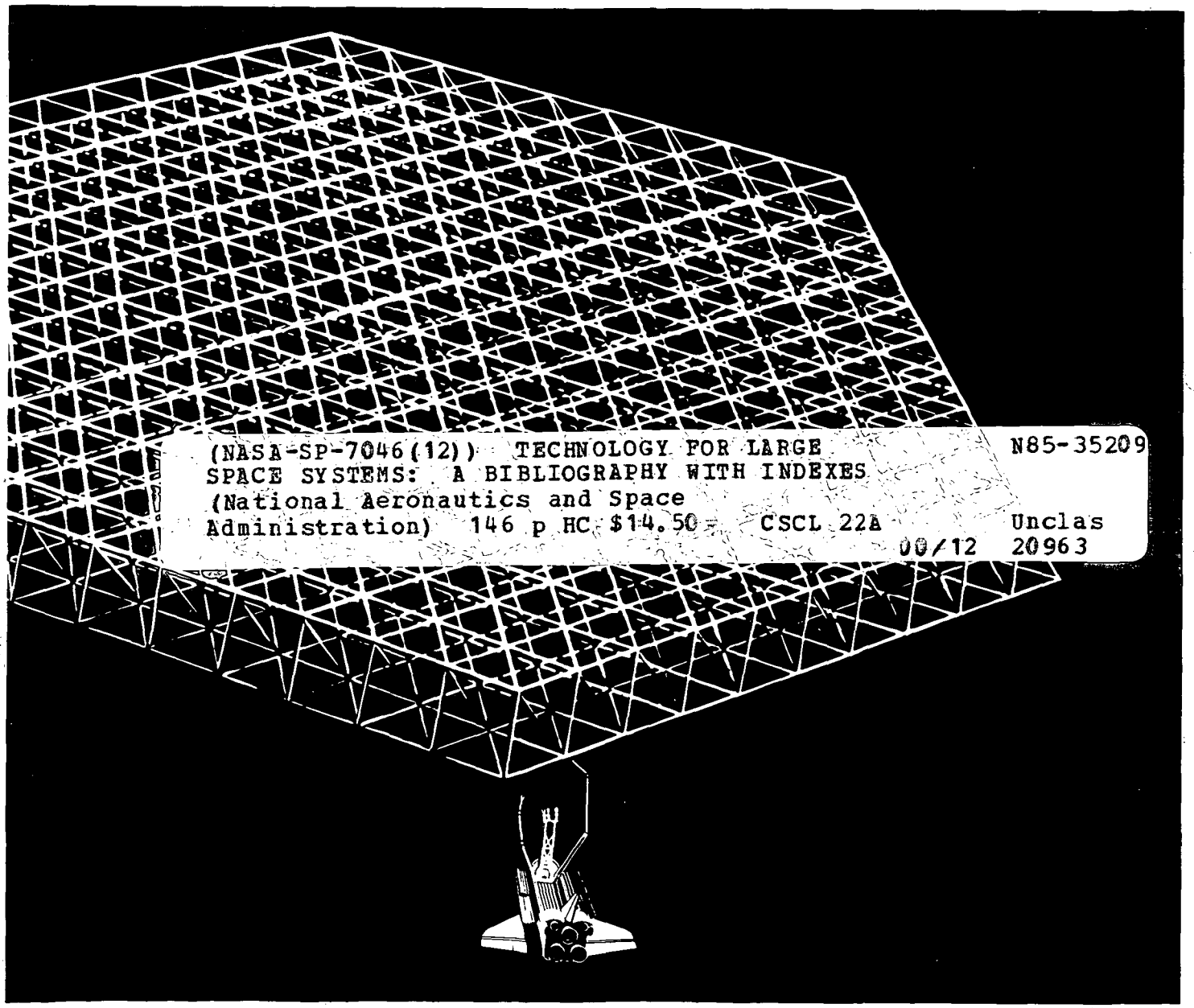
NASA SP-7046(12)
July 1985

Technology for Large Space Systems

(Includes Special Space Station Section)

A Bibliography
with Indexes

SPECIAL NOTICE ENCLOSED
NEW FOREIGN TECHNOLOGY INDEX INCLUDED IN THIS ISSUE



NASA SP-7046(12)
Technology for Large Space Systems
A Bibliography with Indexes
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SPECIAL NOTICE

FOREIGN TECHNOLOGY INDEX IN THIS ISSUE

Documents referred to in this bibliography whose country of intellectual origin is other than the United States are listed in the Foreign Technology Index (see page D-1).

A great deal of excellent scientific and technical work is done throughout the world. To the extent that U.S. researchers, engineers, and industry can utilize what is done in foreign countries, we save our resources. We can thus increase our country's productivity.

We are testing out this approach by helping readers bring foreign technology into focus. We would like to know whether it is useful, and how it might be improved.

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NASA SP-7046(12)

TECHNOLOGY FOR LARGE SPACE SYSTEMS
(Includes Special Space Station Section)

A BIBLIOGRAPHY WITH INDEXES

Supplement 12

Compiled by
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A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between July 1 and December 31, 1984 in

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

NASA Scientific and Technical Information Branch 1985
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 ($14.50 domestic; $29.00 foreign).

INTRODUCTION

This bibliography is designed to be helpful to the researcher and manager engaged in 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 516 reports, articles and other documents announced between July 1, 1984 and December 31, 1984 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 platforms and 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 special space station category is included to cover space station technology that does not fit into any LSST category, but may be applicable to other large structure programs. Beginning with the next issue, covering the first six months of 1985, space station items not applicable to large space structures will not be in LSST. They will be included in a separate semiannual space station bibliography.

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

AVAILABILITY OF CITED PUBLICATIONS

IAA ENTRIES (A84-10000 Series)

All publications abstracted in this Section are available from the Technical Information Service, American Institute of Aeronautics and Astronautics, Inc. (AIAA), as follows: Paper copies of accessions are available at $8.50 per document. Microfiche[1] of documents announced in *IAA* are available at the rate of $4.00 per microfiche on demand. Standing order microfiche are available at the rate of $1.45 per microfiche for *IAA* source documents.

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

Avail: NTIS. Sold by the National Technical Information Service. Prices for hard copy (HC) and microfiche (MF) are indicated by a price code preceded by the letters HC or MF in the *STAR* citation. Current values for the price codes are given in the tables on page viii.

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Initially distributed microfiche under the NTIS SRIM (Selected Research in Microfiche) is available at greatly reduced unit prices. For this service and for information concerning subscription to NASA printed reports, consult the NTIS Subscription Section, Springfield, Va. 22161.

NOTE ON ORDERING DOCUMENTS: When ordering NASA publications (those followed by the * symbol), use the N accession number. NASA patent applications (only the specifications are offered) should be ordered by the US-Patent-Appl-SN number. Non-NASA publications (no asterisk) should be ordered by the AD, PB, or other *report* number shown on the last line of the citation, not by the N accession number. It is also advisable to cite the title and other bibliographic identification.

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(1) A microfiche is a transparent sheet of film, 105 by 148 mm in size containing as many as 60 to 98 pages of information reduced to micro images (not to exceed 26.1 reduction).

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

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

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DOMESTIC: NASA and NASA-sponsored documents and a large number of aerospace publications are available to the public for reference purposes at the library maintained by the American Institute of Aeronautics and Astronautics, Technical Information Service, 555 West 57th Street, 12th Floor, New York, New York 10019.

EUROPEAN: An extensive collection of NASA and NASA-sponsored publications is maintained by the British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England for public access. The British Library Lending Division also has available many of the non-NASA publications cited in *STAR.* European requesters may purchase facsimile copy or microfiche of NASA and NASA-sponsored documents, those identified by both the symbols # and * from ESA — Information Retrieval Service European Space Agency, 8-10 rue Mario-Nikis, 75738 CEDEX 15, France.

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NOTICE

A special Space Station section is included since the Space Station is a special class of large structures and large quantities of information are being generated that may be applicable to other large structures programs.

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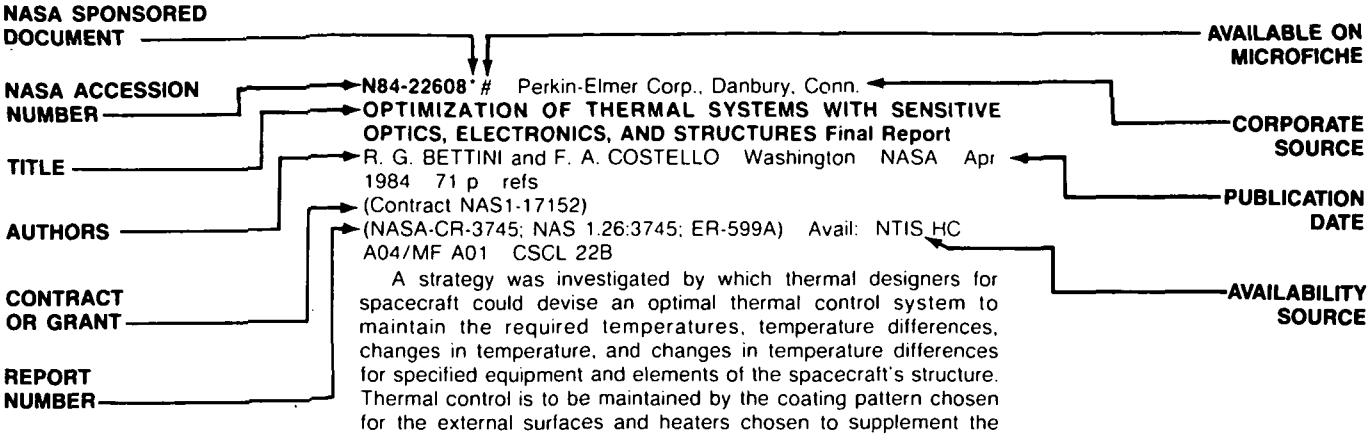

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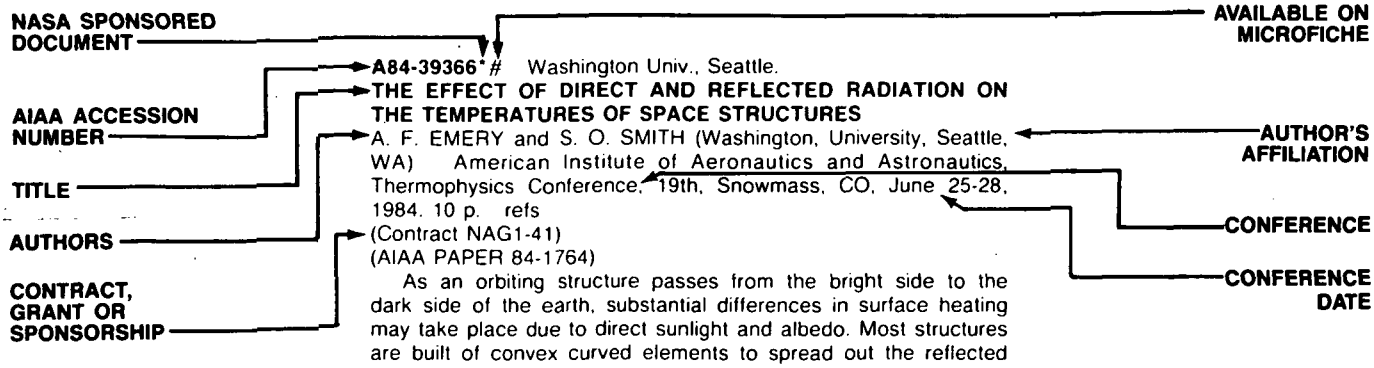

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 12)

JULY 1985

01

SYSTEMS

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

A84-30551* Martin Marietta Aerospace, Denver, Colo.
MISSION PLANNING FOR LARGE MICROWAVE RADIOMETERS
W. A. SCHARTEL (Martin Marietta Aerospace, Denver, CO) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 San Diego, CA, Univelt, Inc., 1984, p. 435-442.
(Contract NAS1-16756)
(AAS PAPER 83-348)

Earth orbiting, remote sensing platforms that use microwave radiometers as sensors are susceptible to data interpretation difficulties. The capability of the large microwave radiometer (LMR) was augmented with the inclusion of auxillary sensors that expand and enhance the LMR capability. The final system configuration demonstrates a holistic approach in the design of future orbiting remote sensing platforms that use a LMR as the core instrument. Author

A84-30554
SOME CONSIDERATIONS ON THE ORBITAL TRANSFER OF LARGE DEPLOYABLE SYSTEMS
C. E. FARRELL (Martin Marietta Aerospace, Denver, CO) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 485-493. refs
(AAS PAPER 83-356)

An analysis of orbital transfer requirements for a typical LDS antenna was performed to provide data to assist in selecting the mode of transfer, deployed or undeployed. Forces and torques due to aerodynamic and solar pressures and gravity gradient were predicted to determine linear and rotational impulse losses incurred during transfer. Results show that linear impulse losses will not significantly increase primary propellant requirement. However, torques encountered exceed the capability of the electric thrusters selected to meet on-orbit ACS requirements for the LDS model of the study. Author

A84-32273#
A SPACECRAFT FOR FUTURE ORBITAL INFRASTRUCTURE [EIN RAUMFAHRZEUG FUER DIE KUENFTIGE ORBITALE INFRASTRUKTUR]
D. E. KOELLE (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 5, 1st Quarter 1984, p. 3-7. In German.

A concept for an operational spacecraft to be used in earth orbit in the process of industrializing space is introduced. The demand for interorbital travel is briefly discussed. The structure of the spacecraft, which consists of six modules which can be combined in different ways for different tasks, is described and depicted. The propulsion module is also shown and briefly described. The structure and function of a permanent polar platform are briefly presented. C.D.

A84-34007#
SHUTTLE TETHERED SATELLITE SYSTEM DEVELOPMENT PROGRAM
D. S. CROUCH (Martin Marietta Aerospace, Denver, CO) and M. M. VIGNOLI (Aeritalia S.p.A., Naples, Italy) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 21-31.
(AIAA PAPER 84-1106)

This paper contains an overview of the Shuttle Orbiter-based Tethered Satellite System which is being jointly developed by the United States of America and Italy. Operation of the system is described including interfaces with the orbiter and crew, and with the Johnson Space Center Mission Control Center and Payload Operations Control Center. A brief description is provided of the Tethered Satellite System hardware located in the orbiter cargo bay, scientific capabilities of the overall system, and subsystems required of the Italian satellite. The system orbital dynamics computer simulation model is summarized, and typical design reference mission parameters illustrated. Author

A84-37044
EUROPEAN SPACE MISSIONS OF THE FUTURE [FUTUROLOGIE APPLIQUEE AL'ESPACE EUROPEEN]
H. CURIEN (Centre National d'Etudes Spatiales, Paris, France) Air et Cosmos (ISSN 0044-6971), May 5, 1984, p. 261-263, 265-267. In French.

Directions European space research and programs will follow in the near term are outlined. Earth resources monitoring on a commercial basis will begin with the launch of the SPOT satellite. Other satellites of the next decade will include Meteosat improvements, ERS-1 and Telecom 1. A debate is beginning regarding the feasibility of a solely European space station. Studies are under way on a configuration of the Solaris unmanned experimental pallet satellite. A Shuttle-like vehicle, the Hermes, is also under consideration, as are joint NASA-ESA missions that include: a 'rover' vehicle to explore the Martian surface, a spacecraft rendezvous with several asteroids, and a Saturn-orbiting spacecraft. M.S.K.

A84-37376
DISCOVERY WILL ERECT 102-FT. STRUCTURE
C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 120, June 18, 1984, p. 57-60, 64.

Mission features and objectives of the maiden flight of the Shuttle Discovery are outlined. Hormones will be produced in an electrophoresis machine that is a prototype of a commercial operation. A Large Format Camera (LFC) will be used for earth imaging of objects as small as 65 ft across, as well as for stars and horizon shots. The Leasat (Syncom 4) will be launched from the bay using a Frisbee technique to impart a 2 rpm spin. A deployable 102 ft mast supporting a large solar array will be deployed and retrieved several times as part of the space station development effort. Indium crystal growth will be studied in the Fluids Experiment Apparatus and a new remote manipulator arm will be put through engineering trials. Most of the mission will be flown at 173 n mi altitude unitl the later phases, when the orbit

will be switched to lower altitudes to test the LFC. The Discovery is scheduled to land at Edwards AFB after a 168 hr flight.
M.S.K.

A84-38128* National Aeronautics and Space Administration, Washington, D. C.
THE CURRENT PROGRAMS OF THE U.S. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
K. S. PEDERSEN and U. J. SAKSS (NASA, International Affairs Div., Washington, DC) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 3-10.

This paper discusses the U.S. civil space programs carried out by the U.S. National Aeronautics and Space Administration (NASA). The current status of NASA's major program elements, including current funding, for space transportation systems, space science, and space applications are described. In discussing each area, the current status of NASA's major international cooperative projects is briefly described in terms of the respective responsibilities of the partners and the anticipated launch date and operational period of each mission. Also described are NASA's plans for future missions using the Space Transportation System (STS), with emphasis on possible development of an earth-orbiting manned space station. Author

A84-38177
HIGH ACCURACY DEPLOYABLE ANTENNA FOR COMMUNICATIONS SATELLITE
M. WATANABE, M. MISAWA, M. MINOMO, and T. YASAKA (Nippon Telegraph and Telephone Public Corp., Yokosuka Electrical Communication Laboratory, Yokosuka, Kanagawa, Japan) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 401-406.

