wheels for attitude stabilization and maneuvering of large space vehicles and space structures were studied. Wheels with diameters of 50 and 80 cm and momentum ceilings of 300 and 1000 Nms, respectively, and control moment gyros (CMG) derived from them were considered. Spoked wheel designs are preferred, and data tables that define wheel families in each of the two size categories are provided. Suggestions for CMG devices bases on these wheels are presented. ESA

N87-12802# Sandia National Labs., Albuquerque, N. Mex.
LI CORROSION RESISTANT GLASSES FOR HEADERS IN AMBIENT TEMPERATURE LI BATTERIES Patent Application
E. E. HELLSTROM, inventor (to DOE) and R. D. WATKINS, inventor (to DOE) 11 Oct. 1985 18 p
(Contract DE-AC04-76DP-00789)
(DE86-013754; US-PATENT-APPL-SN-786561) Avail: NTIS HC A02/MF A01

Glass compositions containing 10 to 50 mol% CaO, 10 to 50 mol% AlO, 30 to 60 mol% BO, and 0 to 30 mol% MgO are provided. These compositions are capable of forming a stable glass-to-metal seal possessing electrical insulating properties for use in a lithium battery. Also provided are lithium cells containing a stainless steel body and molybdenum center pin electrically insulated by means of a seal produced according to the invention. DOE

N87-13476*# Catholic Univ. of America, Washington, D.C.
DISTRIBUTED ACTIVE CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES Semiannual Progress Report
C. C. NGUYEN and A. BAZ Nov. 1986 39 p
(Contract NAG5-749)
(NASA-CR-179941; NAS 1.26:179941) Avail: NTIS HC A03/MF A01 CSCL 22B

This progress report summarizes the research work performed at the Catholic University of America on the research grant entitled Distributed Active Control of Large Flexible Space Structures, funded by NASA/Goddard Space Flight Center, under grant number NAG5-749, during the period of March 15, 1986 to September 15, 1986. Author

N87-13478*# California Univ., Los Angeles. Dept. of Mechanical, Aerospace and Nuclear Engineering.
UNIFIED CONTROL/STRUCTURE DESIGN AND MODELING RESEARCH Final Report
D. L. MINGORI, J. S. GIBSON, P. A. BLELLOCH, and A. ADAMIAN 8 Jan. 1986 143 p Prepared for JPL
(Contract NAS7-918)
(NASA-CR-179948; JPL-9950-1206; NAS 1.26:179948; REPT-957114-3) Avail: NTIS HC A07/MF A01 CSCL 22B

To demonstrate the applicability of the control theory for distributed systems to large flexible space structures, research was focused on a model of a space antenna which consists of a rigid hub, flexible ribs, and a mesh reflecting surface. The space antenna model used is discussed along with the finite element approximation of the distributed model. The basic control problem is to design an optimal or near-optimal compensator to suppress the linear vibrations and rigid-body displacements of the structure. The application of an infinite dimensional Linear Quadratic Gaussian (LQG) control theory to flexible structure is discussed. Two basic approaches for robustness enhancement were investigated: loop transfer recovery and sensitivity optimization. A third approach synthesized from elements of these two basic approaches is currently under development. The control driven finite element approximation of flexible structures is discussed. Three sets of finite element basic vectors for computing functional control gains are compared. The possibility of constructing a finite element scheme to approximate the infinite dimensional Hamiltonian system directly, instead of indirectly is discussed. B.G.

N87-13479# WEA, Cambridge, Mass.
WAVE PROPAGATION AND DYNAMICS OF LATTICE STRUCTURES Final Report, 1 Apr. 1983 - 30 Sep. 1985
J. H. WILLIAMS, JR. 1 Oct. 1985 27 p
(Contract F49620-83-C-0092)
(AD-A170316; AFOSR-86-0489TR) Avail: NTIS HC A03/MF A01 CSCL 22B

Many papers and reports have been written on the concepts, design and potential uses of lattice structures in outer space. Such structures include large antennae, solar power systems and

habitable stations for support of space colonies. Currently, both deployable and erectable concepts are being investigated for the implementation of lattice structures. Also, investigations of size considerations indicate that small antennae ranging from tens of meters in span to solar power collectors ranging up to several thousand meters have been proposed. Such structural sizes along with stringent operational requirements will require considerable information of dynamics, control, materials, nondestructive evaluation (NDE), environmental effects and wave propagation relating to their design and analysis. Much has been written on the theoretical aspects of the control of such structures. Also, a large number of vibration analyses have been undertaken. However, despite a distinct recognition of the importance of wave propagation in many of the control, vibration and NDE investigations, virtually no thing can be found on wave propagation in large space structures (LSS). The goals of this program were to initiate and to pursue the development of several aspects of wave propagation analyses in LSS. Author (GRA)

N87-13485# Engineering System International, Rungis (France).
APPLICATION OF DYNAMIC ELEMENTS AND CONTINUUM METHODS TO LARGE SPACE STRUCTURES, VOLUME 2 Final Report
A. BOSSAVIT, J. CLINCKEMAILLIE, E. HAUG, J. DUBOIS, DOWLATYARI, and Y. OUALI Paris, France ESA Dec. 1985 293 p
(Contract ESTEC-5209/82-NL-PB(SC))
(ED/82-362/RD-VOL-2; ESA-CR(P)-2217-VOL-2; ETN-86-98151) Avail: NTIS HC A13/MF A01

Methods for the analysis of complex and large structures are reviewed. Dynamic synthesis and reduction methods taking the symmetry of the structure into account are considered. Improvements of the accuracy of dynamic elements (bar, continuum, beam) by a better discretization of the mass matrix are identified. The two identified approaches (Stavrinidis and Second Order) can reduce the error in frequency, stresses, etc., in typical cases by a factor of more than 2. It is recommended to further explore these improvements since significant accuracy can be achieved with no extra computational effort. ESA

N87-13788*# Catholic Univ. of America, Washington, D.C. Dept. of Mechanical Engineering.
STATIC DEFLECTION CONTROL OF FLEXIBLE BEAMS BY PIEZO-ELECTRIC ACTUATORS
A. M. BAZ 19 Dec. 1986 43 p
(Contract NASA WORK ORDER 30429-D)
(NASA-CR-179947; NAS 1.26:179947) Avail: NTIS HC A03/MF A01 CSCL 20K

This study deals with the utilization of piezo-electric actuators in controlling the static deformation of flexible beams. An optimum design procedure is presented to enable the selection of the optimal location, thickness and excitation voltage of the piezo-electric actuators in a way that would minimize the deflection of the beam to which these actuators are bonded. Numerical examples are presented to illustrate the application of the developed optimization procedure in minimizing the structural deformation of beams of different materials when subjected to different loading and end conditions using ceramic or polymeric piezo-electric actuators. The results obtained emphasize the importance of the devised rational procedure in designing beam-actuator systems with minimal elastic distortions. Author

N87-15262*# Martin Marietta Aerospace, Denver, Colo.
DYNAMIC TESTING OF A TWO-DIMENSIONAL BOX TRUSS BEAM Final Report
CHARLES W. WHITE Washington NASA Jan. 1987 64 p
(Contract NAS1-17551)
(NASA-CR-4039; NAS 1.26:4039; MCR-86-575) Avail: NTIS HC A04/MF A01 CSCL 22B

Testing to determine the effects of joint freeplay and pretensioning of diagonal members on the dynamic characteristics of a two-dimensional box truss beam was conducted. The test article was ten bays of planar truss suspended by long wires at each joint. Each bay measured 2 meters per side. Pins of varying size were used to simulate various joint freeplay conditions. Single-point random excitation was the primary method of test. The rational fraction polynomial method was used to extract modal characteristics from test data. A finite element model of the test article was generated from which modal characteristics were predicted. These were compared with those obtained from tests. With the exception of the fundamental mode, correlation of theoretical and experimental results was poor, caused by the resonant coupling of local truss member bending modes with global truss beam modes. This coupling introduced many modes in the frequency range of interest whose frequencies were sensitive to joint boundary conditions. It was concluded that local/global coupling must be avoided in the frequency range where accurate modal characteristics are required. Author

N87-15263# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
OPTIMIZATION OF CLOSED LOOP EIGENVALUES MANEUVERING, VIBRATION CONTROL AND STRUCTURE/CONTROL DESIGN ITERATION FOR FLEXIBLE SPACECRAFT Final Report, Jun. 1985 - May 1986
JOHN L. JUNKINS 31 May 1986 151 p Prepared in cooperation with Texas A and M Univ., College Station
(Contract F49620-83-K-0032)
(AD-A172716; AFOSR-86-0905TR) Avail: NTIS HC A08/MF A01 CSCL 22B

This report summarizes new results on spacecraft dynamics and control. Perturbation methods are presented for computing nonlinear open and closed loop optimal maneuver control. Homotopy optimization algorithms are presented for tuning linear regulators vis-a-vis eigenvalue placement and robustness. A simultaneous structure/controller design optimization algorithm is developed. GRA

N87-16017*# Air Force Rocket Propulsion Lab., Edwards AFB, Calif. Interdisciplinary Space Technology Branch.
SPACECRAFT DYNAMICS AND CONTROL PROGRAM AT AFRPL
A. DAS, L. K. S. SLIMAK, and W. T. SCHLOEGEL *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 25-40 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

A number of future DOD and NASA spacecraft such as the space based radar will be not only an order of magnitude larger in dimension than the current spacecraft, but will exhibit extreme structural flexibility with very low structural vibration frequencies. Another class of spacecraft (such as the space defense platforms) will combine large physical size with extremely precise pointing requirement. Such problems require a total departure from the traditional methods of modeling and control system design of spacecraft where structural flexibility is treated as a secondary effect. With these problems in mind, the Air Force Rocket Propulsion Laboratory (AFRPL) initiated research to develop dynamics and control technology so as to enable the future large space structures (LSS). AFRPL's effort in this area can be subdivided into the following three overlapping areas: (1) ground experiments, (2) spacecraft modeling and control, and (3) sensors and actuators. Both the in-house and contractual efforts of the AFRPL in LSS are summarized. Author

N87-16019*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
ACTIVE CONTROL EVALUATION FOR SPACECRAFT (ACES)
J. PEARSON and W. YUEN *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 67-84 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

The Air Force goal is to develop vibration control techniques for large flexible spacecraft by addressing sensor, actuator, and control hardware and dynamic testing. The Active Control Evaluation for Spacecraft (ACES) program will address the Air Force goal by looking at two leading control techniques and

implementing them on a structural model of a flexible spacecraft under laboratory testing. The first phase in the ACES program is to review and to assess the High Authority Control/Low Authority Control (HAC/LAC) and Filter accomodated Model Error Sensitivity Suppression (FAMESS) control techniques for testing on the modified VCOSS structure. Appropriate sensors and actuators will be available for use with both techniques; locations will be the same for both techniques. The control actuators will be positioned at the midpoint and free end of the structure. The laser source for the optical sensor is mounted on the feed mast. The beam will be reflected from a mirror on the offset antenna onto the detectors mounted above the shaker table bay. The next phase is to develop an analysis simulation with the control algorithms implemented for dynamics verification. The third phase is to convert the control laws into high level computer language and test them in the NASA-MSFC facility. The final phase is to compile all analytical and test results for performance comparisons. Author

N87-16025*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE 15 METER HOOP-COLUMN ANTENNA DYNAMICS: TEST AND ANALYSIS

W. KEITH BELVIN and HAROLD H. EDIGHOFFER (Edighoffer, Inc., Newport News, Va.) *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 167-185 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 20N

A 15 meter model of the hoop-column antenna concept has been vibration tested for model characterization and analytical model verification. Linear finite element analysis predicted the global vibration frequencies accurately. Good agreement between analysis and test data was obtained only after the analytical model was refined using static test data. As structures become more flexible, structural properties determined from static data become more accurate and should be used to update analytical models. Global vibration modes are not significantly affected by the surface mesh which permits simplified analytical models to be used for prediction of global behavior. These reduced models are believed sufficient for preliminary design and controls simulations where only global behavior is desired. The mesh modes were highly damped due to the knit mesh used for the reflector surface. These modes were also highly coupled and very difficult to measure in the laboratory. The inability to fully characterize the antenna mesh modes in the laboratory indicates robust methods for active surface vibration suppression will be needed. Fortunately, the surface mesh exhibits high passive damping which should be beneficial to active control systems. Author

N87-16026*# TRW, Inc., Redondo Beach, Calif.

APPLICATION OF PHYSICAL PARAMETER IDENTIFICATION TO FINITE ELEMENT MODELS

ALLEN J. BRONOWICKI, MICHAEL S. LUKICH, and STEVEN P. KURITZ *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 187-206 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 12A

A time domain technique for matching response predictions of a structural dynamic model to test measurements is developed. Significance is attached to prior estimates of physical model parameters and to experimental data. The Bayesian estimation procedure allows confidence levels in predicted physical and modal parameters to be obtained. Structural optimization procedures are employed to minimize an error functional with physical model parameters describing the finite element model as design variables. The number of complete FEM analyses are reduced using approximation concepts, including the recently developed convoluted Taylor series approach. The error function is represented in closed form by converting free decay test data to a time series model using Prony' method. The technique is demonstrated on simulated response of a simple truss structure. Author

N87-16028*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COFS 1: BEAM DYNAMICS AND CONTROL TECHNOLOGY OVERVIEW

JOHN L. ALLEN *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 221-232 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 20N

The Control of Flexible Structures (COFS) 1 Project provides the invaluable opportunity to test, validate, and measure the effectiveness of theories, structural concepts, control systems, and flight certification processes for future missions through a research program focusing on multiple issues in large flexible structures, dynamics, and controls. The COFS 1 Project consists of a series of ground and flight activities building progressively from modeling and dynamic characterization of large space systems to the more complex issues of flexible-body control. The program objectives are to: determine the degree to which theory and ground testing can predict flight performance of next-generation low-frequency structures; evaluate structural fidelity of representative next-generation large deployable precision structure; assess math modeling requirements for large lightweight complex systems on which ground test results are questionable; determine degree to which scale model analysis and tests can be correlated to full-scale performance; evaluate system identification and state estimation algorithms on complex lightweight structures in the space environment; evaluate and verify controls/structures modeling capability; evaluate control laws and control systems; and evaluate damping effects in micro-g environment. Author

N87-16032*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

MAST FLIGHT SYSTEM DYNAMIC PERFORMANCE

L. DAVIS, D. HYLAND, T. OTTEN, and F. HAM *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 281-298 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 20K

The MAST Flight System as a test bed for large space structure control algorithms is discussed. An overview is given of the control system architecture. The actuators, the sensors, the control computer, and the baseline damping algorithm are discussed. R.J.F.

N87-16035*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COFS 2: 3-D DYNAMICS AND CONTROLS TECHNOLOGY

JON S. PYLE *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 327-345 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 22B

The Control of Flexible Structures (COFS) 2 project is a complex and ambitious undertaking which will address several critical technology areas. Among them are modeling, structural dynamics, controls, and ground testing issues which are not only germane to this effort, but to other large space structure programs being contemplated. This effort requires the early integration of controls and structural dynamics considerations in order to achieve mission success. Several technology advances must be achieved in the areas of system modelling, control synthesis and methodology, sensor/actuator development, and ground testing techniques for system evaluation and on-orbit performance prediction and verification. This project offers a unique opportunity for the integration of several disciplines to produce technology advances which will benefit many future programs. In addition, the opportunities available to participate in the various levels in the phase of this project, e.g., analytical development and modelling, ground testing, and flight testing, permit for the involvement of a significant number of interested researchers and organizations from government, universities and industry. Author

N87-16036*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

COFS 3: MULTIBODY DYNAMICS AND CONTROL TECHNOLOGY

ROBERT LETCHWORTH and PAUL E. MCGOWAN *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 347-370 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 20K

COFS 3 is the third project within the Control of Flexible Structures (COFS) program. It deals with developing multibody dynamics and control technology for large space structures. It differs from COFS 1 and 2 in two respects. First, it addresses a more complex class of structure, and second it is basically a scale model ground test and analysis program while COFS 1 and 2 feature Shuttle flight experiments. The specific technology thrusts within COFS 3 are model sensitivities, test methods, analysis validation, systems identification, and vibration suppression. The COFS 3 project will develop the methods for using dynamically scaled models and analysis to predict the structural dynamics of large space structures. The project uses the space station as a focus because it is typical of the structures of interest and provides the first opportunity to obtain full-scale on-orbit dynamics data. Author

N87-16037*# General Electric Co., Philadelphia, Pa. Space Div.

CONCEPTUAL DESIGN OF POINTING CONTROL SYSTEMS FOR SPACE STATION GIMBALLED PAYLOADS

ROBERT O. HUGHES *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 371-381 Nov. 1986 Previously announced as A86-47411

Avail: NTIS HC A23/MF A01 CSCL 22B

A conceptual design of the control system for Payload Pointing Systems (PPS) is developed using classic Proportional-Integral-Derivatives (PID) techniques. The major source of system pointing error is due to the disturbance-rich environment of the space station in the form of gimbal baseplate motions. These baseplate vibrations are characterized using Fast Fourier Transform (FFT) techniques. Both time domain and frequency domain dynamics models are developed to assess control system performance. Three basic methods exist for the improvement of PPS pointing performance: increase control system bandwidth, add Image Motion Compensation, and/or reduce (or change) the baseplate disturbance environment. Author

N87-16040*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SYSTEM IDENTIFICATION FOR MODELING FOR CONTROL OF FLEXIBLE STRUCTURES

EDWARD METTLER and MARK MILMAN *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 419-429 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 22B

The major components of a design and operational flight strategy for flexible structure control systems are presented. In this strategy an initial distributed parameter control design is developed and implemented from available ground test data and on-orbit identification using sophisticated modeling and synthesis techniques. The reliability of this high performance controller is directly linked to the accuracy of the parameters on which the design is based. Because uncertainties inevitably grow without system monitoring, maintaining the control system requires an active on-line system identification function to supply parameter updates and covariance information. Control laws can then be modified to improve performance when the error envelopes are decreased. In terms of system safety and stability the covariance information is of equal importance as the parameter values themselves. If the on-line system ID function detects an increase in parameter error covariances, then corresponding adjustments must be made in the control laws to increase robustness. If the error covariances exceed some threshold, an autonomous calibration sequence could be initiated to restore the error enveloped to an acceptable level. Author

N87-16041*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

DEVELOPMENT AND USE OF A LINEAR MOMENTUM EXCHANGE DEVICE

GEORGE B. DOANE, III (Control Dynamics Co., Huntsville, Ala.), HENRY WAITES, and G. DAVID EDGEMON *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 431-440 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 14B

In 1981 the Marshall Space Flight Center (MSFC) began establishing an inhouse facility for testing control concepts to be applied to Large Space Structures (LSS). The original concept called for a long flexible beam suspended from the ceiling by a low friction support system. The lower end of the beam was to be mounted to the Advanced Gimbal System (AGS). Analysis and system engineering soon showed that a more tenable design would be where the whole system was inverted, i.e., the AGS hung from the ceiling with the beam hanging down from it. While this configuration, augmented by a base excitation table (RET) was being built, an ASTROMAST obtained from the Jet Propulsion Laboratory was extended, analyzed and tested. From that basic configuration was evolved the cruciform, VCOSS and ACES configurations as shown. The addition of the cruciform added low frequency nested modes and the additional instrument package at the tip contains gyros to monitor tip motion. Author

N87-16043*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

DISTRIBUTED CONTROL FOR COFS 1

R. C. MONTGOMERY, JEFF SULLA (PRC Kentron, Inc., Hampton, Va.), and D. K. LINDNER (Virginia Polytechnic Inst. and State Univ., Blacksburg) *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 457-473 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 22B

An overview is given of the work being done at NASA LaRC on developing the Control of Flexible Structures (COFS) 1 Flight Experiment Baseline Control Law. This control law currently evolving to a generic control system software package designed to supply many, but not all, guest investigators. A system simulator is also described. It is currently being developed for COFS-1 and will be used to develop the Baseline Control Law and to evaluate guest investigator control schemes. It will be available for use whether or not control schemes fall into the category of the Baseline Control Law. First, the hardware configuration for control experiments is described. This is followed by a description of the simulation software. Open-loop sinusoid excitation time histories are next presented both with and without a local controller for the Linear DC Motor (LDCM) actuators currently planned for the flight. The generic control law follows and algorithm processing requirements are cited for a nominal case of interest. Finally, a closed-loop simulation study is presented, and the state of the work is summarized in the concluding remarks. Author

N87-16044*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

PASSIVE DAMPING AUGMENTATION FOR FLEXIBLE STRUCTURES

J. R. SESAK, M. J. GRONET, and G. M. MARINOS *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 475-493 Nov. 1986

Avail: NTIS HC A23/MF A01 CSCL 22B

The present work concentrates on the application and extension of absorber design and optimization techniques to a multimode, multi-DOF, large space structure, namely the NASA space station. The principal issue addressed is the optimal tuning of several absorbers for the transient response of a multi-DOF system, including the effects of modal coupling, existing structural damping, absorber placement, and adsorber mass. The space station is subject to many transient disturbances such as docking, orbit reboost, crew motion, and payload slewing. A notable steady-state excitation source is the Science Research Centrifuge, which rotates at a frequency in the bandwidth of the primary structural modes. Because of the relatively advanced state of development of

steady-state absorber design techniques, only the transient cases are considered in this study. Author

N87-16045*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIDISCIPLINARY ANALYSIS OF ACTIVELY CONTROLLED LARGE FLEXIBLE SPACECRAFT
PAUL A. COOPER, JOHN W. YOUNG, and THOMAS R. SUTTER *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 495-514 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

The control of Flexible Structures (COFS) program has supported the development of an analysis capability at the Langley Research Center called the Integrated Multidisciplinary Analysis Tool (IMAT) which provides an efficient data storage and transfer capability among commercial computer codes to aid in the dynamic analysis of actively controlled structures. IMAT is a system of computer programs which transfers Computer-Aided-Design (CAD) configurations, structural finite element models, material property and stress information, structural and rigid-body dynamic model information, and linear system matrices for control law formulation among various commercial applications programs through a common database. Although general in its formulation, IMAT was developed specifically to aid in the evaluation of the structures. A description of the IMAT system and results of an application of the system are given. Author

N87-16046*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYSIS AND SIMULATION OF THE MAST (COFS-1 FLIGHT HARDWARE)
LUCAS G. HORTA, JOANNE L. WALSH, GARNETT C. HORNER, and JAMES P. BAILEY (PRC Kentron, Inc., Hampton, Va.) *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 515-532 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

In-house analysis work in support of the Control of Flexible Structures (COFS) program is being performed at the NASA Langley Research Center. The work involves evaluation of the proposed design configuration, controller design as well as actuator dynamic modeling, and MAST/actuator dynamic simulation of excitation and damping. A complete finite element model of the MAST has been developed. This finite element model has been incorporated into an optimization procedure which minimizes total mass while maintaining modal coupling. Results show an increase in the total mass due to additional constraints (namely, the diagonal frequency constraint) imposed on the baseline design. A valid actuator dynamic model is presented and a complete test sequence of the proposed flight experiment is demonstrated. The actuator dynamic model is successfully used for damping and the stroke limitations for first mode excitation are demonstrated. Plans are to incorporate additional design variables and constraints into the optimization procedure (such as actuator location) and explore alternative formulations of the objective function. A different actuator dynamic model to include hardware limitations will be investigated. Author

N87-16047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SURFACE CONTROL SYSTEM FOR THE 15 METER HOOP-COLUMN ANTENNA
JAMES B. MILLER, ELVIN L. AHL, JR., DAVID H. BUTLER, and FRANK PERI, JR. *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 533-545 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

The 15-meter hoop-column antenna fabricated by the Harris Corporation under contract to the NASA Langley Research Center is described. The antenna is a deployable and restowable structure consisting of a central telescoping column, a 15-meter-diameter folding hoop, and a mesh reflector surface. The hoop is supported and positioned by 48 quartz cords attached to the column above the hoop, and by 24 graphite cords from the base of the antenna column. The RF reflective surface is a gold plated molybdenum wire mesh supported on a graphite cord truss structure which is attached between the hoop and the column. The surface contour is controlled by 96 graphite cords from the antenna base to the rear of the truss assembly. The antenna is actually a quadaperture reflector with each quadrant of the surface mesh shaped to produce an offset parabolic reflector. Results of near-field and structural tests are given. Controls structures and electromagnetics interaction, surface control system requirements, mesh control adjustment, surface control system actuator assembly, surface control system electronics, the system interface unit, and control stations are discussed. Author

N87-16048*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ROBUST MULTIVARIABLE CONTROLLER DESIGN FOR FLEXIBLE SPACECRAFT
SURESH M. JOSHI and ERNEST S. ARMSTRONG *In its* NASA/DOD Control/Structures Interaction Technology, 1986 p 547-562 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 22B

Large, flexible spacecraft are typically characterized by a large number of significant elastic modes with very small inherent damping, low, closely spaced natural frequencies, and the lack of accurate knowledge of the structural parameters. Summarized here is some recent research on the design of robust controllers for such spacecraft, which will maintain stability, and possible performance, despite these problems. Two types of controllers are considered, the first being the linear-quadratic-Guassian-(LQG)-type. The second type utilizes output feedback using collocated sensors and actuators. The problem of designing robust LQG-type controllers using the frequency domain loop transfer recovery (LTR) method is considered, and the method is applied to a large antenna model. Analytical results regarding the regions of stability for LQG-type controllers in the presence of actuator nonlinearities are also presented. The results obtained for the large antenna indicate that the LQG/LTR method is a promising approach for control system design for flexible spacecraft. For the second type of controllers (collocated controllers), it is proved that the stability is maintained in the presence of certain commonly encountered nonlinearities and first-order actuator dynamics. These results indicate that collocated controllers are good candidates for robust control in situations where model errors are large. Author

N87-16050*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC ANALYSIS OF THE LARGE DEPLOYABLE REFLECTOR
ROBERT E. CALLESON and A. DON SCOTT Jan. 1987 34 p (NASA-TM-89056; NAS 1.15:89056) Avail: NTIS HC A03/MF A01 CSCL 22B

The Large Deployable Reflector (LDR) is to be an astronomical observatory orbiting above Earth's obscuring atmosphere and operating in the spectral range between 30 microns and 1000 microns wavelength. The LDR will be used to study such astronomical phenomena as stellar and galactic formation, cosmology, and planetary atmospheres. The LDR will be the first observatory to be erected and assembled in space. This distinction brings with it several major technological challenges such as the development of ultra-lightweight deployable mirrors, advanced mirror fabrication techniques, advanced structures, and control of vibrations due to various sources of excitation. The purpose of this analysis is to provide an assessment of the vibrational response due to secondary mirror chopping and LDR slewing. The dynamic response of two 20-m LDR configurations was studied. Two mirror support configurations were investigated for the Ames concept, the first employs a six-strut secondary mirror support structure, while the second uses a triple-bipod support design. All three configurations were modeled using a tetrahedral truss design for the primary mirror support structure. Response resulting from secondary mirror chopping was obtained for the two Ames configurations, and the response of the primary mirror from slewing was obtained for all three configurations. Author

N87-16056# Massachusetts Univ., Amherst. Dept. of Civil Engineering.
PARAMETRIC INVESTIGATION OF FACTORS INFLUENCING THE MECHANICAL BEHAVIOR OF LARGE SPACE STRUCTURES Final Technical Report, 1 Nov. 1982 - 30 Jun. 1985
WILLIAM A. NASH and THOMAS J. LARDNER 30 May 1986 451 p
(Contract AF-AFOSR-0025-83)
(AD-A172880; AFOSR-86-0858TR) Avail: NTIS HC A20/MF A01 CSCL 22B

The investigation has two objectives: (1) To investigate the relative importance of factors such as thermal gradients, differential gravitational effects, solar radiation pressure, albedo effects, and spatial pressure gradients on structural behavior of large space structures; and (2) To investigate structural behavior of a very thin membrane subject to combined internal pressure as well as mechanical and thermal loadings. GRA

N87-16059# Lockheed Missiles and Space Co., Palo Alto, Calif.
WAVE DISPERSION MECHANISMS IN LARGE SPACE STRUCTURES Final Report, Oct. 1983 - Oct. 1985
K. C. PARK 25 Nov. 1985 7 p
(Contract F49620-83-C-0018)
(AD-A173967; LMSC-F104499; AFOSR-86-1007TR) Avail: NTIS HC A02/MF A01 CSCL 22B

This report describes an investigation into wave dispersion phenomena in large lattice space structures. Particular results were: (1) That local member dynamic characteristics significantly influence global dynamic response; (2) That it is possible to increase dispersion of wave energy in lattice-truss structures by adopting a nonuniform lattice construction; and (3) That local member dynamics characteristics require detailed modeling techniques which are capable of capturing member bending behavior in order to assess, realistically, the influence of local phenomena on global dynamic response. GRA

N87-16341*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
DISCRETE MECHANISM DAMPING EFFECTS IN THE SOLAR ARRAY FLIGHT EXPERIMENT
E. D. PINSON *In* NASA. Lewis Research Center The 20th Aerospace Mechanics Symposium p 277-289 May 1986
Avail: NTIS HC A14/MF A01 CSCL 20K

Accelerometer data were collected during on-orbit structural dynamic testing of the Solar Array Flight Experiment aboard the Space Shuttle, and were analyzed at Lockheed Missile and Space Co. to determine the amount of damping present in the structure. The results of this analysis indicated that the damping present in the fundamental in-plane mode of the structure substantially exceeded that of the fundamental out-of-plane mode. In an effort to determine the source of the higher in-plane damping, a test was performed involving a small device known as a constant-force spring motor or constant-torque mechanism. Results from this test indicate that this discrete device is at least partially responsible for the increased in-plane modal damping of the Solar Array Flight Experiment structure. Author

N87-16766*# Alabama Univ., Huntsville. Dept. of Mathematics.
STOCHASTIC MODELING AND CONTROL SYSTEM DESIGNS OF THE NASA/MSFC GROUND FACILITY FOR LARGE SPACE STRUCTURES: THE MAXIMUM ENTROPY/OPTIMAL PROJECTION APPROACH
WEI-SHEN HSIA *In* NASA. Marshall Space Flight Center Research Reports: 1986 NASA/ASEE Summer Faculty Fellowship Program 13 p Nov. 1986
Avail: NTIS HC A99/MF E04 CSCL 22B

In the Control Systems Division of the Systems Dynamics Laboratory of the NASA/MSFC, a Ground Facility (GF), in which the dynamics and control system concepts being considered for Large Space Structures (LSS) applications can be verified, was designed and built. One of the important aspects of the GF is to design an analytical model which will be as close to experimental data as possible so that a feasible control law can be generated. Using Hyland's Maximum Entropy/Optimal Projection Approach, a procedure was developed in which the maximum entropy principle is used for stochastic modeling and the optimal projection technique is used for a reduced-order dynamic compensator design for a high-order plant. Author

N87-16871# Integrated Systems, Inc., Palo Alto, Calif.
ADAPTIVE CONTROL TECHNIQUES FOR LARGE SPACE STRUCTURES Annual Report, 1 Jun. 1985 - 31 May 1986
ROBERT L. KOSUT and MICHAEL G. LYONS 15 Sep. 1986 117 p
(Contract F49620-85-C-0094)
(AD-A173083; ISI-85; AFOSR-86-0885TR) Avail: NTIS HC A06/MF A01 CSCL 22A

The Large Space Structure (LSS) research program was originally formulated in response to increasing concern that performance robustness of Air Force LSS systems would be inadequate to meet mission objectives. Uncertainties in both system dynamics and disturbance spectra characterizations (both time varying and stochastic uncertainty) significantly limit the performance attainable with fixed gain, fixed architecture controls. Therefore, use of an adaptive system, where disturbances and/or plant models are identified prior to or during control, gives systems designers more options for minimizing the risk in achieving performance objectives. 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 to give the controller intelligence. To realize this aim, both a theory of stability and performance of such inherently nonlinear controls is essential as well as a technology capable of achieving the implementation. The present research concentrated on: (1) on line robust design from identified models - what is referred to here as adaptive calibration; and (2) an analysis of slow-adaptation for adaptive control for LSS. GRA

N87-16872# Oklahoma Univ., Norman. Dept. of Mathematics.
ESTIMATION AND CONTROL OF DISTRIBUTED MODELS FOR CERTAIN ELASTIC SYSTEMS ARISING IN LARGE SPACE STRUCTURES Annual Report, 2 Jul. 1984 - 1 Jan. 1986
LUTHER W. WHITE 1986 7 p
(Contract AF-AFOSR-0271-84)
(AD-A175019; AFOSR-86-2193TR) Avail: NTIS HC A02/MF A01 CSCL 20K

This project is to study the estimation and control of elastic systems composed of beams and plates in order to develop efficient and accurate estimation and control algorithms. Results have been obtained for the estimation in static beams and plates, control and location of actuators for static beams and plates, and identifiability for discrete approximations of second order elliptic boundary value problems. Currently testing codes are being developed for numerical experimentation for estimation of damping and elastic coefficients in dynamic linear plate models, estimation of boundary parameters for second order elliptic problems, estimation of elastic coefficients in cantilevered beams using perturbed boundary conditions, optimal location of actuators for the control of beams, and control of plates through forces at points and forces distributed over sets of small measure and curves. The plan is to next investigate boundary control and estimation, estimation and control in structures, use of friction as an active control, and parallelization of estimation and control algorithms. GRA

N87-16880*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPOSITE SPACE ANTENNA STRUCTURES: PROPERTIES AND ENVIRONMENTAL EFFECTS
CAROL A. GINTY and NED M. ENDRES (Sverdrup Technology, Inc., Cleveland, Ohio) 1986 22 p Presented at the 18th International SAMPE Technical Conference, Seattle, Wash., 7-9 Oct. 1986
(NASA-TM-88859; E-3225; NAS 1.15:88859) Avail: NTIS HC A02/MF A01 CSCL 11D

The thermal behavior of composite spacecraft antenna reflectors has been investigated with the integrated Composites Analyzer (ICAN) computer code. Parametric studies have been conducted on the face sheets and honeycomb core which constitute the sandwich-type structures. Selected thermal and mechanical properties of the composite faces and sandwich structures are presented graphically as functions of varying fiber volume ratio, temperature, and moisture content. The coefficients of thermal expansion are discussed in detail since these are the critical design parameters. In addition, existing experimental data are presented and compared to the ICAN predictions. Author

N87-16926# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Space and Ballistics Systems.
MECHANICAL AND CONTROL STUDY OF A 7 M OFFSET UNFURLABLE TRACKING ANTENNA
G. LABRUYERE, L. PASSERON, M. PASTORINO, and E. SCHAFFAR *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 23-30 Aug. 1986
Avail: NTIS HC A12/MF A01

An antenna module for a tracking S-band satellite antenna mechanical concept is presented. The offset unfurlable reflector, the 15 deg antenna pointing mechanism, and the feed system support are described. Antenna pointing control, in presence of multiple flexible structures, is analyzed. ESA

N87-16942# TICRA A/s, Copenhagen (Denmark).
SIMPLE APPROACH FOR EVALUATING MECHANICAL REFLECTOR ANTENNA DISTORTIONS
KNUD PONTOPPIDAN *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 165-170 Aug. 1986
Avail: NTIS HC A12/MF A01

Satellite reflector surface degradations originating from relatively slowly varying distortions, such as thermal deformations and creep are discussed. These surface errors scatter the field from the main beam into the region of the first few sidelobes, thereby deteriorating the isolation between frequency reuse beams. To investigate these errors, the concepts of Zernike modes are introduced. It is demonstrated how this method facilitates the insight and understanding of the physical phenomena occurring when a reflector surface is deformed. An inflatable antenna is used as a test example. ESA

N87-16947# Ricerche e Progetti s.r.l., Turin (Italy).
DYNAMICS AND CONTROL ANALYSIS PACKAGE (DCAP): AN AUTOMATED ANALYSIS AND DESIGN TOOL FOR STRUCTURAL CONTROL OF SPACE STRUCTURES
R. P. SINGH, R. J. VANDERVOORT, C. ARDUINI, A. FESTA (Aeritalia S.p.A., Torino, Italy), C. MACCONE, and D. SCIACOVELLI (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 211-218 Aug. 1986
Avail: NTIS HC A12/MF A01

The Dynamics and Control Analysis Package (DCAP) automated design and checking tool for the dynamics and control of large flexible structures is described. The DCAP includes programs for nonlinear simulation of multibody systems dynamics; linear or linearized system analysis with frequency and time domain response, stability and sensitivity analysis; modal analysis and order reduction; and control design. It is presently being endowed with a user friendly interactive preprocessor, higher speed capabilities, and an LQG package providing for both analog and digital controls. ESA

N87-17029 California Univ., Los Angeles.
A MODIFIED LOOP TRANSFER RECOVERY APPROACH FOR ROBUST CONTROL OF FLEXIBLE STRUCTURES Ph.D. Thesis
PAUL ANDREW BLELLOCH 1986 214 p
Avail: Univ. Microfilms Order No. DA8621022

A procedure is developed for dealing with performance and robustness issues in the design of multi-input multi-output compensators for lightly damped flexible structures. The procedure is based upon representing errors in the plant design model as structured uncertainties, and applying a modified version of the Loop Transfer Recovery (LTR) design method. Real parameter errors such as frequency errors, damping errors or modal displacement errors can be treated. The modified method may be implemented in either of two slightly different forms, both of which permit a controlled tradeoff between performance and robustness. The first approach is the main focus. It involves adjusting the cost function in the regulator problem and the process noise model in the estimator problem in a particular manner which reflects the assumed structure of the modeling errors. Numerical examples dealing with the control of a large flexible space antenna with uncertain frequencies demonstrate that this approach represents a considerable improvement over standard LTR methods. Convenient design parameters can be varied until a satisfactory compromise is achieved between performance and robustness. The second approach is a variation on the first in that it uses a similar procedure for adjusting the cost function in the (full-state feedback) regulator problem. Instead of implementing the controller with an estimator, an algebraic procedure is used to achieve loop recovery with a compensator whose poles can be placed at arbitrary locations. Dissert. Abstr.

N87-17449 Stanford Univ., Calif.
ADAPTIVE CONTROL OF A FLEXIBLE STRUCTURE Ph.D. Thesis
MICHAEL DAVID SIDMAN 1986 205 p
Avail: Univ. Microfilms Order No. DA8619822

The demonstration of a high-performance adaptive control system for a lightly-damped flexible mechanical structure, such as found in large space structures, lightweight robots, and computer peripherals, is discussed. The system accurately identifies the frequencies of three resonances and one anti-resonance, as well as the overall gain of the experimental plant, the Stanford Four Disk System. The robustness and reliability of the system were demonstrated in the presence of large, sudden changes in plant dynamics that include a complex pole-zero flip and near pole-zero cancellation that occur as payload mass is added to the system. Fixed-gain robust control performance, both colocated and noncolocated, are compared to noncolocated adaptive control performance. A new method of pole-placement ensures excellent reference-command step responses, substantial active damping of modeled modes, modest amount of control effort and low computational intensity despite major changes in plant dynamics. Techniques ensure stable control, at least a minimum level of performance at all times and fast recovery after large sudden changes in plant parameters that occur even while the plant is in a quiescent state. Dissert. Abstr.

N87-17822*# Howard Univ., Washington, D. C.
ISSUES IN MODELING AND CONTROLLING THE SCOLE CONFIGURATION
PETER M. BAINUM, A. S. S. R. REDDY, CHEICK MODIBO DIARRA, and FEIYUE LI *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 11-67 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

The parametric study of the in-plane Spacecraft Control Laboratory Experiment (SCOLE) system, the Floquet Stability Analysis, and three dimensional formulations of the SCOLE system dynamics are examined. Control issues are discussed, such as: control of large structures with delayed input in continuous time;

control with delayed input in discrete time; control law design for SCOLE using Linear Quadratic Gaussian (LQC)/TRR technique; and optimal torque control for SCOLE slewing maneuvers. B.G.

N87-17823*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
OPTIMAL TORQUE CONTROL FOR SCOLE SLEWING MANEUVERS
P. M. BAINUM and FEIYUE LI *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 69-82 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

The Spacecraft Control Laboratory Experiment (SCOLE) was slewed from one attitude to the required attitude and an integral performance index which involves the control torques was minimized. Kinematic and dynamical equations, optimal control, two-point boundary-value problems, and estimation of unknown boundary conditions are presented. B.G.

N87-17824*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MATHEMATICAL MODELING OF SCOLE CONFIGURATION WITH LINE-OF-SIGHT ERROR AS THE OUTPUT
S. M. JOSHI *In its* Proceedings of the 3rd Annual SCOLE Workshop p 83-92 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

The Spacecraft Control Laboratory Experiment (SCOLE) linear model; Taylor's coordinate system; Robertson's system; and the flexible linear model are presented. B.G.

N87-17825*# North Carolina Univ., Charlotte. Dept. of Electrical Engineering.
SLEW MANEUVER DYNAMICS OF THE SPACECRAFT CONTROL LABORATORY EXPERIMENT
Y. P. KAKAD *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 93-108 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

Mathematical expressions for slew maneuver dynamics are presented. The total kinetic energy expression of the system is given as $T = T(0) + T(1) + T(2)$, where T(0), T(1), and T(2) refer to the kinetic energies of the shuttle, the flexible beam, and the tip mass (the reflector), respectively. The specific equations for each of these are defined and integrated into the total energy expression. Using the chain rule in the Lagrange equations and an expression allowing the transformation of the orbiter angular velocity from the inertial frame to the body-fixed frame, the rotational equations are obtained. Finally, the vibration equations for the beam are derived, again using the Lagrange equations. M.G.

N87-17827*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ON INCORPORATING DAMPING AND GRAVITY EFFECTS IN MODELS OF STRUCTURAL DYNAMICS OF THE SCOLE CONFIGURATION
LARRY TAYLOR, TERRY LEARY (George Washington Univ., Washington, D.C.), and ERIC STEWART *In its* Proceedings of the 3rd Annual SCOLE Workshop p 121-148 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

The damping for structural dynamic models of flexible spacecraft is usually ignored and then added after modal frequencies and mode shapes are calculated. It is common practice to assume the same damping ratio for all modes, although it is known that damping due to bending and that due to torsion are sometimes ignored. Two methods of including damping in the modeling process from its onset are examined. First, the partial derivative equations of motion are analyzed for a pinned-pinned beam with damping. The end conditions are altered to handle bodies with mass and inertia for the Spacecraft Control Laboratory Experiment (SCOLE) configuration. Second, a massless beam approximation is used for the modes with low frequencies, and a clamped-clamped system is used to approximate the modes for arbitrarily high frequency. The model is then modified to include gravity effects and is compared with experimental results. Author

N87-17829*# Rensselaer Polytechnic Inst., Troy, N.Y. Dept. of Electrical, Computer and Systems Engineering.
MODEL REFERENCE CONTROL OF DISTRIBUTED PARAMETER SYSTEMS: APPLICATION TO THE SCOLE PROBLEM
H. KAUFMAN, D. MINNICK, M. BALAS, and A. MUSALEM *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 163-228 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

The model reference control of lumped linear systems and the model reference control of the distributed parameter system (DPS) are presented with their theory and Spacecraft Control Laboratory Experiment (SCOLE) applications. B.G.

N87-17830*# Naval Research Lab., Washington, D. C.
PROOF-MASS ACTUATOR PLACEMENT STRATEGIES FOR REGULATION OF FLEXURE DURING THE SCOLE SLEW
SHALOM (MIKE) FISHER *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 229-260 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

An analysis was performed in order to find the best placement for proof-mass actuators and to determine the importance of placement, i.e., what is the sensitivity of beam flexure to actuator placement. The analysis was performed by using the NASTRAN finite element model for a flexible beam with 21 grid points on beam, by using the nonlinear DISCOS simulation of 20 deg slew and the use of a closed-loop linear quadratic regulator (lqr). Some conclusions reached are: (1) proof-mass actuators can reduce flexure amplitude and damp oscillations; (2) amplitude of deformations during slew is relatively insensitive to placement of actuators; (3) damping factor of oscillations is sensitive to actuator placement; and (4) the degree of controllability method indicates most effective placement for actuators. E.R.

N87-17831*# Control Research Corp., Lexington, Mass.
ACTIVE DAMPING OF VIBRATIONS IN SCOLE EXCITED BY SLEWING
JIGUAN GENE LIN *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 261-312 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

Control simulations were performed to study active damping of vibrations in SCOLE excited by minimum-time rapid slewing. Highlights of the numerical results are presented. Some conclusions reached are: (1) modal-dashpot and modal-spring controllers provide quick and effective vibration control; (2) high gain problems can be avoided by proper selection of modeled modes and proper level of augmentation; (3) modal dashpots and modal springs are most effective during the initial period of large vibrations; and (4) line of sight error due solely to each mode excited by the disturbance provides a sound measure of importance of individual modes. E.R.

N87-17832*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
CONTROL OF SCOLE
L. MEIROVITCH and M. A. NORRIS *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 313-320 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

A relatively low order model is used to control SCOLE. Drastic truncation of the discretized model is proposed by means of a modal expansion. An open loop eigenvalue problem is illustrated as is truncated modal equations, modal state equations, actual output vector and modal Kalman filter. Also illustrated is independent modal-space control. E.R.

N87-17833*# Purdue Univ., West Lafayette, Ind.
REGULATION OF THE SCOLE CONFIGURATION
GREGORY A. NORRIS, EMMANUEL G. COLLINS, and ROBERT E. SKELTON *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 321-336 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

Studies were performed to determine location for proof mass actuators, if a significant reduction in the number of sensors would work, and to design a control law to meet requirements for line of sight error and actuators. Conclusions are drawn and briefly discussed. E.R.

N87-17834*# University of Southern California, Los Angeles.
EVALUATION OF ON-LINE PULSE CONTROL FOR VIBRATION SUPPRESSION IN FLEXIBLE SPACECRAFT
G. A. BEKEY, S. F. MASRI, and R. K. MILLER *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 337-366 Jan. 1987
Avail: NTIS HC A20/MF A01 CSCL 22B

On-line pulse control for vibration suppression in a flexible spacecraft was evaluated. A continuous beam vs. a truss was modeled. A linear finite element model was used to determine the truss characteristics. Control issues outlined are ED pulse actuator development, pseudo pulse algorithm development, and large nonlinear simulation problems. E.R.

N87-17835*# California Univ., Los Angeles. Dept. of Electrical Engineering.
ACTIVE STABILITY AUGMENTATION OF LARGE SPACE STRUCTURES: A STOCHASTIC CONTROL PROBLEM
A. V. BALAKRISHNAN *In* NASA. Langley Research Center Proceedings of the 3rd Annual SCOLE Workshop p 367-384 Jan. 1987 Presented at the IFAC Conference on Stochastic Control, Vilnius, May 1986
(Contract NAG1-464)
Avail: NTIS HC A20/MF A01 CSCL 22B

A problem in SCOLE is that of slewing an offset antenna on a long flexible beam-like truss attached to the space shuttle, with rather stringent pointing accuracy requirements. The relevant methodology aspects in robust feedback-control design for stability augmentation of the beam using on-board sensors is examined. It is framed as a stochastic control problem, boundary control of a distributed parameter system described by partial differential equations. While the framework is mathematical, the emphasis is still on an engineering solution. An abstract mathematical formulation is developed as a nonlinear wave equation in a Hilbert space. That the system is controllable is shown and a feedback control law that is robust in the sense that it does not require quantitative knowledge of system parameters is developed. The stochastic control problem that arises in instrumenting this law using appropriate sensors is treated. Using an engineering first approximation which is valid for small damping, formulas for optimal choice of the control gain are developed. Author

N87-17845# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
EXPERIMENTAL STUDY OF ACTIVE VIBRATION CONTROL Annual Technical Report, 1 Jan. 1985 - 30 Jan. 1986
WILLIAM L. HALLAUER, JR. and ANTHONY J. KUBIS, JR. 31 Jul. 1986 88 p
(Contract F49620-85-C-0024)
(AD-A173144; AFOSR-86-1003TR) Avail: NTIS HC A05/MF A01 CSCL 22B

Complementary experimental-theoretical studies were conducted on three separate topics, all of which are related to the dynamics and control of highly flexible large space structures (LSS) in Earth orbit: (1) active damping of vibrations; (2) structural wave propagation; and (3) development of small, flexible laboratory structures having a maneuverable rigid body mode. In the active damping study on a laboratory structure of moderate modal complexity, very good agreement was achieved between experimental measurements and theoretical predictions. The type of active damping applied, output feedback with dual (colocated) control sensors and actuators, should be considered as a candidate for implementation on first-generation LSS because of its stability robustness. The study of wave propagation is focused primarily on transient flexural response of a two-dimensional grid structure to a suddenly applied sinusoidal force at one point. The study is not completed, so results are not presented. New laboratory structures with a maneuverable rigid body mode were built and analyzed. They were relatively simple planar structures composed of thin-walled beam members. They exhibited some unusual dynamic characteristics such as variable natural frequencies, snap buckling, and other nonlinearities. Finite element modeling generally failed to predict the measured vibration modes and the unusual characteristics. GRA

N87-18101# Lawrence Livermore National Lab., Calif.
DECENTRALIZED OPTIMAL CONTROL OF LARGE FLEXIBLE STRUCTURES
S. H. WANG, S. C. LU, and I. K. FONG 14 Jul. 1986 12 p Presented at the 29th Midwest Symposium on Circuits and Systems, Lincoln, Nebr., 11 Aug. 1986
(Contract W-7405-ENG-48)
(DE86-013906; UCRL-94993; CONF-860899-1) Avail: NTIS HC A02/MF A01

This paper studies the problem of controlling large flexible structures by using decentralized feedback control. The proposed algorithm is initially applied to the control of a flexible beam. Two independent forces are applied at each tip of the beam. One displacement sensor and one velocity sensor are colocated with each force actuator. Computer simulations indicate that the decentralized feedback is effective in suppressing the structural vibrations of the beam. DOE

N87-18600*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
GROUND FACILITY FOR LARGE SPACE STRUCTURES DYNAMICS AND CONTROL VERIFICATION
HENRY WAITES Nov. 1986 15 p
(NASA-TM-86558; NAS 1.15:86558) Avail: NTIS HC A02/MF A01 CSCL 22B

NASA Marshall Space Flight Center has developed a facility in which closed loop control of Large Space Structures (LSS) can be demonstrated and verified. The main objective of the facility is to verify LSS control system techniques so that on-orbit performance can be unsured. The facility consists of an LSS test article or payload which is connected to a 3-axis angular pointing mount assembly that provides control torque commands. The angular pointing mount assembly is attached to a base excitation system which will simulate disturbances most likely to occur for Orbiter and DOD payloads. The control computer contains the calibration software, the reference systems, the alignment procedures, the telemetry software, and the control algorithms. The total system is suspended in such a fashion that the LSS test article has the characteristics common to all LSS. Author

N87-18879*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTIMIZATION PROCEDURE TO CONTROL THE COUPLING OF VIBRATION MODES IN FLEXIBLE SPACE STRUCTURES
JOANNE L. WALSH Feb. 1987 12 p Proposed for presentation at the 28th AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, Monterey, Calif., 6-8 Apr. 1987
(NASA-TM-89115; NAS 1.15:89115) Avail: NTIS HC A02/MF A01 CSCL 20K

As spacecraft structural concepts increase in size and flexibility, the vibration frequencies become more closely-spaced. The identification and control of such closely-spaced frequencies present a significant challenge. To validate system identification and control methods prior to actual flight, simpler space structures will be flown. To challenge the above technologies, it will be necessary to design these structures with closely-spaced or coupled vibration modes. Thus, there exists a need to develop a systematic method to design a structure which has closely-spaced

vibration frequencies. This paper describes an optimization procedure which is used to design a large flexible structure to have closely-spaced vibration frequencies. The procedure uses a general-purpose finite element analysis program for the vibration and sensitivity analyses and a general-purpose optimization program. Results are presented from two studies. The first study uses a detailed model of a large flexible structure to design a structure with one pair of closely-spaced frequencies. The second study uses a simple equivalent beam model of a large flexible structure to obtain a design with two pairs of closely-spaced frequencies. Author

N87-18880*# Catholic Univ. of America, Washington, D.C. Dept. of Mechanical Engineering.
OPTIMUM VIBRATION CONTROL OF FLEXIBLE BEAMS BY PIEZO-ELECTRIC ACTUATORS
A. BAZ and S. POH Mar. 1987 71 p
(Contract NAG5-250; NASA ORDER 30429-D)
(NASA-CR-180209; NAS 1.26:180209) Avail: NTIS HC A04/MF A01 CSCL 20K

The utilization of piezoelectric actuators in controlling the structural vibrations of flexible beams is examined. A Modified Independent Modal Space Control (MIMSC) method is devised to enable the selection of the optimal location, control gains and excitation voltage of the piezoelectric actuators in a way that would minimize the amplitudes of vibrations of beams to which these actuators are bonded, as well as the input control energy necessary to suppress these vibrations. The developed method accounts for the effects that the piezoelectric actuators have on changing the elastic and inertial properties of the flexible beams. Numerical examples are presented to illustrate the application of the developed MIMSC method in minimizing the structural vibrations of beams of different materials when subjected to different loading and end conditions using ceramic or polymeric piezoelectric actuators. The obtained results emphasize the importance of the devised method in designing more realistic active control systems for flexible beams, in particular, and large flexible structures in general. Author

N87-19434# Boston Univ., Mass.
THE CONTROL THEORY OF FLEXIBLE AND ARTICULATED SPACECRAFT Interim Report, 15 Apr. 1985 - 14 Apr. 1986
JOHN BAILLIEUL and MARK LEVI 15 May 1986 45 p
(Contract AF-AFOSR-0144-85)
(AD-A174880; AFOSR-86-2082TR) Avail: NTIS HC A03/MF A01 CSCL 22B

This report summarizes work done on the dynamics and control of flexible and articulated spacecraft. The combined dynamical effects of elasticity and a rotating reference frame have been explored for structures in a zero gravity environment. A simple yet general approach to modeling was developed, and applied to analyze the dynamics of a specific prototypical structure. The effects of energy dissipation were included and studied in depth for a model problem. Equilibria, bifurcations, and asymptotic stability were analyzed in some carefully chosen examples which capture the essential general features of nonlinear distributed parameter models of rotating elastic structures. GRA

N87-19435# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
PASSIVELY DAMPED JOINTS FOR ADVANCED SPACE STRUCTURES Final Report, 15 May 1983 - 15 Jan. 1986
JAMES H. PEEBLES, RICHARD W. TRUDELL, CREED E. BLEVINS, and JACKY C. PRUCZ 28 Mar. 1986 190 p
(Contract F49620-83-C-0117)
(AD-A174914; MDC-H2334; AFOSR-86-2075TR) Avail: NTIS HC A09/MF A01 CSCL 22B

This report includes: (1) the development of a viscoelastic materials selection guide for this research activity; (2) the development of an analytic statics model of the joint specimens; (3) the designs, fabrication and testing of 21 viscoelastic joint specimens, including the development of a new material; (4) the procurement, fabrication and assembly of test equipment for the test program at the Georgia Institute of Technology as well as the development of data reduction computer programs; (5) the development and successful demonstration of transient pulse and simplified steady state methods for evaluating energy losses in joints; and (6) the performance of outgassing tests on several viscoelastic materials. GRA

N87-19755*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
PASSIVE STABILIZATION FOR LARGE SPACE SYSTEMS
J. R. SESAK, M. J. GRONET, and G. M. MARINOS Washington NASA Apr. 1987 140 p
(Contract NAS1-17660)
(NASA-CR-4067; NAS 1.26:4067) Avail: NTIS HC A07/MF A01 CSCL 22B

The optimal tuning of multiple tuned-mass dampers for the transient vibration damping of large space structures is investigated. A multidisciplinary approach is used. Structural dynamic techniques are applied to gain physical insight into absorber/structure interaction and to optimize specific cases. Modern control theory and parameter optimization techniques are applied to the general optimization problem. A design procedure for multi-absorber multi-DOF vibration damping problems is presented. Classical dynamic models are extended to investigate the effects of absorber placement, existing structural damping, and absorber cross-coupling on the optimal design synthesis. The control design process for the general optimization problem is formulated as a linear output feedback control problem via the development of a feedback control canonical form. The techniques are applied to sample micro-g and pointing problems on the NASA dual keel space station. Author

06

ELECTRONICS

Includes techniques for power and data distribution, antenna RF performance analysis, communications systems, and spacecraft charging effects.

A87-15898#
A CONCEPT OF THE ENERGY STORABLE ORBITAL POWER STATION (ESOPS)
R. AKIBA, T. TAKANO, and H. YOKOTA (Tokyo, University, Japan) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 9 p. refs
(IAF PAPER 86-149)

To avoid the foreseeable difficulties and risks associated with large scale development of the Space Power Station on GEO at a remote distance, the Energy Storable Orbital Power Station (ESOPS) placed in a near earth orbit is proposed. The most promising orbit for ESOPS is a fixed periapsis pseudo sun synchronous orbit. A thermodynamical power generation is preferable owing to its inherent insensitive nature against radiation suffered on the medium altitude orbit. Thermal energy storage using latent heat of fusion seems the best choice for this system. The power transmission from ESOPS to the ground station presents the most critical problems due to nonstationary characteristics. Author

A87-16019#
A 21ST CENTURY NUCLEAR POWER STRATEGY FOR MARS
J. A. ANGELO, JR. (Florida Institute of Technology, Melbourne) and D. BUDEN (Science Applications International Corp., Albuquerque, NM) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 16 p. refs
(IAF PAPER 86-322)

Within the context of an emerging extraterrestrial civilization, the paper details the power requirements associated with the advanced exploration and eventual settlement of Mars. An account

is given of the most recent Mars exploration and development scenarios and it is shown how the four basic nuclear energy source phenomena could play a leading role in the conquest of Mars in the next century. Radioactive decay and nuclear fission processes represent compact and self-sufficient power and propulsion technologies for detailed surface exploration, manned operations, base camp operations and the successful functioning of early settlements. Controlled thermonuclear fusion and/or the production and storage of useful quantities of antimatter represent energy technology breakthroughs that would revolutionize earth-to-Mars space transportation systems. K.K.

A87-16041#
ANTENNA SYSTEM ALTERNATIVES FOR DATA RELAY SATELLITES WITH MULTIPLE STEERABLE BEAMS
H. DODEL, D. FASOLD, E. FRISCH, and M. LIEKE (MBB/ERNO, Ottobrunn, West Germany) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 7 p. ESA-supported research. refs
(IAF PAPER 86-349)

Antenna system alternatives for data relay satellites are presented. To that end, the European Data Relay Satellite (DRS) as planned by ESA is described in terms of its mission. Constraints on the antenna system are discussed such as imposed by the launcher; the mission as planned foresees an Ariane double launch/bottom position. Various possibilities of combining the S-Band and Ka-Band are outlined, including combined feeds, dichroic reflectors and subreflectors, auxiliary reflectors, beam-waveguide systems, and phased arrays. A considerable number of candidate antenna concepts satisfying the mission requirements are presented (in deployed and stowed configuration on a SPACEBUS-200 type of spacecraft) and their trade-off scores listed. Author

A87-16132#
LUNAR-BASED POWER SYSTEMS
D. R. CRISWELL and R. D. WALDRON (California, University, La Jolla) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 8 p. refs
(IAF PAPER 86-507)

An evaluation is made of the feasibility and possible performance characteristics of various energy systems for the realization of a small lunar research base, with attention to the prospects for use of lunar materials in these construction efforts. It is noted that a functionally superior version of the space solar power satellite system can be built on the moon from lunar materials and used to beam microwave-converted solar power to the base. It is estimated that about 60 people, using less than 1000 tons of manufacturing facilities, tools and habitats could manufacture one installation of this kind in 30 days. O.C.

A87-17368
SPACECRAFT GLOWS FROM SURFACE-CATALYZED REACTIONS
I. L. KOFSKY and J. L. BARRETT (PhotoMetrics, Inc., Woburn, MA) Planetary and Space Science (ISSN 0032-0633), vol. 34, Aug. 1986, p. 665-681. refs

Existing data on the optical glows that extend from low earth-orbiting spacecraft are shown to be consistent with recombination of ambient atmospheric species on ram-exposed surfaces. Surface-catalyzed exothermic recombination qualitatively explains the reported differences as well as similarities among spacecraft in spectral intensities and spatial distribution of glows, and predicts further emission at ultraviolet, infrared, and to a lesser extent visible, wavelengths. The contextual information concerning such recombination is systematically reviewed with a view to designing experiments which will serve to predict the spectral intensities of optical foregrounds off spacecraft materials exposed to the thermosphere. C.D.

A87-17836*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
A CONSIDERATION OF ATOMIC OXYGEN INTERACTIONS WITH THE SPACE STATION
L. J. LEGER and J. T. VISENTINE (NASA, Johnson Space Center, Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Sept.-Oct. 1986, p. 505-511. Previously cited in issue 07, p. 875, Accession no. A85-19773. refs

A87-18075
ARABSAT SOLAR GENERATOR CONCEPT AND IN ORBIT PERFORMANCE
J. J. JUILLET and L. PELENC (Aerospatiale, Cannes, France) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1452-1457.

The capabilities of the Arabsat solar generator are studied. The electrical power subsystem of the satellite which is based on a dual bus direct energy transfer system is examined. The satellite receives its electric energy from two single-axis sun-pointing solar array wings. The components and operation of the solar array wings are described; the solar network is based on silicon solar cells. The performance of the solar array in transfer and geosynchronous orbits and on-station are evaluated by analyzing telemetry data. I.F.

A87-18113
MULTIMEGAWATT POWER DISTRIBUTION CONSIDERATIONS
S. K. GOTO and J. H. HAYDEN (Hughes Aircraft Co., El Segundo, CA) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1660-1662.

Strategic Defense Initiative (SDI) power systems are required to operate at low power for extended periods, yet provide burst power of hundreds of megawatts for up to hundreds of seconds for electromagnetic launchers and various directed energy weapons. High power levels and the separation between the prime power source and the weapon because of the physical size of each makes the design of the electrical power transmission and distribution system of great significance. Preliminary analysis of SDI power system architectures indicate that power distribution equipment and its thermal control are significant portions of the total spacecraft weight. It appears that proper choice of distribution voltage and conductor material can significantly reduce the total system mass by eliminating all active thermal control systems and allowing conductor temperatures to rise during the engagement. This paper examines several concepts to minimize distribution system weight. Author

A87-18144
DESIGN OF A SUPERCONDUCTING ALTERNATOR FOR SPACE-BASED POWER GENERATION
R. E. DODGE, JR., E. P. COOMES (Battelle Pacific Northwest Laboratories, Richland, WA), J. L. KIRTLEY, JR., and S. J. MCCABE (MIT, Cambridge, MA) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1869-1874. refs

A study was performed to assess the feasibility of using a superconducting alternator for space power generation and to develop a preliminary machine design. The superconducting alternator consists of a rotor with superconducting field windings and a counter rotating armature with normally conducting helical windings. A unique feature of this design is the counter rotation of the alternator armature which permits balancing of the rotational inertia in the machine so that no torque is applied to the space platform. K.K.

A87-18149
SOLAR ARRAYS FOR SPACE STATION AND PLATFORMS
R. V. ELMS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1898-1902.

Current large area solar array technology combined with short term technology advancements can power the initial Space Station and Platforms based on the NASA Phase B Space Station design requirements. This approach provides low schedule, cost, and performance risk for the initial Space Station. This approach also allows the Phase C/D program funding to be shaped to take advantage of the advanced technology status of large area solar arrays. The current approach to IOC Space Station power sources uses a hybrid photovoltaic (PV) - Solar Dynamic (SD) system. NASA has conducted studies to select the ratio of PV to SD. These studies involve a number of Space Station system variables as well as the closely related energy storage system design. This paper discusses the current and advanced solar array technology which will have application to the Space Station solar arrays. The solar array sizes for supporting different fractions of the IOC Space Station user bus power are presented along with the arrays for the platforms. Potential atomic oxygen protection designs are also presented. Author

A87-18319
CONTROL OF SOLAR BATTERY ARRAYS OF SPACECRAFT WITH CONSIDERATION OF THE STRUCTURAL FLEXIBILITY
T. FUKUDA, H. HOSOGAI (Tokyo, Science University, Japan), N. YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan), and Y. KURIBAYASHI IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 945-950. MOESC-supported research. refs

The problem dealt with here is how to estimate and control vibrational modes of flexible booms of solar arrays of spacecrafts in a reliable way, even in large angle attitude maneuvers. A proposed mode estimation method based on differential outputs of instrument solar cells and a linear optimal filtering is shown to give good estimation results of vibrational modes. It is shown here that even static output maximization control of the flexible solar array in a desired direction cannot work stably without flexibility consideration based on the mode estimation, and that the dynamic control can give good results to suppress the vibration of the arrays even in large angle attitude maneuvers. Furthermore, a reliable control method is shown to have fault tolerant properties, such as self-degradability as faults get worse. Author

A87-18342* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE POTENTIAL IMPACT OF NEW POWER SYSTEM TECHNOLOGY ON THE DESIGN OF A MANNED SPACE STATION
J. S. FORDYCE and H. J. SCHWARTZ (NASA, Lewis Research Center, Cleveland, OH) IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 1099-1105. Previously announced in STAR as N84-31272. refs

Larger, more complex spacecraft of the future such as a manned Space Station will require electric power systems of 100 kW and more, orders of magnitude greater than the present state of the art. Power systems at this level will have a significant impact on the spacecraft design. Historically, long-lived spacecraft have relied on silicon solar cell arrays, a nickel-cadmium storage battery and operation at 28 V dc. These technologies lead to large array areas and heavy batteries for a Space Station application. This, in turn, presents orbit altitude maintenance, attitude control, energy management and launch weight and volume constraints. Size (area) and weight of such a power system can be reduced if new higher efficiency conversion and lighter weight storage technologies are used. Several promising technology options including concentrator solar photovoltaic arrays, solar thermal dynamic and ultimately nuclear dynamic systems to reduce area are discussed. Also, higher energy storage systems such as nickel-hydrogen and the regenerative fuel cell (RFC) and higher voltage power distribution which add system flexibility, simplicity and reduce weight are examined. Emphasis placed on the attributes and development status of emerging technologies that are sufficiently developed so that they could be available for flight use in the early to mid 1990's. Author

A87-19707
ADVANCED OPTO-ELECTRONICAL SENSORS FOR AUTONOMOUS RENDEZVOUS-/DOCKING AND PROXIMITY OPERATIONS IN SPACE
B. KUNKEL, R. LUTZ, and S. MANHART (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Solid state imagers and their applications; Proceedings of the Meeting, Cannes, France, November 26, 27, 1985. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 138-148. refs.