High frequency multi-beam satellite antennas have been studied to realize increased communication capacity, simplified earth stations, and multiple frequency reuse. The satellite antenna needs a highly accurate and large reflector. To overcome the launching vehicle's constraints in size and weight, a solid deployable antenna is under development. A petal antenna (PETAL), composed of solid shell elements, has been studied as a high frequency use deployable antenna. It is an axi-symmetric antenna composed of a fixed central shell and deployable triangular and square shells. During the launch phase, a restraining cable is bound around the periphery of deployable elements stowed in a hexagonal configuration. Deployment is initiated by pyrotechnic cable cutters, and the shells are deployed by spring action. Author

A84-38235
COMMUNICATIONS SATELLITES - SPACECRAFT AND SYSTEM ARCHITECTURE EVOLUTION
P. L. BARGELLINI (COMSAT Laboratories, Clarksburg, MD) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 811-817. Research sponsored by the Communications Satellite Corp. refs

Since the launch of Intelsat I in 1965, technological advances in spacecraft design have resulted in longer lifetime, increased reliability, and a fifty-fold increase in communications capability. Since in-orbit mass and primary power have increased only by factors of between 20 and 30, considerable economical gains have been achieved. Further technological advances will make it possible to achieve additional increases in communications capacity with concomitant, but proportionally smaller, increases of spacecraft mass and power, resulting in further cost reductions. This paper outlines possible future trends, focusing upon three approaches. In the first case, it is assumed that individual dedicated spacecraft, similar to those employed until now, will be used. The second case deals with large space structures intended to provide multiple-function services. The third case presents the grouping of smaller satellites in closely spaced constellations, or clusters.
Author

A84-38319
INTELSAT V-OPERATIONAL SUCCES OF A LARGE THREE-AXIS COMMUNICATION SATELLITE
C. F. HOEBER, J. T. NEER, J. MCNAMARA, and J. M. KAYNE (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 1433-1442. Research sponsored by the International Telecommunications Satellite Organization.

This paper describes the technical and operational aspects of the first 4 in a series of 15 Intelsat V satellites. Flights 5 through 15 contain additional payloads beyond the basic Intelsat V payload of the first four spacecraft. The successful launch of the four satellites took place between December 6, 1980 and March 4, 1982. Following nominal transfer orbit operations, the satellites were placed into near circular drift orbit by firing solid apogee kick motors. The drift orbit operations included a spin mode orbit correction maneuver followed by despin and transition to the three-axis-stabilized configuration. Following solar array and antenna deployments, a series of detailed functional tests was performed to validate the health and performance of the satellites. All redundant spacecraft hardware, mechanisms, and critical operational modes were verified for all satellites. All test results agreed with prelaunch data. Communications tests validated that the critical payload elements (antennas, feeds, and transponders) were not adversely affected by launch. Author

A84-40608* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SATELLITE SERVICING TECHNOLOGY DEVELOPMENT MISSIONS
R. MIDDLETON (NASA, Marshall Space Flight Center, Huntsville, AL), D. WALTZ (TRW, Inc., Test and Field Operations Div., Redondo Beach, CA), and S. SCHROCK (Martin Marietta Aerospace, Denver, CO) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IC-15 to IC-28.

A new capability regarding the U.S. space efforts will be related to the servicing of satellites in orbit utilizing first-generation space station as the collection point or base for Shuttle-delivered payloads. Orbital maneuvering vehicles could move payloads or spacecraft assembled at the Shuttle/space station terminus to other earth orbit locations. It is assumed that such a capability will be initially available in the early 1990's. The benefits provided by satellite servicing in orbit are discussed, taking into account extended satellite lifetimes, lower acquisition cost, improved satellite performance, the possibility to change a satellite's mission, optimized science, and higher satellite reliability. The requirements for Satellite Servicing Technology Development Missions (TDMs) are considered. It is found that existing technology is insufficient, in various areas, to perform the servicing operations. A list is provided of critical technologies which must be developed. G.R.

A84-40618* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
TELEOPERATOR MANEUVERING SYSTEM (TMS) MISSION APPLICATIONS AND BENEFITS
D. C. CRAMBLIT and J. R. TURNER (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IIB-30 to IIB-55.

Studies conducted by NASA have shown that the operating range of the Shuttle can be substantially increased and cost of payload operation be decreased by making use of the Teleoperator Maneuvering System (TMS). The TMS is remotely controlled, free-flying, orbital mini-tug vehicle capable of performing a wide range of remote satellite services missions. It can operate out of the Shuttle cargo bay, from a space station, or on top of an upper stage like Centaur. For high energy missions up to and including geostationary orbit, the TMS propulsion stage will augment the Transfer Orbit Stage (TOS) recently proposed for commercial

development in providing an effective low-cost second-stage system for delivering intermediate sized payloads to geosynchronous orbit (GEO). Attention is given to TMS capabilities for both long duration and short term orbital missions, taking into account also Space Station support operations. G.R.

A84-40619* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
FUTURE SCIENTIFIC MISSIONS FOR STS
C. E. DE SANCTIS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IIB-56 to IIB-70. refs

The present investigation is concerned with a number of astrophysics missions which are currently being studied by NASA. The missions will be initially flown on the Space Transportation System (STS) and subsequently could be conducted in connection with the utilization of a Space Station on Space Platform. One of the missions involves the use of a large antenna system designed to significantly extend the aperture synthesis technique of earth-based very long baseline interferometry technique (orbiting VLBI). It has been recommended that a space VLBI antenna be launched in low earth orbit during this decade. Another mission considered is related to the Advanced Solar Observatory (ASO). ASO is a long duration space observatory. It will consist of four major instrument groupings including a High Resolution Solar Telescope Cluster (HRSTC), a Pinhole Occulter Facility, a Solar High Energy Facility, and a Solar Low Frequency Radio Facility. Attention is also given to a new program entitled Capabilities for Opportunity Payload Experiments (COPE). G.R.

A84-40625
FUTURE REQUIREMENTS AND APPLICATIONS FOR ORBITAL TRANSFER VEHICLES
D. E. CHARHUT and W. J. KETCHUM (General Dynamics Corp., Convair Div., San Diego, CA) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IIC-26 to IIC-34. refs

The Space Transportation System (STS) has the objective to provide increased launch opportunity at a lower cost. The present investigation is concerned with orbital transfer vehicles (OTV) for a transfer from low earth orbit to higher orbits. High OTV performance minimizes the need for propellants and maximizes payload. The highest performance in a chemical combustion rocket propulsion system can currently be obtained by using hydrogen and oxygen as propellants. For this reason, the Centaur is being incorporated into the STS. Centaur is the world's first liquid-hydrogen-powered space vehicle. It is expected that hydrogen-oxygen OTV will be employed for many years until noncombustion propulsion (chemical-electric) becomes available. Integrating a modified Centaur high-energy stage with the Space Shuttle offers a significant increase in the high earth orbit and earth-escape performance capabilities of the STS. A space-based OTV is envisioned for far-term requirements. G.R.

A84-41356*# Kentron International, Inc., Hampton, Va.
A MEANS FOR STATIONING ADDITIONAL GEOSYNCHRONOUS SATELLITES AND SPACE LADDER
J. DEYOUNG (Kentron International, Inc., Aerospace Technologies Div., Hampton, VA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 8 p.
(Contract NAS1-16000)
(AIAA PAPER 84-1984)

A practical method is analytically shown for multiplying the number of orbital slots for synchronous satellites. This is by radially tethering satellites above the synchronous orbit (forces outwards) balanced to satellites below this orbit (forces inwards). The term practical applies because the tether tension force is of second order smallness. Thus, several thousand miles of synchronous satellites can be radiated along a small tether line sized for tension of about one percent of a satellite weight. A vertical tether line also provides a track for transport, that is, a ladder or elevator. Analysis for an optimized diameter tether line is developed which is particularly effective when the tether, line is extended to the ground, thus, making a space ladder. Mars is the best candidate for a space ladder. With the optimized tether the total system mass is minimum when the outer satellite is far out. Tethered satellites have G-forces. Author

A84-43664#
FEASIBILITY STUDIES FOR A GLOBAL WIND MEASURING SATELLITE SYSTEM (WINDSAT) - ANALYSIS OF SIMULATED PERFORMANCE
R. M. HUFFAKER (Coherent Technologies, Inc., Boulder, CO), T. R. LAWRENCE, M. J. POST, J. T. PRIESTLEY, F. F. HALL, JR., R. A. RICHTER (NOAA, Wave Propagation Laboratory, Boulder, CO), and R. J. KEELER (National Center for Atmospheric Research, Boulder, CO) Applied Optics (ISSN 0003-6935), vol. 23, Aug. 1, 1984, p. 2523-2536. refs

A detailed computer simulation of the Windsat global wind measuring process has been developed and used to establish error limits as a function of design parameters. Studies were conducted for a Windsat research system in a 300- and an 800-km orbit. Wind measuring errors were less than 2 m/sec in the troposphere for the recommended set of parameters. The study results indicate the feasibility of measuring global winds from a space platform using a coherent laser radar. Author

A84-43890*# National Aeronautics and Space Administration, Washington, D. C.
NASA'S FUTURE DIRECTIONS IN SPACE EXPLORATION
W. J. ODONNELL (NASA, Washington, DC) AIAA Student Journal (ISSN 0001-1460), vol. 21, Spring 1983, p. 8-11.

The Presidential policy statement of July 4, 1982 has outlined basic U.S. goals for activities in space which include strengthening security, maintaining space leadership, obtaining economic and scientific benefits, expanding private sector investment and involvement in space-related activities, promoting international cooperative activities, and cooperating with other nations in maintaining freedom of space for activities enhancing the security and welfare of mankind. NASA's priorities include: operational status for a four-Orbiter Shuttle fleet, demonstration of the Shuttle's ability to recover and repair the Solar Maximum Mission Satellite, the first launch of Spacelab, and the 1986 launch of the Space Telescope. Future projects include the Venus Radar Mapper, the Advanced Communications Technology Satellite, and the establishment of large permanent space facilities. It is stated that the United States must take the necessary steps now to achieve an understanding of the potential benefits of continued manned operations in space. J.P.

A84-43894#
CONFIGURATIONAL DESIGN OF A CLOSED-LOOP, PSEUDOGRAVITATIONAL, ENVIRONMENTAL RESEARCH FACILITY IN LOW EARTH ORBIT
J. B. JONES-OLIVEIRA AIAA Student Journal (ISSN 0001-1460), vol. 21, Winter 1983, p. 10-15, 27.

The configurational design is presented for a manned Low Earth Orbit (LEO) orbital research facility called Satellite Pseudogravitational Operational Research Environment (SPORE). The SPORE accommodates eleven conditions of the centrifugally-induced pseudogravitational environment varying from 0-g in 0.1 increments to 1.0-g. The mission of the SPORE involves marine, botanical, and medical experiments aimed at defining and maintaining a closed-loop eco-system. The analysis of the experimental results is to be employed for space optimization which maximizes health and productivity while minimizing costs. Consideration is given to the main design objective, safety requirements, the configurational design, and radiation protection. The SPORE includes ten space habitats with pseudogravity of different values experienced in each of the habitats, the spokes which are elevator shafts, and the central axis. The structure is flexible and gains its rigidity from its spinning motion. Configurations

of the SPORE with ten, five, and two spokes (one, two, and five habitats per spoke, respectively) have been analyzed with emphasis on stability, safety and cost. The requirement is to construct the habitats intact on earth, transport them to LEO, and assemble on site. I.R.

A84-43904
A NEW GENERATION
F. C. WEAVER and E. R. WALTHALL (RCA, Astro Electronics Div., Princeton, NJ) Satellite Communications (ISSN 0147-7439), vol. 8, Aug. 1984, p. 34-36, 38.

The present discussion is concerned with a new series of communications satellites, which was developed by an American aerospace company with the objective to satisfy increasing demands of the customers. The customers for communications satellites are now seeking higher transponder power output, more payload capacity, and longer lifetime from manufacturers. Design features of the new series, the Series 4000, include larger payload panels for increased mounting area and thermal dissipation, heat pipes for increased thermal distribution over the payload panels, accommodation of solar arrays up to 500 sq ft, and launch compatibility with the Space Shuttle and the dual-launch Ariane 4. Attention is given to the design objectives, a physical description, the attitude determination and control subsystems for the Series 4000 satellites, the command structure, and the Shuttle compatible orbit transfer subsystem. G.R.

A84-43950
INTERNATIONAL COOPERATION AND SPACE MISSIONS; INTERNATIONAL ASTRONAUTICAL FEDERATION, CONGRESS, 34TH, BUDAPEST, HUNGARY, OCTOBER 10-15, 1983, SELECTED PAPERS
L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) New York, American Institute of Aeronautics and Astronautics (IAF International Advances in Space Technology. Volume 1), 1984, 749 p. No individual items are abstracted in this volume.

The history, current status, and future of international cooperation in space activity are discussed and illustrated in reviews and reports on individual projects. Chapters are devoted to systems and missions, applications, and supporting technologies. Subjects examined include Spacelab, the Space Station design process, ESA Space Station activities, Shuttle/Centaur, the Italian upper-stage system for IRIS, French participation in the Vega project, direct-broadcasting satellites, MARECS-A for maritime communications, emergency communications via satellite, microwave instrumentation and processing algorithms for ERS-1, remote sensing of vegetation, microgravity experiments on multiphase combustion and fluid physics, NASA SETI activities, Indonesian sounding rockets, dynamics and control of large space structures, control laws for large flexible orbiting antennas, and generation of trajectories by multiple planetary swingbys. T.K.

A84-44485#
THE PLEIADES PROJECT - A STUDENT DESIGN FOR AN ORBITING SPACE SCIENCE SYSTEM
Stanford Aerospace Engineer, vol. 4, April 1984, p. 5-10.

The Pleiades project is a student design program which has as its goal the definition of a viable orbiting space science laboratory that will be compatible with the Space Shuttle and able provide system and experiment environmental control, orbital trajectory control, telemetry, and a high degree of modularity for maximum flexibility. The primary consideration in such a design effort is the fact that many of the scientific instruments to be integrated are mutually incompatible, contaminating and even destroying each other if placed in proximity. The Pleiades system will accordingly employ a 'flotilla' concept, in which several separate spacecraft operate together as a network that consists of a Coordinating Platform, associated coorbiting platforms and free-flying instruments, Service Vehicles, and a data relay subsystem. O.C.

A84-45676
ROYAL SOCIETY, DISCUSSION ON TECHNOLOGY IN THE 1990: THE INDUSTRIALIZATION OF SPACE, LONDON, ENGLAND, DECEMBER 7, 8, 1983, PROCEEDINGS
G. K. C. PARDOE, ED. (General Technology Systems, Ltd., Brentford, Middx., England) Royal Society (London), Philosophical Transactions, Series A (ISSN 0080-4614), vol. 312, no. 1519, July 26, 1984, 140 p. For individual items see A84-45677 to A84-45689.

An overview of the industrialization of space is considered along with international communications satellites of global and European regional systems, African satellite communication systems and their implications, the British direct broadcast satellite system Unisata, mobile communications via satellite in the 1990s, and earth stations for fixed and mobile services. Attention is also given to the future potential of navigation satellites, finance for space, the Ariane program, the Space Shuttle system, and the payload and potential of ERS-1. Other subjects explored are related to the processing and use of data from earth observation satellites, global habitability and earth remote sensing, space stations and their potential uses, and the commercial potential of large orbital space platforms. G.R.

A84-45689
THE COMMERCIAL POTENTIAL OF LARGE ORBITAL SPACE PLATFORMS
I. V. FRANKLIN (British Aerospace, PLC, Space and Communications Div., Bristol, England) (Royal Society, Discussion on Technology in the 1990s: The Industrialization of Space, London, England, Dec. 7, 8, 1983) Royal Society (London), Philosophical Transactions, Series A (ISSN 0080-4614), vol. 312, no. 1519, July 26, 1984, p. 133-140.

The demonstration of the feasibility of the reusable launcher system known as the Space Shuttle has encouraged the consideration of space activities and related facilities for the next decades. The study of concepts regarding a manned space station and large orbital space platforms appears of particular interest. Facilities envisaged in connection with the space station concept are related to a permanent manned laboratory in space for scientific research in astronomy, earth observation and life sciences, a base for manufacturing activities in space for the exploitation of microgravity, and a transport node for spacecraft destined for high orbit. Attention is given to space station characteristics and environment, reasons for placing people in space, related disciplines and potential users, and European potential users. G.R.

A84-46479*# National Aeronautics and Space Administration, Washington, D. C.
SPACE STATION - THE NEXT LOGICAL STEP
J. M. BEGGS (NASA, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 22, Sept. 1984, p. 46-50, 52.