Experimental work on three types of candidate optical sensors for rendezvous and docking tasks, active laser diode radars, CCD cameras and position detector sensors, plus a combination of these is presented. The results obtained up to now with a test lab (including motion simulation) make each of them a promising candidate for this kind of application for different range regimes. These sensors are conceived as multisensor head systems together with a central processing unit to provide applicability beyond docking of space platforms. A description of the sensors, their technical development requirements, achieved performance results, and combination packages, plus a proposal for in-orbit test missions is given. Author

A87-19872
IN-ORBIT PERFORMANCE OF HUGHES HS 376 SOLAR ARRAYS
STEVEN W. GELB, LELAND J. GOLDHAMMER, and DANA X. KEROLA (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: Photovoltaic Specialists Conference, 18th, Las Vegas, NV, October 21-25, 1985, Conference Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 362-367. refs

The synchronous orbit performance of Hughes Aircraft Company HS 376 spacecraft solar arrays employing the K7 solar cell is presented and compared with ground-based computer predictions for orbital durations greater than 4 years. The HS 376 spacecraft whose solar array performance is discussed include the Satellite Business Systems SBS F-1, F-2, and F-3; the Telesat Canada Anik C-2, C-3, D-1, and D-2; and the Western Union Westar IV and V. Launch of the first Hughes HS 376 satellite with a K7 solar array, the SBS F-3, occurred on November 15, 1980. A brief description of each solar array and the general methodology for predicting solar array performance are presented. The in-space performance data indicate forward solar array power degradation of 13.2 percent for SBS F-3 after 52 months in orbit, 11.2 percent for Anik C-3 after 28 months in orbit, and 11.7 percent for Anik D-1 after 31 months in orbit. The predicted output of each of these solar arrays is within 2 percent of the actual output as obtained through telemetry. The ability to accurately predict solar array performance within telemetry accuracy is demonstrated. This capability combines the solar array electrical measurements in the as-built configuration, manufacturing consistency, and sound computer modeling techniques. Author

A87-19874*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROTECTION OF SOLAR ARRAY BLANKETS FROM ATTACK BY LOW EARTH ORBITAL ATOMIC OXYGEN
BRUCE A. BANKS, MICHAEL J. MIRTICH, SHARON K. RUTLEDGE, and HENRY K. NAHRA (NASA, Lewis Research Center, Cleveland, OH) IN: Photovoltaic Specialists Conference, 18th, Las Vegas, NV, October 21-25, 1985, Conference Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 381-386. refs

The ram impact of low earth orbital atomic oxygen causes oxidation of spacecraft materials including polymers such as polyimides. The rate of oxidation is sufficiently high to potentially compromise the long term durability of Kapton solar array blankets. Ion beam sputter deposited atomic oxygen protective coatings of aluminum oxide, silicon dioxide, and codeposited silicon dioxide with small amounts of polytetrafluoroethylene were evaluated both in RF plasma asher tests and in low earth orbit. Deposition techniques, mechanical properties, and atomic oxygen protection performance are presented. Author

A87-19878
HIGH VOLTAGE SOLAR ARRAY PLASMA PROTECTION TECHNIQUES
JOHN R. BARTON, WILLIAM G. DUNBAR, and AMY C. REISS (Boeing Aerospace Co., Seattle, WA) IN: Photovoltaic Specialists Conference, 18th, Las Vegas, NV, October 21-25, 1985, Conference Record . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 411-417. refs

Spacecraft power levels have continuously increased since the inception of the Space Age, and this trend will continue into the distant future. Solar arrays requiring 100s of kilowatts are expected by the mid 1990s, and the higher power levels will require voltage levels of 100s if not 1000s of volts. Unfortunately, unprotected solar arrays cannot operate at these high voltages because of the interaction between the solar array and the space plasma. This interaction can cause voltage-charge buildups to the kilovolt level, followed by arc discharges, material damage, and the disruption of spacecraft electronics. Consequently, unprotected solar arrays below altitudes of 10,000 km should be limited to voltages less than 250 V dc, and lower than 150 V dc in some low-altitude orbits. However, high-voltage designs can be used if plasma interaction is significantly reduced by protecting the solar array. Solar array protection concepts are presented, including encapsulation and the addition of zero-potential ground planes. Two concentrator configurations are presented which utilize their inherent structure as ground planes, and planar arrays are presented which utilize encapsulation and ground planes in the form of 'lightning rods', 'chicken wire', and/or conductive grid-pattern coatings. Author

A87-22417*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF HARD PARTICLE IMPACTS ON THE ATOMIC OXYGEN SURVIVABILITY OF REFLECTOR SURFACES WITH TRANSPARENT PROTECTIVE OVERCOATS
DANIEL A. GULINO (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 8 p. Previously announced in STAR as N87-11838. refs
(AIAA PAPER 87-0104)

Silver mirror samples with protective coatings were subjected to a stream of 27 microns alumina particles to induce pinhole defects. The protective coating consisted of a layer of aluminum dioxide over silver followed by a layer of silicon dioxide over the alumina. Samples were prepared on both graphite-epoxy composite and fused quartz substrates. After exposure to the hard particle stream, the samples were exposed to an oxygen plasma environment in a laboratory plasma asher. The effects of both the hard particles and the oxygen plasma were documented by both reflectance measurements and scanning electron microscopy. The results indicated that oxidative damage to the silver reflecting layer continues beyond that of the erosively exposed silver. Oxidative undercutting of the silver layer and graphite-epoxy substrate continues in undamaged areas through adjacent, particle damaged defect sites. This may have implications for the use of such mirrors in a space station solar dynamic power system. Author

A87-22659#
A SEVERE SPACECRAFT-CHARGING EVENT ON SCATHA IN SEPTEMBER 1982
H. C. KOONS, P. F. MIZERA, J. L. ROEDER, and J. F. FENNELL (Aerospace Corp., Space Sciences Laboratory, El Segundo, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 6 p. refs
(Contract F04701-85-C-0086)
(AIAA PAPER 87-0475)

Large amplitude electrostatic discharges were detected by the engineering instruments aboard the SCATHA satellite on September 22, 1982. The Pulse Analyzer detected 29 pulses on that date. Seventeen of the pulses exceeded the maximum voltage discrimination level which was set to 7.4 volts. This is the worst instance of electrostatic discharges encountered to date by the SCATHA satellite. Three different spacecraft anomalies occurred on SCATHA on September 22, 1982. The most serious was a two minute loss of data. Data from the Satellite Surface Potential Monitor confirmed that these electrostatic discharges occurred during one of the largest spacecraft charging events recorded by the instruments aboard the SCATHA satellite. Author

A87-22968#
FLEXIBILITY CONTROL OF SOLAR BATTERY ARRAYS. II - VIBRATION AND ATTITUDE CONTROL BASED ON STATE ESTIMATION OF DIFFERENTIAL SOLAR CELL SENSORS
TOSHIO FUKUDA, HIDEMI HOSOKAI (Tokyo Science University, Japan), YUTAKA KURIBAYASHI (Mitsubishi Electric Corp., Kamakura, Japan), and NOBUYUKI YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, Sept. 1986, p. 3116-3120. refs

In this paper, a differential solar cell sensor consisting of a pair of adjacent solar cells is proposed as a new type of sensors to measure vibration of flexible solar battery arrays and to orient the array toward the sun correctly. This sensor, which is small and light, has linear characteristics and can be implemented easily without compensation for distance. To eliminate noises in the sensor outputs, the Kalman filtering method is employed, based on the dynamics of a flexible solar array which is developed differently from the previous paper. Then all states can be fed back in an optimal closed control system, so that the control performance can be improved in vibration and attitude control. Author

A87-22969#
FLEXIBILITY CONTROL OF SOLAR BATTERY ARRAYS. III - VIBRATION AND ATTITUDE CONTROL WITH CONSIDERATION OF THE DYNAMICS OF A REACTION WHEEL AS AN ACTUATOR
TOSHIO FUKUDA, HIDEMI HOSOKAI (Tokyo Science University, Japan), and NOBUYUKI YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, Sept. 1986, p. 3121-3125.

A87-25533
THE USSR AND SPACE POWER PLANTS
ALAIN DUPAS (CNES, Paris, France) Space Policy (ISSN 0265-9646), vol. 2, Nov. 1986, p. 361, 362. refs

Soviet policy on space power plants is examined. Research from Soviet space experts relating to the feasibility and development of space power plants is analyzed. Consideration is given to the time scale and costs of development, and the use of laser technology in satellite solar power stations. The research reveals that Soviet space experts are in favor of developing space power plants. I.F.

A87-25700
RECTENNA COMPOSED OF A CIRCULAR MICROSTRIP ANTENNA
KIYOHIKO ITOH, TAKEO OHGANE, and YASUTAKA OGAWA (Hokkaido University, Sapporo, Japan) (Institute of Electronics and Communications Engineers of Japan, IEEE, and URSI, International Symposium on Antennas and Propagation /ISAP '85/, Kyoto, Japan, Aug. 20-22, 1985) Space Power (ISSN 0883-6272), vol. 6, no. 3, 1986, p. 193-198.
(Contract MOESC-56460102)

One of the big problems in the SPS system is reradiation of the harmonic waves generated by the rectifying diode. The use of a circular microstrip antenna (CMSA) is proposed as a solution, since the CMSA has no higher resonance-harmonic which is an integer multiple of the dominant resonance frequency. However, characteristics of a large rectenna array of CMSAs have not been clarified. This paper is concerned with the absorption efficiency of the rectenna composed of the CMSA. The efficiency is estimated explicitly using an infinite array model. The results show that the absorption efficiency of the infinite rectenna array composed of the CMSA is 100 percent. Also, this paper considers the effect of the losses of the CMSA. Author

A87-26060
ACOUSTIC CLEANING OF LARGE SPACE STRUCTURES
J. BUSH, L. AGUILAR, and S. KWAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Institute of Environmental Sciences, Annual Technical Meeting, 32nd, Dallas and Fort Worth, TX, May 6-8, 1986, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1986, p. 493-500.

Two sets of acoustic experiments related to contamination control of the Hubble Space Telescope modules are reported. In the particle distribution experiments, the maximum fallout from the vertical one square foot source was 64 inches horizontally away from the wall, and the 139 dB experiment resulted in a maximum fallout six inches away from the vertical surface. The experiment dealing with the acoustic cleaning of a Light Shield Test Specimen (LSTS) indicated that cleaning in a horizontal attitude during acoustic exposure results in lower surface level particulate count, but shows the same particulate fallout as the LSTS in the vertical orientation. R.R.

A87-27018
THE IMPORTANCE OF ACCURATE SECONDARY ELECTRON YIELDS IN MODELING SPACECRAFT CHARGING
IRA KATZ, MYRON MANDELL, GARY JONGEWARD (Systems Science and Software, La Jolla, CA), and M. S. GUSSENHOVEN (USAF, Geophysics Laboratory, Bedford, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Dec. 1, 1986, p. 13739-13744. refs
(Contract F19628-82-C-0081)

Spacecraft charging has commonly been attributed to electrons with several kilovolts of energy impinging upon spacecraft surfaces. Recent experimental evidence from the SCATHA satellite has shown that charging correlates well with electrons of energies greater than 30 keV. In this paper it is shown that the SCATHA observations are consistent with the model of charging in which a satellite is immersed in a Maxwellian plasma, particle collection is orbit limited, and dominant surface effects are the emission of secondary and backscattered electrons. The energy dependence of the secondary yield for multikilovolt incident electrons determines the charging threshold. In the past, inadequate representations of the secondary yield have led experimenters to question the validity of the charging model. The accuracy of the secondary electron yield formulation based on electron stopping power, such as the one in NASA. Charging Analyzer Program (NASCAP), gives good agreement with the SCATHA results. A Maxwellian representation of the magnetospheric plasma is justified by choosing effective temperatures and densities that minimize the error in calculating charging current densities. Author

A87-27180
MICROWAVE POWER TRANSMISSION FOR USE IN SPACE
PETER E. GLASER (Arthur D. Little, Inc., Cambridge, MA) Microwave Journal (ISSN 0026-2897), vol. 29, Dec. 1986, p. 44, 46, 48 (6 ff.). refs

The availability of power for use in space is a key requirement for future space activities. The power levels needed to enable the evolution of a space infrastructure that will support the Space Shuttle, a Space Station and lunar missions are reviewed in this article from an industry point of view. The status of solar and nuclear energy source developments for use in space and power transmission technologies is discussed. Possible mission-specific applications of microwave power transmission are highlighted. Technology development directions for microwave power transmission are summarized and related studies are cited. Author

A87-29753
OPTIMIZATION OF A MICROWAVE-BEAM ENERGY TRANSMISSION CHANNEL [OPTIMIZATSIIA TRAKTA PEREDACHI ENERGII SVCH PUCHKOM]
B. A. BANKE, S. K. LESOTA, and A. V. RACHNIKOV Radiotekhnika (ISSN 0033-8486), Nov. 1986, p. 17-20. In Russian. refs

The optimization of microwave energy transmission for a satellite solar power system is considered. Attention is given to the achievement of maximum energy transmission efficiency between apertures for a fixed ratio of the maximum power density at the receiving antenna to the power density at its edge. Non-Gaussian directivity patterns with a field-intensity gap at the beam axis are presented which assure high utilization coefficients of the receiving antenna and high levels of transmitted power. B.J.

A87-30893* National Aeronautics and Space Administration, Washington, D.C.
COMMUNICATIONS TECHNOLOGY
C. LOUIS CUCCIA (NASA, Washington, DC) and JOSEPH SIVO IN: Space science and applications: Progress and potential . New York, IEEE Press, 1986, p. 227-250.

The technologies for optimized, i.e., state of the art, operation of satellite-based communications systems are surveyed. Features of spaceborne active repeater systems, low-noise signal amplifiers, power amplifiers, and high frequency switches are described. Design features and capabilities of various satellite antenna systems are discussed, including multiple beam, shaped reflector shaped beam, offset reflector multiple beam, and mm-wave and laser antenna systems. Attitude control systems used with the antenna systems are explored, along with multiplexers, filters, and power generation, conditioning and amplification systems. The operational significance and techniques for exploiting channel bandwidth, baseband and modulation technologies are described. Finally, interconnectivity among communications satellites by means of RF and laser links is examined, as are the roles to be played by the Space Station and future large space antenna systems. M.S.K.

A87-31223*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PLASMA ELECTRON COLLECTION THROUGH BIASED SLITS IN A DIELECTRIC
M. R. CARRUTH, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Jan.-Feb. 1987, p. 79-85. refs

A large number of experimental and analytical efforts have been directed toward understanding the plasma sheath growth and discharge phenomena which lead to high-voltage solar array/space plasma interactions. An important question which has not been addressed is how the voltage gradient in the plasma sheath near the surface of such an array may affect these interactions. The purpose of the experimental study described in this paper is to examine the merging of the sheaths around biased slits in a dielectric and how this affects the collection of electrons through these slits. The data, which are obtained by emissive

probes and direct measurement of the current collected through the slits, indicate that when the sheaths merge the current collection by the slits is significantly altered with the most positive slit collecting more electrons than it otherwise would. Therefore, the effect of a voltage gradient in the sheath around a solar array should be considered when evaluating solar array performance.
Author

N87-11352# British Aerospace Dynamics Group, Bristol (England). Space and Communications Div.
HPSA: HIGH POWER SOLAR ARRAY STUDY Final Report
C. P. LEE Paris ESA Jul. 1985 156 p
(Contract ESA-6064/84-NL-PB)
(BAE-TP-8071; HPSA/RPT/8071; ESA-CR(P)-2201; ETN-86-98086) Avail: NTIS HC A08/MF A01

A 30 kW solar array design for ESA's Columbus program was established. Realistic array requirements were identified using the ESA recommended designed reference mission. System and subsystem level studies lead to preferred design solutions for silicon and gallium arsenide cell technologies. A development philosophy and test plan to pursue the identification of critical aspects was derived and a preliminary cost appraisal was made. It is concluded that a planar double roll out array employing silicon cells represents the most attractive solution, with a gallium arsenide roll out as a logical derivative. ESA

N87-13864# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systemes Balistiques et Spatiaux.
HIGH POWER RIGID SOLAR ARRAY Final Report
L. PELENC Paris, France ESA 19 Sep. 1985 121 p
(Contract ESTEC-6061/84-NL-PB(SC))
(SNIAS-917A-CA/CG; ESA-CR(P)-2202; ETN-86-98087) Avail: NTIS HC A06/MF A01

The feasibility and complexity of a 30 kW solar array scaling 15 to 60 kW for the Columbus space station, with silicon cells and with gallium arsenide cells were studied. The specifications were modified, thereby changing the concept choice for the study. The multideployment/retraction (300 for the mission) and the 20% power required in partial deployment (under 3 kN reboost engines) favor rigid arrays for both silicon and gallium arsenide cells, with a very simple and reliable pantograph deployment/retraction system. ESA

N87-15377# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
L-BAND ANTENNAS FOR REGIONAL MOBILE COMMUNICATION SATELLITES
A. ROEDERER *In* ESA Proceedings of an ESA Workshop on Land Mobile Services by Satellite p 75-80 Sep. 1986
Avail: NTIS HC A08/MF A01

Satellite L-band antennas ranging for state of the art small reflector systems to multibeam arrays, to large array-fed reflectors, with frequency reuse, flexible channel to beam allocation and/or steerable beam capabilities over an extended European coverage are reviewed. Both 2.5 to 5 m multifeed reflectors and foldable multibeam arrays are valid candidates for regional mobile communication satellites in the next decade. The foldable multibeam arrays have the major advantage over the multifeed reflectors of quasi-total traffic to beam allocation flexibility. In the longer term, when increase in traffic is such that on board minimum gains greater than 35 dBi are required, unfurlable reflectors with diameters greater than 10 m are preferable, since direct radiating arrays with equivalent aperture area cannot easily be deployed. Technologies for foldable arrays and reflectors up to 5 m diameter should be available for flight in the early nineties from present hardware developments. The same technology is applicable up to greater than 10 m, but with a serious additional effort required, particularly in testing. ESA

N87-16941# Construcciones Aeronauticas S.A., Madrid (Spain). Space and Systems Div.
DEVELOPMENT OF MM-WAVE RADIOMETER ANTENNA REFLECTOR
P. CORDERO, G. LOPEZ, and R. GARCIA *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 151-159 Aug. 1986
(Contract ESA-5263/82-NL-GM)
Avail: NTIS HC A12/MF A01

The development of an antenna for a passive microwave radiometer for the 90 to 300 GHz frequency range is discussed. The operating frequency-range imposes ultrahigh surface accuracy and stability, and electrical reflectivity close to that of the best conductive metals. Critical design areas and technological problems (e.g., CFRP metallizing) are reviewed. ESA

N87-16943# Centro Studi e Laboratori Telecomunicazioni, Turin (Italy).
PREDICTION OF THE ELECTRICAL PERFORMANCE OF INFLATABLE SPACE RIGIDIZED STRUCTURE (ISRS) OFFSET ANTENNA REFLECTORS AND CORRELATION WITH RF MEASUREMENTS
E. PAGANA and M. C. BERNASCONI (Contraves Corp., Zurich, Switzerland) *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 171-177 Aug. 1986
Avail: NTIS HC A12/MF A01

The electrical design and testing at microwave frequencies (3 to 22 GHz) on the first Large Offset Antenna Demonstrator (LOAD) breadboard are summarized. The electrical analysis shows the quality of mock-up reflector and contributes to an electrical antenna model. The performance of a large inflatable antenna can be predicted, with good accuracy, only on the basis of the mechanical measurements of a proper set of reflector surface points. ESA

N87-16971*# Colby Coll., Waterville, Maine. Dept. of Physics and Astronomy.
LEO HIGH VOLTAGE SOLAR ARRAY ARCING RESPONSE MODEL Interim Report, Feb. 1987
ROGER N. METZ Feb. 1987 32 p
(Contract NAG3-576)
(NASA-CR-180073; NAS 1.26:180073) Avail: NTIS HC A03/MF A01 CSCL 09A

A series of mathematical models were developed that describe the electrical behavior of a large solar cell array floating electrically in the low Earth orbit (LEO) space plasma and struck by an arc at a point of negative bias. There are now three models in this series: ARCII, which is a fully analytical, linearized model; ARCIII, which is an extension of ARCIII that includes solar cell inductance as well as load reactance; Nonlinear ARC, which is a numerical model able to treat effects such as non-linearized, i.e., logarithmic solar cell I/V characteristics, conductance switching as a solar cell crosses plasma ground on a voltage excursion and non-ohmic plasma leakage current collection. Author

N87-17277# Naval Research Lab., Washington, D. C. Space Systems and Technology Div.
APPLICATION OF SPACEBORNE DISTRIBUTED APERTURE/ COHERENT ARRAY PROCESSING (SDA/CAP) TECHNOLOGY TO ACTIVE AND PASSIVE MICROWAVE REMOTE SENSING
M. S. KAPLAN *In* ESA Proceedings of the 1986 International Geoscience and Remote Sensing Symposium (IGARSS '86) on Remote Sensing: Today's Solutions for Tomorrow's Information Needs, Volume 1 p 697-701 Aug. 1986
Avail: NTIS HC A99/MF E03; ESA, Paris, France, 3 volume set $90 Member States, AU, CN, and NO (+20% others)

Application of spaceborne distributed aperture/coherent array processing (SDA/CAP) to environmental remote sensing missions is discussed. This technology differs from conventional monostatic remote sensing approaches in that sensor elements are distributed among many space platforms. It is possible to coherently combine the inputs from many receiving spacecraft in order to form a very large distributed aperture, thousands of kilometers in size. This

enormous effective aperture size can provide nanoradian resolution in the microwave region of the spectrum. Relative spacecraft phase measurement accuracies on the order of a fraction of a wavelength are required to support the technology. Spacecraft relative position and time measurement via hydrogen maser time references on each spacecraft and laser ranging between spacecraft is proposed. Intersatellite laser ranging technology needs to be developed to support the application of SDA/CAP techniques for advanced space environmental remote sensor systems. ESA

N87-18598*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATED STRUCTURE ELECTROMAGNETIC OPTIMIZATION OF LARGE SPACE ANTENNA REFLECTORS
SHARON L. PADULA, HOWARD M. ADELMAN, and M. C. BAILEY Feb. 1987 12 p Proposed for presentation at the AIAA/ASME/ASCE/AHS 28th Structures, Structural Dynamics and Materials Conference, Monterey, Calif., 6-8 Apr. 1987
(NASA-TM-89110; NAS 1.15:89110; AIAA-87-0824-CP) Avail: NTIS HC A02/MF A01 CSCL 22B

The requirements for extremely precise and powerful large space antenna reflectors have motivated the development of a procedure for shape control of the reflector surface. A mathematical optimization procedure has been developed which improves antenna performance while minimizing necessary shape correction effort. In contrast to previous work which proposed controlling the rms distortion error of the surface thereby indirectly improving antenna performance, the current work includes electromagnetic (EM) performance calculations as an integral of the control procedure. The application of the procedure to a radiometer design with a tetrahedral truss backup structure demonstrates the potential for significant improvement. The results indicate the benefit of including EM performance calculations in procedures for shape control of large space antenna reflectors. Author

N87-20063*# Air Force Geophysics Lab., Hanscom AFB, Mass.
PLASMA INTERACTIONS WITH LARGE SPACECRAFT
RITA C. SAGALYN and NELSON C. MAYNARD *In* JPL, Space Technology Plasma Issues in 2001 p 51-68 1 Oct. 1986
Avail: NTIS HC A20/MF A01 CSCL 20I

Space is playing a rapidly expanding role in the conduct of the Air Force mission. Larger, more complex, high-power space platforms are planned and military astronauts will provide a new capability in spacecraft servicing. Interactions of operational satellites with the environment have been shown to degrade space sensors and electronics and to constrain systems operations. The environmental interaction effects grow nonlinearly with increasing size and power. Quantification of the interactions and development of mitigation techniques for systems-limiting interactions is essential to the success of future Air Force space operations. Author

N87-20069*# TRW Space Technology Labs., Redondo Beach, Calif. System Integration Lab.
HIGH VOLTAGE SYSTEM: PLASMA INTERACTION SUMMARY
N. JOHN STEVENS *In* JPL, Space Technology Plasma Issues in 2001 p 167-193 1 Oct. 1986
Avail: NTIS HC A20/MF A01 CSCL 20I

The possible interactions that could exist between a high voltage system and the space plasma environment are reviewed. A solar array is used as an example of such a system. The emphasis in this review is on the discrepancies that exist in this technology in both flight and ground experiment data. It has been found that, in ground testing, there are facility effects, cell size effects and area scaling uncertainties. For space applications there are area scaling and discharge concerns for an array as well as the influence of the large space structures on the collection process. There are still considerable uncertainties in the high voltage-space plasma interaction technology even after several years of effort. Author

N87-20080*# York Univ., Toronto (Ontario). Dept. of Physics.
SPACECRAFT CHARGING IN THE AURORAL PLASMA: PROGRESS TOWARD UNDERSTANDING THE PHYSICAL EFFECTS INVOLVED Abstract Only
J. G. LAFRAMBOISE and L. W. PARKER (Parker, Lee W., Inc., Concord, Mass.) *In* JPL, Space Technology Plasma Issues in 2001 p 311 1 Oct. 1986
(Contract F19628-83-K-0028)
Avail: NTIS HC A20/MF A01 CSCL 22B

The work is presented in four parts. First, main differences between the plasma environments in geostationary orbit and low polar orbit with regard to high-voltage charging situations are reviewed. Next, results are presented from a calculation of secondary-electron escape currents from negatively-charged spacecraft surfaces having various orientations relative to the local magnetic-field direction. It is shown that for finite ranges of combinations of electric and magnetic field directions, secondary-electron escape is completely suppressed and therefore cannot help to discharge the spacecraft. In such circumstances, secondary electrons may travel distances many times their gyroradii before reimpacting, and this may produce greatly increased secondary-electron surface currents. Thirdly, a simple rough estimate of the required conditions for high-voltage auroral-zone charging is developed. The results suggest that for any given spacecraft, surface potentials are likely to depend more strongly on the ratio of ambient flux of high-energy electrons to that of all ions, than on any other environmental parameter. Finally, preliminary results are presented of numerical simulation work directed toward testing this hypothesis. Numerical instabilities encountered in doing this simulation work probably are closely related to physical sensitivities inherent in the physics of the ion wake behind the spacecraft, and especially to beam-like constituents of the ion population in the wake. Author

07

ADVANCED MATERIALS

Includes matrix composites, polyimide films, thermal control coatings, bonding agents, antenna components, manufacturing techniques, and space environmental effects on materials.

A87-11355*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
AN ESTIMATE OF THE OUTGASSING OF SPACE PAYLOADS AND ITS GASEOUS INFLUENCE ON THE ENVIRONMENT
J. J. SCIALDONE (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, July-Aug. 1986, p. 373-378. Previously cited in issue 17, p. 2471, Accession no. A85-37616. refs

A87-11384
FABRICATION OF A CARBON FIBRE/ALUMINIUM ALLOY COMPOSITE UNDER MICROGRAVITY
Y. MISHIMA, M. HORI, T. SUZUKI, and S. UMEKAWA (Tokyo Institute of Technology, Yokohama, Japan) Journal of Materials Science (ISSN 0022-2461), vol. 21, Aug. 1986, p. 2763-2766. Research supported by the National Space Development Agency of Japan and Science and Technology Agency. refs

Fabrication of a composite material with ultralow density and high stiffness under microgravity is the objective of the present investigation. The composite structure to be obtained is a random three-dimensional array of high modulus, short carbon fibers bounded at contact points by an aluminum alloy coating on the fibers. The material is highly porous, and thus has a very low density. The motivation toward the investigation, simulation experiments, choice of the component materials, and in-flight experiment during ballistic trajectory of a National Space Development Agency rocket, are described herein. Supporting experimental evidence shows that the cohesion between the

carbon fiber and the aluminum alloy is excellent, by which the achievement of desired properties of such composites seems probable. Author

A87-11847* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE RADIATION EFFECTS ON THE DIMENSIONAL STABILITY OF A TOUGHENED EPOXY GRAPHITE COMPOSITE
G. F. SYKES and D. E. BOWLES (NASA, Langley Research Center, Hampton, VA) SAMPE Quarterly (ISSN 0036-0821), vol. 17, July 1986, p. 39-45. refs

The effects of a simulated space radiation environment on the dimensional stability of an elastomer-toughened epoxy-graphite composite were determined. The response of the material was characterized following exposure to radiation doses equivalent to geosynchronous orbit lifetimes ranging from 6 months to 30 years. The results show that radiation interacts with the epoxy matrix to embrittle the composite, beginning at relatively low total doses (10 to the 7th power rads). The embrittlement results in thermal expansion changes and significant laminate microcracking during thermal cycling. These property changes could limit the service life of this material in some spacecraft applications. Author

A87-13067
SPACE MATERIALS IN EUROPE
J. DAUPHIN (ESA, Materials Section, Noordwijk, Netherlands) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 276-290. refs

A comprehensive evaluation is made of the development status of materials for such space structures as those of satellites and space probes that have been constructed under the aegis of the ESA. Attention is given to the performance criteria for which spacecraft materials that will be subjected to ionizing radiation, temperature extremes and vacuum (potentially outgassing) conditions must be qualified. The organizational details of product assurance and approval procedure management are also presented. Representative of advanced materials-employing spacecraft are the Marecs maritime satellite, the Giotto Halley comet probe, and the Space Telescope's solar array; these respectively employ a carbon fiber-reinforced aluminum honeycomb antenna, a 'Sepcarb' carbon/carbon composite rocket nozzle, and novel silicone adhesives. O.C.

A87-13071
EFFECT OF ELECTRON-BEAM RADIATION ON GRAPHITE EPOXY COMPOSITES
J. ENOMOT, K. NAKAZAKI, K. MURAYAMA, and K. SONODA (Mitsubishi Electric Corp., Amagasaki, Japan) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 352-361. Research sponsored by the Agency of Industrial Science and Technology. refs

Specimens of unidirectional graphite/epoxy laminates were irradiated by 10-MeV electrons up to a total dose of 5000 Mrads at 50, 150, and 250 C and then tested mechanically to determine their flexural and interlaminar shear strengths. The radiation-generated volatile products and the components extracted by a solvent from the irradiated specimens were analyzed by gas-chromatographic and mass spectrometric techniques; the degradation of the matrix resin (bisphenol based epoxy) was characterized by FT-IR spectroscopy. It is found that the flexural strength of the specimens irradiated in air decreases with increasing dose. The flexural strength of the irradiated specimens, however, can be almost completely restored through a thermal cycling treatment. It is also shown that the degradation of the matrix increases with the irradiation dose. V.L.

A87-13097
THERMOPLASTIC-BASED COMPOSITES WITH LOW CTE FOR SPACE STRUCTURES AND CIRCUIT BOARD APPLICATIONS
A. MAHAMAD IBRAHIM, T. K. SHAH, L. J. MATIENZO, and J. D. VENABLES (Martin Marietta Laboratories, Baltimore, MD) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 669-680. refs

A variety of organic and inorganic woven fabric reinforced high-performance thermoplastic composites have been investigated with a view to developing new composite systems with a low or near-zero coefficient of thermal expansion (CTE) in the X-Y direction and a reasonably low CTE in the Z direction. A high-performance semicrystalline thermoplastic, polyphenylene sulfide (PPS) has been selected as the model thermoplastic matrix system. The results obtained indicate that the use of this matrix system makes it possible to achieve more uniform thermal expansion behavior in all directions for composites used in space structures and circuit board applications. V.L.

A87-13098
PROTECTIVE COATING FOR THE KU-BAND REFLECTOR
J. R. DENMAN and L. C. MALDOON (Hughes Aircraft Co., Technology Support Div., Los Angeles) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 681-692.

Several protective coatings have been tested with a view to selecting a coating system capable of protecting the KU-band antenna reflector used on the Space Shuttle against damage in the low earth orbit (LEO) environment. Of the coatings tested, CV 1144, a flexible room temperature curing silicone coating, has been selected as the best product. This coating system does not affect the operation of the reflector while providing protection against the hostile LEO environment for extended periods. Some test results are presented. V.L.

A87-13159
FABRICATION OF A SPACE STATION COMPOSITE TETRATRUSS MODEL
J. F. DUBEL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: International SAMPE Symposium and Exhibition, 31st, Los Angeles, CA, April 7-10, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 1469-1475.

Attention is given to the design, fabrication and assembly processes associated with a prototype composites-employing 'tetratruss' for Space Station-related use. Unidirectional and chopped fiber-reinforced composites have been chosen for the fabrication of the truss structure's tubular struts and fittings, respectively. The tubes' unidirectional material will be plied in order to yield the requisite longitudinal modulus and thermal expansion coefficient while retaining acceptable transverse modulus; the chopped graphite fiber reinforced for the frame's nodes, tube ends and hinge fittings will produce somewhat greater thermal expansion. The overall design, test, verification, fabrication and assembly process data generated by this prototype will be used as a basis for Space Station composite primary structure cost projections. O.C.

A87-14312* Massachusetts Inst. of Tech., Cambridge.
FUNDAMENTALS AND ADVANCES IN THE DEVELOPMENT OF REMOTE WELDING FABRICATION SYSTEMS
J. E. AGAPAKIS (Automatix, Inc., R&D Group, Billerica; MIT, Cambridge, MA), K. MASUBUCHI (MIT, Cambridge, MA), and C. VON ALT (Woods Hole Oceanographic Institute, MA) Welding Journal (ISSN 0043-2296), vol. 65, Sept. 1986, p. 21-32. MIT-NASA-supported research. refs

Operational and man-machine issues for welding underwater, in outer space, and at other remote sites are investigated, and recent process developments are described. Probable remote welding missions are classified, and the essential characteristics

of fundamental remote welding tasks are analyzed. Various possible operational modes for remote welding fabrication are identified, and appropriate roles for humans and machines are suggested. Human operator performance in remote welding fabrication tasks is discussed, and recent advances in the development of remote welding systems are described, including packaged welding systems, stud welding systems, remotely operated welding systems, and vision-aided remote robotic welding and autonomous welding systems. C.D.

A87-16163
DESIGN AND MANUFACTURING ASPECTS OF TUBULAR CARBON FIBRE COMPOSITE/TITANIUM BONDED JOINTS
J. FRANZ and H. LAUBE (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) (Imperial College of Science and Technology and Ciba-Geigy Plastics, International Symposium on Joining and Repair of Fibre-Reinforced Plastics, London, England, Sept. 10, 11, 1986) Composite Structures (ISSN 0263-8223), vol. 6, no. 1-3, 1986, p. 183-196.

The structure of the satellite SPAS-01 consists of a framework built by carbon fiber composite/titanium strut and node elements. The key point of the whole structure is the connection between the carbon fiber composite tube and the titanium end fitting, which has been designed and constructed in the form of a scarf, double-shear bonded joint. The present paper describes the structural requirements and their verification in the phases of design, analysis, test and fabrication of the satellite structure. Author

A87-18271
THE ELECTRON IRRADIATION TEST OF THERMAL CONTROL MATERIAL
T. MATSUSHITA, M. FUNAKI (National Space Development Agency of Japan, Tokyo), Y. IDO, K. IWAMOTO, Y. MIYAZAKI (Toshiba Corp., Kawasaki, Japan) et al. IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 565-569.

Facilities developed for NASDA to study the degradation and charging effect of thermal control materials are described. The combined irradiation test facility for thermal control materials and the electron irradiation test are presented. The test facility is intended for the following two purposes: investigation of the effect of individual parameters (UV wavelength, electron flux, and temperature) and investigation of combined irradiation of UV and electrons. The test samples of thermal-control material were exposed to 20-keV electron irradiation with flux 2.7 x 10 to the 14th e/sq cm hr. During the test, electrical discharges were frequently observed on the surfaces of test samples such as silvered teflon and OSR. Their solar absorptance and emittance were measured in situ by using a dynamic thermal vacuum technique. Author

A87-18554
ELECTRICALLY CONDUCTIVE ORGANIC POLYMERS FOR ADVANCED APPLICATIONS
D. B. COTTS and Z. REYES (SRI International, Menlo Park, CA) Research sponsored by the U.S. Air Force. Park Ridge, NJ, Noyes Data Corp., 1986, 222 p. refs

Attention is given to the properties of electrically conducting, semiconducting, and semiinsulating polymers, with a view to the conduction mechanisms involved and to the mechanical properties and space-related systems applicability of the various substances. High electron mobilities are noted to be observed only in systems that form a periodic superlattice of localized states; substances synthesized on the basis of this model are not only highly conductive but processable in organic solvents. Emphasis is given to space applications. O.C.

A87-18867
MATERIALS - THE CHALLENGE OF SPACE
G. MARSH Space (ISSN 0267-954X), vol. 2, Sept.-Nov. 1986, p. 10-12, 14, 15.

A comprehensive evaluation is made of the state of development and applicability to spacecraft structures of various advanced materials technologies, some of which are noted to have been overlooked by designers despite substantial promises of performance improvement in space environments characterized by extreme temperatures and radiation exposures. Attention is given to beryllium, lithium-aluminum and titanium alloys, carbon-carbon and ceramic composite refractories, and refractory metals, as well as space-applicable polymer-matrix composites. O.C.

A87-19122* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE EFFECTS OF RADIATION ON THE INTERLAMINAR FRACTURE TOUGHNESS OF A GRAPHITE/EPOXY COMPOSITE
J. G. FUNK and G. F. SYKES (NASA, Langley Research Center, Hampton, VA) Journal of Composites Technology and Research (ISSN 0885-6804), vol. 8, Fall 1986, p. 92-97. refs

An experimental study is made of the effect of electron irradiation (10 to the 10th rad), simulating a 30-year geosynchronous orbit exposure, on the fracture toughness of a graphite/epoxy composite, T300/934. The double cantilever beam (DBC) test is used to determine Mode I (peel) critical strain energy release rate and the edge delamination tension (EDT) test is used to determine mixed Mode I and II (peel and shear) critical strain energy release rate. It is found that the electron interaction of the epoxy matrix material enhances the fracture toughness properties of the composite and that the test temperature has a significant effect on the fracture toughness of both baseline and irradiated material. V.L.

A87-19342
USE OF GRAPHITE/EPOXY COMPOSITES IN SPACECRAFT STRUCTURES - A CASE STUDY
R. D. JAMISON (U.S. Naval Academy, Annapolis, MD), O. H. GRIFFIN, JR. (Virginia Polytechnic Institute and State University, Blacksburg), J. A. ECKER, and W. E. SKULLNEY (Johns Hopkins University, Laurel, MD) Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 7, July-Sept. 1986, p. 290-294. refs

The redesign of the Polar Bear satellite's center support structure is taken as a demonstration case in evaluating the applicability of graphite/epoxy composite structures for the fabrication of critical spacecraft structures. Attention is given to the results of analyses conducted for the strength, stiffness, thermal, and buckling characteristics of the support structure design. It is found that the substitution of composite for metal material is straightforward and can be accomplished with available design tools. O.C.

A87-19343
EROSION STUDIES ON SOLAR MAX SAMPLES
R. M. FRISTROM, R. C. BENSON, C. B. BARGERON, T. E. PHILLIPS, C. E. VEST (Johns Hopkins University, Laurel, MD) et al. Johns Hopkins APL Technical Digest (ISSN 0270-5214), vol. 7, July-Sept. 1986, p. 308-314.
(Contract N00024-85-C-5301)

The condition of damaged material samples from the Solar Max satellite, namely a kapton/dacron/aluminized mylar protective blanket, a piece of silver-coated teflon shielded from the sun, and another such piece of teflon that had been exposed to solar radiation, has been studied in order to infer the erosiveness of the near-space environment. Surface damage caused by high energy molecular species, submicronic micrometeorite impacts, and low energy oxygen atom erosion are discussed in light of laboratory analyses of the materials after their subjection to simulations of these processes. O.C.

A87-19805
HOLOGRAPHIC NON-DESTRUCTIVE TESTING FOR COMPOSITE MATERIALS USED IN AEROSPACE
M.-A. DE SMET (Bruxelles, Universite Libre, Brussels, Belgium) IN: Optics in engineering measurement; Proceedings of the Meeting, Cannes, France, December 3-6, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 46-52. refs

An analysis and comparisons are presented for the holographic interferometry and ultrasonic methods' results concerning the function of the application of external fields to a composite material test specimen. Holographic interferometry is judged capable of yielding systematic process control data; it is noted that a slight temperature elevation allows such defects as composite fiber breaks, delaminations and disbonds to be visualized. O.C.

A87-20149
ADHESIVE BONDING OF AEROSPACE MATERIALS - SURFACE CHARACTERIZATION OF METALLIC ADHERENDS
M. CHARBONNIER, M. ROMAND, A. ROCHE, and F. GAILLARD (Lyon I, Universite, Villeurbanne, France) International Journal of Adhesion and Adhesives (ISSN 0143-7496), vol. 6, Oct. 1986, p. 199-206. refs

It is well known that surfaces of 'as-received' materials are chemically very different from the bulk composition and are usually unsuitable for adhesive bonding. Consequently, surfaces of such materials have to be submitted to appropriate chemical or electrochemical prebonding treatments in order to modify both their morphology and chemistry. This paper discusses the surface characterization of aluminum, titanium, and their alloys at various prebonding stages. Practical applications of X-ray fluorescence spectroscopy, low-energy electron-induced X-ray spectroscopy, and glow discharge optical spectroscopy are described. Author

A87-21992* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ELECTRON-RADIATION EFFECTS ON THE AC AND DC ELECTRICAL PROPERTIES AND UNPAIRED ELECTRON DENSITIES OF THREE AEROSPACE POLYMERS
SHEILA ANN T. LONG, EDWARD R. LONG, JR. (NASA, Langley Research Center, Hampton, VA), HEIDI R. RIES, and WYNFORD L. HARRIES (Old Dominion University, Norfolk, VA) (IEEE, DNA, Sandia National Laboratories, and NASA, 1986 Annual Conference on Nuclear and Space Radiation Effects, 23rd, Providence, RI, July 21-23, 1986) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-33, Dec. 1986, pt. 1, p. 1390-1395. refs

The effects of gigarad-level total absorbed doses from 1-MeV electrons on the post-irradiation alternating-current (ac) and direct-current (dc) electrical properties and the unpaired electron densities have been studied for Kapton, Ultem, and Mylar. The unpaired electron densities (determined from electron paramagnetic resonance spectroscopy) and the dc electrical conductivities of the irradiated materials were monitored as functions of time following the exposures to determine their decay characteristics at room temperature. The elevated-temperature ac electrical dissipations of the Ultem and Mylar were affected by the radiation. The dc conductivity of the Kapton increased by five orders of magnitude, while the dc conductivities of the Ultem and Mylar increased by less than an order of magnitude, due to the radiation. The observed radiation-generated changes in the ac electrical dissipations are explained in terms of known radiation-generated changes in the molecular structures of the three materials. A preliminary model relating the dc electrical conductivity and the unpaired electron density in the Kapton is proposed. Author

A87-21993
ANALYSIS OF THE ION SPOT PHENOMENON ON BEAM-CHARGED DIELECTRICS
GORDON MCKEIL and K. G. BALMAIN (Toronto, University, Canada) (IEEE, DNA, Sandia National Laboratories, and NASA, 1986 Annual Conference on Nuclear and Space Radiation Effects, 23rd, Providence, RI, July 21-23, 1986) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-33, Dec. 1986, pt. 1, p. 1396-1401. refs
(Contract AF-AFOSR-84-0342; NSERC-A-4140)

Computer simulation of particle trajectories in two dimensions using a simple static accumulated charge model reveals the mechanism for the focussing of ions into a central, sharply defined 'spot', duplicating the luminescent spot which did not arc-discharge observed during laboratory exposure of polymer film to monoenergetic electrons and low energy ions. A model which follows the time evolution of such charging situations is developed and initial results are presented. Author

A87-23702* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROPERTIES AND POTENTIAL APPLICATIONS OF BROMINATED P-100 CARBON FIBERS
D. A. JAWORSKE, J. R. GAIER, C. C. HUNG, and B. A. BANKS (NASA, Lewis Research Center, Cleveland, OH) SAMPE Quarterly (ISSN 0036-0821), vol. 18, Oct. 1986, p. 9-14. refs

A review of the properties and potential applications of bromine-intercalated pitch-based carbon fibers is presented. The dynamics of the intercalation reaction are summarized, and characteristics, such as resistivity, density, and stability, are discussed. In addition, the mechanical and electrical properties of bromine-intercalated fiber-epoxy conposites will be addressed. With conductivities comparable to stainless steel, these brominated carbon fibers may be used in a number of composite applications, such as electromagnetic interference shielding containers, large conductive space structures, lightning strike-tolerant aircraft surfaces, and aircraft deicing applications. Author

A87-24919*# Physical Sciences, Inc., Andover, Mass.
ENERGETIC OXYGEN ATOM MATERIAL DEGRADATION STUDIES
GEORGE E. CALEDONIA and ROBERT H. KRECH (Physical Sciences, Inc., Andover, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract NAS7-938)
(AIAA PAPER 87-0105)

As part of a study designed to test potential Shuttle surface materials for the extents of degradation and mass loss expected to be suffered in space from the velocity impacts of ambient oxygen atoms, a novel technique was developed for generation of a high flux of energetic oxygen atoms. The generation technique involves laser-induced breakdown of molecular oxygen followed by a rapid expansion of energetic oxygen atoms. The high-velocity streams developed in an evacuated hypersonic nozzle have average O-atom velocities of about 5 to 13 km/s, with an estimated total production of 10 to the 18th atoms per pulse over pulse durations of several microseconds. Results on preliminary material degradation tests conducted with this test facility have been reported by Caledonia et al. (1987). Diagrams of the experimental setup are included. I.S.

A87-27178* Virginia Polytechnic Inst. and State Univ., Blacksburg.
SPACE RADIATION EFFECTS ON THE THERMO-MECHANICAL BEHAVIOR OF GRAPHITE-EPOXY COMPOSITES
SCOTT M. MILKOVICH, CARL T. HERAKOVICH (Virginia Polytechnic Institute and State University, Blacksburg), and GEORGE F. SYKES (NASA, Langley Research Center, Hampton, VA) Journal of Composite Materials (ISSN 0021-9983), vol. 20, Nov. 1986, p. 579-593. refs
(Contract NAG1-343)

This investigation of composite material properties utilized T300/934 graphite-epoxy that was subjected to 1.0 MeV electron

radiation for a total dose of 1.0 x 10 to the 10th rads at a rate of 5.0 x 10 to the 7th rads/hour, simulating a worst-case exposure equivalent to 30 years in space. Mechanical testing was performed on 4-ply unidirectional laminates over the temperature range of -250 F (116 K) to +250 F (394 K). In-plane elastic tensile and shear properties as well as strength were obtained. The results show that electron radiation degrades the epoxy matrix and produces products that volatilize at the temperatures considered. These degradation products plasticize the epoxy at elevated temperatures and embrittle it at low temperatures, thereby altering the mechanical properties of the composite. Author

A87-27936*# Physical Sciences, Inc., Andover, Mass.
A HIGH FLUX SOURCE OF ENERGETIC OXYGEN ATOMS FOR MATERIAL DEGRADATION STUDIES
GEORGE E. CALEDONIA, ROBERT H. KRECH, and BYRON D. GREEN (Physical Sciences, Inc., Andover, MA) (Shuttle Environment and Operations II Conference, Houston, TX, Nov. 13-15, 1985, Technical Papers, p. 153-159) AIAA Journal (ISSN 0001-1452), vol. 25, Jan. 1987, p. 59-63. Previously cited in issue 03, p. 267, Accession no. A86-14399. refs
(Contract NAS7-938)

A87-31300*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE SURVIVABILITY OF LARGE SPACE-BORNE REFLECTORS UNDER ATOMIC OXYGEN AND MICROMETEOROID IMPACT
DANIEL A. GULINO (NASA, Lewis Research Center, Cleveland, OH) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 9 p. Previously announced in STAR as N87-14423. refs
(AIAA PAPER 87-0341)

Solar dynamic power system mirrors for use on Space Station and other spacecraft flown in low earth orbit (LEO) are exposed to the harshness of the LEO environment. Both atomic oxygen and micrometeoroids/space debris can degrade the performance of such mirrors. Protective coatings will be required to protect oxidizable reflecting media, such as silver and aluminum, from atomic oxygen attack. Several protective coating materials have been identified as good candidates for use in this application. The durability of these coating/mirror systems after pinhole defects have been inflicted during their fabrication and deployment or through micrometeoroid/space debris impact once on-orbit is of concern. Studies of the effect of an oxygen plasma environment on protected mirror surfaces with intentionally induced pinhole defects have been conducted at NASA Lewis and are reviewed. It has been found that oxidation of the reflective layer and/or the substrate in areas adjacent to a pinhole defect, but not directly exposed by the pinhole, can occur. Author

N87-10184*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF THERMAL CYCLING ON GRAPHITE-FIBER-REINFORCED 6061 ALUMINUM
G. A. DRIES (PRC Kentron, Inc., Hampton, Va.) and S. S. TOMPKINS Oct. 1986 29 p
(NASA-TP-2612; L-16139; NAS 1.60:2612) Avail: NTIS HC A03/MF A01 CSCL 11D

Graphite-reinforced aluminum alloy metal-matrix composites are among materials being considered for structural components in dimensionally stable space structures. This application requires materials with low values of thermal expansions and high specific stiffnesses. They must remain stable during exposures to the space environment for periods extending to 20 years. The effects of thermal cycling on the thermal expansion behavior and mechanical properties of Thornel P100 graphite 6061 aluminum composites, as fabricated and after thermal processing to eliminate thermal strain hysteresis, have been investigated. Two groups of composites were studied: one was fabricated by hot roll bonding and the other by diffusion bonding. Processing significantly reduced strain hysteresis during thermal cycling in both groups and improved the ultimate tensile strength and modulus in the diffusion-bonded composites. Thermal cycling stabilized the as-fabricated composites by reducing the residual fabrication stress and increased the matrix strength by metallurgical aging. Thermal expansion behavior of both groups after processing was insensitive to thermal cycling. Data scatter was too large to determine effects of thermal cycling on the mechanical properties. The primary effects of processing and thermal cycling can be attributed to changes in the metallurgical condition and stress state of the matrix. Author

N87-10932# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Strukturmechanik.
THE K1-K2 INTERACTION FOR MATRIX SPLITTING IN UNIDIRECTIONAL LAMINATES OF CARBON FIBER REINFORCED EPOXY
H. EGGERS and L. KIRSCHKE *In* ESA Proceedings of an International Conference on Spacecraft Structures p 335-340 Apr. 1986
Avail: NTIS HC A19/MF A01

Rectangular side-notched specimens of multilayered unidirectional off-axis laminates of carbon-fiber reinforced epoxy T300-914C were tested for matrix splitting. For quasi-static loads the notch opening displacements, specimen elongations and crack lengths were measured. A finite element technique combined with theoretical formulas for the straining of the material at the crack tip were used. Cracks always develop parallel to the fibers. Misaligned fibers or layers act as crack stoppers. In thin laminates the cracks initiate earlier but propagate with less speed than in thick ones. The energy release rate is not a material constant, suitable to describe the crack propagation uniquely. Cracks initiate by a critical combination of the stress intensity factors. Crack propagation depends predominatly on the crack opening mode 1 and very little on the shear mode 2. ESA

N87-10933# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Fachbereich Technische Mechanik.
DEBONDING ANALYSIS OF THERMALLY STRESSED FIBER-REINFORCED COMPOSITE MATERIALS
F. G. BUCHHOLZ and K. H. SENGER *In* ESA Proceedings of an International Conference on Spacecraft Structures p 341-346 Apr. 1986
Avail: NTIS HC A19/MF A01

The effects of two ways of micromechanical modeling on the debonding analysis of thermally stressed unidirectionally fiber-reinforced composite materials are investigated. The models are a simple single circular unit cell and a more complex hexagonal unit cell embedded in the surrounding compound, as different orders of approximation to a real composite material. Correlation between the thermally induced elastic strain energy and the energy release rate of a curved interface crack, debonding an individual fiber from the adherent matrix material in both models is studied. The influence of increasing fiber volume fractions on the debonding behavior is assessed. Results show that the elastic strain energies induced in the models nearly coincide, although they differ distinctly in their geometrical contours and boundary conditions. For fiber volume fractions 10% it is shown that only the more complex model can deliver relevant results for the thermally induced plane strain debonding process in a real material. ESA

N87-10934# Societe Nationale Industrielle Aerospatiale, Cannes (France).
SPACE TECHNOLOGIES AND MATERIALS: A LOOK BACK AND FUTURE PERSPECTIVES [TECHNOLOGIES ET MATERIAUX SPATIAUX: RETROSPECTIVE ET PERSPECTIVES D'AVENIR]
J. A. MASSONI and J. L. CECCONI *In* ESA Proceedings of an International Conference on Spacecraft Structures p 347-351 Apr. 1986 In FRENCH
Avail: NTIS HC A19/MF A01

The evolution in satellite construction materials from aluminum alloys to carbon-resin structures is discussed. Future applications of metal matrix composites, aluminum-lithium composites, and silicon carbide reinforced aluminum composites are examined. ESA

N87-10935# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. for Structural Mechanics.
PERFORMANCE CHARACTERISTICS OF COMPOSITE MATERIALS
H. W. BERGMANN, M. GAEDKE, and H. C. GOETTING *In* ESA Proceedings of an International Conference on Spacecraft Structures p 353-359 Apr. 1986
Avail: NTIS HC A19/MF A01

Allowable stresses for multidirectional laminates with arbitrary stacking orders are predicted analytically using the characteristics of unidirectional plies established by test. The forecast properties for static tension loading include first ply failure and ultimate strength and take into account the state of prestress induced by widely varying environmental conditions. In laminates mechanically fatigued at R = 0.1 the influences of temperature and moisture are shown to be moderate. In matrix-controlled laminates, elevated temperature and moisture saturation degrade the fatigue strength, while in fiber-controlled laminates the presence of moisture tends to be beneficial. In multidirectional laminates the slopes of the delta-N curves are essentially unaffected in various hot-wet conditions. Matrix-controlled laminates subjected to severe thermal cycling exhibit strength and stiffness degradations depending on the brittleness of the matrix systems. Moderate to severe matrix cracking is observed. ESA

N87-10940# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
A METHOD OF STUDYING THE BEHAVIOR OF COMPOSITE MATERIALS IN SIMULATED SPACE ENVIRONMENTS [MOYEN D'ETUDE DU COMPORTEMENT EN AMBIANCE SPATIALE SIMULEE DE MATERIAUX COMPOSITES]
F. ALBUGUES, P. PLOTARD, M. F. GOMEZ (Office National d'Etudes et de Recherches Aerospatiales, Toulouse, France), A. PAILLOUS, and M. D. JUDD (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands) *In* ESA Proceedings of an International Conference on Spacecraft Structures p 393-397 Apr. 1986 In FRENCH
Avail: NTIS HC A19/MF A01

A method to evaluate the mechanical properties of composite spacecraft structural materials in simulated space vacuum, radiation, and thermal conditions was developed. It can irradiate in secondary vacuum a test batch of which a part is measured in situ and the rest afterwards. Different stages of aging due to UV and electron irradiation can be accounted for. ESA

N87-10949# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Rech. en Technol. Spatiale.
DESIGN IMPROVEMENT AND RADIATION, CONTAMINATION TESTS. PRESTUDY 1: ULTRAVIOLET RADIATION ACCELERATION, VOLUME 1 Final Report [AMELIORATION ET ESSAIS: CONTAMINATION PLUS IRRADIATION. PREETUDE 1: ACCELERATION DES IRRADIATIONS ULTRAVIOLETTES. TOME 1: ESSAIS ET CONCLUSIONS]
J. MARCO, P. MILLAN, A. PAILLOUS, C. SABLE, and J. SIFFRE Paris ESA Dec. 1985 92 p In FRENCH
(Contract ESTEC-5781/83-NL-AB)
(CERT-4193-VOL-1; CERT-419300/PR1/T01-DERTS; ESA-CR(P)-2227-VOL-1; ETN-86-98105) Avail: NTIS HC A05/MF A01

The influence of increasing the ultraviolet radiation intensity on the degradation of satellite thermal control surface coatings is studied. Several materials were insolated for the equivalent of 1000 solar hours with intensities 2 to 8 times stronger than the radiation of the Sun, at wavelengths under 400 nm. Visible light and infrared radiation were filtered out. The materials include white paints, aluminized kapton, black paints, aluminum paints, and silver coatings. The results are extremely variable, the absorption spectra vary with the degradation of the coating, and the degradation at the higher intensities is not always greater than at relatively low intensities. ESA

N87-10950# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Rech. en Technol. Spatiale.
DESIGN IMPROVEMENT AND RADIATION CONTAMINATION TESTS. PRESTUDY 1: ULTRAVIOLET RADIATION ACCELERATION. VOLUME 2: APPENDIX, DETAILED RESULTS Final Report [AMELIORATION ET ESSAIS: CONTAMINATION PLUS IRRADIATION. PREETUDE 1: ACCELERATION DES IRRADIATIONS ULTRAVIOLETTES. TOME 2: ANNEXES, RESULTATS DETAILLES]
J. MARCO, P. MILLAN, A. PAILLOUS, C. SABLE, and J. SIFFRE Paris ESA Dec. 1985 200 p In FRENCH
(Contract ESTEC-5781/83-NL-AB)
(CERT-4193-VOL-2; ESA-CR(P)-2227-VOL-2; ETN-86-98106)
Avail: NTIS HC A09/MF A01

The influence of increasing ultraviolet radiation intensity on the degradation of satellite thermal control surface coatings is studied. Several materials were insolated for the equivalent of 1000 hr with intensities 2 to 8 times stronger than the radiation of the Sun, at wavelengths under 400 nm. Visible light and infrared were filtered out. The materials included white paints, aluminized Kepton, black paints, alinum paints and silver coatings. The results are extremely variable, the absorption spectra vary with the degradation of the coating, and the degradation at the higher intensities is not always greater than at relatively low intensities. ESA

N87-10951# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Rech. en Technol. Spatiale.
IMPROVING THE IRRADIATION PLUS CONTAMINATION TESTS. PRESTUDY 2: SUCCESSIVE IRRADIATIONS AND SYNERGICS. VOLUME 1: TESTS AND CONCLUSIONS Final Report [AMELIORATION ET ESSAIS: CONTAMINATION PLUS IRRADIATION. PREETUDE 2: IRRADIATIONS SUCCESSIVES ET SYNERGIE. TOME 1: ESSAIS ET CONCLUSIONS]
J. MARCO, P. MILLAN, A. PAILLOUS, C. SABLE, and J. SIFFRE Paris ESA Dec. 1985 65 p In FRENCH
(Contract ESTEC-5781/83-NL-AB)
(CERT-4193-VOL-3; CERT-419300/PR2/T01-DERTS; ESA-CR(P)-2227-VOL-3; ETN-86-98107) Avail: NTIS HC A04/MF A01

A simulation of 1 yr exposure to a geosynchronous orbit space environment was carried out. Ultraviolet radiation, protons, and electrons acted on surface coatings used on satellite thermal control equipment. The low sensitivity of the optical measurement prevents quantitative comparison. Nevertheless, observations regarding degradable materials are included. ESA

N87-10952# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Rech. en Technol. Spatiale.
IMPROVING RADIATION PLUS CONTAMINATION TESTS. PRESTUDY 2: SUCCESSIVE IRRADIATIONS AND SYNERGICS. VOLUME 2: ANNEXES. ANNEX 1: DETAILED RESULTS. ANNEX 2: CONTROL AND IMPROVEMENT OF OPTICAL MEASUREMENTS Final Report [AMELIORATION ET ESSAIS: CONTAMINATION PLUS IRRADIATION. PREETUDE 2: IRRADIATIONS SUCCESSIVES ET SYNERGIE. TOME 2: ANNEXES. ANNEXE 1: RESULTATS DETAILLES. ANNEXE 2: CONTROLE ET AMELIORATION DES MESURES OPTIQUES]
J. MARCO, P. MILLAN, A. PAILLOUS, C. SABLE, and J. SIFFRE Paris ESA Dec. 1985 63 p In FRENCH
(Contract ESTEC-5781/83-NL-AB)
(CERT-4193-VOL-4; ESA-CR(P)-2227-VOL-4; ETN-86-98108)
Avail: NTIS HC A04/MF A01

A simulation of 1 yr exposure to a geosynchronous orbit space environment was carried out. Ultraviolet radiation, protons and electrons were used on surface coatings employed on satellite thermal control equipment. The low sensitivity of the optical measurements precludes a quantitative comparison. Nevertheless, observations regarding degradable materials are included. ESA

N87-10954# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France). Dept. d'Etudes et de Rech. en Technol. Spatiales.
IMPROVING RADIATION/CONTAMINATION TESTS Final Report [AMELIORATION DES ESSAIS: CONTAMINATION PLUS IRRADIATION]
J. MARCO and A. PAILLOUS Paris ESA Jul. 1985 95 p In FRENCH
(Contract ESTEC-5781/83-NL-AB)
(CERT-419300/1-DERTS; ESA-CR(P)-2245; ETN-86-98123; PS-4)
Avail: NTIS HC A05/MF A01

The characteristics of optical fibers in the wavelengths from 300 to 2500 nm are studied in order to define an improved optical spectral measuring instrument able to determine in situ the reflection factor of satellite coatings. The measuring system would have fixed samples and movable detector (optical fibers) in a high vacuum environment. A detailed study of optical fiber bundles is included. Energy balance of different systems using fibers is compared. Possible solutions are examined concluding that improved systems based on the use of optical fibers are feasible.
ESA

N87-10960*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OXIDATION-RESISTANT REFLECTIVE SURFACES FOR SOLAR DYNAMIC POWER GENERATION IN NEAR EARTH ORBIT
D. A. GULINO, R. A. EGGER (Cleveland State Univ., Ohio), and W. F. BANHOLZER (General Electric Co., Schenectady, N. Y.) 1986 16 p Presented at the 33rd National Symposium of the National Vacuum Society, Baltimore, Md., 27-31 Oct. 1986
(NASA-TM-88865; E-3268; NAS 1.15:88865) Avail: NTIS HC A02/MF A01 CSCL 10B

Reflective surfaces for space station power generation systems are required to withstand the atomic oxygen-dominated environment of near Earth orbit. Thin films of platinum and rhodium, which are corrosion resistant reflective metals, have been deposited by ion beam sputter deposition onto various substrate materials. Solar reflectances were then measured as a function of time of exposure to a RF-generated air plasma. Similarly, various protective coating materials, including MgF2, SiO2, Al2O3, and Si3N4, were deposited onto silver-coated substrates and then exposed to the plasma. Analysis of the films both before and after exposure by both ESCA and Auger spectroscopy was also performed. The results indicate that Pt and Rh do not suffer any loss in reflectance over the duration of the tests. Also, each of the coating materials survived the plasma environment. The ESCA and Auger analyses are discussed as well.
Author

N87-10982# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
COMPOSITES DESIGN HANDBOOK FOR SPACE STRUCTURE APPLICATIONS. EXECUTIVE SUMMARY Final Report
Paris ESA Sep. 1985 6 p
(Contract ESTEC-5816/84-NL-PB(SC))
(ESA-CR(P)-2196; ETN-86-98082) Avail: NTIS HC A02/MF A01

The ESA composites design handbook is divided into eight main chapters. These chapters are entitled: Handbook organization and user instructions; Material properties and applications; Calculation methods of laminates; General design aspects; Load transfer and design of joints; Structural design; Integrity control; and Verification guidelines.
ESA

N87-12601# California Univ., Los Angeles. Dept. of Materials Science and Engineering.
NEW MATERIALS FOR SPACECRAFT STABILITY AND DAMPING: A FEASIBILITY STUDY Final Technical Report, 1 Oct. 1983 - 30 Sep. 1984
J. D. MACKENZIE Nov. 1985 52 p
(Contract AF-AFOSR-0221-83)
(AD-A169826; AFOSR-86-0308TR) Avail: NTIS HC A04/MF A01 CSCL 11D

A preliminary feasibility study has been conducted on some new materials for use as structure components of spacecrafts. These included some new glasses, glass-ceramics, fibers and composites such as low expansion copper aluminosilicate glasses, hollow and oval glass fibers and hollow fiber-glass-polymer composites. The low temperature expansion coefficients, elastic moduli and damping constants were measured. Recommendations are made for further research and development of some selected materials which appeared to be promising candidates for spacecraft structures.
GRA

N87-13572# United Kingdom Atomic Energy Authority, Harwell (England). Polymer and Composites Group.
DEVELOPMENT OF A CONTINUOUS MANUFACTURING METHOD FOR A CFRP COLLAPSIBLE TUBE MAST Final Report
D. H. BOWEN, R. DAVIDSON, R. J. LEE, and T. THORPE Jun. 1986 105 p
(Contract ESTEC-6106/84/NL/AN(SC))
(AERE-G-3898; HL86/1252(C14)) Avail: NTIS HC A06/MF A01

A sequential molding process was developed for forming continuous lengths of profiled carbon fiber reinforced plastic (CFRP) sheet, and for the edge-bonding of two identical profiles to produce a lenticular-shaped collapsible tube mast (CTM). The process was designed to enable a wide range of CTM sizes, characterized by the shape radius r, to be produced, and it will accept either thermosetting or thermoplastic matrix composites. The Tube Manufacturing Method (TMM) was proved by the construction of a laboratory scale rig and its use to produce continuously 10 m lengths of mast profile of uniform section and surface finish. The mechanical properties of the fabrics impregnated with the two resins were measured to provide basic tube mast design data. Viscoelastic relaxations in both types of composites were determined after storing sections of mast profile in the flattened condition over periods of time as a function of temperature.
Author

N87-13589# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
ACTIVITIES REPORT IN MATERIALS AND CONSTRUCTION Annual Report, 1985 [FORSCHUNGSBEREICH WERKSTOFFE UND BAUWEISEN]
1985 114 p In GERMAN
(ISSN-0174-3910; ETN-86-98280) Avail: NTIS HC A06/MF A01

Research in materials and construction methods is presented. Structural mechanics, aeroelasticity, and space simulation are covered.
ESA

N87-14383*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
RESULTS OF EXAMINATION OF MATERIALS FROM THE SOLAR MAXIMUM RECOVERY MISSION
J. J. PARK *In its* Proceedings of the SMRM Degradation Study Workshop p 211-226 1985
Avail: NTIS HC A16/MF A01 CSCL 22B

Four years and two months in space at 310 nautical miles orbit has produced different effects on Kapton, silver/Teflon, and on aluminum. Kapton, a polyimide, lost up to 31% in thickness, though other locations showed much less loss. The degradation of silver/Teflon was drastic but very localized, due perhaps to the formation of silver oxide, Ag2O, through cracks in the protective Inconel layer which exposed the silver to the oxygen atom environment. Penetrations of the thin aluminum sheet in the form of thermal louvers and also of the thermal blanket material due to unknown particles were unexpected, making the debris a potentially serious problem because of the threat of damage to components.
Author

N87-14384*# Johns Hopkins Univ., Laurel, Md. Applied Physics Lab.