NASA has been charged with the development, over the next decade, of a permanently manned space station in low earth orbit. The space station system will comprise a manned base and associated unmanned platforms; while one of the platforms will be in polar orbit, another (or several) platforms will, like the manned base, have an orbital inclination of 28.5 deg. Because it is permanent, the space station will have to be semiautonomous from its mission control center. NASA will take a number of steps to foster the commercial utilization of the space station, and one of the design goals of the project is the definition of astronaut facilities that are very 'customer friendly'. Reliance on a single, program-wide contractor has been deemed undesirable; several major aerospace manufacturers will instead distribute responsibility among themselves for the various modules constituting the craft. O.C.

A84-47676*# *National Aeronautics and Space Administration.* Goddard Space Flight Center, Greenbelt, Md.
SPACE ACTIVITIES - A REVIEW AND A LOOK AHEAD
S. H. DURRANI (NASA, Goddard Space Flight Center, Greenbelt, MD) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-20, July 1984, p. 311-315.

The paper reviews the progress made in manned and unmanned space programs during the last 25 years and names several major accomplishments. The ingredients of success are identified as good engineering, good technology, and good management of a very complex enterprise. An argument is made that the pace of progress will be governed not by technological advances, which can be very rapid, but rather by future institutional arrangements, which are much slower to evolve. It is predicted that the most likely space activities for the next 20 years will be those relating to space commercialization, and several examples are cited. A hope is expressed that policy makers and entrepreneurs will match the spirit of adventure and risk-taking exhibited by engineers in exploring uncharted territory. Author

A84-48520
THE COLUMBUS PROJECT - A SPACE STATION FOR ALL SEASONS?
C. BULLOCH Interavia (ISSN 0020-5168), vol. 39, Sept. 1984, p. 947-950.

The space-station module Columbus, which has been proposed by ESA to its member states on the basis of phase-A studies, is discussed with a focus on the political and economic issues. Columbus is presently conceived as the ESA contribution to the NASA Space Station, with pressurized-cabin, service, payload-carrier, and resource configurations possible, and utilizes Spacelab and Eureca concepts throughout. The modular format, however, could also permit free-flying operation (with the addition of some hardware) as a small European space station. The strongest support for Columbus is seen as coming from the FRG and France, with some backing from Italy and only moral support from the UK; the overall cost of the program is roughly estimated as $1.558 billion, with the FRG, France, and Italy loosely committed to shares of 50, 20-23, and 15 percent, respectively. T.K.

A84-49146#
LEASECRAFT - A COMMERCIAL SPACE PLATFORM
D. R. BURROWBRIDGE (Fairchild Space Co., Germantown, MD) IN: Satellite land remote sensing advancements for the eighties; Proceedings of the Eighth Pecora Symposium, Sioux Falls, SD, October 4-7, 1983 . Sioux Falls, SD, Augustana College, 1984, p. 228-243.

The Multimission Modular Spacecraft (MMS) is the result of a NASA program concerned with the identification of new approaches to spacecraft design. A mandatory requirement regarding the MMS was flexibility to accommodatae a wide variety of payloads. MMS derived subsystems will provide a platform in low orbit for scientific, commercial, and government users on a leased or service contract basis. The payload may consist of scientific instruments, materials processing equipment, or remote sensors. Secondary payloads may be mounted in standard MMS module boxes. The platform forms a part of the 'Leasecraft' system, which was developed by an American aerospace company. Attention is given to the Leasecraft vehicle, details regarding the Leasecraft platform, and payload accommodations and Leasecraft missions. G.R.

A84-49249
PAYLOAD TECHNOLOGY FOR THE EUROPEAN LARGE TELECOMMUNICATIONS SATELLITE (L-SAT)
R. BONHOMME, W. GREINER, and N. NEALE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: ICC '83 - Integrating communication for world progress; International Conference on Communications, Boston, MA, June 19-22, 1983, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1983, p. 333-337.

The circuitry and performance requirements for the ESA L-SAT are surveyed.L-SAT will function at 12/14 GHz and will have a four-element payload: The specialized services element will provide pilot specialized or business services and aid in identifying needs for future, more specialized European spacecraft. The video segment will be a two-channel configuration at 27 MHz. Communications will include video conferencing, tele-education, and data and video transmission. Antennas on the spacecraft will comprise propagation horns, a telecommand/telemetry dish, and nonintegrated reflector-feed assemblies. Block diagrams are provide for all payload elements. M.S.K.

A84-49278
FUTURE TRENDS IN COMMERCIAL AND MILITARY SYSTEMS
F. E. BOND (Aerospace Corp., Los Angeles, CA) IN: ICC '83 - Integrating communication for world progress; International Conference on Communications, Boston, MA, June 19-22, 1983, Conference Record. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1983, p. 882-887. refs

Commercial and military satellite communication systems are addressed, with a review of current applications and typical communication characteristics of the space and earth segments. Drivers for the development of future commercial systems include: the pervasion of digital techniques and services, growing orbit and frequency congestion, demand for more entertainment, and the large potential market for commercial 'roof-top' service. For military systems, survivability, improved flexibility, and the need for service to small mobile terminals are the principal factors involved. Technical trends include the use of higher frequency bands, multibeam antennas and a significant increase in the application of onboard processing. Military systems will employ a variety of techniques to counter both physical and electronic threats. The use of redundant transmission paths is a particularly effective approach. Successful implementation requires transmission standards to achieve the required interoperability among the pertinent networks. For both the military and commercial sectors, the trend toward larger numbers of terminals and more complex spacecraft is still persisting. Author

N84-24082# Science Applications, Inc., McLean, Va.
UPPER OCEAN SHEAR DURING JASIN: A DETERMINISTIC AND STATISTICAL ANALYSIS Final Report
D. M. RUBENSTEIN Feb. 1984 87 p
(Contract N00014-83-C-0057)
(AD-A139077; SAI-84-1027) Avail: NTIS HC A05/MF A01 CSCL 08C

The shear field measured by the W1 mooring during JASIN 1978 was analyzed, using deterministic and statistical approaches. A significant fraction of the shear variance was at the semidiurnal tidal frequency. In order to determine whether the shear was associated with internal wave trains propagating from single or multiple sources, the eccentricity of the shear ellipse was analyzed. During seven periods of intense shear, the minor-to-major axis ratio was consistent with the theoretically predicted ratio of 0.89 for coherent internal waves. From the orientation of the shear ellipse, the probable source of the internal tides during three intense periods was found to be the Rockall Bank. A statistical model of shear was applied two periods of the JASIN experiment. Internal wave-induced shear during Period 2 was comparable in level to that measured during MILE, but levels recorded during period 1 were 40% higher. This variability is attributed to changes in the propagation of the internal tide, associated with the evolving field of mesoscale eddies. GRA

N84-24476*# Howard Univ., Washington, D. C. School of Engineering.
NASA/HOWARD UNIVERSITY LARGE SPACE STRUCTURES INSTITUTE Semiannual Progress Report
T. H. BROOME, JR. 22 Mar. 1984 254 p refs
(Contract NAG1-383)
(NASA-CR-173425; NAS 1.26:173425) Avail: NTIS HC A12/MF A01 CSCL 05I

Basic research on the engineering behavior of large space structures is presented. Methods of structural analysis, control, and optimization of large flexible systems are examined. Topics of investigation include the Load Correction Method (LCM) modeling

technique, stabilization of flexible bodies by feedback control, mathematical refinement of analysis equations, optimization of the design of structural components, deployment dynamics, and the use of microprocessors in attitude and shape control of large space structures. Information on key personnel, budgeting, support plans and conferences is included.

M.A.C.

N84-24507# Committee on Commerce, Science, and Transportation (U. S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT
Washington GPO 1984 69 p Repl. to accompany H. R. 5154 presented by the Comm. on Com., Sci., and Transportation, 98th Congr., 2nd Sess., 17 May 1984
(S-REPT-98-455; GPO-31-010) Avail: US Capitol, Senate Document Room

Committee adjustments to NASA's request for fiscal year 1985 are elaborated and summarized. The appropriations authorized total $7,582,400,00. A.R.H.

N84-24600*# National Academy of Sciences - National Research Council, Washington, D. C.
ACTIVITIES OF THE AERONAUTICS AND SPACE ENGINEERING BOARD COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS Summary Report, 1 Jan. - 31 Mar. 1984
Apr. 1984 7 p
(Contract NASW-3455)
(NASA-CR-173529; NAS 1.26:173529; SR-14) Avail: NTIS HC A02/MF A01 CSCL 13B

The agenda of the Aeronautics and Space Engineering Board meeting is reviewed. Items discussed included; engineering and technical requirements of the space station, NASA's altitude wind tunnel, rocket engine casings, advanced flight vehicle technology, the space shuttle, and on-orbit space maintenance. Board members along with their institutional affiliation are listed. R.S.F.

N84-24632*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LONG DURATION EXPOSURE FACILITY (LDEF). MISSION 1 EXPERIMENTS
L. G. CLARK, ed., W. H. KINARD, ed., D. L. CARTER, JR., ed., and J. L. JONES, JR., ed. Washington Feb. 1984 196 p
(NASA-SP-473; L-15230; NAS 1.21:473) Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 22A

Spaceborne experiments using the space shuttle payload known as the Long Duration Exposure Facility are described. Experiments in the fields of materials, coatings, thermal systems, power and propulsion, electronic, and optics are discussed.

N84-24700*# Grumman Aerospace Corp., Bethpage, N.Y.
MANNED GEOSYNCHRONOUS MISSION REQUIREMENTS AND SYSTEMS ANALYSIS STUDY EXTENSION Quarterly Review
Feb. 1981 193 p
(NASA-CR-173547; NAS 1.26:173547; QR-3) Avail: NTIS HC A09/MF A01 CSCL 22B

Turnaround requirements for the manned orbital transfer vehicle (MOTV) baseline and alternate concepts with and without a space operations center (SOC) are defined. Manned orbital transfer vehicle maintenance, refurbishment, resupply, and refueling are considered as well as the most effective combination of ground based and space based turnaround activities. Ground and flight operations requirements for abort are identified as well as low cost approaches to space and ground operations through maintenance and missions sensitivity studies. The recommended turnaround mix shows that space basing MOTV at SOC with periodic return to ground for overhaul results in minimum recurring costs. A pressurized hangar at SOC reduces labor costs by approximately 50%. Author

N84-28709*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PROCEEDINGS OF THE LARGE DEPLOYABLE REFLECTOR SCIENCE AND TECHNOLOGY WORKSHOP. VOLUME 1: EXECUTIVE SUMMARY
C. A. LEIDICH and B. PITTMAN Jun. 1984 45 p refs Workshop held at Pacific Grove, Calif., 21-25 Jun. 1982
(NASA-CP-2275-VOL-1; A-9152; NAS 1.55:2275-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 03A

A large ambient temperature, for infrared submillimeter telescope in space was discussed. The results of the scientific and technical activities were summarized. The scientific effort consisted of reviewing the science rationale for the Large Deployable Reflector (LDR) and arriving at a concensus set of scientific requirements. The telescope requirements were then compared to the current and anticipated state of the various technologies involved, and the technological shortfalls identified.

B.G.

N84-30450*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVING SYSTEM. SCIENCE AND MISSION REQUIREMENTS, VOLUME 1, PART 1
Washington Aug. 1984 59 p Original contains color illustrations
(NASA-TM-86129-VOL-1-PT-1; NAS 1.15:86129-VOL-1-PT-1)
Avail: NTIS HC A04/MF A01 CSCL 12B

The Earth Observing System (EOS) is a planned NASA program, which will carry the multidisciplinary Earth science studies employing a variety of remote sensing techniques in the 1990's, as a prime mission, using the Space Station polar platform. The scientific rationale, recommended observational needs, the broad system configuration and a recommended implementation strategy to achieve the stated mission goals are provided.

N84-34483*# Los Alamos Scientific Lab., N. Mex.
A LOW EARTH ORBIT MOLECULAR BEAM SPACE SIMULATION FACILITY
J. B. CROSS *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 193-204 1984 refs
Avail: NTIS HC A13/MF A01 CSCL 04A

A brief synopsis of the low Earth orbit (LEO) satellite environment is presented including neutral and ionic species. Two ground based atomic and molecular beam instruments are described which are capable of simulating the interaction of spacecraft surfaces with the LEO environment and detecting the results of these interactions. The first detects mass spectrometrically low level fluxes of reactively and nonreactively surface scattered species as a function of scattering angle and velocity while the second ultrahigh velocity (UHV) molecular beam, laser induced fluorescence apparatus is capable of measuring chemiluminescence produced by either gas phase or gas-surface interactions. A number of proposed experiments are described.

Author

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ANALYSIS AND DESIGN TECHNIQUES

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

A84-30147* Rockwell International Corp., Downey, Calif.
MECHANICAL DESIGN OF A LOW CONCENTRATION RATIO SOLAR ARRAY FOR A SPACE STATION APPLICATION
M. S. BISS and L. HSU (Rockwell International Corp., Shuttle Integration and Satellite Systems Div., Downey, CA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 1237-1242.
(Contract NAS8-34214)

This paper describes a preliminary study and conceptual design of a low concentration ratio solar array for a space station application with approximately a 100 kW power requirement. The baseline design calls for a multiple series of inverted, truncated, pyramidal optical elements with a geometric concentration ratio (GCR) of 6. It also calls for low life cycle cost, simple on-orbit maintainability, 1984 technology readiness date, and gallium arsenide (GaAs) of silicon (Si) solar cell interchangeability. Due to the large area needed to produce the amount of power required for the baseline space station, a symmetrical wing design, making maximum use of the commonality of parts approach, was taken. This paper will describe the mechanical and structural design of a mass-producible solar array that is very easy to tailor to the needs of the individual user requirement. Author

A84-30549
PARAMETER SIMPLIFICATION IN LINEAR SYSTEMS WITH APPLICATION TO MODEL REDUCTION
A. L. DORAN (Aerospace Corp., El Segundo, CA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 397-415. Research sponsored by the Aerospace Corp. refs
(AAS PAPER 83-341)

When a set of equations is transformed to one containing fewer parameters some properties of the original set may be lost. This paper explores parameter simplifications which can be affected on linear systems with application to model reduction by the method of Component Cost Analysis. It is shown that several parameter reducing transformations are permissible for model reduction. The model reduction quality of these reduced systems is shown to be the same as that of the original system. A small dimension example is included to illustrate the ideas. It is shown how systematic parameter elimination enables a complete evaluation of coordinate selections. Author

A84-31700#
COMBINED EXPERIMENTAL/ANALYTICAL MODELING USING COMPONENT MODE SYNTHESIS
D. R. MARTINEZ, T. G. CARNE, D. L. GREGORY, and A. K. MILLER (Sandia National Laboratories, Albuquerque, NM) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 140-152. refs
(AIAA PAPER 84-0941)

This study evaluates the accuracy of computed modal frequencies and mode shapes obtained from a combined experimental/analytical model for a simple beam structure. The structure was divided into two subsystems and one subsystem was tested to obtain its free-free modes. Using a Component Mode Synthesis (CMS) technique, the experimental modal data base for one subsystem was directly coupled with a finite element model of the other subsystem to create an experimental/analytical model of the total structure. Both the translational and rotational elements of the residual flexibilities and mode shapes at the interface of the experimental subsystem were measured and used in the coupling. The modal frequencies and mode shapes obtained for the combined experimental/analytical model are compared to those for a reference finite element model of the entire structure. The sensitivity of the CMS model predictions to errors in the modal parameters and residual flexibilities, which are required to define a subsystem, is also examined. Author

A84-36835* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONCEPTUAL SPACECRAFT SYSTEMS DESIGN AND SYNTHESIS
R. L. WRIGHT, D. D. DERYDER, and M. J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 43rd, Atlanta, GA, May 21-23, 1984. 31 p. refs
(SAWE PAPER 1622)

An interactive systems design and synthesis is performed on future spacecraft concepts using the Interactive Design and Evaluation of Advanced Systems (IDEAS) computer-aided design and analysis system. The capabilities and advantages of the systems-oriented interactive computer-aided design and analysis system are described. The synthesis of both large antenna and space station concepts, and space station evolutionary growth designs is demonstrated. The IDEAS program provides the user with both an interactive graphics and an interactive computing capability which consists of over 40 multidisciplinary synthesis and analysis modules. Thus, the user can create, analyze, and conduct parametric studies and modify earth-orbiting spacecraft designs (space stations, large antennas or platforms, and technologically advanced spacecraft) at an interactive terminal with relative ease. The IDEAS approach is useful during the conceptual design phase of advanced space missions when a multiplicity of parameters and concepts must be analyzed and evaluated in a cost-effective and timely manner. Author

A84-38238
NEW CONFIGURATION OF A TELECOMMUNICATION MULTIMISSION SATELLITE SYSTEM
G. BERRETTA (ESA, Directorate of Applications, Paris, France) and A. SAITTO (ESA, Technical Directorate, Noordwijk, Netherlands) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 837-844. refs

The results of a preliminary study of an advanced configuration for a multimission multifrequency GEO spacecraft to be launched by the Ariane IV are presented. The multiple use of the platform requires multiple antennas and thereby redesign of the antenna booms, increases in the platform weight, long feeders from the electronics units to the antenna system, and upgraded control and stabilization systems. A possible solution is an antenna with a reflector feed system, one or two reflectors used for different functions, in-orbit servicing, and extensive use of dichroic surfaces. The communications packages would be modular to aid in on-orbit servicing. A payload with capabilities for L-, C-, X-, and K-band transmission/reception is described, as is a reflector compatible with Ariane IV configuration limitations. M.S.K.