STUDIES OF EROSION OF SOLAR MAX SAMPLES OF KAPTON AND TEFLON

R. M. FRISTROM, R. C. BENSON, C. B. BARGERON, T. E. PHILLIPS, C. E. VEST, C. H. HOSHALL, F. G. SATKIEWICZ, and O. M. UY *In* NASA. Goddard Space Flight Center Proceedings of the SMRM Degradation Study Workshop p 227-242 1985

Avail: NTIS HC A16/MF A01 CSCL 22B

Several samples of Kapton and Teflon which was exposed to solar radiation were examined. The samples represent material behavior in near Earth space. Clues to the identity of erosive processes and the responsible species were searched for. Interest centered around oxygen atoms which are ubiquitous at these altitudes and are known to erode some metal surfaces. Three diagnostic methods were employed: optical microscopy, scanning electron microscopy, and fourier transform infrared spectroscopy. Two types of simulation were used: a flow containing low energy oxygen atoms and bombardment with 3000 volt Ar ions. Results and conclusions are presented. E.R.

N87-14385*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ANALYSIS OF MICROMETEORITE MATERIAL CAPTURED BY THE SOLAR MAX SATELLITE

L. S. SCHRAMM (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.), D. S. MCKAY, H. A. ZOOK, and G. A. ROBINSON *In* NASA. Goddard Space Flight Center Proceedings of the SMRM Degradation Study Workshop p 243-244 1985

Avail: NTIS HC A16/MF A01 CSCL 22B

A Solar Maximum satellite was retrieved and repaired after being subjected for four years and 55 days to impacts by micrometeorites and Earth-orbiting space debris. The chemical variety and physical condition of particles associated with two particular impact structures in the insulation blanket of the main electronics box are studied. A scanning electron microscope equipped with an energy dispersive X ray analyzer was used to determine morphology and chemistry of impacted areas and associated particles. Some details are discussed. E.R.

N87-14386*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

EXAMINATION OF RETURNED SOLAR-MAX SURFACES FOR IMPACTING ORBITAL DEBRIS AND METEOROIDS

D. J. KESSLER, H. A. ZOOK, A. E. POTTER, D. S. MCKAY, U. S. CLANTON (Department of Energy, Las Vegas, Nev.), J. L. WARREN (Northrop Services, Inc., Houston, Tex.), L. A. WATTS, R. A. SCHULTZ (Purdue Univ., West Lafayette, Ind.), L. S. SCHRAMM (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.), S. J. WENTWORTH et al. *In* NASA. Goddard Space Flight Center Proceedings of the SMRM Degradation Study Workshop p 245-246 1985

Avail: NTIS HC A16/MF A01 CSCL 22B

The thermal insulation of the Solar Maximum Mission launched on 14 February 1980 which consisted of 17 layers of alumized Kapton offers an excellent opportunity to obtain chemistry of impacting particles. To date, approximately 0.7 sq. met. of the insulation and 0.05 sq. met. of the aluminum louvers have been mapped by optical microscope for crater diameters larger than 40 microns. Atomic oxygen has eroded up to 20 microns of the exposed Kapton surfaces removing the older and smaller craters. The crater size distribution found on 3 different Kapton surfaces is shown. About 250 chemical spectra were recorded of particles observed in or around impact pits or in the debris pattern found on the second layer beneath impact holes in the outer layer. The debris populations are listed and discussed. E.R.

N87-14388*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SSM ATOMIC OXYGEN REACTIONS ON KAPTON AND SILVERIZED TEFLON

R. LINTON and A. WHITAKER *In* NASA. Goddard Space Flight Center Proceedings of the SMRM Degradation Study Workshop p 265-272 1985

Avail: NTIS HC A16/MF A01 CSCL 22B

Surface morphology studies using scanning electron microscopy on Kapton and Inconel silver coated Teflon material samples retrieved from the Solar Maximum Mission spacecraft revealed significant changes attributed to orbital atomic oxygen induced reactions. The Kapton recession observed on the aluminized Kapton material samples appeared equivalent in nature with that observed on previous Space Shuttle LEO missions. SSM Teflon taped material samples, coated on the back side with films of Inconel protected silver were observed degraded on both sides. Visibly severe reactions on the back side produced total blackening, generally restricted to areas of tape with a narrow direct view-factor of the external orbital environment. High magnification scanning electron microscope views provided evidence of near total silver reaction, flaking, and subsequent erosion of the underlying Teflon itself. Only three of the extensive S.E.M. photographs illustrating the basic reactions observed are included pending further detailed investigations. E.R.

N87-14389*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

PRELIMINARY RESULTS OF SMM EXPOSED ALUMINIZED KAPTON AND SILVERED TEFLON

B. SANTOS-MASON *In* NASA. Goddard Space Flight Center Proceedings of the SMRM Degradation Study Workshop p 273-286 1985

Avail: NTIS HC A16/MF A01 CSCL 22B

Early Space Shuttle flights revealed that organic materials, such as those used in thermal control blankets and paints in the payload bay, were adversely affected in the low Earth orbit environment. Examination of eroded surfaces on these early flights and materials experiments performed on subsequent flights led to the conclusion that atomic oxygen present at Shuttle operating altitudes was responsible for surface degradation. The Solar Maximum Mission provided surfaces that had been exposed in real time to atomic oxygen and ultraviolet radiation. Preliminary results of studies of the microscopic surface effects on silvered Teflon and aluminized Kapton used for thermal control on the Solar Maximum Mission are presented. E.R.

N87-14391*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ANALYSIS OF NORMAL AND TRANSPARENT SILVER TEFLON

W. K. STUCKEY, A. A. GALUSKA, and J. UHT *In its* Proceedings of the SMRM Degradation Study Workshop p 317-336 1985

Avail: NTIS HC A16/MF A01 CSCL 22B

Samples of Inconel/silver/Teflon exposed to solar radiation, and atomic oxygen on Solar Max were microcharacterized. Those samples exposed to atomic oxygen from the metallic side had become transparent while those exposed from the Teflon side remained reflective. The difference between the transparent and non-transparent material was determined. Microcharacterization of these Inconel/silver/Teflon samples was performed using scanning electron microscopy with windowless energy dispersive X ray analysis, secondary ion mass spectrometry, and X ray photoelectron spectroscopy. Author

N87-14392*# Jet Propulsion Lab., California Inst. of Tech., Pasadena. Applied Mechanics Technology Section.
DEGRADATION STUDIES OF SMRM TEFLON
R. H. LIANG, K. L. ODA, and S. Y. CHUNG *In* NASA. Goddard Space Flight Center Proceedings of the SMRM Degradation Study Workshop p 337-342 1985
Avail: NTIS HC A16/MF A01 CSCL 22B

A working group was organized to study materials and components of the Solar Max Satellite (SMS) that was returned by the STS 41C. These materials were exposed in space for 50 months and represent the only real time long term exposure data available to date. In the molecular modeling of material and energetic oxygen atom interaction, it is pointed out that the importance of developing correlation between accelerated exposure data from STS and some real time data. In particular, it was predicted that Teflon which showed no detectable degradation on various STS flights may be susceptible to atomic oxygen degradation under real time conditions. Initial inspection of returned SMS samples showed that Teflon suffered visual damage such as cracking and yellowing. The results of examination of these samples are given. Author

N87-15252# Indian Space Research Organization, Trivandrum.
POSSIBLE AREAS OF COLLABORATION BETWEEN DFVLR AND ISRO IN THE FIELDS OF STRUCTURES AND MATERIALS
V. GOWARIKER *In* DFVLR Colloquium about Joint Projects within the DFVLR/ISRO Cooperation p 143-148 Jul. 1986
Avail: NTIS HC A08/MF A01; DFVLR, Cologne, West Germany DM 46

Research possibilities in large space structures and microgravity experiments on composites and polymers are outlined. ESA

N87-15990# Joint Publications Research Service, Arlington, Va.
OVERVIEW OF PLANNED TESTS OF SPACE MATERIALS
In its Japan report: Science and Technology (JPRS-JST-86-018) p 41-43 2 Jul. 1986 Transl. into ENGLISH from Toshi Keizai (Tokyo, Japan), Jan. 1986 p 52-53
Avail: NTIS HC A05/MF A01

The National Space Development Agency (Japan) started space materials tests by using the two-stage rocket TT III 500 A. As the next step, full scale space tests that make use of the Spacelab are scheduled to take place in early 1988. The next rounds of tests that follow will take place on the space station. These projects are briefly outlined. B.G.

N87-16015*# Ametek, Inc., Anaheim, Calif. Composite Materials and Applications Div.
ADVANCED COMPOSITES FOR LARGE NAVY SPACECRAFT
WILLIAM E. DAVIS *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 1-10 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 11D

An overview is given of work conducted on contract for the Naval Sea Systems Command. The objective of this contract was to provide direction for the development of high modulus graphite reinforced metal matrix composites. These advanced materials can have a significant effect on the performance of a spacecraft before, during and after an evasive maneuver. The work conducted on this program was organized into seven technical tasks. Task 1 was development of a generic Navy spacecraft model. Finite element models of candidate structural designs were developed. In Task 2, the finite-element model(s) of the structure were used to conduct analytical assessments involving conventional materials, resin matrix composites and metal matrix composites (MMC). In Task 3 and 4, MMC material design, fabrication and evaluation was conducted. This consisted of generating material designs and developing a data base for a broad range of graphite reinforced MMC materials. All material was procured according to specifications which set material quality and material property standards. In Task 5, a set of evasive maneuvering requirements were derived and used in Task 6 to conduct analytical simulations. These analytical simulations used current SOA material properties and projected material properties to provide an indication of key payoffs for material development. In Task 7, a set of material development recommendations was generated. Author

N87-16929# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ANALYSIS OF HIGH PRECISION COMPOSITE SANDWICH ANTENNAS
G. HELWIG *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 51-55 Aug. 1986
Avail: NTIS HC A12/MF A01

A data base for all common types of spacecraft antenna skin and core materials was established. Based on these material properties, it is possible to predict accurately the performance of high precision antennas, and there is good agreement between analyses and tests. The orthotropic behavior of the sandwich should be improved by developments of skin and core materials. The research should be directed to a composite sandwich with an overall coefficient of expansion close to zero, giving composite sandwich panels with accuracies better than 1 micron rms for most kinds of temperature loads. ESA

N87-16930# Rome Univ. (Italy). Dept. of Aerospace.
EFFECTS OF CURING STRESSES ON COMPOSITE STRUCTURES
M. MARCHETTI, F. MORGANTI (Selenia S.p.A., Rome, Italy), and S. TIZZI *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 57-62 Aug. 1986 Sponsored by Max-Planck Inst.
Avail: NTIS HC A12/MF A01

The effects of the residual stresses which arise during the manufacturing of laminates constituting the skins of high stability telecommunications antennas for space applications are discussed. A dedicated software to simulate the behavior of a composite structure from the curing temperature to the room condition was developed. The numerical simulation method takes into account all the nonlinearity effects which influence the final results, like viscoelastic properties of the material (creep) and the dependance of the mechanical properties on temperature. ESA

N87-16936# Selenia S.p.A., Rome (Italy).
DEVELOPMENT OF LIGHTWEIGHT DIMENSIONALLY STABLE CARBON FIBER COMPOSITE ANTENNA REFLECTORS FOR THE INSAT-1 SATELLITE
A. PACE, I. LAROSA, and R. STONIER *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 103-110 Aug. 1986
Avail: NTIS HC A12/MF A01

A lightweight dimensionally stable carbon fiber composite deployable antenna reflector structure utilizing a rib stiffened thin shell design was developed. Reflectors based on this design were manufactured and tested for the INSAT-1 satellites, and the same technology was used for the reflectors for the ARABSAT satellites. Structural materials were qualified and used on antenna reflector structures. The outstanding in-orbit performance of eight antennas on two INSAT-1 and two ARABSAT satellites, clearly demonstrates the technical success of the program. Three additional satellites with six more antennas/reflectors will be launched. ESA

N87-17056# Aeritalia S.p.A., Torino (Italy). Space System Div.
THE WELDING OF ALUMINUM ALLOYS: A NEW TECHNOLOGY IN SPACE APPLICATION
P. MARCHESE and G. BANING *In* AGARD Advanced Joining of Aerospace Metallic Materials 11 p Jul. 1986
Avail: NTIS HC A12/MF A01

The optimization of the structural weight of the Spacelab structure, the first European manned laboratory designed according to shuttle requirements, led to the choice of 2219-T851 aluminum alloy, T.I.G. welded with the process completely developed and qualified from Aeritalia as briefly described is this paper. To demonstrate the high quality and reliability of the welded primary structure, new inspection techniques, many different tests on the welded joint, and expensive fracture mechanics analysis were

applied. The main assumptions and results are presented. The main efforts were concentrated on the reduction of number and size of welding defects, improving, on the one side, the welding technique and on the otherside, inspecting single defects after fracture mechanics analysis based on sophisticated measurement of their dimensions, on the schematization of embedded flaw in tension and bending, and on carefull measurement of material properties. Possible improvements of T.I.G. application for future space programs (space station) or its substitution with plasma welding processes are also mentioned. Author

N87-17863# Martin Marietta Aerospace, Denver, Colo.
METALLURGICAL CHARACTERIZATION OF THE INTERFACES AND THE DAMPING MECHANISMS IN METAL MATRIX COMPOSITES Progress Report, 1 Oct. 1985 - 30 Sep. 1986
MOHAN S. MISRA 30 Sep. 1986 5 p
(Contract N00014-84-C-0413)
(AD-A173470; MCR-85-605-ISSUE-4) Avail: NTIS HC A02/MF A01 CSCL 11D

High inherent damping is a material property requirement to meet the need for dynamic dimensional precision and weight savings in space structures. A preliminary investigation indicates that MMC exhibit improved damping with respect to conventional structural alloys of aluminum or titanium. In the present investigation, a graphite-aluminum composite (P55/6061) has been selected to study the microstructural features and mechanisms responsible for damping in MMC. During this investigation, methodology to measure damping by clamped free flexure and uniaxial tension-tension test techniques were developed. Work conducted within the reporting period: (1) Preliminary results with free-free flexure indicate that this method can be used sucessfully to measure damping in metal matrix composites; (2) TEM of Gr/Al composites show that the dislocations adjacent to the fiber matrix interface are thermal expansion mismatch of the fiber and matrix during the fabrication process; (3) Strain amplitude dependent damping is the result of dislocation motion and correlates well with the Granato-Lucke theory of dislocation damping. GRA

N87-17906*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TRIBOLOGICAL PROPERTIES OF POLYMER FILMS AND SOLID BODIES IN A VACUUM ENVIRONMENT
ROBERT L. FUSARO 1987 34 p Prepared for presentation at the Annual Meeting of the American Society of Lubrication Engineers, Anaheim, Calif., 11-14 May 1987
(NASA-TM-88966; E-3429; NAS 1.15:88966) Avail: NTIS HC A03/MF A01 CSCL 11B

The tribological properties of ten different polymer based materials were evaluated in a vacuum environment to determine their suitability for possible lubrication applications in a space environment, such as might be encountered on the proposed space station. A pin-on-disk tribometer was used and the polymer materials were evaluated either as solid body disks or as films applied to 440C HT stainless steel disks. A 440C HT stainless steel hemispherically tipped pin was slid against the polymer materials. For comparison, similar tests were conducted in a controlled air atmosphere of 50 percent relative humidity air. In most instances, the polymer materials lubricated much better under vacuum conditions than in air. Thus, several of the materials show promise as lubricants for vacuum applications. Friction coefficients of 0.05 or less and polymer material wear rates of up to 2 orders of magnitude less than in air were obtained. One material showed considerable promise as a traction drive material. Relatively high friction coefficients (0.36 to 0.52) and reasonably low wear rates were obtained in vacuum. Author

N87-18015# Centre d'Etudes et de Recherche de la Machine-Outil, Saint-Martin-d'Heres (France). Lab. TIM3.
DIGITAL IMAGE PROCESSING: BINARY IMAGES
J. M. CHASSERY *In* Von Karman Inst. for Fluid Dynamics Flow Visualization and Digital Image Processing 13 p 1986
Avail: NTIS HC A24/MF A01

The basic geometric concepts used to describe the spatial organization of the points on the support of the image are analyzed. The definitions include connectedness, connected components, interior and border, picture representation, structure representation, and interpretation modes. An iterative method for image labeling is described. Structure interpretation by Fourier representation of contour and filtering spline functions approximation methods are commented on. ESA

N87-18613*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SEAMLESS METAL-CLAD FIBER-REINFORCED ORGANIC MATRIX COMPOSITE STRUCTURES AND PROCESS FOR THEIR MANUFACTURE Patent Application
RAYMOND M. BLUCK, inventor (to NASA) (Lockheed Missiles and Space Co., Sunnyvale, Calif.), HAROLD G. BUSH, inventor (to NASA), and ROBERT R. JOHNSON, inventor (to NASA) 21 Oct. 1986 10 p
(NASA-CASE-LAR-13562-1; NAS 1.71:LAR-13562-1; US-PATENT-APPL-SN-921572) Avail: NTIS HC A02/MF A01 CSCL 11D

The invention relates to seamless metal clad filament reinforced resin matrix composite tubular structures and processes for their manufacture and is particularly useful in the construction of spacecraft and space structures. Metal clad composites make a significant advancement over those composite systems being used for both spacecraft and aircraft; however, the material consolidation and tooling advances necessary to realize the potential of such metal clad composites had not hitherto been achieved. Accordingly, it is an object of this invention to provide an efficient method of producing seamless metal clad composite structures. A metallic outer sleeve is provided which is capable of enveloping a hollow metallic inner member having continuous reinforcing fibers attached to the distal end thereof. Inner member is then introduced into outer sleeve until inner member is completely enveloped by outer sleeve. A liquid matrix material is then injected into the space between inner member and outer sleeve. A pressurized heat transfer medium is flowed through the inside of inner member, thereby forming a fiber reinforced matrix composite material. The wall thicknesses of both inner member and outer sleeve are then reduced to the appropriate size by chemical etching, to adjust the thermal expansion coefficient of the metal-clad composite structure to the desired value. The novelty of this invention resides in the development of a efficient method of producing seamless metal clad fiber reinforced organic matrix composite structures. NASA

N87-18669*# Boeing Aerospace Co., Seattle, Wash.
PROTECTIVE COATINGS FOR COMPOSITE TUBES IN SPACE APPLICATIONS
HARRY W. DURSCH and CARL L. HENDRICKS 1987 12 p Prepared for presentation at the 3rd International SAMPE Symposium, Anaheim, Calif., 6-9 Apr. 1987
(Contract NAS1-16854)
(NASA-CR-178116; NAS 1.26:178116) Avail: NTIS HC A02/MF A01 CSCL 11B

Protective coatings for graphite/epoxy (Gr/Ep) tubular structures for a Manned Space Station truss structure were evaluated. The success of the composite tube truss structure depends on its stability to long-term exposure to the Low Earth Orbit (LEO) environment with particular emphasis placed on atomic oxygen. Concepts for protectively coating Gr/Ep tubes include use of inorganic coated metal foils and electroplating. These coatings were applied to Gr/Ep tubes and then subjected to simulated LEO environmnet to evaluate survivability of coatings and coated tubes. Evaluation included: atomic oxygen resistance, changes in optical properties and adhesion, abrasion resistancem surface preparation required, coating uniformity, and formation of

microcracks in the Gr/Ep tubes caused by thermal cycling. Program results demonstrated that both phosphoric and chromic acid anodized Al foil provided excellent adhesion to Gr/Ep tubes and exhibited stable optical properties when subjected to simulated LEO environment. The SiO2/Al coatings speuttered onto Al foils also resulted in an excellent protective coating. Electroplated Ni exhibited unaccepatble adhesion loss to Gr/Ep tubes during atomic oxygen exposure. Author

N87-19457# Materials Sciences Corp., Spring House, Pa.
THERMOVISCOELASTIC CHARACTERIZATION AND ANALYSIS OF FIBER COMPOSITE SPACE STRUCTURES Final Report, 1 Oct. 1984 - 31 Dec. 1985
B. J. SULLIVAN, E. A. HUMPHREYS, and ZVI HASHIN Feb. 1986 170 p
(Contract F49620-85-C-0004)
(AD-A175024; MSC-TFR-1614/1505; AFOSR-86-2111TR) Avail: NTIS HC A08/MF A01 CSCL 11D

This report begins with the development of the time and temperature-dependent effective constitutive equations for unidirectional fiber composites. The fibers were represented as transversely isotropic and linearly elastic, temperature dependent elements. The deviatoric components of the isotropic matrix material were treated as linearly viscoelastic and thermorheologically complex, while the dilatation components were represented as elastic and temperature dependent. Numerical simulations of a series of isothermal creep tests were performed to determine the effective creep compliance parameters of the composite constitutive equations. The macromechanical response of a composite structural element, as predicted by the effective constitutive equations and their derived parameters, was then verified using results computed using a micromechanical model which explicitly included the fiber and matrix as discrete phases. To determine the potential existence and form of a composite complex modulus, the response of unidirectional composite structural elements to simultaneous sinusoidal temperature and mechanical loads was investigated. Finally, solutions of free vibration and transient dynamic analyses of some simple composite structures were performed to examine the effects of the thermoviscoelastic behavior on the damped response of some simple composite structures. GRA

08

ASSEMBLY CONCEPTS

Includes automated manipulator techniques, EVA, robot assembly, teleoperators, and equipment installation.

A87-11359#
SPACE CONSTRUCTIBLE RADIATOR ON-ORBIT ASSEMBLY
P. J. OTTERSTEDT, J. HUSSEY, and J. P. ALARIO (Grumman Aerospace Corp., Bethpage, NY) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, July-Aug. 1986, p. 397-400. Previously cited in issue 17, p. 2472, Accession no. A85-37667.

A87-12285
TWO-DIMENSIONAL ARTICULATED SYSTEMS DEVELOPABLE ON A SINGLE OR DOUBLE CURVATURE SURFACE
A. ZANARDO (Padova, Universita, Padua, Italy) Meccanica (ISSN 0025-6455), vol. 21, June 1986, p. 106-111. refs
(Contract CNR-PSN-83-098)

The geometry and the kinematics of two articulated systems built up of a set of rigid rectilinear elements pin-jointed together are illustrated. In the first case, there is a kinematic grid which, from its initial closed shape, expands along two directions on an open (or closed) cylindrical surface. In the second case, the kinematic grid expands on a double curvature surface like, for instance, a paraboloid. The characteristics of the two surfaces require, for a single or double curvature, two different solutions. Author

A87-13706* National Aeronautics and Space Administration, Washington, D.C.
THE ROLE OF AUTOMATION AND ROBOTICS IN SPACE STATIONS
D. C. BLACK (NASA, Office of Space Station, Washington, DC) IN: Space station automation; Proceedings of the Meeting, Cambridge, MA, September 17, 18, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 2-9.

Automation and robotics have played important roles in space research, most notably in planetary exploration. While an increased need for automation and robotics in space research is anticipated, some of the major challenges and opportunities for automation and robotics will be provided by the Space Station. Examples of these challenges are briefly reviewed. Author

A87-13707* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE MISSIONS FOR AUTOMATION AND ROBOTICS TECHNOLOGIES (SMART) PROGRAM
D. L. CIFFONE and H. LUM, JR. (NASA, Ames Research Center, Moffett Field, CA) IN: Space station automation; Proceedings of the Meeting, Cambridge, MA, September 17, 18, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 10-16.

The motivations, features and expected benefits and applications of the NASA SMART program are summarized. SMART is intended to push the state of the art in automation and robotics, a goal that Public Law 98-371 mandated be an inherent part of the Space Station program. The effort would first require tests of sensors, manipulators, computers and other subsystems as seeds for the evolution of flight-qualified subsystems. Consideration is currently being given to robotics systems as add-ons to the RMS, MMU and OMV and a self-contained automation and robotics module which would be tended by astronaut visits. Probable experimentation and development paths that would be pursued with the equipment are discussed, along with the management structure and procedures for the program. The first hardware flight is projected for 1989. M.S.K.

A87-13712
AN INTRODUCTION TO THE CONCEPT OF ROBOT FACTORS AND ITS APPLICATION TO SPACE STATION AUTOMATION
W. C. CHIOU, SR. (Lockheed Research Laboratories, Palo Alto, CA) and S. A. STARKS (Texas, University, Arlington) IN: Space station automation; Proceedings of the Meeting, Cambridge, MA, September 17, 18, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 53-57.

Basic operating considerations resulting from the unique environment of space are discussed, along with those resulting from the current and projected state of Automation and Robotics (A&R) which will influence the initial layout and maintenance of the Space Station. A concept called 'robot-factors' is introduced which deals with the telerobot working environment and its organizational relationships with other robots. The robot factors are considered from the point of view of the overall system architecture of the Space Station. Design considerations concerning the physical nature of the Space Station complex, as well as those concerning the data management system, are examined. Emphasis is on making the robot's tasks safe and easy to perform, and on the telerobot's welfare in terms of that of other cooperating telerobots in the performance of a common task. Author

A87-13714* Massachusetts Inst. of Tech., Cambridge.
REMOTELY MANIPULATED AND AUTONOMOUS ROBOTIC WELDING FABRICATION IN SPACE
J. E. AGAPAKIS (Automatix, Inc., Billerica, MA) and K. MASUBUCHI (MIT, Cambridge, MA) IN: Space station automation; Proceedings of the Meeting, Cambridge, MA, September 17, 18, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 68-77. NASA-MIT-supported research. refs

The results of a NASA sponsored study, performed in order to establish the feasibility of remotely manipulated or unmanned welding fabrication systems for space construction, are presented. Possible space welding fabrication tasks and operational modes are classified and the capabilities and limitations of human operators and machines are outlined. Human performance in remote welding tasks was experimentally tested under the sensing and actuation constraints imposed by remote manipulation in outer space environments. Proposals for the development of space welding technology are made and necessary future R&D efforts are identified. The development of improved visual sensing strategies and computer encoding of the human welding engineering expertise are identified as essential, both for human operator assistance and for autonomous operation in all phases of welding fabrication. Novel uses of machine vision for the determination of the weld joint and bead geometry are proposed, and a prototype of a rule-based expert system is described for the interpretation of the visually detected weld features and defects. Author

A87-13715
MULTIARM COLLISION AVOIDANCE USING THE POTENTIAL-FIELD APPROACH
J. K. MYERS (SRI International, Menlo Park, CA) IN: Space station automation; Proceedings of the Meeting, Cambridge, MA, September 17, 18, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 78-87. refs
(Contract F49620-82-K-0034)

A generalized potential-field approach to manipulator collision avoidance is presented. The potential-field approach consists of four algorithms: repulsion away from obstacles, attraction towards a goal, a method of combining these, and a resulting method of incrementing the arm. Alternatives for these algorithms are discussed. A multiple-robot system demonstrating the concepts is described. The system uses a detailed rigid model of the entire arms and surrounding objects to avoid collisions. The system operates in close-to-real-time, and is demonstrated with two PUMA robots moving concurrently. Results are applicable to any type of anthropomorphic arm, including the Remote Manimulator System. Author

A87-13949
MATTER OF EASE
W. H. GREGORY Commercial Space (ISSN 8756-4831), vol. 2, Summer 1986, p. 58-60.

The following human factors and robotics research vehicles, developed at the Massachusetts Institute of Technology, are presented: (1) Beam Assembly Teleoperator, (2) Multimode proximity Operations Device, and (3) Integrated Control Station. Underwater simulations carried out to determine which tasks in space should be accomplished by astronauts and which should be handled by machine are described. Knowledge derived from the EASE (Experimental Assembly of Structures in EVA) experiment is reviewed. K.K.

A87-15191#
DEVELOPMENT OF A TEST PROCEDURE AND FACILITY FOR THE INVESTIGATION OF A CANADARM JOINT BRAKE ANOMALY
J. M. TRENOUTH (National Aeronautical Establishment, Ottawa, Canada) and C. W. MACKENZIE (National Research Council of Canada, Ottawa) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, June 1986, p. 131-138.

The 15 ft Remote Manipulator System arm of the Shuttle has spring-loaded clutch-type brakes which are activated whenever power is off or whenever commanded manually. During thermal vacuum cycling qualification tests one of the brake motors suffered degradation of the slip torque and the brake failed failure to meet specifications. Full capability returned in ambient atmosphere conditions. Subsequent brake tests were performed in temperatures at 10 C intervals between -36 to +93 C and in ambient and vacuum conditions while spinning the brakes in an unloaded condition. M.S.K.

A87-15407
MAINTAINABILITY TECHNOLOGY
P. H. ZORGER (General Electric Co., Space Systems Div., Reston, VA) IN: 1986 Annual Reliability and Maintainability Symposium, Las Vegas, NV, January 28-30, 1986, Proceedings . New York, Institute of Electrical and Electronics Engineers, Inc., 1986, p. 77-82. refs

A brief background and the current application status of maintainability technology are presented. The application of this technology to large systems is discussed, emphasizing some of the problems associated with the technology when applied to a space environment. Three deficiencies in the technology are discussed: the addition of a maintainability program task on testability to determine the 'time' to detect, locate, and isolate faults/failures; 'time' data sources their application and use, and a methodology to synthesize 'time' values; and the conversion of 'time' values for use in a space environment. The frame work for the discussion is a total and complete proposed maintainability program. Some additional and new tasks are suggested as needed additions to MIL-STD-470A and all tasks are defined for a complete and comprehensive maintainability program. Author

A87-15935#
ASSEMBLY OF THERMOELASTIC CONTINUOUS ELEMENTS
C. ARDUINI (Roma, Universita, Rome, Italy) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 31 p. refs
(IAF PAPER 86-207)

Techniques for assembling the continuous-scheme models of thermoelastic beams and plates derived by Arduini and Ponzi (1982) and Arduini et al. (1985) into more complex structures are developed analytically and demonstrated. Both modal-synthesis and distributed-element approaches are extended to treat thermal and thermostructural problems, and numerical results for the static heating of a tubular triangular beam are presented graphically. T.K.

A87-17401
ENGINEERING CONSIDERATIONS FOR ON-ORBIT WELDING OPERATIONS
J. K. WATSON (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 34, Apr.-June 1986, p. 121-132. refs

The capability to perform on-orbit fabrication, maintenance, and repair will become increasingly necessary with the deployment of large, complex space systems in the 1990s and beyond. Just as it is indispensible for such operations on earth, welding will be an important technology in space. This paper describes a number of welding processes that may be applicable, discusses requirements for automation, and considers the supporting technologies required for successful welding operations. Author

A87-18148
SPACE STATION CHALLENGE - ON-ORBIT ASSEMBLY OF A 75-KW POWER SYSTEM
A. GLINES (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1892-1897. refs

Designing the NASA Space Station (SS) presents formidable challenges in all onboard systems. An excellent example is the electrical power system (EPS), one of the largest systems on the

station and the first to be assembled. This paper focuses on those features of the SS EPS and its associated transverse truss which facilitate on-orbit assembly, servicing, and maintenance by astronauts during extra-vehicular activity (EVA). It reviews NASA's EPS assembly guidelines and design requirements, particularly those relating to EVA. The paper concludes with a discussion of EVA design verification using astronauts working on full-scale equipment mock-ups in NASA's neutral buoyancy facilities.
Author

A87-18481
RESEARCH AND DEVELOPMENT OF A SMALL-SIZED SPACE MANIPULATOR
K. MACHIDA, Y. TODA, T. IWATA, K. NAKAYAMA (Ministry of International Trade and Industry, Electrotechnical Laboratory, Sakura, Japan), K. TSUCHIYA (Mitsubishi Electric Corp., Amagasaki, Japan) et al. IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 481-494. refs
(AAS PAPER 85-660)

Recent space activities require many types of manipulators or robots for assembling and servicing in space, and especially demand small-sized manipulators for dexterous tasks. A 1-meter class articulated manipulator with space environment durability and lightweight has been developed. This paper presents the system design of the manipulator and development efforts of its components. Tribological study of mechanical elements in the vacuum environment, the design of actuator with high torque-to-weight ratio, the control system with the multi-microprocessor and the dynamic control algorithm of the arm are described. A bilateral force-reflecting master-slave control system, using a six dimensional force/torque sensor of the slave arm is also discussed. Author

A87-18486
ROBOTICS CONCEPTS FOR THE U.S. SPACE STATION
D. DORROUGH (Boeing Artificial Intelligence Center, Seattle, WA) IN: Space exploitation and utilization; Proceedings of the Symposium, Honolulu, HI, December 15-19, 1985 . San Diego, CA, Univelt, Inc., 1986, p. 539-568. refs
(AAS PAPER 85-666)

The advanced basic concepts of machine intelligence are covered that will be required to produce an operator system interface (OSI) to provide reasonable autonomy on the part of an extravehicular space-station automation. The OSI is considered for a free-flying robot that transits from one task space to another in close proximity to the earth-orbiting Space Station. The OSI would thus perform path planning, track and control, object recognition, fault detection/isolation/correction, and plan modifications in connection with the EV robot operations. To implement such an OSI implies the use of natural languages, voice recognition and synthesis, speech understanding, expert cooperative diagnostic and advisory knowledge systems, and machine learning. The latter technologies are expected to evolve through three distinct phases, where in the first phase the robot is in the primary control loop (human directed), in the second the robot is both primary controller and planner (human monitored), and in the third the robot provides its own goals (human instruction and crisis intervention). Results of Project TAARGET (Transational Assessment of Autonomous Robotic Generational and Evolutionary Technology) suggest that it will not be possible to deploy a fully autonomous EV robot and OSI by the time the Space Station is constructed in orbit. D.H.

A87-20083*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PULTRUSION PROCESS DEVELOPMENT FOR LONG SPACE BOOM MODELS
MAYWOOD L. WILSON and ROBERT MISERENTINO (NASA, Langley Research Center, Hampton, VA) IN: Reinforced Plastics/Composites Institute, Annual Conference, 41st, Atlanta, GA, January 27-31, 1986, Preprint . Lancaster, PA, Technomic Publishing Co., 1986, 8 p. refs

Long flexible boom models were required to develop ground vibration test methods for very low frequency space structures with applications to the proposed MAST program and Space Station. Pultruded quasi-isotropic composite beams were selected as an option over extruded aluminum alloy structures because of the lower cost potential, higher specific strength, flexural properties, and dynamic similarity considerations. A comparison is made of four different pultrusions having varied matrices and fiber orientations. Test results indicate that the pultrusion process can be used to produce quasi-isotropic composite structures by selective fiber orientation using the knit-lock fabric concept.
Author

A87-23229*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A FLEXIBLE TELEROBOTIC SYSTEM FOR SPACE OPERATIONS
NANCY ORLANDO SLIWA and RALPH W. WILL (NASA, Langley Research Center, Hampton, VA) Workshop on Space Telerobotics, Pasadena, CA, Jan. 20-22, 1987, Paper. 9 p.

This paper describes the objective and design of a proposed goal-oriented knowledge-based telerobotic system for space operations. This design effort encompasses the elements of the system executive and user interface and the distribution and general structure of the knowledge base, the displays, and the task sequencing. The objective of the design effort is to provide an expandable structure for a telerobotic system that provides cooperative interaction between the human operator and computer control. The initial phase of the implementation provides a rule-based, goal-oriented script generator to interface to the existing control modes of a telerobotic research system, in the Intelligent Systems Research Lab at NASA Research Center. Author

A87-25756
THE ROLE OF ROBOTICS IN SPACE
LELLAND A. C. WEAVER (Westinghouse Electric Advanced Production Technology, Ltd., Coventry, England) IN: Space Tech '86; Proceedings of the International Conference, Geneva, Switzerland, May 14-16, 1986 . London, Online International, Ltd., 1986, p. 61-67.

Consideration is given to the monitoring and maintenance of the Space Station's systems and facilities using AI and robotics. The applications of expert systems, signal processing, and voice data entry or speech recognition to the Station are discussed and examples are provided. The capabilities of the Remotely Operated Service Arm, which is based on robotic systems and AI and is to be utilized to repair the Station's systems and facilities are described. The development of the Cell Management Language to coordinate the operations of different machines and create automated factories with automated manufacturing and processing for the space Station is examined. I.F.

A87-25757
A ROBOTIC SYSTEM FOR DEXTEROUS TASKS
PIERGIOVANNI MAGNANI (Fabbrica Italiana Apparecchiature Radioelettriche S.p.A., Milan, Italy) IN: Space Tech '86; Proceedings of the International Conference, Geneva, Switzerland, May 14-16, 1986 . London, Online International, Ltd., 1986, p. 69-89.

There are a range of tasks and operative conditions in the space environment which may be efficiently managed by a 'small dimension dexterous manipulator'. The configuration of such a manipulator and its main characteristics are considered in this paper. The aspects evaluated are: articulation, position/orientation

envelope working area, actuation, and sensoriality. The robotic system analyzed is suitable to be mounted on a moving frame, to be brought in the working area, and then to perform a given envelope of tasks. The moving frame can be a service manipulator arm for external space applications or a moving guide for S/C internal applications. Author

A87-27454
SATELLITE CONSTRUCTION
GERARD MURPHY Space (ISSN 0267-954X), vol. 2, Dec. 1986-Feb. 1987, p. 20, 21.

Features and design goals of communications satellites which distinguish them from other high tech aerospace systems are outlined. Satellites must function reliably without maintenance, thereby requiring redundant systems, expensive testing, and extensive failure mode identification analyses. Three-axis stabilization is the favored mode for ensuring pointing accuracy for satellites, and for flexibility in spacecraft configuration design. Al components are being replaced by CFRP materials to lower the mass of spacecraft. Combination apogee and attitude thrusters have extended the lifetime of spacecraft to 10 yr. Finally, electric pumps may replace He pressurant systems for electric propulsion thrusters. M.S.K.

A87-27616#
A PRELIMINARY LOGISTICS SUPPORT CONCEPT FOR SPACE-BASED SDI ASSETS
FRANK W. MOSS, PAT R. ODOM, CLANCY J. HATLEBERG, THOMAS P. OBRIEN, BOBBIE L. JONES (Advanced Technology, Inc., Hutsville, AL) et al. IN: Space Logistics Symposium, 1st, Huntsville, AL, Mar. 24-26, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 94-102.
(AIAA PAPER 87-0689)

Preliminary results are presented of studies being performed to define a logistics-support design for space-based SDI assets and the associated ground-based equipment. The studies are considering the SDI systems architecture, the transportation architecture and the requirements for space assembly, maintenance and servicing. Several assumptions being made regarding the available launch systems, telerobotic systems, and the achievability of standardized parts are outlined, as are on-orbit hazards to repair crew and equipment. Optimized orbital positions for the weapons and surveillance systems being investigated are summarized, along with the types of on-orbit support missions that would be flown. The hardware requirements for the ground- and space-based SDI components are discussed. M.S.K.

A87-31122#
DESIGN AND CONTROL OF MODULAR, KINEMATICALLY-REDUNDANT MANIPULATORS
JAMES P. KARLEN, JACK M. THOMPSON, JR., and JAMES D. FARRELL (Robotics Research Corp., Milford, OH) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 12 p. refs
(AIAA PAPER 87-1694)

Design considerations, the database on robot manipulator arms and the requirements of manipulator arms for space applications are discussed. At least six degrees of freedom are needed for complete control of the position and orientation of the object held by a manipulator. For space applications, however, at least seven degrees of freedom are asserted to be necessary for general purpose manipulation systems. Four basic types of general purpose manipulator geometry are identified and the advantages of using extra joints, i.e., kinematic redundancy, in an articulated arm are described, including extra joints to permit flexibility in reaching around objects. Joint-mounted actuators are recommended for spatial volume utilization efficiency. Techniques are described for developing the motion control software architecture, and design parameters are summarized for manipulator systems for various space applications. M.S.K.

A87-31220#
DEPLOYMENT ANALYSIS OF THE OLYMPUS ASTROMAST AND COMPARISON WITH TEST MEASUREMENTS
M. EIDEN, O. BRUNNER, and C. STAVRINIDIS (ESA, European Space Research and Technology Center, Noordwijk, Netherlands) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, Apr. 15-17, 1985, Technical Papers. Part 1, p. 325-332) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Jan.-Feb. 1987, p. 63-68. Previously cited in issue 13, p. 1894, Accession no. A85-30264.

N87-10398 Stanford Univ., Calif.
RAPID PRECISE END POINT CONTROL OF A WRIST CARRIED BY A FLEXIBLE MANIPULATOR Ph.D. Thesis
W. W. CHIANG 1986 141 p
Avail: Univ. Microfilms Order No. DA8612724

The speed and accuracy of a robot manipulator can be increased by using end-point sensors for motion measurement and control, along with an accurate dynamic model of the mechanical system in the control algorithm. However, the closed-loop control bandwidth of a robot manipulator is still physically limited ultimately by its structural flexibility, since the end effector and the actuator are separated. Analyses were performed to study the dynamic interaction between the motion of a minimanipulator and the structural flexibility of the main robot arm. A plane-motion mechanical system was built to demonstrate several fast maneuvers of such a mini-macro manipulator system. A frequency identification scheme was also developed and implemented successfully in a closed-loop adaptive control on a separate mechanical laboratory system consisting of two inertia disks connected by a torsional rod. It is believed that the same frequency identification scheme can be used to improve further the performance of the mini-macro manipulator system when adaptive control is employed. Dissert. Abstr.

N87-15260*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MOBILE REMOTE MANIPULATOR SYSTEM FOR A TETRAHEDRAL TRUSS Patent Application
CLARENCE J. WESSELSKI, inventor (to NASA) and WILLIAM C. SCHNEIDER, inventor (to NASA) 5 Sep. 1986 25 p
(NASA-CASE-MSC-20985-1; NAS 1.71:MSC-20985-1; US-PATENT-APPL-SN-904134) Avail: NTIS HC A02/MF A01 CSCL 22B

The mobile remote manipulator system (MRMS) was initially developed for transit about the trusses of the delta space station; however, it can be utilized just as easily for transit about the trusses of the dual keel station. The MRMS is comprised of a mobile platform B having a rail system formed of transversely disposed T-shaped tracks, which engage with guide pins located at the nodes of the trusses. The guide pins form a grid and the tracks are so designed as to permit travel in either of two orthogonal directions. For travel the MRMS is provided with retractable, reversible chain drive systems, which selectively engage sprockets on the guide pins for either longitudinal or transverse travel. The MRMS is also provided with direction changing means at the intersection of the track systems to change from longitudinal to transverse travel. The MRMS provides a near-uniform traversing velocity with minimal dynamic loading on the system. NASA

N87-15472# Fabrica Italiana Apparecchi Radio S.p.A., Milan.
ROBOT SYSTEM FOR DEXTEROUS TASKS (FOR SPACE APPLICATIONS)
PIERGIOVANNI MAGNANI 1986 16 p
(ETN-86-98562) Avail: NTIS HC A02/MF A01

A robot system for dexterous tasks in space applications, which can be mounted on a moving frame, to be brought to the working area (by the moving frame) and then perform a given envelop of tasks, is discussed. The moving frame can be a service manipulator arm (for external space applications) or a moving guide (for internal applications). ESA

N87-16326*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DESIGN AND ANALYSIS OF A KEEL LATCH FOR USE ON THE HUBBLE SPACE TELESCOPE
JOHN CALVERT and MELANIE STINSON *In* NASA. Lewis Research Center The 20th Aerospace Mechanics Symposium p 55-71 May 1986
Avail: NTIS HC A14/MF A01 CSCL 13I

The mechanical design of the keel latch is discussed, as well as the stress analysis of the keel latch. Background information; mechanical design requirements; some of the initial design considerations; the design considerations that led to the selection of the final design; the mechanics of the final design; testing that has been and will be accomplished to verify that design requirements have been met; and future tests are discussed. Author

N87-18595*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
LOCKING HINGE Patent Application
CLARENCE J. WESSELSKI, inventor (to NASA) 29 Oct. 1986 16 p
(NASA-CASE-MSC-21056-1; NAS 1.71:MSC-21056-1; US-PATENT-APPL-SN-924397) Avail: NTIS HC A02/MF A01 CSCL 22B

The space station configuration currently being studied utilizes structures which require struts to be hinged in the middle in stowed configuration and locked into place in the deployed configuration. Since there are hundreds of hinges involved, it is necessary that they have simple, positive locking features with a minimum of joint looseness or slack. The instant invention comprises two similar housings hinged together with a spring loaded locking member which assists in making the lock as well as breaking it. The instant invention comprises a bracket hinge and bracket members with a spring biased and movable locking member. The locking or latch member has ear parts received in locking openings where wedging surfaces on the ear parts cooperate with complimentary surfaces on the bracket members for bringing the bracket members into a tight end-to-end alignment when the bracket members are in an extended position. When the locking member is moved to an unlocking position, pivoting of the hinge about a pivot pin automatically places the locking member to retain the locking member in an unlocked position. In pivoting the hinge from an extended position to a folded position, longitudinal spring members are placed under tension over annular rollers so that the spring tension in a folded position assists in return of the hinge from a folded position to an extended position. Novelty lies in the creation of a locking hinge which allows compact storage and easy assembly of structural members having a minimal number of parts. NASA

N87-18596*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION ERECTABLE MANIPULATOR PLACEMENT SYSTEM Patent Application
MARGARET E. GRIMALDI, inventor (to NASA) 13 Nov. 1986 13 p
(NASA-CASE-MSC-21096-1; NAS 1.71:MSC-21096-1; US-PATENT-APPL-SN-929865) Avail: NTIS HC A02/MF A01 CSCL 22B

A habitable space station has been proposed for low Earth orbit, to be constructed from components which will be separately carried up from the Earth and thereafter assembled. A suitable manipulating system having extraordinary manipulative capability is required. The invention is an erectable manipulator placement system for use on a space station and comprising an elongate, lattice-like boom having guide tracks attached thereto, a carriage-like assembly pivotally mounted on and extending from said dolly. The system further includes a turntable base pivotally interconnected with the proximal end of the boom and positioned either on a part of a transferring vehicle, or on another payload component being carried by said transferring vehicle, or on the space station. Novelty resides in the use of a turntable base having a hinged boom with a dolly translatable therealong to carry the arm-like assembly, thus providing an additional 3 degrees of freedom to the arm. NASA

N87-18984*# Grumman Aerospace Corp., Bethpage, N.Y. Space Systems Div.
TELEROBOTIC ASSEMBLY OF SPACE STATION TRUSS STRUCTURE
GRAHME FISCHER 1986 10 p Presented at the 1986 Space Telerobotics Workshop, Pasadena, Calif., 20-22 Jan. 1987 (Contract NAS9-17229)
(NASA-CR-180239; NAS 1.26:180239) Avail: NTIS HC A02/MF A01 CSCL 05H

Discussed are methods of assembling the space station's structure utilizing only telerobotic devices, i.e.: (1) an approximately anthropomorphic telerobot with two dextrous arms; (2) the Shuttle Remote Manipulator System (SRNS); (3) various material handling machines. Timelines and task recommendations for autonomous operations are also included. Also described are some experimental results comparing two manipulator control devices. Author

N87-19441# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
RENDEZVOUS AND DOCKING AND SPACE ROBOTICS PROXIMITY OPERATIONS. PART 5: EXECUTIVE SUMMARY Final Report
J. J. M. PRINS and C. N. A. PRONK 10 Jul. 1985 67 p
(Contract ESA-6060/84)
(NLR-TR-85099-U; ETN-87-99278) Avail: NTIS HC A04/MF A01

In preparation for ESA's Columbus program, test requirements were derived for: full scale testing of final translation (last 10 m) including docking (RVD); full scale testing of any manipulator operations both for free space and during mechanical contact; and scaled testing of fly-around and translation along the docking axis (RVD). Automatic as well as human operator controlled operations need to be tested. ESA

N87-20351*# McDonnell-Douglas Astronautics Co., St. Louis, Mo.
ADVANCED EVA SYSTEM DESIGN REQUIREMENTS STUDY: EVAS/SPACE STATION SYTEM INTERFACE REQUIREMENTS
T. G. WOODS 15 Nov. 1985 122 p
(Contract NAS9-17299)
(NASA-CR-171981; NAS 1.26:171981; MDC-W0070) Avail: NTIS HC A06/MF A01 CSCL 22B

The definition of the Extravehicular Activity (EVA) systems interface requirements and accomodations for effective integration of a production EVA capability into the space station are contained. A description of the EVA systems for which the space station must provide the various interfaces and accomodations are provided. The discussion and analyses of the various space station areas in which the EVA interfaces are required and/or from which implications for EVA system design requirements are derived, are included. The rationale is provided for all EVAS mechanical, fluid, electrical, communications, and data system interfaces as well as exterior and interior requirements necessary to facilitate EVA operations. Results of the studies supporting these discussions are presented in the appendix. B.G.

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PROPULSION

Includes propulsion concepts and designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.

A87-15913#
ADVANCED PROPULSION STATUS IN WESTERN EUROPE
M. ANDRENUCCI (Pisa, Universita, Italy), A. ATZEI, C. BARTOLI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands), G. BAIOCCHI (SNIA-BPD S.p.A., Colleferro, Italy), H. BASSNER (MBB/ERNO, Munich, West Germany) et al. IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 22 p. refs
(IAF PAPER 86-172)

A technology development assessment is made for state-of-the-art spacecraft launch vehicles in Western Europe, where ESA sponsorship is noted to have been extended to all major electric propulsion concepts and the full range of specific impulse, thrust and power levels. Attention is given to such electric propulsion concepts as field emission electric propulsion, RF ion thrusters, MPD, and electrostatic propulsion, as well as to activities under way in the universities of Giessen, Munich, Pisa, Rome, Stuttgart, and Vienna. The Comet Nucleus Sample Return mission's propulsion requirements are discussed. O.C.

A87-31133*# General Dynamics Corp., San Diego, Calif.
EVALUATION OF ON-ORBIT CRYOGENIC PROPELLANT DEPOT OPTIONS FOR THE ORBITAL TRANSFER VEHICLE
J. R. SCHUSTER, F. O. BENNETT, M. W. LIGGETT, C. N. TORRE (General Dynamics Corp., Space Systems Div., San Diego, CA), and N. BROWN (NASA, Marshall Space Flight Center, Huntsville, AL) ASME, Intersociety Cryogenics Symposium, 6th, New Orleans, LA, Nov. 16-21, 1986, Paper. 43 p. refs
(Contract NAS8-36612)

An orbital cryogenic propellant storage facility will be required for a space-based Orbital Transfer Vehicle. The facility tanks will have features to permit fluid acquisition and transfer in low gravity and to limit cryogen boiloff caused by environmental heating. Boiloff management features will include thick multilayer insulation, vapor-cooled shields, low conductance structural supports and penetrations, and possibly refrigeration systems. Author

N87-10151 Communications Satellite Corp., Washington, D.C.
EFFICIENCY ECCENTRICITY CONTROL USING CONTINUOUS, VECTORED THRUSTING FOR SATELLITES WITH LARGE AREA/MASS RATIOS
V. J. SLABINSKI *In* CNES Proceedings of an International Conference on Space Dynamics for Geostationary Satellites p 589-613 1986
Avail: CEPADUES-Editions, 111 rue Nicolas-Vauquelin, 31100 Toulouse, France

It is shown that varying geostationary satellite thrust direction so as to counteract only the secular perturbations from the force can reduce the impulse requirement by 6.6%. For thrusting in the orbit plane, an analytic calculus-of-variations minimization shows that the thrust direction should vary + or 19.5 deg at twice the orbit frequency, about the Sun's projection onto the orbit plane. The thrust direction then lies between the Sun's projection and the orbit tangent at the satellite. If the thrust can be vectored out of the orbit plane, the secular rotation of the orbit plane due to Sun and Moon gravity can also be countered. Minimization for this case shows that the thrust direction must oscillate approximatively + or - 26 deg about the orbit plane with the orbit frequency, in addition to the in-plane oscillation. The impulse must also be increased by a m/sec/yr, but this eliminates the need for 46 m/sec/yr of separate thrusting normal to the orbit plane for orbit plane control. ESA

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GENERAL

Includes either state-of-the-art or advanced technology which may apply to Large Space Systems and does not fit within the previous categories. Publications of conferences, seminars, and workshops are covered in this area.

A87-10026
SPACE CONGRESS, 23RD, COCOA BEACH, FL, APRIL 22-25, 1986, PROCEEDINGS
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1986, 469 p. For individual items see A87-10027 to A87-10053.

Papers concerned with developing space for tomorrow's society are presented. Consideration is given to international space activities, the use of computers in space, low-cost Shuttle payloads, streamling ground operations, and the commercialization of space. Topics discussed include contracts and management, Space Station technology, the effects of satellites on daily activities, second generation space transportation systems and launch vehicles technology, and the use of robotics and AI in aerospace operations. I.F.

A87-10997
LARGE OPTICS TECHNOLOGY; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, AUGUST 19-21, 1985
G. M. SANGER, ED. (United Technologies Research Center, West Palm Beach, FL) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 571), 1986, 276 p. For individual items see A87-10998 to A87-11019.
(SPIE-571)

The present conference on telescope primary mirror design and manufacturing technologies considers topics in mirror fabrication and testing, novel technology currently under development, recently instituted large optics development programs, and large mirror materials. Among the topics discussed are aspheric figure generation using feedback from an IR phase-shifting interferometer, thermal stability tests of CFRP sandwich panels for far-IR astronomy, 'Zerodur' lightweight (large mirror) blanks, and the precision machining of grazing-incidence X-ray mirror substrates. Also treated are the rapid fabrication of large aspheric optics, steps toward 8-m honeycomb mirrors, a novel telescope design employing the refraction of prism rows, telescope technology for the Far-UV Spectroscopic Explorer, hot isostatic-pressed Be for large optics, and a concept for a moderate cost large deployable reflector. O.C.

A87-11003
APPLICATION OF REPLICATED GLASS MIRRORS TO LARGE SEGMENTED OPTICAL SYSTEMS
M. H. KRIM (Perkin-Elmer Corp., Space Science Div., Danbury, CT) IN: Large optics technology; Proceedings of the Meeting, San Diego, CA, August 19-21, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 60-75.

Attention is given to the approach by which large, high specular reflectance, lightweight mirrors able to withstand thousands of deep heating and cooling cycles without degradation (for unlimited orbital operation) can be designed. An account is given to the principal sources of optics degradation, together with the effect of cumulative LCCs of different candidate materials. The potential advantages of glass are noted. Concentrator segment design and fabrication concepts are presented, with a view to their possible application to such other projects as long wavelength IR imaging systems. O.C.

A87-11008
ITEK OPTICAL TECHNOLOGY IN MANUFACTURING AND METROLOGY
I. M. EGDALL and R. K. LEE (Litton Industries, Inc., Itek Optical Systems Div., Lexington, MA) IN: Large optics technology; Proceedings of the Meeting, San Diego, CA, August 19-21, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 115-122. refs

There is a wide spectrum of optical systems contemplated for use in future astronomy missions. At Itek, the systems range from the large, lightweight, deployable optics required for the Large Deployable Reflector (LDR) to the precision of grazing incidence X-ray optics for the Advanced X-ray Astrophysical Facility (AXAF). This paper describes some of the technological initiatives that Itek has developed to enhance the manufacturability and the measurement of the surface quality of the spectrum of optical assemblies to be manufactured for the astronomical telescopes. Author

A87-11013
PARAMETRIC STUDY OF STABLE OPTICAL REFERENCES FOR LARGE FLEXIBLE STRUCTURES IN SPACE
M. J. CLAYTON and A. L. WERTHEIMER (Eastman Kodak Co., Rochester, NY) IN: Large optics technology; Proceedings of the Meeting, San Diego, CA, August 19-21, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1986, p. 149-157.

Several concepts for keeping track of small relative angular motions between a reference point and a remote platform, when the two are located at separate points on a flexible structure, are discussed. The goal is to accurately transfer knowledge of the orientation of the remote platform relative to the reference point. First-order equations and order-of-magnitude calculations are presented for image centroiding and interference fringe projection approaches for space station applications. Author

A87-13051* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERNATIONAL SAMPE SYMPOSIUM AND EXHIBITION, 31ST, LOS ANGELES, CA, APRIL 7-10, 1986, PROCEEDINGS
J. L. BAUER, ED. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and R. DUNAETZ, ED. (Hughes Aircraft Co., El Segundo, CA) Symposium and Exhibition sponsored by the Society for the Advancement of Material and Process Engineering. Covina, CA, Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 31), 1986, 1897 p. For individual items see A87-13052 to A87-13185.

The present conference on the development status of advanced structural materials considers topics arising in such areas as automated structural manufacturing, advanced material and structure design techniques, environmental effects on materials, composite matrix processing, computer modeling for materials and processes, materials development trends in Europe and in Japan, fiber and whisker reinforcement development status, and novel thermoplastic materials and their applications. Also discussed are pressure-sensitive adhesive systems, materials suitable for space applications, polyimide resin systems, electronic materials, novel resin chemistries, ceramic and metallic systems, and the impact performance of state-of-the-art materials. O.C.

A87-13301
1986 AMERICAN CONTROL CONFERENCE, 5TH, SEATTLE, WA, JUNE 18-20, 1986, PROCEEDINGS. VOLUMES 1, 2, & 3
Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1986. Vol. 1, 678 p.; vol. 2, 757 p.; vol. 3, 807 p. For individual items see A87-13302 to A87-13460.

Papers are presented on robustness and modeling issued in process control, stochastic control, stability theory for adaptive control, robotics, artificial intelligence in process control, direct-drive robot arms, and estimation and tracking. Also considered are performance/robustness tradeoffs inc ontroller design, linear and nonlinear systems, advances in model predictive control, simulation tools for control systems, control of flexible spacecraft, missile navigation, guidance and control, and aerospace and aircraft control applications. Other topics include real-time applications of parallel processing technology, identification, control in mechanical and optical systems, web handling, and reconfiguration strategies for flight control systems. R.R.

A87-13434* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TRAJECTORY SHAPING RENDEZVOUS GUIDANCE
A. R. KLUMPP (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1986 American Control Conference, 5th, Seattle, WA, June 18-20, 1986, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 1545-1550. NASA-supported research.

The Space Station will bring a great increase in rendezvous traffic. Formerly, rendezvous has been expensive in terms of time and crew involvement. Multiple trajectory adjustments on separate orbits have been required to meet safety, lighting, and geometry requirements. This paper describes a new guidance technique in which the approach trajectory is shaped by a sequence of velocity increments in order to satisfy multiple constraints within a single orbit. The approach phase is planned before the mission, leaving a group of free parameters that are optimized by onboard guidance. Fuel penalties are typically a few percent, compared to unshaped Hohmann transfers, and total fuel costs can be less than those of more time-consuming ways of meeting the same requirements. Author

A87-13705
SPACE STATION AUTOMATION; PROCEEDINGS OF THE MEETING, CAMBRIDGE, MA, SEPTEMBER 17, 18, 1985
W. C. CHIOU, SR., ED. (Lockheed Research Laboratories, Palo Alto, CA) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 580), 1985, 105 p. For individual items see A87-13706 to A87-13717.
(SPIE-580)

Applications of artificial intelligence (AI), image science and robotics to enhancing automation for implementation in Space Station (SS) operations are discussed and current research is reviewed. Attention is given to the functional requirements, missions and potential configurations of automation and robotics on space stations, orbital maneuvering vehicles and the Orbiter. Expert systems are investigated for control of power transmission and consumption in the SS Common Modules. Automated guidance, position and target location sensors and image processors and docking systems for orbital maneuver systems are described. Consideration is devoted to robot vision techniques for welding, collision avoidance, automated life sciences experimentation, and automated SS inspection systems. Finally, a systems approach is delineated for use in the design of the SS and the selection of its missions. M.S.K.

A87-13708
THE SYSTEM APPROACH FOR APPLYING ARTIFICIAL INTELLIGENCE TO SPACE STATION AUTOMATION
V. L. GROSE (National Transportation Safety Board, Washington, DC) IN: Space station automation; Proceedings of the Meeting, Cambridge, MA, September 17, 18, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 21-27.

The systems approach and an establishment issue Totem Pole (EITP) are described as a means to facilitate the incorporation of artificial intelligence features into the Space Station (SS). It is recommended that, in order to take a systems approach, the geography of the SS be defined explicitly, along with the known inputs and desired outputs and a balance between cost, performance and schedule. The evolutionary, dynamic character of the SS must be acknowledged to recognize that the outputs will change the objectives. The EITP is to be developed from a functional flow block diagram, which is a product of intended inputs and desired outputs. The means used to achieve an SS which

could use the inputs and produce the outputs are ranked in terms of criticality. AI then incorporates the hierarchy and will allocate resources in a sequence that will yield the best return on minimal resource investment. M.S.K.

A87-15376
SPACE STATION BEYOND IOC; PROCEEDINGS OF THE THIRTY-SECOND ANNUAL INTERNATIONAL CONFERENCE, LOS ANGELES, CA, NOVEMBER 6, 7, 1985
M. J. FRIEDENTHAL, ED. (TRW, Inc., Federal Systems Div., Redondo Beach, CA) Conference sponsored by AAS. San Diego, CA, Univelt, Inc. , 1986, 187 p. For individual items see A87-15377 to A87-15390.

The progress in the design of the Space Station, mainly for the IOC, as of the end of 1985 is assessed, and plans for growth and applications of the Station are discussed. Emphasis is placed on the technologies which will require further development if the cost and timetable aspects of the Station are to be met. The tasks assigned in the individual Work Packages for the contracters and subcontracters are described, as are Station uses as a materials science, space physics, pharmaceuticals laboratory and astrometric observatory. M.S.K.

A87-15805#
SATELLITE MOTION ANALYSIS VIA LASER REFLECTOR PATTERN PROCESSING FOR RENDEZ-VOUS AND DOCKING
I. NAKATANI, T. TANAMACHI, and K. NINOMIYA (Tokyo, University, Japan) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 10 p. refs
(IAF PAPER 86-06)

A practical method for estimating the relative attitude and distance between a target satellite (TS) and a rendezvous satellite using laser reflectors together with a CCD camera is discussed. A new arrangement of the reflectors on the TS is proposed where the data size required to identify and locate reflector points on the image plane is quite small and the state equations of motion are remarkably simple because the proposed scheme makes it possible to separate the rotational motion from translational motion. Thus it is possible to estimate the motion of the TS in real time using the Kalman filter technique and an onboard computer. C.D.

A87-15806#
RENDEZVOUS AND DOCKING VERIFICATION AND IN-ORBIT DEMONSTRATION
P. P. NGUYEN (Aerospatiale, Paris, France), W. FEHSE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands), A. GETZSCHMANN (MBB/ERNO, Bremen, West Germany), and B. CLAUDINON (Matra, S.A., Velizy-Villacoublay, France) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 19 p. refs
(IAF PAPER 86-07)

A novel, autonomous rendezvous and docking (RVD) concept is under development in Europe with a view to application in manned vehicles. The system encompasses navigation and guidance sensors, docking/berthing mechanism hardware, and onboard processors and software. The software is responsible for guidance and navigation intelligence, trajectory and attitude control, and control mode sequencing logic. Attention is given to a verification mission involving two Eureca platforms, one of which is deployed and the other retrieved during a Space Shuttle flight. O.C.

A87-15808#
NAVIGATION, GUIDANCE, RENDEZ-VOUS AND DOCKING - ACTIVITIES CARRIED OUT FOR COLUMBUS BY THE FLIGHT OPERATIONS ORGANIZATION
A. BURATTI IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 9 p.
(IAF PAPER 86-09)

Orbit and attitude optimization and control are examined. The routine orbit is affected by the transfer orbits and the maneuvers required for each experiment; additional factors which must be considered in order to select proper operating orbits are discussed. Two orbits were selected for Columbus: the International Space Station orbit with an altitude of 463 km and an inclination of 28.5 deg and the polar sun-synchronous orbit with an altitude of 850 km and an inclination of 98.8 deg. It is observed that ESA S-band stations provide good accuracy for navigating the polar platform and the TDRSS will be used for communication on Columbus. I.F.

A87-15871#
FACTORS INFLUENCING SELECTION OF SPACE TRANSPORTATION OPTIONS
R. H. MILLER, D. G. STUART, and A. AZARBAYEJANI IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 27 p. refs
(IAF PAPER 86-108)

An evaluation is made of the economic feasibility of two concepts for the lofting of cargo into LEO, as will be required by the building of large Space-Station and satellite-power-system structures. One of the alternatives considered is a fully reusable horizontal-takeoff-and-landing aircraft whose first stage is airbreathing and manned, while the second is rocket-powered and unmanned; the second alternative is fully expendable, with vertical takeoff, two rocket stages, and no crew or reentry provisions. It is found that costs are critically dependent on the assumed future traffic demand as well as on the choice of vehicle payload capability. O.C.

A87-15959#
INSTABILITY OF ROTATING BLADES IN SPACE
M. NATORI (Tokyo, University, Japan) and S. NEMAT-NASSER (California, University, La Jolla) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 9 p. refs
(IAF PAPER 86-242)

Basic aspects of instability of a flexible rotating blade due to solar radiation pressure are studied as a first step toward an instability study of future bladed space vehicles. A fundamental set of equations for coupled flap-lag-pitch motion of a very flexible rotation blade is presented, including the coupling and nonlinear terms associated with the structural, inertial, and solar dynamic operators. Basic instability characteristics of lag-pitch coupling through nonlinear terms are presented, and the effects of pitch control and torsional rigidity are clearly shown. C.D.

A87-16081#
METEOROID AND ORBITAL DEBRIS PROTECTION CONCEPTS
E. BAUER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 11 p. refs
(IAF PAPER 86-419)

Meteoroid and orbital debris impacts are an important, design driving requirement of future Space Station elements. For the European Columbus elements, the potential safety requirements as well as the resulting impact particle diameters and velocities are discussed. Major parts of this presentation deal with the general design and verification aspects necessary for the realization of an orbital impact protection system. Additionally, a caution and warning system needed for an immediate determination of the actual impact results is described. The possible repair activities required for maintaining the safety critical space vehicle functions are explained. Author

A87-16141#
REDUCED MODELING AND ANALYSIS OF LARGE REPETITIVE SPACE STRUCTURES VIA CONTINUUM/DISCRETE CONCEPTS
K. C. SAW (West Virginia University, Morgantown) IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986. 12 p. refs
(IAF PAPER ST-86-08)

A reduced modeling/analysis approach applicable for repetitive lattice configuration is described with emphasis on tetrahedral-type

space structures. Using scaling transformations and constitutive properties derived via the concept of 'equivalent continuum', the actual models are transformed to significantly reduced discrete configurations. Therein, the approach seeks to model/analyze the much simpler and reduced configurations, wherein, transformations and extrapolation/interpolation procedures are utilized to relate back the response to that of significantly complex actual configurations. The effectiveness and accuracy of the approach is demonstrated via comparisons with detailed analysis of the actual models. Results obtained are in good agreement and the approach offers potential for further extension. The basic concepts can be extended to general repetitive lattice structures as well. Author

A87-17834*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PATH-CONSTRAINED RENDEZVOUS - NECESSARY AND SUFFICIENT CONDITIONS
K. M. SOILEAU (NASA, Johnson Space Center, Houston, TX) and S. A. STERN (Colorado, University, Boulder) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Sept.-Oct. 1986, p. 492-498. refs

The problem of path-constrained rendezvous in the vicinity of a Large Space Structure (LSS) was first introduced some years ago. The present contribution to this field centers on a demonstration that the problem can be reduced from a path-constraint problem to one of end-point constraints or certain (common) LSS geometries, under the assumption of an unrestrictive upper limit on the transfer time. This finding has been made under the assumption of a circular Keplerian orbit, and has been normalized with respect to orbital semimajor axis and LSS size. In addition to demonstrating this important simplification of the path-constrained rendezvous problem, the results of numerical simulations of path-constrained transfers from point-to-point on large spherical structures in orbit are discussed, and a series of conclusions having both architectural (design) and operational implications for LSS designers/operators is derived. Author

A87-17841#
FEASIBILITY STUDY OF A LOW-TEMPERATURE EXPANDABLE MEGAWATT PULSE POWER RADIATOR
L. C. CHOW (Kentucky, University, Lexington), E. T. MAHEFKEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH), and J. E. YOKAJTY Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Sept.-Oct. 1986, p. 539-541. Abridged. USAF-sponsored research. Previously cited in issue 17, p. 2472, Accession no. A85-37686. refs

A87-18026
IECEC '86; PROCEEDINGS OF THE TWENTY-FIRST INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, SAN DIEGO, CA, AUGUST 25-29, 1986. VOLUMES 1, 2, & 3
Conference sponsored by AChS, SAE, AIAA, et al. Washington, DC, American Chemical Society, 1986, p. Vol. 1, 673 p.; vol. 2, 737 p.; vol. 3, 897 p. For individual items see A87-18027 to A87-18181.