A84-42379* Bendix Corp., Teterboro, N.J.
APPROXIMATING A FINITE ELEMENT MODEL OF A HYBRID DEPLOYABLE TRUSS BY A DISCRETE MASS MODEL
F. D. CHICHESTER and I. S. EMMANUEL (Bendix Corporate Simulation Center, Teterboro, NJ) IN: Annual Pittsburgh Conference, 13th, Pittsburgh, PA, April 22, 23, 1982, Proceedings. Part 1 . Research Triangle Park, NC, Instrument Society of America, 1982, p. 13-18. refs
(Contract NAS8-33979)

The NASTRAN finite element model of the MSFC/hybrid deployable truss is approximated by a model consisting of four bodies serially connected by a spring hinge suspension. The truss is decomposed into four serially connected modules determining the total mass and rotational inertias for a rigid body with its mass center on the axis of the truss for each module. A five-body cantilever truss model is developed along with an undamped form of this model. Spring coefficient values are generated to match eigenvalues of the latter model with those of the NASTRAN model. Damping coefficients are then determined that provide n percent of critical damping for the model. C.D.

A84-49508#
MODAL ANALYSIS OF A DEPLOYABLE TRUSS USING THE FINITE ELEMENT METHOD
D. V. HUTTON (Washington State University, Pullman, WA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 21, Sept.-Oct. 1984, p. 468-472. refs

Development of a large-scale space station will require similarly large structural elements capable of assembly, fabrication, or deployment in space. Weight and volume constraints of the Space Shuttle Orbiter payload bay make deployable structures with minimum on-orbit assembly requirements the favored alternative. Current deployable structure concepts involve folding, three-dimensional trusses with automated deployment/retraction systems having high deployed-to-stowed volume ratios. Such designs employ a large number of pin joints to allow the rotational motion required for deployability. To assess the dynamic characteristics of a deployable space truss, a finite element model of the Science and Applications Space Platform truss has been formulated. The model incorporates all additional degrees of freedom associated with the pin-jointed members. Comparison of results with Structural Performance and Redesign models of the truss shows that the joints of the deployable truss affect the vibrational modes of the structure significantly only if the truss is relatively short. Author

N84-24479*# Howard Univ., Washington, D. C. Dept. of Mathematics.
MATHEMATICAL ANALYSIS
J. A. DONALDSON *In its* NASA/Howard Univ. Large Space Structures Inst. p 69-76 22 Mar. 1984 refs
Avail: NTIS HC A12/MF A01 CSCL 05I

Simple continuum models used in the design, analysis, and control of large space structures are examined. Particular emphasis is placed on boundary value problems associated with the Load Correction Method and control problems involving partial differential equations for the large space structure models. Partial differential equations will be used to model a large space structure, base the design of an optimal controller on this model, approximate the resulting optimal control model, and compare the results with data from other methods. M.A.C.

N84-24480*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
OPTIMIZATION OF SPACE STRUCTURES
R. REISS, S. RAMACHANDRAN, and B. QUIAN *In its* NASA/Howard Univ. Large Space Structures Inst. p 77-96 22 Mar. 1984 refs
Avail: NTIS HC A12/MF A01 CSCL 05I

Computational methods for the design of structures for specified transient response, truss beam units with specified attached vibration absorbers, and laminates for structural components of large space structures are examined. Equations for the measurement of structural stiffness that are maximized for a specific total mass and that will reduce the structural weight are presented. A model for a cantilevered space truss beam of a specific mass and with a specified tip vibration absorber is explained. Design criteria of the laminates include minimizing the weight as well as frequency, buckling, and global stiffness constraints. Other variables include orientation of the lamina and the thickness of each layer. M.A.C.

N84-26214# Boston Coll., Chestnut Hill, Mass.
REQUIREMENTS FOR VALIDATING SYSTEM MODELS
M. S. GUSSENHOVEN *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 407-415 25 Jan. 1983 refs
(Contract F19628-82-K-0011; F19628-81-K-0032)
(AD-P002128) Avail: NTIS HC A18/MF A01 CSCL 09B

An analogy is made between the development and presentation of analytic scientific theory and that of computer models in order to suggest that there are additional requirements to be made on computer models to test their validity. These constraints include code development, testing over the entire range of variables, refinement of the scope of the model, and access to measurable or testable internal outputs. GRA

N84-28893*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERACTIVE SYSTEMS DESIGN AND SYNTHESIS OF FUTURE SPACECRAFT CONCEPTS
R. L. WRIGHT, D. D. DERYDER, and M. J. FEREBEE, JR. Jun. 1984 39 p refs Presented at the AIAA Profess. Study Seminar, Newport Beach, Calif., 4 Jun. 1984
(NASA-TM-86254; NAS 1.15:86254) Avail: NTIS HC A03/MF A01 CSCL 22B

An interactive systems design and synthesis is performed on future spacecraft concepts using the Interactive Design and Evaluation of Advanced spacecraft (IDEAS) computer-aided design and analysis system. The capabilities and advantages of the systems-oriented interactive computer-aided design and analysis system are described. The synthesis of both large antenna and space station concepts, and space station evolutionary growth is demonstrated. The IDEAS program provides the user with both an interactive graphics and an interactive computing capability which consists of over 40 multidisciplinary synthesis and analysis modules. Thus, the user can create, analyze and conduct parametric studies and modify Earth-orbiting spacecraft designs (space stations, large antennas or platforms, and technologically advanced spacecraft) at an interactive terminal with relative ease. The IDEAS approach is useful during the conceptual design phase of advanced space missions when a multiplicity of parameters and concepts must be analyzed and evaluated in a cost-effective and timely manner. Author

03

STRUCTURAL CONCEPTS

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

A84-31716#
STRUCTURAL MODIFICATIONS TO REDUCE THE LOS-ERROR IN LARGE SPACE STRUCTURES
N. S. KHOT, V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and F. E. EASTEP (Dayton, University, Dayton, OH) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 296-305. refs
(AIAA PAPER 84-0997)

This paper deals with the study of the dynamic behavior of large space structures due to changes in the stiffness of the members. The stiffness of the members was modified to satisfy an optimum design criterion, to satisfy static displacements associated with the line-of-sight (LOS) and to satisfy frequency constraints. The response of the LOS to different initial displacement conditions was investigated for various modified designs. Author

A84-34010#
MATERIALS AND STRUCTURES FOR SPACE APPLICATIONS
J. F. GARIBOTTI, W. E. DAVIS, and N. R. ADSIT (HR Textron, Inc., Irvine, CA) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 50-58. refs
(AIAA PAPER 84-1121)

The present investigation is concerned with the state of the art in materials and structures for space applications, taking into account also future trends regarding these technologies. It is pointed out that the development of the Space Shuttle Orbiter required significant advances in the technologies of structures and materials. Some of these advances are related to the reusable thermal protection system, the light weight, high strength main frame truss structure, and the extensive use of lightweight composites for major components. Attention is given to the tile/pad/substrate profile, the remote manipulator system, the arm boom design, the space telescope major subsystems, and constructional changes from graphite epoxy to graphite aluminum. Structures, mechanisms, and materials technology needs for space stations are discussed, and a future space transportation system is described. G.R.

A84-34489
CONTROLLING THE GEOMETRICAL PARAMETERS OF LARGE-SCALE STRUCTURES IN SPACE [KONTROL' GEOMETRICHESKIKH PARAMETROV INZHENERNYKH SOORUZHENII V KOSMOSE]
E. V. GROMOV, V. I. KRYLOV, and IU. M. MANAKOV (Moskovskii Institut Inzhenerov Geodezii, Aerofotos'emki i Kartografii, Moscow, USSR) Geodeziia i Aerofotos'emka (ISSN 0536-101X), no. 1, 1984, p. 3-9. In Russian. refs

The paper examines the use of a geodesic method, the method of three-dimensional direct linear intersection, to control the geometrical parameters of large-scale structures. Two schemes for the arrangement of the measuring instruments are proposed, and error-distribution diagrams are obtained for the monitoring of spherical-antenna surfaces. The proposed geodesic method is compared with the polar intersection method, and it is concluded that the former method is more accurate and does not require additional measuring instruments. B.J.

A84-38176* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DEVELOPMENT OF THE STRUCTURAL TECHNOLOGY OF A LARGE DEPLOYABLE ANTENNA
B. K. WADA, R. E. FREELAND (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), and A. A. WOODS, JR. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: *International Symposium on Space Technology and Science, 13th*, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 395-400. refs
(Contract NAS7-100)

The current NASA-sponsored Antenna Technology Development Program of the offset wrap-rib antenna concept is based on a ground test program of 'proof of concept' hardware whose potential on-orbit performance is based on analytical estimates. The ground demonstration hardware represents a partial 55-meter diameter reflector and feed support structure. Testing will include automated deployment, reflector surface quality evaluation and validation of analytical performance models. Test results and hardware fabrication costs will be used to refine the models that will be the basis for the preliminary design of a 100-meter diameter wrap-rib antenna system. Additionally, the design, processes, tooling, fabrication techniques, fixturing and assembly approaches used for the 'proof of concept' hardware are directly applicable to building flight systems up to 100 meters in diameter. Author

N84-25757# Goodyear Aerospace Corp., Akron, Ohio.
INNOVATIVE STRUCTURES FOR SPACE APPLICATIONS
Oct. 1982 54 p refs
(GAC-19-1563) Avail: NTIS HC A04/MF A01

Expandable/flexible/rigidized structures are compatible with the space environment for both manned and unmanned applications. Materials for use in the Spacelab transfer tunnel are tested. This effort includes flammability, off/gassing, tensile, peel adhesion, lap joint strength, vacuum debond, and permeability tests. Material specimens are fabricated and tested to determine the effect of cut fill yarns, cyclic loading, cure/post cure, and vacuum bakeoff on strip tensile strength and peel adhesion. Several light weight, wire grid rigidized spheres are discussed. M.A.C.

N84-29335*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELIMINARY SPACE STATION SOLAR ARRAY STRUCTURAL DESIGN STUDY
J. T. DORSEY, H. G. BUSH, and M. M. MIKULAS, JR. *In* NASA. Lewis Research Center Space Photovoltaic Res. and Technol. 1983 p 182-192 1984 refs
Avail: NTIS HC A12/MF A01 CSCL 10A

Structurally efficient ways to support the large solar arrays (3,716 square meters which are currently considered for space station use) are examined. An erectable truss concept is presented for the on orbit construction of winged solar arrays. The means for future growth, maintenance, and repair are integrally designed into this concept. Results from parametric studies, which highlight the physical and structural differences between various configuration options are presented. Consideration is given to both solar blanket and hard panel arrays. M.A.C.

N84-30328*# Astro Research Corp., Carpinteria, Calif.
***SUPPORT STRUCTURES FOR LARGE INFRARED TELESCOPES* Final Report**
J. M. HEDGEPETH Washington NASA Jul. 1984 47 p refs
(Contract NAS1-16923)
(NASA-CR-3800; NAS 1.26:3800; ARC-TN-1121) Avail: NTIS HC A03/MF A01 CSCL 20K

An infrared telescope requires an accuracy of its reflecting surfaces of less than a micrometer. Future missions may require such accuracy from telescopes that are 20 meters or larger in diameter. The structure for supporting such a telescope will most probably take the form of a deep truss. Various approaches for constructing the primary mirror in space are illustrated. One that

employs automated deployment of interconnected reflector-structure modules was described in detail. Estimates were made of the precision obtainable with properly configured truss structures and the required ability of active control systems for achieving the desired accuracy. Author

04

STRUCTURAL AND THERMAL ANALYSIS

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

A84-34915*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THERMOELASTIC LIMIT CYCLING OF ZIPPERED CROSS SECTION SPACECRAFT BOOMS
R. A. LASKIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 25 p. NASA-supported research. refs
(AIAA PAPER 84-1065)

The phenomenon of thermal flutter of open cross section storable tubular extendible member (STEM) spacecraft booms was first observed in OGO IV and subsequently on a number of other satellites. Theoretical work ultimately ascribed the anomalous, undamped oscillations to the low torsional rigidity of the open section booms. This was confirmed when 'zippered' cross section booms, with substantially higher torsional rigidity, were later flown without exhibiting thermal flutter. However, zippered STEM booms generally have sizeable torsional backlash zones. It is shown here that small amplitude thermoelastic limit cycling within this backlash zone is theoretically possible and is the likely explanation for undamped oscillations recorded on Voyager 1 and 2 in the early stages of the Voyager mission. Author

A84-37491*# Old Dominion Univ., Norfolk, Va.
SELF-SHADOWING EFFECTS ON THE THERMAL-STRUCTURAL RESPONSE OF ORBITING TRUSSES
E. A. THORNTON and J. MAHANEY (Old Dominion University, Norfolk, VA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 11 p. NASA-supported research. refs
(AIAA PAPER 84-1765)

An investigation of self-shadowing effects on the thermal-structural response of orbiting trusses is described. The shadowing, heating, thermal and structural analyses are summarized. The significance of shadowing on the thermal-structural behavior of a single member and a beam constructed from truss members is described. For the trusses considered, the study shows that member self-shadowing effects significantly alter the behavior and must be included to predict the thermal-structural response correctly. Author

A84-37498#
ADVANCED THERMAL CONTROL TECHNIQUES FOR EMERGING COMMUNICATION SATELLITES
B. HARWELL and F. EDELSTEIN (Grumman Aerospace Corp., Bethpage, NY) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 7 p. refs
(AIAA PAPER 84-1774)

Advanced thermal control concepts to meet near-term communications satellite weight, size and reliability needs are explored. The working principles of vacuum conductance heat pipes (VCHP), high-capacity monogroove heat pipes (HCP), deployable radiator panels, flat plate transverse heat pipes, capillary pumped plates and mechanically pumped two-phase loops (MPTP) are described. Appropriate applications for each concept are discussed, together with examples of test data and design concepts. VCHPs have already delivered reliable tight temperature control on low power budgets in zero-g environments. Customized isothermal panel designs are possible because of new high capacity spliceable and bendable monogroove heat pipes. Very large communications satellites will probably use either HCP or MPTP systems once the technology is proven flight-ready. M.S.K.

A84-37500#
THERMAL CONTROL OF LARGE SPACECRAFT ANTENNA REFLECTORS
D. BENTON (RCA, Astro-Electronics Div., Princeton, NJ) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 6 p. refs
(AIAA PAPER 84-1777)

The impact of structural and RF considerations on spacecraft antenna reflector thermal design is assessed. Design goals include adequate RF performance and minimized weight, packaging limitations, and thermooptical and electrical interference, as well as sufficient stiffness. Thermal control is needed to minimize distortions and stresses in the structure. Design alternatives for solid or mesh, metal or composite structures and interface configurations are described, together with proven reflector coatings and their thermooptical properties. Design features of a high-power, Ku-band communications satellite shaped-beam antenna with a deployed solid reflector illustrate the design principles. M.S.K.

A84-37512*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A SINDA MODELING TECHNIQUE FOR PUMPED TWO-PHASE SPACECRAFT COOLING SYSTEMS
S. OLLENDORF (NASA, Goddard Space Flight Center, Greenbelt, MD) and F. A. COSTELLO (Frederick A. Costello, Inc., Herndon, VA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 9 p.
(AIAA PAPER 84-1796)

The purpose of this paper is to present a modeling technique that has proven successful in simulating pumped, two-phase cooling systems. The technique uses the standard SINDA thermal-analysis program and thereby extends the capabilities of SINDA to complex, active spacecraft thermal-control systems. This paper provides sufficient detail that a current SINDA user will be able to apply the technique by reference to this paper alone. Author

A84-38212
ANALYSIS OF VARIABLE CONDUCTANCE HEAT PIPE RADIATOR FOR THE COOLING FLUID LOOP OF THE SPACE PLATFORM
H. HWANGBO (MRJ, Inc., Fairfax, VA) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 661-666.

A84-39305*# OAO Corp., Greenbelt, Md.
DESIGN, DEVELOPMENT AND TEST OF A CAPILLARY PUMP LOOP HEAT PIPE
E. J. KROLICZEK, J. KU (OAO Corp., Greenbelt, MD), and S. OLLENDORF (NASA, Goddard Space Flight Center, Greenbelt, MD) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 10 p. refs
(AIAA PAPER 84-1720)

The development of a capillary pump loop (CPL) heat pipe, including computer modeling and breadboard testing, is presented. The computer model is a SINDA-type thermal analyzer, combined with a pressure analyzer, which predicts the transients of the CPL heat pipe during operation. The breadboard is an aluminum/ammonia transport system which contains multiple parallel evaporator and condenser zones within a single loop. Test results have demonstrated the practicality and reliability of such a

design, including heat load sharing among evaporators, liquid inventory/temperature control feature, and priming under load. Transport capability for this system is 65 KW-M with individual evaporator pumps managing up to 1.7 KW at a heat flux of 15 W/sq cm. The prediction of the computer model for heat transport capabilities is in good agreement with experimental results. Author

A84-39366*# Washington Univ., Seattle.
THE EFFECT OF DIRECT AND REFLECTED RADIATION ON THE TEMPERATURES OF SPACE STRUCTURES
A. F. EMERY and S. O. SMITH (Washington, University, Seattle, WA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 10 p. refs
(Contract NAG1-41)
(AIAA PAPER 84-1764)

As an orbiting structure passes from the bright side to the dark side of the earth, substantial differences in surface heating may take place due to direct sunlight and albedo. Most structures are built of convex curved elements to spread out the reflected energy. A change in the shortwave absorptivity and emissivity maintains the temperature of electronic components within a narrow range. Temperature extremes may also be reduced by the use of thermal capacity of the system or by shielding the surface from direct sunlight. For an instrument deployed from a Shuttle, a temperature must be established for it in the cargo bay before deployment. The effect of obstructed views by surfaces such as the Shuttle arm complicates solar flux computations because of the object's mobility. For typical orbits, the earth's albedo and the direct long wavelength radiation may be as much as 30 percent of the direct solar flux. Irradiation due to direct and reflected solar, long wave radiation and reflected radiation from earth, and from Shuttle surfaces is largely dependent on the specular reflection from the radiators as the Shuttle rolls and its surfaces block the sun. Through a judicious choice of surface properties, thermal capacitance and orbit attitude programming, the temperature response of a system can be controlled. J.P.