Recent developments in the technology of energy conversion are discussed in reviews and reports. Topics examined include advanced conversion concepts, geothermal conversion, energy policy, pyroelectric conversion materials, large cogeneration systems, coal conversion, biomass energy, rock-fluid interactions, hydrogen energy, and nuclear energy. Consideration is given to heat pumps and engines, MHD conversion, thermal storage, batteries, solar conversion, and power-conversion requirements and technologies for space use. T.K.

A87-18114
1986 LECEC STABILITY AND TRANSIENT MODELING OF A LARGE SPACECRAFT POWER SYSTEM
J. CHEN and M. GLASS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IECEC '86; Proceedings of the Twenty-first Intersociety Energy Conversion Engineering Conference, San Diego, CA, August 25-29, 1986. Volume 3 . Washington, DC, American Chemical Society, 1986, p. 1672-1676.

As space power systems grow and computer aided engineering workstations mature, computer modeling becomes a critical design step. This paper outlines the modeling process of a multi kw spacecraft power system comprised of eight solar powered converter/battery channels, three control loops including the peak power tracker, and a common output bus. The computer models predicted small signal stability margins, bus impedances, and fault induced voltage transients. Author

A87-18201
INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 14TH, TOKYO, JAPAN, MAY 27-JUNE 1, 1984, PROCEEDINGS
M. NAGATOMO, ED. Symposium sponsored by Ad-Melco Co., Ltd., Akashi Seisakusho, Ltd., Anritsu Electric Co., Ltd., et al. Tokyo, AGNE Publishing, Inc., 1984, 1718 p. For individual items see A87-18202 to A87-18418.

Progress in space science and technology is discussed in reviews and reports, with emphasis on developments in Japan. Topics examined include propulsion, materials and structure, fluid dynamics, thermophysics and thermochemistry, electronic devices, space communication, guidance and control, systems engineering, balloons and recovery technology, earth and planetary observations, astronomy, space medicine and biology, material processing, and space law. T.K.

A87-18247
COLLISIONAL PROBABILITY IN SPACE AND THE DEBRIS ENVIRONMENT IN FUTURE
K. SATO (Tokyo, University, Japan) and M. NAGATOMO IN: International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 1, 1984, Proceedings . Tokyo, AGNE Publishing, Inc., 1984, p. 393-398.

The collision of an earth satellite with other orbiting debris is studied to predict the collision probability, using the NASA Satellite Situation Report (1982). To obtain the tendency of number density of debris versus altitude, the lifetime of debris is calculated by the averaging method as a function of the masses of debris and the launch date (on the assumption that each orbit of debris is circular). It is shown that the effect of the periodic solar activity on the number density distribution is significant. The results show that the number of debris continues to increase in the range of altitude between 1000 and 1500 km. Accordingly the collision probability will increase in the same range. Author

A87-18451
SPACE EXPLOITATION AND UTILIZATION; PROCEEDINGS OF THE SYMPOSIUM, HONOLULU, HI, DECEMBER 15-19, 1985
P. M. BAINUM, ED. (Howard University, Washington, DC), K. IKEDA, ED. (Mitsubishi Heavy Industries, Ltd., Tokyo, Japan), T. NOMURA, ED. (Tokyo, University, Japan), T. YAMANAKA, ED. (National Aerospace Laboratory, Tokyo, Japan), G. L. MAY, ED. et al. Symposium organized and sponsored by AAS and Japanese Rocket Society. San Diego, CA, Univelt, Inc. , 1986, 738 p. For individual items see A87-18452 to A87-18470, A87-18472 to A87-18497.

Various papers in the area of space exploitation and utilization are presented. The general topics addressed include: national and international space programs, advanced space-based communications systems, remote sensing of the earth, earth resources satellite technology, future trends in the development of launch vehicle technology, space-based manufacturing, future use of robotic technology for space application, and astrodynamics. C.D.

A87-18852
AEROSPACE COMPUTER SECURITY CONFERENCE, 2ND, MCLEAN, VA, DECEMBER 2-4, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA, American Society for Industrial Security, and DOD Computer Institute. New York, American Institute of Aeronautics and Astronautics, 1986, 142 p. For individual items see A87-18853 to A87-18865.

Papers are presented on a model for the containment of computer viruses, the Commercial Communications Security Endorsement Program, and a design for a multilevel secure database management system. Topics discussed include secure computer systems, electronic mail privacy enhancement, multilevel data storage design, and secure database management system architectural analysis. Particular attention is given to access control and privacy in large distributed systems and the verification of integrity. I.F.

A87-20055* Alabama Univ., Huntsville.
DUAL-SPACECRAFT MEASUREMENTS OF PLASMASPHERE-IONOSPHERE COUPLING
J. L. HORWITZ, R. H. COMFORT (Alabama, University, Huntsville), L. H. BRACE (NASA, Goddard Space Flight Center, Greenbelt, MD), and C. R. CHAPPELL (NASA, Marshall Space Flight Center, Huntsville, AL) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Oct. 1, 1986, p. 11203-11216. refs
(Contract NSF ATM-83-00426; NSF ATM-85-06642; NAG5-475; NAG8-054; NAG8-058; NAS8-33982)

An extensive set of plasmaspheric measurements by the DE 1 satellite and ionospheric measurements by the DE 2 satellite are presented. The developments in the ionosphere and plasmasphere during the recovery phase of a magnetospheric storm are described. Isolated profile comparisons are used to indicate some of the structural relations and complexities involving the ionosphere and plasmasphere latitudinal profiles. A transition in the ionospheric electron temperature Te from a relatively smooth profile of low Te at the base of the inner plasmasphere to enhanced and highly structured Te at higher invariant latitudes occurs near or along a plasmaspheric density gradient. Plasmaspheric enhancements of the heavy ions O(+) and O(2+) are often closely aligned with distinct ionospheric Te enhancements. C.D.

A87-20076
REINFORCED PLASTICS/COMPOSITES INSTITUTE, ANNUAL CONFERENCE, 41ST, ATLANTA, GA, JANUARY 27-31, 1986, PREPRINT
Lancaster, PA, Technomic Publishing Co., 1986, 679 p. For individual items see A87-20077 to A87-20093.

The present conference on composite materials technologies encompasses topics in pultrusion techniques and products, matrix-reinforcement interface characteristics, filament winding and ply layup processes, resin curing cycles, marine applications, and reinforced thermoplastics. Also discussed are reaction injection molding processes, transportation applications, product markets, fillers and additives, testing methods, sheet molding compounds, corrosion prevention, design methods, basic research and development topics, and structural applications. O.C.

A87-20144
INTERNATIONAL WEEK ON BONDING AND JOINING TECHNOLOGIES, 1ST, BORDEAUX, FRANCE, APRIL 15-18, 1986, SELECTED PAPERS
Week organized by Adhecom. International Journal of Adhesion and Adhesives (ISSN 0143-7496), vol. 6, Oct. 1986, 72 p. For individual items see A87-20145 to A87-20151.

Papers are presented on bonding composites, stress analysis at the interface in adhesive joints by special finite elements, and the analysis of adhesive-bonded structural joints in space vehicles. Consideration is given to adhesive bonding of aerospace materials, modeling the elementary mechanisms involved in grafting polymers onto metals, and the use of the wedge test to estimate the lifetime of an adhesive joint in an aggressive environment. Other subjects include the physicochemical characterization of aluminum alloy surfaces after sulfochromic pickling prior to bonding, and intrinsic mechanical characterization of structural adhesives. I.S.

A87-21801
SPACE NUCLEAR POWER SYSTEMS 1985; PROCEEDINGS OF THE SECOND SYMPOSIUM, ALBUQUERQUE, NM, JAN. 14-16, 1985. VOLUMES 3 & 4
MOHAMED S. EL-GENK, ED. (New Mexico, University, Albuquerque) and MARK D. HOOVER, ED. (Lovelace Inhalation Toxicology Research Institute, Albuquerque, NM) Symposium organized by the University of New Mexico; Sponsored by American Nuclear Society, Sandia National Laboratories, USAF, et al. Malabar, FL, Orbit Book Co., Inc., 1987. Vol. 3, 192 p.; vol. 4, 218 p. For individual items see A87-21802 to A87-21840.

Papers are presented on the US space nuclear power program, civilian and military applications for nuclear power in space, and the designs, requirements, and costs of space nuclear power missions and systems. Topics discussed include space nuclear reactor fuel and fuel performance, the properties of refractory metal alloys, the development of liquid droplet and heat pipe radiators for thermal management in space, and systems analysis and testing. Consideration is given to methods for converting thermal energy to useable electrical energy in space, control and power conditioning electronics systems for space applications, reactors and shields, options for space nuclear propulsion, and the safety and reliability of using nuclear reactors in space. I.F.

A87-21975
PERSPECTIVE ON NON-U.S. PRESENTATIONS AT THE 37TH CONGRESS OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION - OCTOBER 4-11, 1986, INNSBRUCK, AUSTRIA
J. HARTFORD, ED. (AIAA, New York) New York, American Institute of Aeronautics and Astronautics, 1987, 41 p. No individual items are abstracted in this volume.

Highlights of the plenary events and technical sessions of the 37th Congress of the International Astronautical Federation are presented. Particular attention is given to the state and direction of foreign space technology, and to foreign reaction to U.S. papers. Subject areas include astrodynamics, communications satellites, earth observations, economics, education, global change, history, life sciences, materials and structures, microgravity processes, propulsion, and the search for extraterrestrial intelligence. Consideration is also given to space exploration, space law, space power, space stations, space systems, and space transportation. K.K.

A87-22416#
MODEL FOR RADIATION CONTAMINATION BY OUTGASSING FROM SPACE PLATFORMS
STEPHEN J. YOUNG and RONALD R. HERM (Aerospace Corp., El Segundo, CA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 12 p. refs
(Contract F04701-85-C-0086)
(AIAA PAPER 87-0102)

Infrared sensors mounted on space platforms (e.g. Space Shuttle and satellites) may be subject to infrared radiation contamination from molecular gases released from the platform itself. Models for order-of-magnitude estimates of the contamination level caused by this effect are formulated. Application of the model to estimate the effects that the outgassing of H2O from the Shuttle environment would have on the CIRRIS 1A earth-limb radiance mission indicates that detection in the 2.7-micron spectral region would be only slightly degraded, but that detection around 6.3 microns may be seriously impaired by the mechanism of absorption and reemission of earthshine radiation by the H2O contamination molecules. Author

A87-22738*# Massachusetts Inst. of Tech., Cambridge.
RADIATION FROM LARGE SPACE STRUCTURES IN LOW EARTH ORBIT WITH INDUCED AC CURRENTS
D. E. HASTINGS and S. OLBERT (MIT, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 19 p. refs
(Contract NAG3-695)
(AIAA PAPER 87-0612)

Large conducting space structures in low earth orbit will have a nonnegligible motionally induced potential across their structures. The induced current flow through the body and the ionosphere causes the radiation of Alfven and lower hybrid waves. This current flow is taken to be ac and the radiated power is studied as a function of the ac frequency. The current may be ac due either to inductive coupling from the power system on the structure or by active modulation. A Space Station-like structure and tether are studied. For the Space Station structure the radiation impedance is particularly high for frequencies in the tens of kilohertz range which suggests that the Space Station may be efficient source of lower hybrid waves. The tether is also shown to be a generator of VLF waves up to source ac frequencies in the megahertz range. The implications for these two structures are discussed. Author

A87-24198* Air Force Geophysics Lab., Hanscom AFB, Mass.
BOOM POTENTIAL OF A ROTATING SATELLITE IN SUNLIGHT
S. T. LAI, H. A. COHEN (USAF, Geophysics Laboratory, Bedford, MA), T. L. AGGSON (NASA, Goddard Space Flight Center, Greenbelt, MD), and W. J. MCNEIL (Radex, Inc., Carlisle, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Nov. 1, 1986, p. 12137-12141. refs

An interpretation is provided for the behavior of long boom potential measurements taken on the spinning P78-2 (SCATHA) satellite at near geosynchronous altitudes. This study uses data taken during a quiet day, with the satellite in sunlight. The data show periodic variations with a maximum amplitude of 6 V. The theory explains why the variations correlate well with sun direction but not with the geomagnetic field. A current balance model, assuming a Maxwellian distribution of photoelectrons, is studied. The photoelectron temperature, the degrees of positive charging of the boom and of the satellite, and the ambient electron flux are calculated. Deviations from the model are discussed. Author

A87-24625
OPTIMAL SPACECRAFT ROTATIONAL MANEUVERS
JOHN L. JUNKINS (Texas A & M University, College Station) and JAMES D. TURNER (PRA, Inc., Cambridge, MA) Research supported by the U.S. Air Force, Charles Stark Draper Laboratory, Inc., U.S. Navy, et al. Amsterdam and New York, Elsevier (Studies in Astronautics. Volume 3), 1986, 532 p. refs

Methods of solving problems related to maneuvering spacecraft are discussed, emphasizing the most central analytical and numerical methods for determining optimal rotational maneuvers of spacecraft. Large-angle nonlinear maneuvers are focused on, and large rotational maneuvers of flexible vehicles with simultaneous vibration suppression/arrest are considered. The individual chapters discuss: geometry and kinematics of rotational motion, basic principles of dynamics, rotational dynamics of rigid and multiple rigid body spacecraft, dynamics of flexible spacecraft, elements of optimal control theory, numerical solution of two point boundary value problems, optimal maneuvers of rigid spacecraft, optimal large-angle single-axis maneuvers of flexible spacecraft, frequency-shaped large-angle maneuvers of flexible spacecraft, and computational methods for closed-loop control problems. C.D.

A87-24701
DIGITAL NETWORKS AND THEIR EVOLUTION - SPACE AND TERRESTRIAL SYSTEMS; PROCEEDINGS OF THE THIRTY-THIRD INTERNATIONAL CONGRESS ON ELECTRONICS AND TWENTY-SIXTH INTERNATIONAL MEETING ON SPACE, ROME, ITALY, MAR. 18-20, 1986
Conference supported by the Ministero per il Coordinamento della Ricerca Scientifica e Tecnologica, CNR, ESA, et al. Rome, Rassegna Internazionale dell'Elettronica, dell'Energia, e dello Spazio, 1986, 474 p. For individual items see A87-24702 to A87-24712.

Among the topics presently discussed are the position of space and terrestrial systems in digital communications network evolution, research and experiments on broadband subscriber networks in Italy, ESA satellite communications activities and plans, research on the integrated switching of voice and video transmissions, advanced structures for digital broadband switching, and the use of Banyan networks for high throughput switching exchanges. Also considered are the interconnection of digital systems with different standards, standard compatibility of ISND terminals, the global plan for network layer addressing in open systems interconnection, videoconferencing, ISND and office automation, intelligent networks, the European Data Relay Satellite, the Space Station's data systems, and Columbus communications. O.C.

A87-25426
SOLAR POWER SATELLITE BUILT OF LUNAR MATERIALS
Space Power (ISSN 0883-6272), vol. 6, no. 1, 1986, 99 p. refs

The energy required for transporting lunar material to geosynchronous orbit is less than 8 percent that for terrestrial materials; this is compounded by the lower cost of a launcher that overcomes the moon's low gravity to reach that orbit, to yield a 50:1 advantage over delivery of materials fron earth. An economic evaluation is presently made of the prospects for a solar power satellite built in geosynchronous orbit. It is found that a solar power satellite can be designed which employs less than one percent as much nonlunar material as a baseline, terrestrial materials-employing satellite, despite total mass being 8 percent greater. Si solar cells are used for power generation; the structure is primarily aluminum, and the design is suited to automated construction. O.C.

A87-25451
SPACE STATION: GATEWAY TO SPACE MANUFACTURING; PROCEEDINGS OF THE CONFERENCE, ORLANDO, FL, NOV. 7, 8, 1985
Conference sponsored by Pasha Publications. Arlington, VA, Pasha Publications, 1985, 437 p. For individual items see A87-25452 to A87-25461.

Opportunities for commercial manufacturing operations on the Space Station are discussed in reviews and reports by NASA and industry experts. Topics examined include private initiatives and opportunities, promising new technologies, low-cost starting options, new types of space-operations financing, and initial space laboratories and factories. Extensive diagrams, tables, and drawings are provided. T.K.

A87-25751
SPACE TECH '86; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, GENEVA, SWITZERLAND, MAY 14-16, 1986
London, Online International, Ltd., 1986, 261 p. For individual items see A87-25752 to A87-25769.

Papers are presented on the development of the Space Station, the Japanese laboratory proposal, and the Columbus program. Topics discussed include free flying platforms, the role of robotics in space, switches, lasers, and electronically-hopped beam antennas in space, new communications satellite configurations, geostationary platforms, the mobile communications satellite, and paging by satellite. Consideration is given to space transportation, in particular the Long March launcher, Ariane 5/Hermes, and Hotol. I.F.

A87-25753
JAPANESE LABORATORY PROPOSAL
TADAHICO INADA (National Space Development Agency of Japan, Paris, France) IN: Space Tech '86; Proceedings of the International Conference, Geneva, Switzerland, May 14-16, 1986 . London, Online International, Ltd., 1986, p. 21-31.

Japanese participation in the Space Station Phase B study is concentrated on the experimental module, which is attached to the core module from one side, and other facilities, which are attached to the other side. The basic principles for participation and detailed configuration of the module are described. Author

A87-25976
AEROSPACE APPLICATIONS CONFERENCE, STEAMBOAT SPRINGS, CO, FEB. 1-8, 1986, DIGEST
Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, Inc., 1986, 359 p. For individual items see A87-25977 to A87-26000.

The present conference considers topics concerning the projected NASA Space Station's systems, digital signal and data processing applications, and space science and microwave applications. Attention is given to Space Station video and audio subsystems design, clock error, jitter, phase error and differential time-of-arrival in satellite communications, automation and robotics in space applications, target insertion into synthetic background scenes, and a novel scheme for the computation of the discrete Fourier transform on a systolic processor. Also discussed are a novel signal parameter measurement system employing digital signal processing, EEPROMS for spacecraft applications, a unique concurrent processor architecture for high speed simulation of dynamic systems, a dual polarization flat plate antenna, Fresnel diffraction, and ultralinear TWTs for high efficiency satellite communications. O.C.

A87-27603
SPACE LOGISTICS SYMPOSIUM, 1ST, HUNTSVILLE, AL, MAR. 24-26, 1987, TECHNICAL PAPERS
Symposium sponsored by AIAA and Society of Logistics Engineers. New York, American Institute of Aeronautics and Astronautics, 1987, 167 p. For individual items see A87-27604 to A87-27624.

Logistics problems and possible solutions are identified for planned and proposed space, launch vehicle and ground support systems, services and capabilities. Systems engineering and logistics planning techniques are identified for launching, retrieving and repairing satellites and various free-flying platforms from the Orbiter and/or the Space Station. Alternative design approaches are explored for the construction, growth, maintenance and operation of the Space Station and SDI battle stations and ground support systems. Integrated ground support services are described as a necessary component that must be considered in the systems engineering of affordable, third generation of more-nearly fully reusable manned and unmanned launch systems. Finally, several logistics analysis approaches, which must be applied at the inception of design studies, are delineated for inventory control, launch and maintenance, and repair and refurbishment of future space systems such as the Hubble Space Telescope. M.S.K.

A87-27621#
SPACE LOGISTICS SUPPORT TO MILITARY SPACE SYSTEMS
JOHN C. BAKER (bd Systems, Inc., Torrance, CA) and WILLIAM MOROSOFF IN: Space Logistics Symposium, 1st, Huntsville, AL, Mar. 24-26, 1987, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1987, p. 138-144.
(AIAA PAPER 87-0694)

Deficiencies in current space support capabilities have been examined and compared to evolving infrastructure requirements, both with and without SDI. The resulting needs are documented in the launch, on-orbit and C3 areas. Technology advances and methods of operation that will be required to bring space logistics to an appropriate level so that military activity can become effective in space are identified and documented, and a 10 yr is presented. Supportability is shown to be an important force multiplier for military space systems. Author

A87-28526
INTERNATIONAL MODAL ANALYSIS CONFERENCE, 4TH, LOS ANGELES, CA, FEB. 3-6, 1986, PROCEEDINGS. VOLUMES 1 & 2
Conference sponsored by Union College. Schenectady, NY, Union College, 1986. Vol. 1, 850 p.; vol. 2, 911 p. For individual items see A87-28527 to A87-28584.

Techniques and applications of structural modal analysis and testing are examined in reviews and reports. Topics covered include experimental case histories, analytical methods, structural-dynamics modifications, linking analysis and tests, and techniques for rotating machinery. Consideration is given to substructuring, structure modeling, processing modal data, analysis of nonlinear structures, FEM analysis, noise acoustics, vehicle design, transducers and instrumentation, and design methods. T.K.

A87-29401
SPACE COMMERCE '86; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE AND EXHIBITION ON THE COMMERCIAL AND INDUSTRIAL USES OF OUTER SPACE, MONTREUX, SWITZERLAND, JUNE 16-20, 1986
VIVECA C. OTT, ED. Geneva, Interavia Publishing Group, 1986, 489 p. For individual items see A87-29402 to A87-29440.

Progress in the commercialization and industrialization in space is assessed with emphasis on near- and medium-term developments. Details of the history and status of Intelsat and other satellite-based telecommunications systems are explored, along with factors of importance for competing systems, DBS systems, and the evolution of the Intelsat services. NASA, ESA and NASDA efforts to further space industrialization through the Space Station/COLUMBUS program are discussed in great detail. Attention is also given to the encouragement the space agencies are providing to private industries to identify materials processing and other technologies which have the potential for commercial scale manufacturing in space. Spinoffs from space activities which have had significant impacts for terrestrial industries are examined, as are potential and historically proven methods of attracting venture capital to the financing of space projects. The status and prospects for international space law regulating space commercialization are discussed. M.S.K.

A87-29441
AEROSPACE TESTING SEMINAR, 9TH, LOS ANGELES, CA, OCT. 15-17, 1985, PROCEEDINGS
Seminar sponsored by the Institute of Environmental Sciences and Aerospace Corp. Mount Prospect, IL, Institute of Environmental Sciences, 1986, 268 p. For individual items see A87-29442 to A87-29471.

Papers are presented on the qualification/acceptance program for the Hubble Space Telescope, launch vehicle platform and high-energy upper stage acceptance testing, the integrated spacecraft automated test system, characteristics of electromagnetic interference generated by arc discharging, and strain gage selection and bonding techniques for application in a cryogenic-pyrotechnic environment. Topics discussed include a design verification system for advanced aerospace engines, a Space Station propulsion system test bed, test and verification impact on commercial Space Station operations, cost effective management of space venture risks, and automated microwave testing of spacecraft. Consideration is given to vibration testing of large spacecraft; transfer-orbit-stage off-line processing; utilization, testing, and maintenance of multimission hardware; payload vibroacoustics for Shuttle peculiar environments; and automatic, integrated facility record systems for Shuttle processing at Vandenberg AFB. I.F.

A87-29466#
UTILIZATION, TESTING AND MAINTENANCE OF MULTIMISSION HARDWARE
G. K. JANES and R. L. RADCLIFFE (Martin Marietta Corp., Denver, CO) IN: Aerospace Testing Seminar, 9th, Los Angeles, CA, Oct. 15-17, 1985, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1986, p. 206-210.

The preflight testing, operation, and postflight inspection of the Manned Maneuvering Unit (MMU)/Flight Support Station (FSS) are described. The procedures for testing and maintaining the MMU/FSS, and the functions of the MMU Depot are examined. Examples revealing the preflight and postflight testing and inspection of the MMU/FSS for various space missions are presented. Diagrams of the MMU and FSS are provided. I.F.

A87-31112*# National Aeronautics and Space Administration, Washington, D.C.
SECOND AIAA/NASA USAF SYMPOSIUM ON AUTOMATION, ROBOTICS AND ADVANCED COMPUTING FOR THE NATIONAL SPACE PROGRAM
DALE MYERS (NASA, Washington, DC) AIAA, NASA, and USAF, Symposium on Automation, Robotics and Advanced Computing for the National Space Program, 2nd, Arlington, VA, Mar. 9-11, 1987. 4 p.
(AIAA PAPER 87-1655)

An introduction is given to NASA goals in the development of automation (expert systems) and robotics technologies in the Space Station program. Artificial intelligence (AI) has been identified as a means to lowering ground support costs. Telerobotics will enhance space assembly, servicing and repair capabilities, and will be used for an estimated half of the necessary EVA tasks. The general principles guiding NASA in the design, development, ground-testing, interactions with industry and construction of the Space Station component systems are summarized. The telerobotics program has progressed to a point where a telerobot servicer is a firm component of the first Space Station element launch, to support assembly, maintenance and servicing of the Station. The University of Wisconsin has been selected for the establishment of a Center for the Commercial Development of Space, specializing in space automation and robotics. M.S.K.

N87-10113 Centre National d'Etudes Spatiales, Toulouse (France).
PROCEEDINGS OF AN INTERNATIONAL CONFERENCE ON SPACE DYNAMICS FOR GEOSTATIONARY SATELLITES
1986 869 p In ENGLISH and FRENCH Conference held in Toulouse, France, Oct. 1985
(ISBN-2-85428-149-7; ETN-86-98079) Avail:
CEPADUES-Editions, 111 rue Nicolas-Vauquelin, 31100 Toulouse, France

Geostationary satellite mission analysis, attitude determination, orbit determination, (onboard technology, low-thrust techniques, station acquisition, stationkeeping) ground segments, and future developments were discussed.
ESA

N87-10720*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
PROCEEDINGS OF THE 5TH ANNUAL USERS' CONFERENCE
M. SZCZUR, ed. and E. HARRIS, ed. 1985 400 p Conference held at Greenbelt, Md., 4-6 Jun. 1985
(NASA-CP-2399; NAS 1.55:2399) Avail: NTIS HC A17/MF A01 CSCL 09B

The Transportable Applications Executive (TAE) was conceived in 1979. It was proposed to be a general purpose software executive that could be applied in various systems. The success of this concept and of TAE was demonstrated. Topics included: TAE current status; TAE development; TAE applications; and UNIX emphasis. B.G.

N87-10886# European Space Agency, Paris (France).
PROCEEDINGS OF AN INTERNATIONAL CONFERENCE ON SPACECRAFT STRUCTURES
W. R. BURKE, comp. Apr. 1986 433 p In ENGLISH and FRENCH Conference held in Toulouse, France, 3-6 Dec. 1985
(ESA-SP-238; ISSN-0379-6566; ETN-86-98078) Avail: NTIS HC A19/MF A01

Spacecraft structural analysis, including dynamic analysis and tests, dynamical identification, and acoustics analysis; design engineering; and spacecraft construction materials were discussed.
ESA

N87-10945*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROCEEDINGS OF THE 2ND ANNUAL SCOLE WORKSHOP
L. W. TAYLOR, JR., comp. Oct. 1986 268 p Workshop held in Hampton, Va., 9-10 Dec. 1985
(NASA-TM-89048; NAS 1.15:89048) Avail: NTIS HC A12/MF A01 CSCL 22B

Proceedings of the Second Annual Spacecraft Control Laboratory Experiment (SCOLE) Workshop held at the NASA Langley Research Center, Hampton, Va., December 9 to 10, 1985 are presented. Author

N87-10947# Oak Ridge National Lab., Tenn.
PROTECTION OF SPACECRAFT FROM METEOROIDS AND ORBITAL DEBRIS
A. P. FRAAS Mar. 1986 66 p
(Contract DE-AC05-84OR-21400)
(DE86-009996; ORNL/TM-9904) Avail: NTIS HC A04/MF A01

This report presents a review of information on the incidence of meteoroids and solid debris in orbital space, the damaging effects of these materials, and the principles that may be used to design protective shields for orbiting spacecraft. The report was prepared as part of a current Oak Ridge National Laboratory effort to develop and evaluate conceptual designs of space power systems. DOE

N87-10956# Marconi Space Systems Ltd., Portsmouth (England).
MODERN CONTROL OF LARGE FLEXIBLE SPACECRAFT, ESA ASTP STUDY Final Report
Paris ESA May 1985 272 p
(Contract ESA-5664/83-NL-BI; ESTEC-5352/83-NL-HP(SC))
(BL-6206-ISSUE-2; ESA-CR(P)-2197; ETN-86-98083) Avail: NTIS HC A12/MF A01

Stability control of large flexible spacecraft using bang-bang nonlinear control based on Sturm's theorem was investigated. A canonical model for preliminary tuning of the Sturm control law was derived. The damping matrix for the control law was studied. Use with one and two flexure modes per array axis; state estimation; stationkeeping maneuver responses; effect of parameter mismatches; and effect of mode spillover were assessed. Comparisons with other techniques show that the Sturm controller is superior, particularly with respect to ability to reject orbital correction disturbance. ESA

N87-11066# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Div.
OFFSET UNFURLABLE ANTENNA. PHASE 2A: EXECUTIVE SUMMARY
Paris ESA Nov. 1985 34 p
(Contract ESTEC-5206/82-NL-PB(SC))
(MBB-R-0200/3069-R; ESA-CR(P)-2199; ETN-86-98085) Avail: NTIS HC A03/MF A01

A 4.5 m radial rib reflector was designed for the 4 GHz Intelsat mission. The reflector was redesigned for the M-Sat 2-beam coverage requirements, resulting in a 5 m dia, 850 MHz offset reflector. It features a radial carbon fiber rib concept where foldable main ribs and intermediate ribs tension a gold plated molybdenum mesh to the required surface contour. The accuracy is varied by applying different numbers of ribs (e.g., 16 for 850 MHz or 30 for

12 GHz) and mesh fastening points. The electrical performance criteria used to establish the acceptable mechanical tolerances is that the level of the gore lobes generated by the ribs remains at least 30 dB below the main beam peak under all orbital conditions. ESA

N87-11717*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RECENT EXPERIENCES IN MULTIDISCIPLINARY ANALYSIS AND OPTIMIZATION, PART 1
J. SOBIESKI, comp. 1984 517 p Symposium held in Hampton, Va., 24-26 Apr. 1984
(NASA-CP-2327-PT-1; NAS 1.55:2327-PT-1) Avail: NTIS HC A22/MF A01 CSCL 01C

Papers presented at the NASA Symposium on Recent Experiences in Multidisciplinary Analysis and Optimization held at NASA Langley Research Center, Hampton, Virginia April 24 to 26, 1984 are given. The purposes of the symposium were to exchange information about the status of the application of optimization and associated analyses in industry or research laboratories to real life problems and to examine the directions of future developments. Information exchange has encompassed the following: (1) examples of successful applications; (2) attempt and failure examples; (3) identification of potential applications and benefits; (4) synergistic effects of optimized interaction and trade-offs occurring among two or more engineering disciplines and/or subsystems in a system; and (5) traditional organization of a design process as a vehicle for or an impediment to the progress in the design methodology.

N87-11750*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RECENT EXPERIENCES IN MULTIDISCIPLINARY ANALYSIS AND OPTIMIZATION, PART 2
J. SOBIESKI, comp. 1984 509 p Symposium held in Hampton, Va., 24-26 Apr. 1984
(NASA-CP-2327-PT-2; L-15830; NAS 1.55:2327-PT-2) Avail: NTIS HC A22/MF A01 CSCL 01C

The papers presented at the NASA Symposium on Recent Experiences in Multidisciplinary Analysis and Optimization held at NASA Langley Research Center, Hampton, Virginia, April 24 to 26, 1984 are given. The purposes of the symposium were to exchange information about the status of the application of optimization and the associated analyses in industry or research laboratories to real life problems and to examine the directions of future developments.