A84-39374#
A TWO-PHASE THERMAL MANAGEMENT SYSTEM FOR LARGE SPACE PLATFORMS
T. J. BLAND, R. S. DOWNING, and D. P. ROGERS (Sundstrand Corp., Advanced Technology Group, Rockford, IL) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 10 p.
(AIAA PAPER 84-1758)

A pumped two-phase cooling loop concept for large space platforms is described. Small spacecraft currently employ passive cooling or pumped single-phase loops for heat rejection. Future space platforms will have thermal power levels in the hundreds of kilowatts with potentially long transport distances. The concept of a two-phase thermal bus has evolved to satisfy these requirements with much lower pumping power requirements than a pumped liquid loop. The system concept employs an electrically driven pitot pump to supply a controlled flow of nearly saturated liquid to the evaporators. It can be connected to any system of evaporators, in series or parallel, and is totally insensitive to the cavitation problems inherent in most pump types. The rotating drum of the pump acts as a separator for the two-phase flow returning from the evaporators. A simple back-pressure regulator is the only control element and maintains a constant pressure in the drum and, hence, a constant liquid temperature to the evaporators. A 25 kW system conceptual design has been generated and modelled using ammonia as the working fluid. Predicted operating characteristics are presented. A demonstration test loop has been built to prove the operational characteristics using Freon 114. Preliminary test results indicate that the system behaves as predicted. Author

A84-48150#
THERMAL POSTBUCKLING BEHAVIOR OF TAPERED COLUMNS
K. KANAKA RAJU (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India) and G. VENKATESWARA RAO AIAA Journal (ISSN 0001-1452), vol. 22, Oct. 1984, p. 1499-1501.

Rayleigh-Ritz solutions are presented for the linear thermal buckling load and thermal load ratios in the postbuckling range for simply supported tapered columns under thermal loading. For an efficient design of aerospace components, such as heat shields and the interstages of launch vehicles together with supporting members of structural components in satellites and large space structures, thermal loading and nonlinear behavior of the structural components including tapered configuration must be considered. The effect of nonlinearity on the thermal load ratios is found to be of the opposite tendency with increasing taper values in the breadthand depth-tapered cases. A few numerical results are presented. S.H.

N84-22608*# Perkin-Elmer Corp., Danbury, Conn.
***OPTIMIZATION OF THERMAL SYSTEMS WITH SENSITIVE OPTICS, ELECTRONICS, AND STRUCTURES* Final Report**
R. G. BETTINI and F. A. COSTELLO Washington NASA Apr. 1984 71 p refs
(Contract NAS1-17152)
(NASA-CR-3745; NAS 1.26:3745; ER-599A) Avail: NTIS HC A04/MF A01 CSCL 22B

A strategy was investigated by which thermal designers for spacecraft could devise an optimal thermal control system to maintain the required temperatures, temperature differences, changes in temperature, and changes in temperature differences for specified equipment and elements of the spacecraft's structure. Thermal control is to be maintained by the coating pattern chosen for the external surfaces and heaters chosen to supplement the coatings. The approach is to minimize the thermal control power, thereby minimizing the weight of the thermal control system. Because there are so many complex computations involved in determining the optimal coating design a computerized approach was contemplated. An optimization strategy including all the elements considered by the thermal designer for use in the early stages of design, where impact on the mission is greatest, and a plan for implementing the strategy were successfully developed. How the optimization process may be used to optimize the design of the Space Telescope as a test case is demonstrated. Author

N84-24649*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL SURFACE EXPERIMENT (S0069)
D. R. WILKES and H. M. KING *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 57-61 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11G

The objectives of this LDEF experiment are to determine the effects of the near Earth orbital environment and the Shuttle induced environment in spacecraft thermal control surfaces. Spectral reflectance measurements will be obtained and used to differentiate between different solid state damage mechanisms of environmental damage to separate the effects of contamination from those of natural environment damage, and for comparison and correlation with laboratory test data. M.G.

N84-27822# Societe Anonyme Belge de Constructions Aeronautiques, Brussels (Belgium).
TWO-PHASE HEAT TRANSPORT SYSTEM CONCEPTUAL STUDIES Final Report
S. VANOOST and J. P. MATHIEU 1 Aug. 1983 138 p refs
(Contract ESA-5346/83/WL-PB(SC))
(SABCA-JPM/LN/HO5/N117; ESA-CR(P)-1873) Avail: NTIS HC A07/MF A01

Thermal management of large space platforms is discussed. Possible concepts include externally driven pump assisted heat

pipe; compressor assisted heat pipe; internally driven pump; oscillating vapor pumps; external return heat pipe; and jet assisted heat pipe. These systems were quantitatively investigated, assessed for their ability to comply with a broad specification set and ranked using a weighting factor technique. The external and the internal pump systems are recommended for further investigation. Author (ESA)

N84-28108*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.

FINITE ELEMENT THERMAL-STRUCTURAL ANALYSIS OF CABLE-STIFFENED SPACE STRUCTUES Final Report for period ending 1 Feb. 1984

E. A. THORNTON, P. DECHAUMPHAI, and A. K. PANDEY Apr. 1984 107 p refs

(Contract NAG1-257)

(NASA-CR-173709; NAS 1.26:173709) Avail: NTIS HC A06/MF A01 CSCL 20K

Finite element thermal-structural analyses of large, cable-stiffened space structures are presented. A computational scheme for the calculation of prestresses in the cable-stiffened structures is also described. The determination of thermal loads on orbiting space structures due to environment heating is discussed briefly. Three finite element structural analysis techniques are presented for the analysis of prestressed structures. Linear, stress stiffening, and large displacement analysis techniques were investigated. These three techniques were employed for analysis of prestressed cable structures at different prestress levels. The analyses produced similar results at small prestress, but at higher prestress, differences between the results became significant. For the cable-stiffened structures studied, the linear analysis technique may not provide acceptable results. The stress stiffening analysis technique may yield results of acceptable accuracy depending upon the level of prestress. The large displacement analysis technique produced accurate results over a wide range of prestress and is recommended as a general analysis technique for thermal-structural analysis of cable-stiffened space structures. R.S.F.

N84-28895# Missouri Univ., Rolla. Dept. of Mechanical and Aerospace Engineering.

WEIGHT CHARACTERISTICS OF FUTURE SPACECRAFT THERMAL MANAGEMENT SYSTEMS Final Report, 1 Jan. - 30 Oct. 1983

J. W. SHEFFIELD Wright-Patterson AFB, Ohio AFWAL Feb. 1984 39 p

(Contract F33615-81-C-2058; AF PROJ. 3145)

(AD-A141403; AFWAL-TR-84-2005) Avail: NTIS HC A03/MF A01 CSCL 22B

This report presents the results of an investigation on the weight characteristics of future spacecraft thermal management systems. The sensitivity of the thermal management system weight to the performance requirements of both evolutionary and revolutionary spacecraft missions has been studied. A numerical analysis modelling the transient heat flow through the thermal management system was performed. The performance parameters included the peak thermal load and the peak-to-average thermal load ratio. In addition the sensitivity of the thermal management system weight to the choice of phase change material for heat storage was determined via a heat of fusion parametric analysis. Author (GRA)

N84-32422*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

STRUCTURAL PERFORMANCE OF ORTHOGONAL TETRAHEDRAL TRUSS SPACE-STATION CONFIGURATIONS

J. T. DORSEY Jul. 1984 38 p refs

(NASA-TM-86260; NAS 1.15:86260) Avail: NTIS HC A03/MF A01

Two 150 kW space station configurations constructed with the orthogonal tetrahedral truss concept are described. One space station consists of a large central platform and two rotating solar wing arrays and the other consists of a long central keel with two rotating arrays. The dynamic characteristics of each configuration are obtained with and without nonstructural components present. The variation in frequencies and mass moments of inertia due to rotation of the two solar wing arrays are given for the long keel space station configuration. The structural performance of the solar wing array is assessed for cases where individual critical struts fail in the array support truss. E.A.K.

N84-34470*# TRW Space Technology Labs., Redondo Beach, Calif.

INNOVATIVE METHOD FOR THE THERMAL CYCLING OF LARGE SPACECRAFT SYSTEMS

C. H. STEIMER and A. D. HALE *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 8-20 1984

Avail: NTIS HC A13/MF A01 CSCL 22B

The use of low cost, off the shelf prefabricated enclosures for spacecraft system thermal cycling applications was indicated. The enclosures are erected in the satellite integration areas without disturbing the test article, electrical test set, or RF interfaces. They are assembled by metal clad, modular urethane panels. These panels are self supporting, and are locked and sealed to each other on assembly. Penetrations for interconnecting cables, coaxial and waveguide services; and temperature conditioning inlet and outlet ducts are easily incorporated where required. The facility and its advantages and intrinsic benefits are described. E.A.K.

05

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.

A84-30526

ASTRODYNAMICS 1983; PROCEEDINGS OF THE CONFERENCE, LAKE PLACID, NY, AUGUST 22-25, 1983. PARTS 1 & 2

G. T. TSENG, ED. (Aerospace Corp., El Segundo, CA), P. J. CEFOLA, ED. (Charles Stark Draper Laboratory, Inc., Cambridge, MA), P. M. BAINUM, ED. (Howard University, Washington, DC), and D. A. LEVINSON, ED. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Conference sponsored by the American Astronautical Society and American Institute of Aeronautics and Astronautics. San Diego, CA, Univelt, Inc. , 1984, Pt. 1, 671 p.; pt. 2, 693 p.

Subjects discussed include attitude dynamics, mission analysis for planetary exploration, orbit determination, attitude determination and control, and celestial mechanics. Attention is given to flexible spacecraft dynamics and control, mission analysis for earth orbiting applications, and orbit transfer and reentry. Autonomous navigation, the space telescope, and trajectory optimization are also covered. C.M.

A84-30527

NONLINEAR VIBRATIONS OF ORBITING TETHERS

A. K. MISRA (McGill University, Montreal, Canada), V. J. MODI (British Columbia, University, Vancouver, Canada), and D. M. XU IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 3-19. refs

(AAS PAPER 83-300)

The paper considers the three dimensional transverse and longitudinal oscillations of a tether connecting a subsatellite to the Shuttle. It is noted that during the terminal phase of retrieval of the subsatellite, when the tension is small, the geometric nonlinearity, (i.e., nonlinearity in strain-displacement relation) becomes quite important. Nonlinear partial differential equations are derived to describe the vibrations and are solved numerically in conjunction with Galerkin's method. Significant change in vibrational behavior is observed when geometric nonlinearity is

taken into account. Schemes are examined for reducing the vibrations during retrieval. Author

A84-30530
NUTATIONAL MOTION OF ASYMMETRIC DUAL-SPIN SPACECRAFT
J. E. COCHRAN, JR. and P. H. SHU (Auburn University, Auburn, AL) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 51-66. refs
(AAS PAPER 83-405)

A perturbation formulation and an averaging method are used to study the effects of energy dissipation on the attitude motion of a dual-spin spacecraft which has an axisymmetric rotor and a slightly asymmetric platform. Energy dissipation is assumed to be caused by a point-mass nutation damper, on first the platform and then the rotor. Approximate equations, valid through first order in the ratio of damper moment of inertia to a spacecraft moment of inertia, are obtained. The asymmetry of the platform and the damper motion are considered to perturb the rotational motion of the spacecraft. The generalized method of averaging is applied to obtain approximate solutions to the equations of motion. Stability criteria are presented and substantiated by numerical solutions to the exact equations of motion. Author

A84-30537* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PERFORMANCE TESTING OF THE GALILEO ATTITUDE CONTROL SYSTEM
C. E. BELL and D. M. DZWONCZYK (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 185-200. NASA-supported research. refs
(AAS PAPER 83-323)

Performance testing plans, procedures, and initial results for the Galileo Attitude and Articulation Control Subsystem are described. The objectives of performance testing include test bed comparisons, examining the interactions between spacecraft dynamics and controllers, and verifying the ability to tune control algorithms in flight to meet specific performance requirements. Two primary test beds are described. One, the Integration Test Laboratory, drives actual flight hardware components and support equipment with a real time computer simulation of spacecraft dynamics. The other, the Functional Simulator, is a nonreal time computer simulation with high fidelity spacecraft dynamics, including flexible appendages, fuel slosh, and simulated hardware components. Initial Functional Simulator results are presented which illustrate spacecraft response to open loop spin-up and turn commands. A closed loop sun acquisition turn is also demonstrated. Future tests for verifying performance of attitude determination, spacecraft control, and scan platform pointing functions are outlined. Author

A84-30539* Howard Univ., Washington, D. C.
ORIENTATION AND SHAPE-CONTROL OF AN ORBITING FLEXIBLE BEAM UNDER THE INFLUENCE OF SOLAR RADIATION PRESSURE
R. KRISHNA and P. M. BAINUM (Howard University, Washington, DC) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 221-238. refs
(Contract NSG-1414)
(AAS PAPER 83-325)

In this paper, the uncontrolled and controlled dynamics of a thin flexible beam in orbit and in the presence of solar radiation disturbance are analyzed. A beam nominally oriented along (i) the local horizontal and carrying a gimballed rigid dumbbell for gravity stabilization, and (ii) a beam nominally oriented along the local vertical are considered. The uncontrolled dynamics of the beam in the presence of the solar radiation pressure disturbance shows the excitation of the rigid pitch mode. The control laws previously designed for the case where the environmental effects were neglected, are found to be inadequate to control the shape and orientation of very flexible beams that are exposed to solar radiation disturbances. The control laws and the gain parameters are reevaluated for both cases of nominal beam orientations; this results, in general, in increased robustness of the closed-loop system. Methods of obtaining a robust control system in the presence of environmental perturbations are discussed. Author

A84-30540* Rensselaer Polytechnic Inst., Troy, N. Y.
OPTIMAL QUASI-STATIC SHAPE CONTROL FOR LARGE AEROSPACE ANTENNAE
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 239-256. refs
(Contract NSF ECS-80-16173; NAG1-171; AF-AFOSR-83-0124)
(AAS PAPER 83-326)

In this paper, an on-line control approach which will adjust the steady-state shape of a large antenna arbitarily close to any achievable desired profile is proposed. The method makes use of distributed parameter system theory and allows refocusing using a limited number of control actuators and sensors. The controller gains are calculated by approximating the solution to an infinite-dimensional optimal quasi-static control problem. A very general convergence result for such quasi-static controllers is proved and applied to the antenna controller to show convergence, using any Galerkin (finite-element) approximation method. Author

A84-30541* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH PRECISION ACTIVE NUTATION CONTROL FOR A FLEXIBLE MOMENTUM BIASED SPACECRAFT
R. A. LASKIN and E. H. KOPF (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 257-276. NASA-supported research. refs
(AAS PAPER 83-330)

The controller design for the Solar Dynamics Observatory (SDO) is presented. SDO is a momentum biased spacecraft with three flexible appendages. Its primary scientific instrument, the solar oscillations imager (SOI), is rigidly attached to the spacecraft bus and has arc-second pointing requirements. Meeting these requirements necessitates the use of an active nutation controller (ANC) which is here mechanized with a small reaction wheel oriented along a bus transverse axis. The ANC does its job by orchestrating the transfer of angular momentum out of the bus transverse axes and into the momentum wheel. A simulation study verifies that the controller provides quick, stable, and accurate response. Author

A84-30547
THE INFLUENCE OF TIME AND NORMALIZATION ON ACTUATOR PLACEMENT BY DEGREE OF CONTROLLABILITY
R. E. LINDBERG, JR. (U.S. Navy, Naval Research Laboratory, Washington, DC) and R. W. LONGMAN (Columbia University, New York, NY) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 371-382. refs
(AAS PAPER 83-338)

The degree of controllability is a quantitative measure of controllability intended as a tool for linear multivariable control system design. Among its uses, it can serve as a criterion for choosing actuator locations for flexible shape control problems. Its evaluation requires the specification of a coordinate frame of interest, a normalization, and a terminal time associated with the control objective. This paper examines the effects that these specifications have on the optimal placement of actuators when the degree of controllability is used. The investigation is motivated by the result that for the shape control of free-free structures, actuators are optimally placed at the corners of the structure when

the normalization is in modal coordinates and the terminal time is large. Author

A84-30548
TIME PERIODIC ATTITUDE CONTROL PROBLEMS
R. A. CALICO, W. E. WIESEL (USAF, Institute of Technology, Wright-Patterson AFB, OH), and G. E. MYERS IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 383-395. refs
(AAS PAPER 83-339)

This paper considers the active control of time periodic linear systems. Modal control is used to change one or more system modes using one of three gain selection techniques. As examples, the attitude motion of a spinning symmetrical satellite in an elliptical orbit and the attitude motion of a spinning unsymmetrical satellite in a circular orbit are considered. In both examples, unstable equilibria are stabilized using the techniques developed. Author

A84-30550* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RESPONSE OF LARGE SPACE STRUCTURES WITH STIFFNESS CONTROL
J.-C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 417-431. refs
(Contract NAS7-100)
(AAS PAPER 83-344)

For large space structures, such as the 100-meter-diameter wrap-rib deployable antenna and spinning solar sail, whose out-of-plane stiffness is derived from in-plane tension, the out-of-plane motion can be actively controlled by time-varying in-plane tension. An elastic string is used to demonstrate the proposed approach, which results in a nonlinear ordinary differential equation. An approximation method is outlined from which the magnitude of time-varying tension can be determined based on the efficiency factor, the time factor or the optimal factor. Author

A84-30555* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AN ADAPTIVE GUIDANCE LOGIC FOR AN AEROASISTED ORBITAL TRANSFER VEHICLE
O. HILL (NASA, Johnson Space Center, Houston, TX) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 495-518.
(AAS PAPER 83-357)

The Orbital Transfer Vehicle (OTV) is to be employed for the delivery of a paylod to a high earth orbit, such as a geosynchronous orbit. Subsequently, the OTV is to return to a low earth parking orbit. The present investigation is concerned with an aeroassisted OTV (AOTV) which achieves the required reduction in velocity on its return to the parking orbit through aerodynamic braking. An adaptive guidance logic is employed to control and AOTV as it passes through the earth's upper atmosphere. Attention is given to details regarding the adaptive guidance logic, and a performance evaluation. It is found that the performance of the adaptive guidance logic is satisfactory for the considered conditions. G.R.