N87-11833# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DOCKING MECHANISMS TECHNOLOGY STUDY Final Report
Paris ESA Nov. 1984 70 p
(Contract ESA-5195/82-NL-BI)
(ESA-CR(P)-2273; ETN-86-98138) Avail: NTIS HC A04/MF A01

A zero impact docking concept, where the attitude orbit control system (AOCS) of the chaser spacecraft performs a close-up maneuver within the range of the latching subassembly, is proposed. The AOCS-controlled closure is a feasible solution of the last meter problem taking typical European rendezvous and docking (RVD) mission scenarios into account. The European standard docking interface is characterized by the prism seats on the chaser and the handles on the target. The servicing concept fits well within the modular docking mechanism subsystem approach with minimum interface problems. The latching concept giving high modularity and adaptability can be tailored to the specific mission needs without changing the baseline. A minimum of RVD equipment has to be furnished additionally to existing chaser capabilities to perform the RVD last-meter-approach. ESA

N87-11838*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF HARD PARTICLE IMPACTS ON THE ATOMIC OXYGEN SURVIVABILITY OF REFLECTOR SURFACES WITH TRANSPARENT PROTECTIVE OVERCOATS
D. A. GULINO 1986 22 p Proposed for presentation at the 25th Aerospace Sciences Meeting, Reno, Nev. 12-15 Jan. 1987; sponsored by the American Institute of Aeronautics and Astronautics
(NASA-TM-88874; E-3281; NAS 1.15:88874) Avail: NTIS HC A02/MF A01 CSCL 10B

Silver mirror samples with protective coatings were subjected to a stream of 27 microns alumina particles to induce pinhole defects. The protective coating consisted of a layer of aluminum dioxide over silver followed by a layer of silicon dioxide over the alumina. Samples were prepared on both graphite-epoxy composite and fused quartz substrates. After exposure to the hard particle stream, the samples were exposed to an oxygen plasma environment in a laboratory plasma asher. The effects of both the hard particles and the oxygen plasma were documented by both reflectance measurements and scanning electron microscopy. The results indicated that oxidative damage to the silver reflecting layer continues beyond that of the erosively exposed silver. Oxidative undercutting of the silver layer and graphite-epoxy substrate continues in undamaged areas through adjacent, particle damaged defect sites. This may have implications for the use of such mirrors in a space station solar dynamic power system. Author

N87-13167*# McDonnell-Douglas Astronautics Co., Houston, Tex.
ADVANCED EVA SYSTEM DESIGN REQUIREMENTS STUDY Final Technical Report
Jan. 1986 248 p
(Contract NAS9-17299)
(NASA-CR-171942; NAS 1.26:171942; MDC-W0072) Avail: NTIS HC A11/MF A01 CSCL 05H

Design requirements and criteria for the Space Station Advanced Extravehicular Activity System (EVAS) including crew enclosures, portable life support systems, maneuvering propulsion systems, and related extravehicular activity (EVA) support equipment were defined and established. The EVA mission requirements, environments, and medical and physiological requirements, as well as opertional, procedures, and training issues were considered. B.G.

N87-13466*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
FORMATIONKEEPING OF SPACECRAFT VIA DIFFERENTIAL DRAG M.S. Thesis
C. L. LEONARD 1 Jul. 1986 159 p Prepared for Massachusetts Inst. of Tech., Cambridge
(Contract NAS9-17560)
(NASA-CR-171939; NAS 1.26:171939; CSDL-T-920) Avail: NTIS HC A08/MF A01 CSCL 22A

The use of differential drag in the formationkeeping of spacecraft is examined. In many future space missions one satellite will be required to fly in a specific position with respect to another satellite; this action is referred to as formationkeeping. In this study, differential drag is the difference in drag between the two satellites. Reasons to use differential drag as an actuator for formationkeeping include the avoidance of jet plume impingement effects on closely spaced satellites and possible fuel savings. The equations of relative motion between the two satellites are derived and a mathematical transformation is made to reduce the formationkeeping problem to the simultaneous solution of a double integrator and a harmonic oscillator. A two part control law is developed that simultaneously and dependently solves cases being driven to a target position; two different simulations are used. The validity of assumptions made in the derivation of the control law is examined in the comparison of similar test cases run through different simulations. The control law developed can drive a satellite from an initial position to a target position and maintain the satellite at that location. Author

N87-13989*# Hamilton Standard, Hartford, Conn. Space and Sea Systems Dept.
DEVELOPMENT OF A PRE-PROTOTYPE POWER ASSISTED GLOVE END EFFECTOR FOR EXTRAVEHICULAR ACTIVITY Final Report
1986 26 p
(Contract NAS9-17020)
(NASA-CR-171940; NAS 1.26:171940; SVHSER-10630) Avail: NTIS HC A03/MF A01 CSCL 05H

The purpose of this program was to develop an EVA power tool which is capable of performing a variety of functions while at the same time increasing the EVA crewmember's effectiveness by reducing hand fatigue associated with gripping tools through a pressurized EMU glove. The Power Assisted Glove End Effector (PAGE) preprototype hardware met or exceeded all of its technical requirements and has incorporated acoustic feedback to allow the EVA crewmember to monitor motor loading and speed. If this tool is to be developed for flight use, several issues need to be addressed. These issues are listed. Author

N87-14359# MATRA Espace, Paris-Velizy (France).
RENDEZVOUS AND DOCKING (RVD) GUIDANCE SIMULATION PROGRAM, RIDER 2 Final Report
C. PAUVERT and R. WORSWICK Paris, France ESA Jan. 1986 212 p Prepared in cooperation with Logica Ltd., London, England
(Contract ESA-5347/83-NL-BI(SC))
(MATRA-EPT/DT/VT068/012; ESA-CR(P)-2238; ETN-86-98116)
Avail: NTIS HC A10/MF A01

Propellant sloshing and structural flexibility were added to the RVD Simulation Program (now called RVD Guidance Simulator). The performance of the modified program for realistic mission configurations and docking conditions was evaluated. The basic structure of the RVD Guidance Simulator (RVD GS) is kept, but to save computing time, a basic two body (chaser+target) version of the program was developed, rather than a three body version including a dummy Earth, previously used to overcome numerical problems. Simulations provide sets of typical docking conditions in terms of spacecraft relative position, velocity, attitude, and attitude rate for various geometric, dynamic, and control configurations. Worst case parameters are derived from the simulations as typical initial conditions to the Docking Simulation Program. ESA

N87-14364# SATCOM International, Paris (France).
ANALYSIS OF RENDEZVOUS AND DOCKING IN GEOSTATIONARY EARTH ORBIT. RIDER TO COMPARISON OF FUTURE COMMUNICATIONS SPACE SEGMENT CONCEPTS Final Report
C. COUGNET, J. M. AUBERTIN, P. LEBOUAR, B. GOVIN, A. AYOUN, and M. CALDICHOURY Toulouse, France Matra Espace Sep. 1982 164 p
(Contract ESA-4818/81-NL-MD)
(DM51-C/PL/FL/0099.82; ESA-CR(P)-2011-VOL-2; ETN-87-98644) Avail: NTIS HC A08/MF A01

Geostationary rendezvous homing, final approach, and docking phases were analyzed. The target is assumed to be a linear telecommunication platform composed of a service module and several payload modules; when operating, the platform must not be disturbed by the rendezvous and docking (RVD) operations. A period of time compatible with the orientation of the solar arrays is allocated each day for the final approach and docking phase. The homing phase and final approach are analyzed with simulations which propose a nominal strategy to meet the constraints and requirements, and to reuse as much as possible hardware already implemented on board. The analysis of docking phase is performed in terms of performance and requirements, and results in the definition of docking mechanism concepts. Block diagram of the RVD is compared to the reference scenario; the applicability of the scenario to ESAS platform and specific RVD hardware are discussed. ESA

N87-14374*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
PROCEEDINGS OF THE SMRM DEGRADATION STUDY WORKSHOP
1985 351 p Workshop held in Greenbelt, Md., 9-10 May 1985
(NASA-TM-89274; REPT-408-SMRM-79-0001; NAS 1.15:89274)
Avail: NTIS HC A16/MF A01 CSCL 22B

The proceedings of the Solar Maximum Repair Mission Degradation Study Workshop, held at the Goddard Space Flight Center in Greenbelt, Maryland on May 9 to 10, 1985 are contained. The results of tests and studies of the returned Solar Maximum Mission hardware and materials are reported. Specifically, the workshop was concerned with the effects of four years' exposure to a low-Earth orbit environment. To provide a background for the reported findings, the summary includes a short description of the Solar Maximum Mission and the Solar Maximum Repair Mission.

N87-14375*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
REPORT ON SMRM C/P MAIN ELECTRONICS BOX COMPONENT AND MATERIALS DEGRADATION EVALUATIONS
R. E. DAVIS *In its* Proceedings of the SMRM Degradation Study Workshop p 33-40 1985
Avail: NTIS HC A16/MF A01 CSCL 22B

The history of the Main Electronics Box (MEB), a description of the the assembly, and handling conditions following the Solar Maximum Repair Mission are contained. B.G.

N87-14394# European Space Agency, Paris (France).
PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM ON FLUID DYNAMICS AND SPACE
W. R. BURKE, comp. Aug. 1986 205 p Symposium held in Rhode-Saint-Genese, Belgium, 25-26 Jun. 1986; organized by ESA, and the Von Karman Inst. for Fluid Dynamics
(ESA-SP-265; ISSN-0379-6566; ETN-87-98893) Avail: NTIS HC A10/MF A01

Reentry aerothermodynamics; rocket engines; spacecraft environments; and fluid dynamic experiments in space were discussed. ESA

N87-14423*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE SURVIVABILITY OF LARGE SPACE-BORNE REFLECTORS UNDER ATOMIC OXYGEN AND MICROMETEOROID IMPACT
D. A. GULINO 1987 18 p Presented at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by AIAA
(NASA-TM-88914; E-3338; NAS 1.15:88914) Avail: NTIS HC A02/MF A01 CSCL 21H

Solar dynamic power system mirrors for use on space station and other spacecraft flown in low Earth orbit (LEO) are exposed to the harshness of the LEO environment. Both atomic oxygen and micrometeoroids/space debris can degrade the performance of such mirrors. Protective coatings will be required to protect oxidizable reflecting media, such as silver and aluminum, from atomic oxygen attack. Several protective coating materials have been identified as good candidates for use in this application. The durability of these coating/mirror systems after pinhole defects have been inflicted during their fabrication and deployment or through micrometeoroid/space debris impact once on-orbit is of concern. Studies of the effect of an oxygen plasma environment on protected mirror surfaces with intentionally induced pinhole defects have been conducted at NASA Lewis and are reviewed. It has been found that oxidation of the reflective layer and/or the substrate in areas adjacent to a pinhole defect, but not directly exposed by the pinhole, can occur. Author

N87-15028# Committee on Commerce, Science, and Transportation (U.S. Senate).
REPORT OF THE NATIONAL COMMISSION ON SPACE
Washington GPO 1986 53 p Hearing before the Subcommittee on Science, Technology and Space of the Committee on Commerce, Science and Transportation, 99th Congress, 2nd Session, 22 Jul. 1986
(S-HRG-99-954; GPO-64-727) Avail: Subcommittee on Science, Technology and Space

The proposed agenda for the civilian space program for the next 20 years and beyond was discussed. The National Commission on Space proposed a broad, long-range, pioneering mission which includes: exploration and development of the space frontier; advancing science, technology, and enterprise; and building institutions and systems that make acessible vast resources and support human settlement beyond Earth orbit, from the highlands of the Moon to the plains of Mars. To accomplish this mission, three mutually-supportive thrusts are outlined: advancing scientific understanding of the planet Earth, the solar system, and the universe; exploring, prospecting, and settling the solar system; and stimulating space enterprise. B.G.

N87-15259*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE SPIDER CRANE Patent Application
IAN O. MACCONOCHIE, inventor (to NASA), JACK E. PENNINGTON, inventor (to NASA), CHARLES F. BRYAN, JR., inventor (to NASA), MARTIN M. MIKULAS, JR., inventor (to NASA), and REBECCA L. KINKEAD, inventor (to NASA) 30 Sep. 1986 18 p
(NASA-CASE-LAR-13411-1SB; NAS 1.71:LAR-13411-1; US-PATENT-APPL-SN-913432) Avail: NTIS HC A02/MF A01 CSCL 84G

A space spider crane for the movement, placement, and/or assembly of various components on or in the vicinity of a space structure is described. As permanent space structures are utilized by the space program, a means will be required to transport cargo and perform various repair tasks. A space spider crane comprising a small central body with attached manipulators and legs fulfills this requirement. The manipulators may be equipped with constant pressure gripping end effectors or tools to accomplish various repair tasks. The legs are also equipped with constant pressure gripping end effectors to grip the space structure. Control of the space spider crane may be achieved either by computer software or a remotely situated human operator, who maintains visual contact via television cameras mounted on the space spider crane. One possible walking program consists of a parallel motion walking program whereby the small central body alternatively leans forward and backward relative to end effectors. NASA

N87-16014*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA/DOD CONTROL/STRUCTURES INTERACTION TECHNOLOGY, 1986
ROBERT L. WRIGHT, comp. Nov. 1986 549 p Conference held in Norfolk, Va., 18-21 Nov. 1986; sponsored by NASA Langley Research Center and AFWAL
(NASA-CP-2447-PT-1; L-16242-PT-1; NAS 1.55:2447-PT-1) Avail: NTIS HC A23/MF A01 CSCL 22B

Control/structures interactions, deployment dynamics and system performance of large flexible spacecraft are discussed. Spacecraft active controls, deployable truss structures, deployable antennas, solar power systems for space stations, pointing control systems for space station gimballed payloads, computer-aided design for large space structures, and passive damping for flexible structures are among the topics covered.

N87-16027*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SENSOR TECHNOLOGY FOR ADVANCED SPACE MISSIONS
N. M. NERHEIM and R. P. DEPAULA *In* NASA. Langley Research Center NASA/DOD Control/Structures Interaction Technology, 1986 p 207-219 Nov. 1986
Avail: NTIS HC A23/MF A01 CSCL 14B

The capability and applications of two sensors, Spatial, High-Accuracy, Position-Encoding Sensor (SHAPES) and Fiber Optics Rotation Sensor (FORS), for advanced missions are discussed. The multiple target, 3-D position sensing capability of SHAPES meets a critical technology need for many developing applications. A major milestone of the SHAPES task was completed on schedule on May 30, 1986, by demonstrating simultaneous ranging to eight moving targets at a rate of 10 measurements per second. The range resolution to static target was shown to be 25 microns. SHAPES scheduled technology readiness will support the sensor needs of a number of early users. The next phase in the development of SHAPES is to incorporate an angular measurement CCD to provide the full 3-dimensional sensing. A flight unit design and fabrication can be complete by FY89. FORS, with its significant improvement over present technology in lifetime, performance, weight, power, and recurrent cost, will be an important technology for future space systems. Technology readiness will be demonstrated with a FORS brassboard with fully integrated IO chips by FY88. The unique capability of miniature remote sensing heads, connected to a central system, will open up new areas in control and stability of large space structures. This application requires additional study. Author

N87-16321*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE 20TH AEROSPACE MECHANICS SYMPOSIUM
May 1986 316 p Symposium held in Cleveland, Ohio, 7-9 May 1986; sponsored by NASA, the California Inst. of Tech. and LMSC
(NASA-CP-2423-REV; E-2904; NAS 1.55:2423-REV) Avail: NTIS HC A14/MF A01 CSCL 20K

Numerous topics related to aerospace mechanisms were discussed. Deployable structures, electromagnetic devices, tribology, hydraulic actuators, positioning mechanisms, electric motors, communication satellite instruments, redundancy, lubricants, bearings, space stations, rotating joints, and teleoperators are among the topics covered.

N87-16338*# Sperry Corp., Phoenix, Ariz. Space Systems Div.
SPACE STATION ROTARY JOINT MECHANISMS
GLEN W. DRISKILL *In* NASA. Lewis Research Center The 20th Aerospace Mechanics Symposium p 241-251 May 1986
Avail: NTIS HC A14/MF A01 CSCL 13I

The mechanism which will be used on the space station to position the solar arrays and radiator panels for Sun pointing and Sun avoidance is described. The unique design features will be demonstrated on advanced development models of two of the joints being fabricated under contract to NASA-MSFC. Author

N87-16366# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
DAMPING 1986 PROCEDURES, VOLUME 2 Summary Report, Feb. 1984 - Feb. 1986
E. D. PINSON, D. W. NICHOLSON, M. G. PRASAD, R. H. LIN, and B. K. WADA May 1986 614 p
(AD-A173950; AFWAL-TR-86-3059-VOL-2) Avail: NTIS HC A99/MF A01 CSCL 20K

Individual conference papers are presented. Some of the titles include: Damping Characteristics of the Solar Array Flight Experiment; Resonant Shift Modal Testing Method for Viscous Damping Coefficient Estimation; Prediction of Spacecraft Damping; On Orbit Flexible Body Parameter Identification for Space Station; Design and Analysis of the PACOSS Representative System; Robust Control Design for Vibration Suppression of Large Space Structures; Active Augmentation of a Passively Damped Representative Large Space System; Active Control for Vibration

Damping; A New Approach to Modeling Linear Viscoelastic Damping for Space Structures; Expertimental Investigations Into Passive and Active Control Using Space Realized Techniques; Material Damping in Aluminum and Metal Matrix Materials; Material Damping in Space Structures; Specific Damping Capacity of Metal Matrix Composites in Tension Tension Fatigue; Response Suppression in Composite Sandwich Shells; Prediction of Material Damping of Laminated Polymer Matrix Composites; The Influence of Fiber Length and Fiber Orientation on Damping and Stiffness of Polymer Composite Materials; A Review of the Damping Mechanisms in Advanced Fiber Reinforced Plates; Damping Measurements by Hilbert Transform on Composite Materials; and A Comparison Among Damping Coefficients on Several Aerospace Composite Materials. GRA

N87-16662# Executive Office of the President, Washington, D.C.
AERONAUTICS AND SPACE REPORT OF THE PRESIDENT: 1985 ACTIVITIES
1986 132 p
Avail: NTIS HC A07/MF A01

The achievements of aeronautics and space programs in the United States for 1985 are summarized in the areas of communications; Earth atmosphere, environment, and resources; space science; space transportation; commercial use of space; space tracking and data systems; space station; and aeronautics and space research and technology. The achievements of each of the following organizations are described: National Aeronautics and Space Administration, Department of Defense, Department of Commerce, Department of Energy, Department of the Interior, Department of Agriculture, Federal Communications Commission, Department of Transportation, Environmental Protection Agency, National Science Foundation, Smithsonian Institution, Department of State, Arms Control and Disarmament Agency, and United States Information Agency. Appendices provide historical information on launches, satellites, manned and unmanned spacecraft, and federal budgets for aeronautical and astronautical activities. J.P.B.

N87-16944# Contraves Italiana, Rome.
CONTRAVES' ANTENNA TIP HINGE MECHANISM FOR SELENIA SPAZIO'S 20/30 GHZ ANTENNA
D. STELLA, F. MORGANTI (Selenia S.p.A., Rome, Italy), and G. NIELSEN (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands) *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 185-194 Aug. 1986
Avail: NTIS HC A12/MF A01

A mechanism which can deploy a folded tip of an antenna in orbit, the Antenna Tip Hinge Mechanism (ATHM) was developed. The ATHM consists of two hinges, each near the edge of the antenna main body and tip interface. Following a command, the antenna tip is released and spiral springs drive the antenna tip to its end position, where latches secure the tip in place. No damping or any form of energy dissipation is provided for, other than that which is caused by friction within the system. Two ATHM's, one at each end of the antenna, enable a 20/30 GHz multibeam antenna to fit in the Ariane 4 shroud. This mechanism can, with minor modifications, be used to deploy a multitude of different systems, provided that they are not too fragile to withstand the deceleration loads that occur at the end of deployment. ESA

N87-16946# Sener, S.A., Madrid (Spain).
A SENER MECHANISM: FINE ADJUSTMENT MECHANISM FOR THE FAR INFRARED AND SUBMILLIMETER SPACE TELESCOPE (FIRST) (F F F)
F. DELCAMPO, J. DELTORO, and J. RIVACOBA *In* ESA Proceedings of the Second ESA Workshop on Mechanical Technology for Antennas p 205-210 Aug. 1986
Avail: NTIS HC A12/MF A01

A mechanism for obtaining very fine variations of the relative angular position of two surfaces having a common hinge axis is presented. The mechanism introduces no backlash, by using flexing elements for articulations. It can be designed for very high torsional stiffness. Applications include controlling the final angular aperture of deployable antennas, e.g., the petals of the FIRST antenna. For this case, main requirements are: minimum angular step 0.001 arc min; total angular range 2.6 arc min; torsional stiffness 900,000 Nm/rad. ESA

N87-17036* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SUN SHIELD Patent
ARTHUR M. FRANK, inventor (to NASA), SILVIO F. DERESPINIS, inventor (to NASA), and JOHN MOCKOVCIAK, JR., inventor (to NASA) 20 Jan. 1987 8 p Filed 12 Aug. 1985 Supersedes N86-20803 (24 - 11, p 1783)
(NASA-CASE-MSC-20162-1; US-PATENT-4,637,447; US-PATENT-APPL-SN-764805; US-PATENT-CLASS-160-265; US-PATENT-CLASS-160-23R; US-PATENT-CLASS-244-121; US-PATENT-CLASS-244-158R; US-PATENT-CLASS-135-903; US-PATENT-CLASS-296-100) Avail: US Patent and Trademark Office CSCL 13I

A shading device which is capable of compactly storing a flexible shade on a biased, window shade type spring roller is disclosed. It is controlled to deliver the shade selectively to either its operative shading or compact storage orientation.
Official Gazette of the US Patent and Trademark Office

N87-17656*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RESEARCH AND TECHNOLOGY Annual Report, 1986
1986 103 p
(NASA-TM-88868; NAS 1.15:88868) Avail: NTIS HC A06/MF A01 CSCL 05A

The research and technology accomplishments of the NASA Lewis Research Center are summarized for the fiscal year 1986, the 45th anniversary year of the Center. Five major sections are presented covering: aeronautics, aerospace technology, space communications, space station systems, and computational technology support. A table of contents by subjects was developed to assist the reader in finding articles of special interest. Author

N87-17810# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
COMBINED ORBIT/ATTITUDE DETERMINATION FOR LOW-ALTITUDE SATELLITES
PAUL WINCHESTER CHODAS Dec. 1986 275 p
(UTIAS-320; ISSN-0082-5255; AD-B109229L) Avail: NTIS HC A12/MF A01

Orbit and attitude determination are studied as a single combined estimation problem, and the coupling between the orbit and attitude dynamics is included. The focus is on missions with large spacecraft in low-altitude Earth orbits. The orbit and attitude motions are coupled by the gravitational forces and torques and the aerodynamic forces and torques, which are the dominant environment effects for the class of missions under consideration. A computer simulation of the combined orbit and attitude determination problem, including the coupled orbit and attitude equations of motion, was implemented. Two combinations of measurement types are studied: ground tracking with onboard star observations, and onboard tracking of known landmarks combined with star observations. The effect of the dynamic orbit-attitude coupling on the position and attitude estimates was studied. It is shown that the inclusion of the dynamic coupling improves the position and attitude estimates substantially. Using covariance analysis techniques, it is demonstrated that the attitude uncertainties are unrealistically small without coupling, and that this lead to divergence in the attitude estimate. The use of process noise to prevent this divergence in the attitude estimate is studied. A process noise model which includes some of the coupling effects is also applied to the problem. Author

N87-17820* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SYSTEMS: A CONTINUING BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 3)
Jan. 1987 205 p
(NASA-SP-7056(03); NAS 1.21:7056(03)) Avail: NTIS HC A10 CSCL 22A

This bibliography lists 780 reports, articles and other documents introduced into the NASA scientific and technical information system between January 1, 1986 and June 30, 1986. 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 system. The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future space station. Author

N87-17821*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PROCEEDINGS OF THE 3RD ANNUAL SCOLE WORKSHOP
LAWRENCE W. TAYLOR, JR., comp. Jan. 1987 457 p Workshop held in Hampton, Va., 17-18 Nov. 1986; sponsored by NASA Langley Research Center and California Univ., Los Angeles
(NASA-TM-89075; NAS 1.15:89075) Avail: NTIS HC A20/MF A01 CSCL 22B

Topics addressed include: modeling and controlling the Spacecraft Control Laboratory Experiment (SCOLE) configurations; slewing maneuvers; mathematical models; vibration damping; gravitational effects; structural dynamics; finite element method; distributed parameter system; on-line pulse control; stability augmentation; and stochastic processes.

N87-17838*# McDonnell-Douglas Astronautics Co., Houston, Tex.
ADVANCED EVA SYSTEM DESIGN REQUIREMENTS STUDY, EXECUTIVE SUMMARY Final Technical Report
Jan. 1986 45 p
(Contract NAS9-17299)
(NASA-CR-171960; NAS 1.26:171960; MDC-W0072) Avail: NTIS HC A03/MF A01 CSCL 22B

Design requirements and criteria for the space station advanced Extravehicular Activity System (EVAS) including crew enclosures, portable life support systems, maneuvering propulsion systems, and related EVA support equipment were established. The EVA mission requirements, environments, and medical and physiological requirements, as well as operational, procedures and training issues were considered. B.G.

N87-18583*# Science Applications International Corp., Schaumberg, Ill. Advanced Planning and Analysis Div.
SATELLITE SERVICING PRICE ESTIMATION INSTRUCTION BOOKLET
Jan. 1987 47 p
(Contract NAS9-17207)
(NASA-CR-171967; NAS 1.26:171967; SAIC-87/1515; SAIC-1-120-778-C15) Avail: NTIS HC A03/MF A01 CSCL 22A

The results of a brief study to develop a possible methodology for estimating the price to non-U.S. Government users for satellite servicing are documented. B.G.

N87-19814# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systems Balistiques et Spatiaux.
THE CONCENTRATION PRINCIPLE APPLIED TO SPACEBORNE SOLAR ARRAYS. APPLICATION TO THE COORBITING PLATFORM MISSION: STUDIES SYNTHESIS
R. LAGET Paris, France ESA 27 Jan. 1986 46 p
(Contract ESA-5978/84-NC-PB(SC))
(SNIAS-975-CA/CG; ESA-CR(P)-2291-VOL-1; ETN-87-99482)
Avail: NTIS HC A03/MF A01

Studies that led to selection of the distributed concentration biplane concept for the solar cell generator to be flown on the coorbiting platform mission, and the major characteristics of such a spaceborne solar array are summarized. It is concluded that there is not a considerable interest in concentration either for array area reduction or cost reduction, although improvements of 15% for both domains are feasible. Only predevelopment activities to verify concentrator performances and system studies to assess respective importance of cost and area saving may increase the level of interest of concentrator solar arrays for this kind of mission. ESA

N87-20057*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE STRUCTURES AND TETHERS WORKING GROUP
G. MURPHY, H. GARRETT, U. SAMIR, A. BARNETT, J. RAITT, J. SULLIVAN, and I. KATZ *In its* Space Technology Plasma Issues in 2001 p 6-11 1 Oct. 1986
Avail: NTIS HC A20/MF A01 CSCL 22B

The Large Structures and Tethers Working Group sought to clarify the meaning of large structures and tethers as they related to space systems. Large was assumed to mean that the characteristic length of the structure was greater than one of such relevant plasma characteristics as ion gyroradius or debey length. Typically, anything greater than or equal to the Shuttle dimensions was considered large. It was agreed that most large space systems that the tether could be better categorized as extended length, area, or volume structures. The key environmental interactions were then identified in terms of these three categories. In the following Working Group summary, these categories and the related interactions are defined in detail. The emphasis is on how increases in each of the three spatial dimensions uniquely determine the interactions with the near-Earth space environment. Interactions with the environments around the other planets and the solar wind were assumed to be similar or capable of being extrapolated from the near-Earth results. It should be remembered in the following that the effects on large systems do not just affect specific technologies but will quite likely impact whole missions. Finally, the possible effects of large systems on the plasma environment, although only briefly discussed, were felt to be of potentially great concern. Author

N87-20071*# Science Applications International Corp., McLean, Va. Plasma Physics Div.
TECHNICAL ISSUES IN THE CONDUCT OF LARGE SPACE PLATFORM EXPERIMENTS IN PLASMA PHYSICS AND GEOPLASMA SCIENCES
EDWARD P. SZUSZCZEWICZ *In* JPL, Space Technology Plasma Issues in 2001 p 225-236 1 Oct. 1986
Avail: NTIS HC A20/MF A01 CSCL 20I

Large, permanently-manned space platforms can provide exciting opportunities for discoveries in basic plasma and geoplasma sciences. The potential for these discoveries will depend very critically on the properties of the platform, its subsystems, and their abilities to fulfill a spectrum of scientific requirements. With this in mind, the planning of space station research initiatives and the development of attendant platform engineering should allow for the identification of critical science and technology issues that must be clarified far in advance of space station program implementation. An attempt is made to contribute to that process, with a perspective that looks to the development of the space station as a permanently-manned Spaceborne Ionospheric Weather Station. The development of this concept requires a synergism of science and technology which leads to several critical design

issues. To explore the identification of these issues, the development of the concept of an Ionospheric Weather Station will necessarily touch upon a number of diverse areas. These areas are discussed. Author

N87-20079*# California Univ., San Diego, La Jolla. Center for Astrophysics and Space Science.

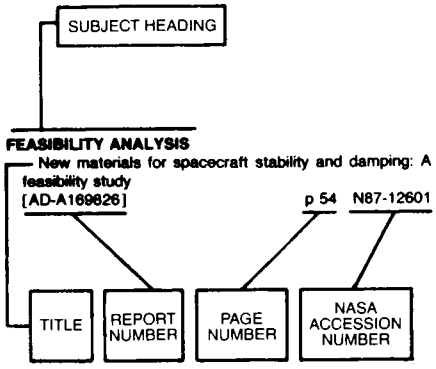
CONTROLLING AND MONITORING THE SPACE-STATION PLASMA INTERACTION: A BASELINE FOR PERFORMING PLASMA EXPERIMENTS AND USING ADVANCED TECHNOLOGY Abstract Only

ELDEN C. WHIPPLE and RICHARD C. OLSEN (Alabama Univ., Huntsville) *In* JPL, Space Technology Plasma Issues in 2001 p 310 1 Oct. 1986

Avail: NTIS HC A20/MF A01 CSCL 22B

The size, complexity, and motion of space station through the Earth's environmental plasma means that there will be a large, complicated interaction region, involving a sheath, wake, charging of surfaces, induced electric fields, secondary emission, outgassing with ionization, etc. This interaction will necessarily be a factor in carrying out and interpreting plasma experiments and in the use of certain technologies. Attention should be given ahead of time to: (1) monitoring this interaction so that it is well described; (2) implifying the interaction by appropriate design and construction of the spacecraft and by appropriate planning of technology use; and (3) controlling the interaction by both active and passive means. Plasma emitters for modifying and controlling the spacecraft charge should be placed in several locations. Portable electrostatic shields could be deployed around noisy sections of the spacecraft in order to carry out sensitive experiments. A particle umbrella could be raised to deflect the ram ions and neutrals in order to provide a controlled environment. These interactions are briefly discussed. Author

Typical Subject Index Listing



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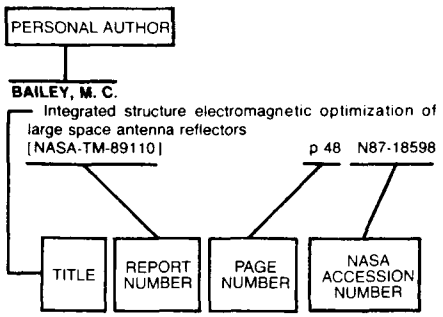

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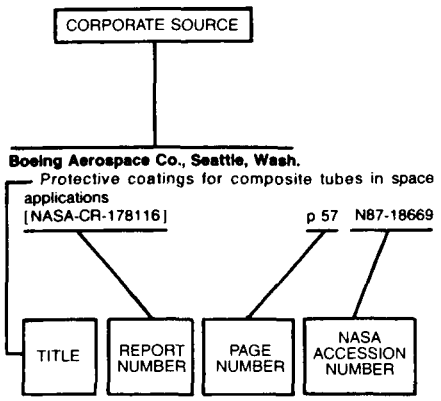

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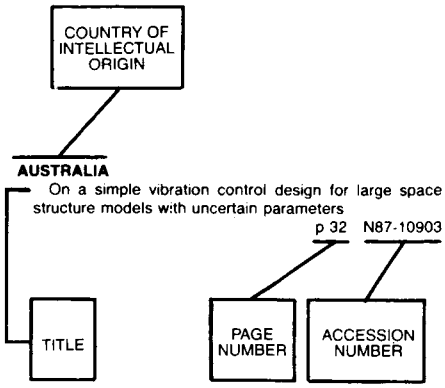

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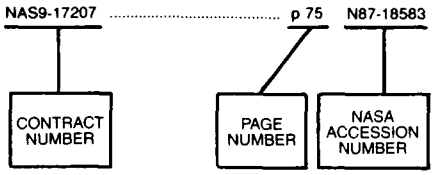

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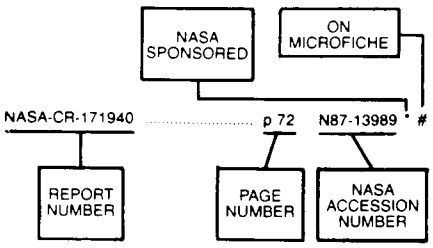

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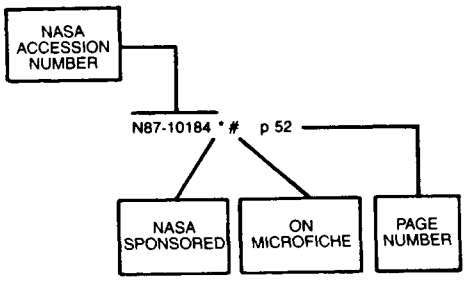

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