A84-30561* Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE TELESCOPE POINTING CONTROL
H. DOUGHERTY, C. RODONI, J. RODDEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and K. TOMPETRINI (Bendix Corp., Systems Div., Teterboro, NJ) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 619-630. refs
(Contract NAS8-32697)
(AAS PAPER 83-365)

The Space Telescope, a long life, high performance spacecraft deployed by the Space Shuttle, will carry five scientific instruments on its first mission. Its pointing control system will permit target-to-target maneuvering and precision pointing on a target star to support scientific objectives. Spacecraft attitude control is achieved by onboard computer processing of attitude and rate sensor data to generate reaction wheel torque commands. A momentum management control system is provided to desaturate the reaction wheels. This paper discusses the pointing control system and the control hardware investigations and improvements leading to system design. Author

A84-30562* Lockheed Missiles and Space Co., Sunnyvale, Calif.
CONTROL SYSTEM TESTING
W. H. WHITTLER and R. E. COLLART (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 631-643. refs
(Contract NAS8-32697)
(AAS PAPER 83-366)

A three stage process of ground testing of the Space Telescope Pointing Control System is used for verification prior to on-orbit operation. First, development tests are conducted in a laboratory environment using flight/engineering model control sensor and actuators configured with an engineering model of the flight computer and data management system breadboards. These development tests validate the results of computer simulations predicting control system performance. Integration tests bring together flight system elements and software interfaced to a software simulation of vehicle dynamics to confirm closed loop performance. The final ground test phase, flight systems testing, is conducted on the fully assembled Space Telescope, verifies interfaces with the Fine Guidance Sensors and includes a thermal vacuum testing period. During the final test phase, the Point Control System is exercised with the dynamics simulator running in real time. Author

A84-30568* Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
OPTIMAL SLEWING MANEUVERS FOR FLEXIBLE SPACECRAFT USING A CLOSED FORM SOLUTION FOR THE LINEAR TRACKING PROBLEM
J. D. TURNER, H. M. CHUN (Charles Stark Draper Laboratory, Inc., Cambridge, MA), and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 2 . San Diego, CA, Univelt, Inc., 1984, p. 717-737. refs .
(AAS PAPER 83-374)

The problem of maneuvering a flexible spacecraft through a large angle while requiring the feedback control system to track a desired output state is considered. The desired output state is assumed to be provided by the corresponding open-loop maneuvering solution for the linear system model. Closed form solutions are provided for the Riccati and prefilter equations defining the optimal control. Example maneuvers are presented where control-rate penalties have been included in the performance index, in order to smooth both the open- and closed-loop control commands. Author

A84-30569* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE-ANGLE MANEUVERS OF FLEXIBLE SPACECRAFT USING A CLOSED FORM SOLUTION FOR THE TERMINAL TRACKING PROBLEM
J.-N. JUAN (NASA, Langley Research Center, Hampton, VA), J. D. TURNER, and H. M. CHUN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 2 . San Diego, CA, Univelt, Inc., 1984, p. 739-757. refs
(AAS PAPER 83-375)

The problem of maneuvering a flexible spacecraft through a large-angle while requiring a sub-vector of the terminal state to exactly satisfy a set of terminal constraints is considered. The necessary conditions for this problem lead to three coupled

nonlinear Riccati-like differential equations, which are solved in closed form. Example maneuvers are presented where control-rate penalties have been included in the performance index, in order to smooth the closed-loop control commands. Furthermore, example maneuvers are presented for both fixed and free and condition problem. Author

A84-30571
FUZZY CONCEPTS OF THE DEGREE OF CONTROLLABILITY AND DEGREE OF OBSERVABILITY
S. W. SIRLIN and R. W. LONGMAN (Columbia University, New York, NY) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 2 . San Diego, CA, Univelt, Inc., 1984, p. 777-795. refs
(Contract NSF CEE-80-19275)
(AAS PAPER 83-378)

It is shown how the concepts of DOC (degree of controllability) and DOO (degree of observability) can be generalized to include fuzzy sets. The generalized concept of a scalar measure which may be made independent of various parameters previously necessary (e.g., time) is the primary theoretical generalization for the DOC case. The scalar measure is also generalized in the DOO case, and a provision is made to include a penalty on how 'long' it takes to observe a state. Consideration is given to special cases of these concepts for DOC and DOO, leading to new measures which are easy to calculate. B.J.

A84-31684
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
Conferences sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1984, 665 p.

Analytical and experimental investigations of structural-dynamics problems are reported, with emphasis on aircraft and spacecraft applications. Topics discussed include separated-flow unsteady aerodynamics for propfans, design-oriented identification of critical times in transient response, unified flutter analysis for composite aircraft wings, Shuttle-payload transient-load analysis, flexible-beam modal-control experiments, decoupled control of large space structures, a photogrammetric method for obtaining frequency-response functions, the Galileo spacecraft modal survey, the aeroelastic behavior of straight and forward-swept graphite/epoxy wings, and geometric methods for multibody dynamics. T.K.

A84-31697#
A MODAL IDENTIFICATION ALGORITHM FOR HIGHER ACCURACY REQUIREMENTS
S. R. IBRAHIM (Old Dominion University, Norfolk, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 117-122. USAF-supported research. refs
(AIAA PAPER 84-0928)

This paper discusses the damping identification accuracy of the time domain modal identification algorithm referred to as the 'ITD' technique. It is shown here that the biased, but bound, errors in the identified damping factors are due to the inherent statistically biased numerical errors in the least squares approach used to compute the matrix of eigenvalues and eigenvectors. A modified least squares solution is presented and shown to eliminate the damping bias and improve its identification accuracy without affecting either the simplicity or the other acknowledged merits of the technique. Author

A84-31701#
COMPONENT MODE SYNTHESIS METHODS FOR TEST-BASED, RIGIDLY CONNECTED, FLEXIBLE COMPONENTS
M. BAKER (Structural Dynamics Research Corp., San Diego, CA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 153-163. refs
(AIAA PAPER 84-0943)

With the objective of enhancing test-based modal synthesis and planning the development of test methods, simple examples were run using finite-element-based components to compare accuracy and define test requirements for a number of approaches to component mode synthesis. These approaches are: restrained modal component, residual flexibility, mass-loaded connect degrees of freedom, and rotational connect degrees of freedom. Author

A84-31708*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VIBRATION AND BUCKLING OF GENERAL PERIODIC LATTICE STRUCTURES
M. S. ANDERSON (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) and F. W. WILLIAMS (University of Wales Institute of Science and Technology, Cardiff, Wales) IN: 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 New York, American Institute of Aeronautics and Astronautics, 1984, p. 206-213. refs
(AIAA PAPER 84-0979)

A method is presented for vibration and buckling analysis of arbitrary lattice structures having repetitive geometry in any combination of coordinate directions. The approach is based on exact member theory for representing the stiffness of an individual member subject to axial load, and in the case of vibration, undergoing harmonic oscillation. The method is an extension of previous work that was limited to specific geometries. The resulting eigenvalue problem is of the size associated with the repeating element of the structure. A computer program has been developed incorporating the theory and results are given for vibration of rectangular platforms and a large antenna structure having rotational symmetry. Buckling and vibration results for cable-stiffened rings are also given. Author

A84-31717#
MODAL-SPACE ACTIVE DAMPING OF A PLANE GRID - EXPERIMENT AND THEORY
WM. L. HALLAUER, JR., G. R. SKIDMORE, and R. N. GEHLING (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 306-316. refs
(Contract AF-AFOSR-82-0217; NSF CME-80-14059; F49620-83-C-0158)
(AIAA PAPER 84-1018)

This paper first reviews a theory of multiple-actuator modal-space active damping (control) which uses spectral filtering for modal estimation; then it describes an experiment in which the control technique was applied in analog form to a laboratory plane grid structure having a dozen modes under 10 Hz. Experimental observations and corresponding theoretical calculations are presented. Active damping of five modes, including a closely spaced pair, was attempted with the use of five control actuators. But coupling between the two close modes and their filters produced a mild system instability. Subsequently, a stable four-mode controller was produced by disabling the control of the mode that had driven the instability. The spectral filtering played an unexpectedly dominant and counterproductive role in the active damping process. Author

A84-31718#
EXPERIMENTAL RESEARCH ON FLEXIBLE BEAM MODAL CONTROL
B. SCHAEFER and H. HOLZACH (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberphaffenhofen, West Germany) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 317-326. refs
(AIAA PAPER 84-1020)

A hardware experiment has been constructed for active vibration control (low-authority control) of a clamped-free flexible beam, where the design methodology is based on direct velocity feedback control. The objective of the experiment is to demonstrate and verify the dynamics and the advanced control laws for the structural element. A further important feature of the experiment is the feasibility of a hardware realization, especially the dedicated non-contacting sensors and actuators. Sensing is provided by a purely optical displacement sensor while an in-house developed electrodynamic force system provides for actuating. Experimental results in comparison with computer simulations are presented for open and closed loop performance for both collocated and dislocated actuator/sensor positions. In most cases of different positioning good agreement could be achieved between experiment and theoretical predictions. Author

A84-31719*# Honeywell, Inc., Clearwater, Fla.
DYNAMICS OF FLEXIBLE BODIES IN TREE TOPOLOGY - A COMPUTER ORIENTED APPROACH
R. P. SINGH, R. J. VANDERVOORT (Honeywell, Inc., Clearwater, FL), and P. W. LIKINS (Lehigh University, Bethlehem, PA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 327-337. NASA-sponsored research. refs
(AIAA PAPER 84-1024)

An approach suited for automatic generation of the equations of motion for large mechanical systems (i.e., large space structures, mechanisms, robots, etc.) is presented. The system topology is restricted to a tree configuration. The tree is defined as an arbitrary set of rigid and flexible bodies connected by hinges characterizing relative translations and rotations of two adjoining bodies. The equations of motion are derived via Kane's method. The resulting equation set is of minimum dimension. Dynamical equations are imbedded in a computer program called TREETOPS. Extensive control simulation capability is built in the TREETOPS program. The simulation is driven by an interactive set-up program resulting in an easy to use analysis tool. Author

A84-31720#
REQUIREMENTS AND ISSUES FOR THE CONTROL OF FLEXIBLE SPACE STRUCTURES
J. F. GARIBOTTI (HR Textron, Inc., Irvine, CA) IN: Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 15-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 338-347.
(AIAA PAPER 84-1025)

This paper is a summary of the Final Report of the NASA Space Systems and Technology Advisory Committee's Ad Hoc Subcommittee on Controls/Structures Interaction. The subcommittee was charged on August 2, 1982 with addressing NASA's need for a flight-ready capability for accurate shape control, vibration suppression, and pointing control for future space structures such as antennas and platforms. The subcommittee objectives were to determine where and to what extent this is a problem for NASA, and what controls/structures research and development is required for future NASA missions. The paper discusses candidate NASA missions that might involve or benefit from Controls/Structure Interaction technology, key technical issues, and on-orbit testing philosophy. The paper concludes with a recommendation for a NASA R and D program. Author

A84-31721#
ACTIVE CONTROL OF SPACE STRUCTURES (ACOSS) - A STATUS REPORT
R. R. STRUNCE, JR. (General Research Corp., McLean, VA) and R. W. CARMAN (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 348-356. refs
(AIAA PAPER 84-1027)

The Active Control of Space Structures (ACOSS) is one of the key enabling technologies for future Large Space Structures (LSS). This paper presents a summary status of the ACOSS technology as well as the relevant technologies necessary for implementation: algorithm sizing, avionics data processing, sensors, actuators, fault tolerant considerations, relevant LSS experiments and LSS vacuum chambers. The reference list included at the end of the paper provides a comprehensive overview of the ACOSS program. Author

A84-31725#
COMPARISON OF VARIOUS CONTROLLER-REDUCTION METHODS SUBOPTIMAL VERSUS OPTIMAL PROJECTION
D. C. HYLAND (Harris Corp., Melbourne, FL) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 381-389. refs
(AIAA PAPER 84-1033)

Several suboptimal approaches to reduced-order controller design are compared with the new optimal projection formulation of the quadratically optimal fixed-form compensator problem. The substantial similarities and significant differences among the various design techniques are highlighted by placing the design equations of all methods within a common notation. Basically, all methods characterize the reduced-order controller by a projection on the full state space. The suboptimal methods construct this projection on the basis of balancing considerations while the optimal projection equations define it as a consequence of optimality conditions. Issues relating to relative computational simplicity and design reliability are explored by applying two of the methods to the same example problem. Author

A84-31726#
DECOUPLED LARGE SPACE STRUCTURE CONTROL
R. A. CALICO, JR. and D. V. TNYFAULT IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 390-395. refs
(AIAA PAPER 84-1034)

The design of a stable multiple controller control system is presented in this paper. Sufficient conditions are given for both the total decoupling of the multiple controllers and for coupled but stable operation of the multiple controllers. The satisfaction of these conditions is shown to lead to requirements on the minimum numbers of sensors and actuators. The control of a thirty three mode model of the CSDL II spacecraft using drect output feedback is presented. Three separate controllers are used to successfully actively control twenty six modes leaving seven residual modes uncontrolled but stable. Author

A84-31727#
THE OPTIMAL PROJECTION EQUATIONS FOR FIXED-ORDER DYNAMIC COMPENSATION OF DISTRIBUTED-PARAMETER SYSTEMS
D. S. BERNSTEIN (MIT, Lexington, MA) and D. C. HYLAND (Harris Corp., Melbourne, FL) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 396-400. USAF-sponsored research. refs
(AIAA PAPER 84-1035)

One of the major difficulties in designing implementable active controllers for distributed parameter systems such as flexible space structures is that such systems are inherently infinite dimensional while controller dimension is severely constrained by on-line computing capability. Suboptimal approaches to this problem usually either seek a distributed parameter control law or design a low-order dynamic controller for an approximate high-order finite-element model. This paper presents a more direct approach by deriving explicit optimality conditions for finite-dimensional steady-state fixed-order dynamic compensation of infinite-dimensional systems. In contrast to the pair of operator Riccati equations for the 'full-order' LQG case, the optimal fixed-order dynamic compensator is characterized by four operator equations (two modified Riccati equations and two modified Lyapunov equations) coupled by a projection whose rank is precisely equal to the order of the compensator and which determines the optimal compensator gains. The coupling represents a graphic portrayal of the demise of the classical separation principle for the reduced-order controller case. The results obtained apply to a semigroup formulation in Hilbert space and thus are applicable to control problems involving a broad range of specific partial and hereditary differential equations. Author

A84-31728*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ENHANCED VIBRATION CONTROLLABILITY BY MINOR STRUCTURAL MODIFICATIONS
R. T. HAFTKA, Z. N. MARTINOVIC, and W. L. HALLAUER, JR. (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 401-410. refs
(Contract NAG1-224; NSF CME-80-14059)
(AIAA PAPER 84-1036)

A procedure for checking whether small changes in a structure have the potential for significant enhancements of its vibration control system is described. The first step in the procedure consists of the calculation of the sensitivity of the required strength of the control system to small changes in structural parameters. The second step consists of the optimization of the structural parameters to produce maximal reduction in required control system strength with minimal change in the structure. The procedure has been demonstrated for a flexible beam supported by four cables and controlled by a rate feedback single-colocated force-actuator velocity-sensor pair. Large changes in control strength requirement were obtained with small structural modifications. Analytical predictions of such effects have also been validated experimentally. Author

A84-31729#
OPTIMAL DESIGN FOR SINGLE AXIS ROTATIONAL MANEUVERS OF A FLEXIBLE STRUCTURE
A. L. HALE and R. J. LISOWSKI (Illinois, University, Urbana, IL) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 411-421. refs
(AIAA PAPER 84-1041)

An optimization problem for rotational maneuvers of a flexible structure is considered. Both structural parameters and active control torques are to be determined so that a specific cost functional is minimized. Obtaining a numerical solution to the problem is shown to be practical if reduced-order structural models are employed. The time and frequency nature of the problem is discussed, and numerical exampls are presented for a single axis slew maneuver of a symmetric four boom structure. Author

A84-31730#
DYNAMICS AND CONTROL OF LATTICE BEAMS USING COMPLEX AND SIMPLIFIED FINITE ELEMENT METHODS
T. Y. YANG, R. E. SKELTON, and D. T. BERRY (Purdue University, West Lafayette, IN) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 422-430. refs
(Contract AF-AFOSR-83-0104)
(AIAA PAPER 84-1043)

The strain and kinetic energies formed by replacing the lattice with an equivalent continuum are used to develop simple beam finite element analysis models for a flexible lattice beam with repetitive geometry. The beam element has six degrees of freedom at each of its two nodes: three orthogonal displacements and three rotations. The performance of the simple finite element formulation in free vibration analysis is evaluated through a comparison with free vibration results of a full or complex finite element model of the lattice formed by using truss bar elements. The accuracy of the frequencies predicted by the simple analysis models is found to increase as the number of repeating cells in each half-wavelength increases. The example analysis performed here demonstrates that the simple finite element analysis models can be used with accuracy in the control law design process for lattice beams with low bandwidth controllers. C.R.

A84-31731#
FREQUENCY CONTROL AND THE EFFECT ON THE DYNAMIC RESPONSE OF FLEXIBLE STRUCTURES
V. B. VENKAYYA and V. A. TISCHLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 431-441. refs
(AIAA PAPER 84-1044)

An automated design analysis procedure for the parallel optimization of spacecraft flexible structures and their active controls is developed and applied. Numerical results for a simple two-bay truss with four actuators are presented in graphs and tables. T.K.

A84-31732#
FREQUENCY DOMAIN ANALYSIS OF A PLATE WITH DISCRETE ELEMENTS ATTACHED
D. J. INMAN (New York, State University, Buffalo, NY) and M. OMRANI IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 442-444. refs
(Contract AF-AFOSR-82-0242)
(AIAA PAPER 84-1045)

In many applications in dynamics and control, discrete springs, dashpots and masses are added to distributed mass structures in an attempt to alter the structure's natural frequencies and response characteristics. This work examines the use of transforms to obtain a frequency domain analysis of distributed parameter model of a plate with various arrangements of attached discrete masses, springs and dashpots, and subject to point loads. The general equations of motion are given in distributed form. Then, following the method reported by Satter for beams, a transform of the solution is calculated and presented in closed form. This solution is then truncated and programmed. The program is then used to perform a numerical study on the plate deflection (response magnitude) at a specified point due to a unit impulse for various combinations and locations of the attached discrete elements. The numerical example is that of a simply supported stainless steel rectangular plate. Author

A84-31733#
AN OPTIMAL SINGLE-SENSOR FEEDBACK CONTROL LAW FOR FLEXIBLE DYNAMIC SYSTEMS
S. B. SKAAR (Iowa State University of Science and Technology, Ames, IA) and L. TANG IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 445-448.
(AIAA PAPER 84-1046)

A new approach to the use of feedback in the control of distributed parameter systems is outlined. Acceleration data is assumed to be available at a single location in the system at which the controlling force or torque acts. This acceleration history is used to correct the motion at any current, midmaneuver instant. Several kinds of disturbances acting on the hub are permitted, including mass loss, nonelastic deformation, extraneous torques, and small, unmodeled elastic regions. The modeled elastic appendages must be regarded as undisturbed, and perfectly modeled as regards their response to the central 'rigid' hub. The method permits specification of final velocities and positions of the hub region as well as a finite number of points on the modeled elastic appendages. C.D.

A84-31735#
A PERTURBATION TECHNIQUE FOR GYROSCOPIC SYSTEMS WITH SMALL INTERNAL AND EXTERNAL DAMPING
L. MEIROVITCH and G. RYLAND (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 457-468. refs
(Contract AF-AFOSR-83-0017)
(AIAA PAPER 84-1049)

The response of linear damped gyroscopic systems can be obtained by means of techniques of linear systems theory, which involves the computation of the transition matrix. The response is in terms of complex quantities, which is likely to cause computational difficulties as the order of the system increases. In the absence of damping, it is possible to derive the response of a linear gyroscopic system with relative ease by working with real quantities alone. When damping is small, one can use a perturbation approach to produce the response by regarding the undamped gyroscopic system as the unperturbed system. In a previous paper, a perturbation analysis was used to derive the response of a gyroscopic system with small internal damping. This paper extends the approach to the case of external damping, which is characterized not only by symmetric coefficients multiplying velocities but also by skew symmetric coefficients multiplying displacements, where the latter terms are known as circulatory. A numerical example is presented. Author

A84-31736*# Texas Univ., Austin.
A GENERALIZED MULTIPLE-INPUT, MULTIPLE-OUTPUT MODAL PARAMETER ESTIMATION ALGORITHM
R. R. CRAIG, JR. (Texas, University, Austin, TX) and M. A. BLAIR (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 469-477. refs
(Contract NAS8-33980)
(AIAA PAPER 84-1050)

A new method for experimental determination of the modal parameters of a structure is presented. The method allows for multiple input forces to be applied simultaneously, and for an arbitrary number of acceleration response measurements to be employed. These data are used to form the equations of motion for a damped linear elastic structure. The modal parameters are then obtained through an eigenvalue technique. In conjunction with the development of the equations, an extensive computer simulation study was performed. The results of the study show a marked improvement in the mode shape identification for closely-spaced modes as the number of applied forces is increased. Also demonstrated is the influence of noise on the method's ability to identify accurate modal parameters. Here again, an increase in the number of exciters leads to a significant improvement in the identified parameters. Author

A84-31737*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACECRAFT STRUCTURAL SYSTEM IDENTIFICATION BY MODAL TEST
J.-C. CHEN, L. F. PERETTI, and J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Applied Mechanics Technology Section, Pasadena, CA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 478-489. NASA-supported research. refs
(AIAA PAPER 84-1051)

A structural parameter estimation procedure using the measured natural frequencies and kinetic energy distribution as observers is proposed. The theoretical derivation of the estimation procedure is described and its constraints and limitations are explained. This procedure is applied to a large complex spacecraft structural system to identify the inertia matrix using modal test results. The inertia matrix is chosen after the stiffness matrix has been updated by the static test results. Author

A84-31739#
DAMPING SYNTHESIS FOR A SPACECRAFT USING SUBSTRUCTURE AND COMPONENT DATA
K. W. LIPS and F. R. VIGNERON (Department of Communications, Communications Research Centre, Ottawa, Canada) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 497-506. refs
(AIAA PAPER 84-1053)

The report demonstrates a method for calculation of system damping factors that is based on solving the 'general' eigenvalue problem for the motion equations, given component data as the

base input information. The method exhibits no computational difficulties and is confirmed by comparison to approximate results based on the Method of Averaging. The method is applied to the Hermes spacecraft, a configuration which consists of a central rigid body, two flexible solar array substructures, a momentum wheel and a liquid mercury damping device. The synthesized modal damping values for the structural modes vary relative to those measured in orbit by factors ranging from zero to five. Author

A84-31741*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A RAPID METHOD FOR OBTAINING FREQUENCY-RESPONSE FUNCTIONS FOR MULTIPLE INPUT PHOTOGRAMMETRIC DATA

M. L. KROEN and J. S. TRIPP (NASA, Langley Research Center, Instrument Research Div., Hampton, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 510-527. refs
(AIAA PAPER 84-1060)

A two-digital-camera photogrammetric technique for measuring the motion of a vibrating spacecraft structure or wing surface and an applicable data-reduction algorithm are presented. The 3D frequency-response functions are obtained by coordinate transformation from averaged cross and autopower spectra derived from the 4D camera coordinates by Fourier transformation. Error sources are investigated analytically, and sample results are shown in graphs. T.K.

A84-31743#

SOME MEASUREMENT AND ANALYSIS METHODS USED IN THE GALILEO SPACECRAFT MODAL SURVEY

R. C. STROUD, M. R. PAMIDI (Synergistic Technology, Inc., Cupertino, CA), and H. P. BAUSCH (Wyle Laboratories, Norco, CA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 542-548. refs
(AIAA PAPER 84-1067)

The Galileo spacecraft has been subjected to a testing program aimed at identifying its most significant structural modes, as well as to verify the FEM analytical model previously developed for it. The primary test method was the classical, tuned-multiexciter sinusoidal dwell technique. The modal analyses were performed by curve fitting in the frequency domain. Natural frequencies, modal damping and mode shapes were determined in the 5-45 Hz range. O.C.

A84-31744#

OPTIMAL SELECTION OF EXCITATION METHODS FOR ENHANCED MODAL TESTING

D. L. HUNT (SDRC, Inc., San Diego, CA), E. L. PETERSON, H. VOLD (SDRC, Inc., Milford, OH), and R. WILLIAMS (SDRC, Inc., Hitchin, Herts., England) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 549-553. refs
(AIAA PAPER 84-1068)

Single-input and multiple-input frequency-response and modal-tuning excitation methods for the modal testing of aircraft and spacecraft structures are compared, and procedures for choosing the method best suited to a particular problem are developed and demonstrated for the Galileo spacecraft. In that case, an increase in the number of modes identified (from 14 to 26) and a reduction of data-collection time (from 3.5 weeks to 2 days) could have been achieved by identifying the optimal method (multiple random input) before testing. T.K.

A84-31745*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

APPLICATION OF MULTIPLE INPUT RANDOM AND POLYREFERENCE ANALYSIS TECHNIQUES TO THE GALILEO SPACECRAFT MODAL TEST

J. C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) and D. L. HUNT (SDRC, Inc., San Diego, CA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 554-560. refs
(AIAA PAPER 84-1069)

An experimental modal analysis of the Galileo spacecraft was required to verify a finite element model used in loads analysis. Multiple input random and polyreference analysis techniques were applied in this program to demonstrate their effectiveness in determining the modal characteristics of a complex space structure. The methods were successful in determining an accurate set of modal data from two days of data acquisition. A complete set of results was available within 24 hours of test completion. Final analysis shows the modes from the multiple input random tests to be more complete and orthogonal than those obtained from classical sine dwell methods. Author

A84-31746*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

EVALUATION OF MODAL TESTING METHODS

J.-C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Applied Mechanics Technology Section, Pasadena, CA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 561-572. NASA-supported research. refs
(AIAA PAPER 84-1071)

Modal tests are playing an increasingly important role in structural dynamics efforts which are in need of analytical model verification or trouble shootings. In the meantime, the existing modal testing methods are undergoing great changes as well as new methods are being created. Although devoted advocates of each method can be found to argue the relative advantages and disadvantages, the general superiority, if any, of one or the other is not yet evident. The Galileo spacecraft, a realistic, complex structural system, will be used as a test article for performing modal tests by various methods. The results will be used to evaluate the relative merits of the various modal testing methods. Author

A84-31747*# State Univ. of New York, Buffalo.

DYNAMIC CHARACTERIZATION AND MICROPROCESSOR CONTROL OF THE NASA/UVA PROOF MASS ACTUATOR

D. C. ZIMMERMAN, D. J. INMAN (New York, State University, Buffalo, NY), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 573-577.
(Contract NGT-33-183-801)
(AIAA PAPER 84-1077)

The self-contained electromagnetic-reaction-type force-actuator system developed by NASA/UVA for the verification of spacecraft-structure vibration-control laws is characterized and demonstrated. The device is controlled by a dedicated microprocessor and has dynamic characteristics determined by Fourier analysis. Test data on a cantilevered beam are shown. T.K.

A84-31752*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONVECTED TRANSIENT ANALYSIS FOR LARGE SPACE STRUCTURES MANEUVER AND DEPLOYMENT
J. HOUSNER (NASA, Langley Research Center, Hampton, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 616-629. refs
(AIAA PAPER 84-1023)

Convected-transient analysis techniques in the finite-element method are used to investigate the deployment and maneuver of large spacecraft structures with multiple-member flexible trusses and frames. Numerical results are presented for several sample problems. T.K.

A84-31753*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
GALILEO SPACECRAFT MODAL IDENTIFICATION USING AN EIGENSYSTEM REALIZATION ALGORITHM
R. S. PAPPA and J.-N. JUANG (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 630-645. refs
(AIAA PAPER 84-1070)

A modal parameter identification technique referred to as the Eigensystem Realization Algorithm (ERA) was applied to free-response measurements from the Galileo spacecraft modal survey test. The data were recorded following single-point random excitation of the structure. This work is one phase in a research project coordinated by the Jet Propulsion Laboratory to compare the performance of various contemporary identification techniques using Galileo data. Principal emphasis is placed on estimating the accuracy of the ERA-identified modal parameters. Various accuracy indicators, such as Modal Amplitude Coherence and Modal Phase Collinearity, are discussed. More than 20 modes of the spacecraft were identified, demonstrating the ability of the ERA method to determine the dynamics of such complex structures using only a few seconds of test data. Author

A84-32615*# Howard Univ., Washington, D. C.
EFFECT OF SOLAR RADIATION DISTURBANCE ON A FLEXIBLE BEAM IN ORBIT
R. KRISHNA and P. M. BAINUM (Howard University, Washington, DC) AIAA Journal (ISSN 0001-1452), vol. 22, May 1984, p. 677-682. refs
(Contract NSG-1414)

Previously cited in issue 05, p. 607, Accession no. A83-16710

A84-32701#
OPTIMAL DISTRIBUTED CONTROL OF A FLEXIBLE SPACECRAFT DURING A LARGE-ANGLE MANEUVER
J. D. TURNER and H. M. CHUN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) (Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981, p. 471-485) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, May-June 1984, p. 257-264. refs

Previously cited in issue 21, p. 3102, Accession no. A83-45126

A84-32702#
ROBUST CONTROL OF SELF-ADJOINT DISTRIBUTED-PARAMETER STRUCTURES
A. L. HALE and G. A. RAHN (Illinois, University, Urbana, IL) (Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers, p. 484-494) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, May-June 1984, p. 265-273. refs

Previously cited in issue 19, p. 2998, Accession no. A82-38977

A84-32703#
CRITICAL PARAMETER SELECTION IN THE VIBRATION SUPPRESSION OF LARGE SPACE STRUCTURES
R. K. YEDAVALLI (Stevens Institute of Technology, Hoboken, N.J.) (Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers, p. 495-499) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, May-June 1984, p. 274-278. refs

Previously cited in issue 19, p. 2998 Accession no. A82-38978

A84-33133*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
IDENTIFICATION OF THE DYNAMICS OF A TWO-DIMENSIONAL GRID STRUCTURE USING LEAST SQUARE LATTICE FILTERS
R. C. MONTGOMERY and N. SUNDARARAJAN (NASA, Langley Research Center, Hampton, VA) American Automatic Control Council, American Control Conference, San Diego, CA, June 6-8, 1984, Paper, 7 p. refs

The basic theory of least square lattice filters and their use in identification of structural dynamics systems is summarized. Thereafter, this theory is applied to a two-dimensional grid structure made of overlapping bars. Previously, this theory has been applied to an integral beam. System identification results are presented for both simulated and experimental tests and they are compared with those predicted using finite element modelling. The lattice filtering approach works well for simulated data based on finite element modelling. However, considerable discrepancy exists between estimates obtained from experimental data and the finite element analysis. It is believed that this discrepancy is the result of inadequacies in the finite element modelling to represent the damped motion of the laboratory apparatus. Author

A84-33139*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ASSESSMENT OF DYNAMIC ANALYSES FOR DEPLOYING SPACE TRUSS STRUCTURES
D. WEIDMAN and J. HOUSNER (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 14 p. refs
(AIAA PAPER 84-0924)

A selected list of references on the analysis of the deployment concepts for large space truss structures are reviewed. The stability of the deployment process is discussed, and stable methods of deployment mentioned. Analytical and experimental needs to assess feasibility and performance of proposed deployment concepts are outlined. Author

A84-34014*# National Aeronautics and Space Administration, Washington, D. C.
PROBLEMS AND CONCEPTS OF SPACE STATION GUIDANCE, NAVIGATION, AND CONTROL
A. K. GUHA and M. CRAIG (NASA, Concept Development Group, Washington, DC) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 89-95.
(AIAA PAPER 84-1139)

The Space Station System is defined as a network of space and ground assets which work together to support a variety of missions including commercial missions, science and applications missions, and technology development missions. The elements of

the Space Station System include a Space Station Base, Space Platforms, Free Flyers, a Teleoperator Manuevering System (TMS), Orbital Transfer Vehicles (OTV), Orbiter Berthing Equipment, and Ground Support Equipment and Facilities. Guidance, navigation, and control (GNC) subsystem requirements are considered along with configuration trades. G.R.

A84-34908#
INTERACTION OF FUNDAMENTAL PARAMETRIC RESONANCES WITH SUBHARMONIC RESONANCES OF ORDER ONE-HALF
A. H. NAYFEH (Virginia Polytechnic Institute and State University, Blacksburg, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 7 p. refs
(AIAA PAPER 84-0978)

The interaction of fundamental parametric resonances with subharmonic resonances of order one-half in a single-degree-of-freedom system with quadratic and cubic nonlinearities is investigated. The method of multiple scales is used to derive two first-order ordinary-differential equations that describe the modulation of the amplitude and the phase of the resonance with the nonlinearity and both resonances. These equations are used to determine the steady-state solutions and their stability. Conditions are derived for the quenching or enhancement of a parametric resonance by the addition of a subharmonic resonance of order one-half. The degree of quenching or enhancement depends on the relative amplitudes and phases of the excitations. The analytical results are verified by numerically integrating the original governing differential equation. Author

A84-34910#
EQUATIONS OF MOTION OF MULTIBODY SYSTEMS FOR APPLICATION TO LARGE SPACE STRUCTURE DEPLOYMENT
J. E. KEAT and J. D. TURNER (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 35 p. refs
(Contract F04611-82-K-0038)
(AIAA PAPER 84-1014)

A formulation for the dynamical equation of multibody systems was developed to simulate the deployment dynamics of large space structures. The interfaces between the rigid or nonrigid bodies were modeled using joints having between 0 and 6 degrees of freedom, and the graph of the system could have closed loops. The application of the velocity transformation technique involved the following: (1) cutting all joints and determining in the time derivatives of absolute velocities a kinetics equation of the multibody system; (2) reconnecting selected joints and developing by transformation of velocities the kinetics equation for this new system; and (3) establishing constraints at the unreconnected joints and introducing them into the formulation. Applications include simulating deployment of a simplified model of a space-based radar. C.M.

A84-34911#
LARGE MOTION DYNAMICS OF A SPACECRAFT WITH A CLOSED-LOOP, ARTICULATED, FLEXIBLE APPENDAGE
A. K. BANERJEE (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) and T. R. KANE (Stanford University, Stanford, CA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 37 p. Research supported by the Lockheed Missiles and Space Co., Inc. refs
(AIAA PAPER 84-1015)

Two issues are treated with regard to the modeling of closed-loop, flexible spacecraft: the efficient formulation of complex equations of motion; and the potential uses for large motions of the component mode representations with good results in the substructure synthesis of small motions. Partial angular velocity matrices and partial velocity matrices are used to simplify expression formation for generalized inertia forces and the dynamical mass matrix. The strategy includes cutting the loop at a hinge, writing equations for the resulting system, and adding loop closure constraints. The equations of motion, constraints, mode shapes, and numerical results are discussed. Hybrid modes produce a representative response, even where normal modes were inadequate. It is concluded that hybrid modes composed of a few normal modes augmented by residual flexibility attachment or inertia relief modes are superior to normal modes alone. C.M.

A84-34912#
DYNAMICS OF A SPINNING SPACECRAFT DURING EXTENSION OF FLEXIBLE APPENDAGES
J. TURNER, J. KEAT (Charles Stark Draper Laboratory, Inc., Cambridge, MA), and A. MESSAC AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 23 p. refs
(AIAA PAPER 84-1021)

This paper addresses the problem of analyzing the deployment of flexible appendages from a central rigid hub of a spinning spacecraft. The rigorous mathematical modeling of mass flow and changing structural configuration of the spacecraft during deployment, while the vehicle experiences small elastic deflection and small angular rate, is presented. The equations of motion are obtained in terms of integro-partial differential equations. An approximate solution for the equations of motion is obtained by using a Raleigh-Ritz method and numerical results are presented for several deployment strategies. For every instantaneous physical configuration of the spacecraft, that extension rate which will lead to unstable behavior is also determined. Author

A84-34913#
DUAL STRUCTURAL-CONTROL OPTIMIZATION OF LARGE SPACE STRUCTURES
J. TURNER (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and A. MESSAC AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984. 29 p. refs
(AIAA PAPER 84-1042)

This paper proposes a new approach 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 design, a quadratic control cost is minimized subject to a constant-mass constraint. The sensitivity of the optimal control cost with respect to the structural design variables is then determined and used to obtain successive structural redesigns, using a constrained 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

A84-36787
DIGITAL STOCHASTIC CONTROL OF DISTRIBUTED-PARAMETER SYSTEMS
L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg, VA) and H. OZ (Ohio State University, Columbus, OH) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 43, June 1984, p. 307-325. refs
(Contract NSF PFR-80-20623)

This paper presents a method for discrete-time control and estimation of flexible structures in the presence of actuator and sensor noise. The approach consists of complete decoupling of the modal equations and estimator dynamics based on the independent modal-space control technique and modal spatial filtering of the system output. The solution for the Kalman filter gains reduces to that of independent second-order modal estimators, thus permitting real-time digital control of distributed-parameter systems in a noisy environment. The method can be used to control and estimate any number of modes without computational restraints and is theoretically free of observation spill-over. Two examples, the first using nonlinear, quantized control and the second using linear, state feedback control are presented. Author

A84-36833*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MANEUVERING OF LARGE FLEXIBLE SPACE ANTENNAS USING OPTIMAL DISCRETE-TIME CONTROLLERS
S. M. JOSHI, L. B. GARRETT, and G. C. ANDERSEN (NASA, Langley Research Center, Hampton, VA) Midwest Symposium on Circuits and Systems, 27th, Morgantown, WV, June 11, 12, 1984, Paper. 5 p. refs

The problem of maneuvering large space structures is formulated as a discrete-time, finite-duration optimal regulator problem. Two methods are considered for minimizing the elastic motion during the maneuver. The methods are applied to retargetting maneuver of a large space antenna, and the results are compared with those obtained using bang-bang control. The optimal regulator designed using the model error sensitivity supression method gives the best performance. Author

A84-38269
A PRELIMINARY STUDY OF ATTITUDE AND ORBIT MANEUVER SEQUENCE FOR THREE-AXIS GEOSYNCHRONOUS SATELLITE
M. KAJII (National Space Development Agency of Japan, Tokyo, Japan), T. OKAMOTO, K. HIRAISHI, H. AYADA, and S. TAKEZAWA (Nippon Electric Co., Ltd., Yokohama, Japan) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 1037-1044. refs

A preliminary study of the attitude and orbit control maneuver sequence for a 3-axis geosynchronous satellite revealed that the solar paddle flexibility was an extremely critical factor. Thus, it became necessary to first define the dynamic interaction problems caused by the solar paddle flexibility. This paper presents a model used to study the effects of solar paddle flexibility on the stability and performance of the wheel and thruster control system and is evaluated from the frequency domain approach. Instability or limit-cycle is shown to occur as a result of control loop delay time and solar paddle flexibility. A conventional method of compensation for flexibility was found to be adequate for the modeled control system. Author

A84-39569* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A METHOD FOR DETECTION OF DEFORMATIONS IN LARGE PHASE ARRAY ANTENNAS FOR SPACEBORNE SYNTHETIC APERTURE RADARS
F. K. LI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. AP-32, May 1984, p. 512-517. NASA-supported research. refs

A method to measure deformations in large, planar phased array antennas used in spaceborne synthetic aperture radars (SAR) is described. This method has the advantages that the deformation measurements can be performed anywhere in orbit and that no additional sensor is required. Indirect test results using the SEASAT SAR data indicate that this technique can detect deformations of small fractions of a wavelength. Author

A84-39726
CONTROL OF DISTRIBUTED PARAMETER SYSTEMS; SYMPOSIUM, 3RD, TOULOUSE, FRANCE, JUNE 29-JULY 2, 1982, PREPRINTS [COMMANDE DES SYSTEMES APARAMETRES REPARTIS; *SYMPOSIUM, 3RD, TOULOUSE, FRANCE, JUNE 29-JULY 2, 1982, PRETIRAGES*]
J. P. BABARY, ED. (CNRS, Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse, France) and L. LE LETTY, ED. (ONERA, Centre d'Etudes et de Recherches de Toulouse, Toulouse, France) Symposium sponsored by the International Federation of Automatic Control, CNRS, DRET, et al. Oxford, Pergamon Press, Ltd., 1982. 609 p. In French and English.

Various topics on the control of distributed parameter systems are considered. The general subjects addressed include: optimal control, identification and estimation, stabilization, flexible structures, stabilizability and controllability, methods and techniques of control, control of thermal processes, optimal design, stochastic processes, energy systems, and modeling. C.D.

A84-39730* California Univ., Los Angeles.
A DECOUPLING APPROACH TO THE CONTROL OF LARGE SPACEBORNE ANTENNA SYSTEMS
P. K. C. WANG (California, University, Los Angeles, CA) IN: Control of distributed parameter systems; Symposium, 3rd, Toulouse, France, June 29-July 2, 1982, Preprints . Oxford, Pergamon Press, Ltd., 1982, p. V.1-V.8. NASA-supported research. refs

A simple practical method for designing antenna-feed positioning control systems for large deployable spaceborne antenna systems with flexible booms is proposed. The approach is based on the mechanical decoupling of the antenna-feed from the boom so that the positioning control system can be designed without taking boom dynamics into consideration, thus avoiding a complex infinite dimensional control problem. The basic idea is illustrated by a simple angular positional control system attached to a flexible boom restricted to torsional motion only. The application of this approach to more complex situations is discussed briefly. Author

A84-39731
A SOLAR OPTICAL TELESCOPE CONTROLLER DESIGN BY COMPONENT COST ANALYSIS
R. E. SKELTON (Purdue University, West Lafayette, IN) and A. YOUSUFF IN: Control of distributed parameter systems; Symposium, 3rd, Toulouse, France, June 29-July 2, 1982, Preprints Oxford, Pergamon Press, Ltd., 1982, p. V.9-V.13. refs

A solar optical telescope is considered as an example to illustrate the design of suboptimal controllers by component cost analysis. Due to the low damping of the structure, the reduced controllers are stable only for a limited bandwidth of the controllers. Skelton's (1981) rate feedback scheme for increasing the damping of the structure by direct feedback is adopted. It is shown that stability of reduced order controllers can be increased by rate feedback, but at the expense of decreased performance. C.D.

A84-40573#
GUIDING HAND ON THE SPACE STATION
S. A. STERN (Colorado, University, Boulder, CO) Aerospace America (ISSN 0740-722X), vol. 22, July 1984, p. 48-50, 52.

Operational capabilities and needs of a space station in the 1990s are projected. The station will actually be part of a network of stations, the Shuttle, teleoperators, orbit transfer vehicles, unmanned platforms, outbound and returning interplanetary probes and large space structures (LSS). The LSS may be targeted for GEO station and constructed in LEO while attached or orbiting near the station. The station itself will be a complex of connected modules. Station maneuvers will be constrained by pointing requirements, structural strength, collision hazards, servicing needs, transfer economics, aerodynamic and geopotential perturbation torques, and contamination dangers from thrusters. Highly automated systems will lower the operational costs and increase productivity and reliability. The guidance and navigation equipment must be designed to accommodate the automation levels and complex mission possibilities of the station. M.S.K.

A84-41251
COLLAPSE: THE BUCKLING OF STRUCTURES IN THEORY AND *PRACTICE; PROCEEDINGS OF THE SYMPOSIUM, UNIVERSITY* COLLEGE, LONDON, ENGLAND, AUGUST 31-SEPTEMBER 3, 1982
J. M. T. THOMPSON, ED. (University College, London, England) and G. W. HUNT, ED. (Imperial College of Science and Technology, London, England) Symposium sponsored by the International Union of Theoretical and Applied Mechanics. Cambridge and New York, Cambridge University Press, 1983, 539 p. For individual items see A84-41252 to A84-41272.

Practical and theoretical problems in frame, plate and shell buckling are discussed, together with concepts such as mode localization, catastrophe theory, strange attractors and chaotic

vibrations. Attention is given to interactive buckling of thin-walled columns, optimizations of structures and the mechanical behavior of periodic lattice structures such as those proposed for large space structures. Advances in aerospace shell buckling techniques are noted in the form of calls for the establishment of an international imperfection data base, the definition of powerful numerical analysis computer programs and the refinement of nondestructive testing methods. M.S.K.

A84-41260* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
BUCKLING OF IMPERFECT PERIODIC LATTICE STRUCTURES
M. S. ANDERSON (NASA, Langley Research Center, Hampton, VA) IN: Collapse: The buckling of structures in theory and practice; Proceedings of the Symposium, London, England, August 31-September 3, 1982 . Cambridge and New York, Cambridge University Press, 1983, p. 209-219. refs

A simplified buckling analysis is presented for a family of periodic lattice structures such as those proposed for large space structures. A transcendental 6 x 6 matrix of eigenvalues is shown to be sufficient for modeling buckling behavior because member stiffnesses are based on an exact solution of the beam-column equation. Exact stiffnesses are derived for a curved member, thus allowing modeling of imperfect lattice structures. Comparisons of predictions of the lattice model with those available from shell and beam theory underscore the inaccuracies introduced by treating the lattice structure as a continuum. Sample calculations are provided for an isogrid cylinder and a three element double-laced truss. M.S.K.

A84-41358*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A MODAL REDUCTION METHOD FOR USE WITH NONLINEAR SIMULATIONS OF FLEXIBLE MULTIBODY SPACECRAFT
G. A. MACALA (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 9 p.
(AIAA PAPER 84-1989)

This paper presents a modal truncation method that can be used to prepare the structural flexibility data required as input to flexible, multibody spacecraft simulation programs. The method allows one to truncate the structural models of each flexible body in the system such that the assembled system is free of undesired high frequency system modes. This truncation method enables reasonable simulation costs to be incurred while maintaining dynamic simulation fidelity in the frequency range of interest. A simple one-dimensional example is presented which provides a physical interpretation of the method's workings. In addition, results are presented from the application of the method to a complex spacecraft. Author

A84-41360*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EFFECTS OF THE MOTIONS OF A PLATFORM-MOUNTED PAYLOAD ON THE NUTATIONAL STABILITY OF A DUAL-SPIN SPACECRAFT - A GALILEO CASE STUDY
G. K. MAN and F. O. EKE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 9 p. refs
(AIAA PAPER 84-1992)

In the presence of spacecraft nutation, tracking of an inertially fixed target by the Galileo scan platform requires the use of two control loops to move the scan platform and the stator in such a way as to compensate for spacecraft motion. The effect of these control loops on spacecraft nutational stability is examined using an eigenvalue analysis approach as well as several computer analysis packages. It was found that the actions of these control loops tend to drive nutation to the point of neutralizing, and even overpowering the damping actions of the spacecraft nutation damper, for pointing directions close to the spacecraft's poles. Stable and unstable zones are mapped out for two sets of spacecraft mass properties, and contributions of rotor asymmetry and stator flexibility are also discussed. Author

A84-41364*# Howard Univ., Washington, D. C.
DYNAMICS AND CONTROL OF ORBITING FLEXIBLE BEAMS AND PLATFORMS UNDER THE INFLUENCE OF SOLAR RADIATION AND THERMAL EFFECTS
R. KRISHNA and P. M. BAINUM (Howard University, Washington, DC) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 10 p. Research supported by the Howard University. refs
(Contract NSG-1414)
(AIAA PAPER 84-2000)

Expressions for thermal deflections of uniform thin beams and plates exposed to solar heating are obtained as a function of the properties of the material and the solar incidence angle. The major effect of the solar radiation pressure interacting with the thermally deformed structure is found to give rise to disturbance moments on the structure. The thermal deformations of the structures are assumed to be within 0.1 percent of the characteristic length of the structure. With the assumed thermal deformations, the resulting uncontrolled transient responses of these geosynchronous orbiting structures to the solar radiation pressure induced disturbances are simulated. The resulting rigid modal oscillations are found to be an order of magnitude larger than for those cases previously considered in which only the solar radiation pressure effect on vibrating structures was treated. Modifications of control laws and/or the feedback gain values are considered in order to improve the transient response characteristics under the thermally induced disturbances. Author

A84-41365#
AN INVESTIGATION OF METHODOLOGY FOR THE CONTROL OF FLEXIBLE STRUCTURES
L. MEIROVITCH, L. R. ANDERSON, and Z. KIM (Virginia Polytechnic Institute and State University, Blacksburg, VA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 11 p. refs
(Contract AF-AFOSR-83-0017)
(AIAA PAPER 84-2003)

This paper examines the merits of four methods of control of flexible structures. The investigation is concerned with various control performance measures, such as control gain magnitude, control energy requirements, settling time and overshoot in transient response, actuator phase and gain margins, and stability in the presence of actuator failure. One major conclusion is that the controller performance improved as the number of actuators increases, with the best performance being achieved when the number of actuators is equal to the number of controlled modes. Another significant conclusion is that in the newly developed minimum gain pole placement method, one can obtain exact pole placement for any set of modes even though the number of degrees of freedom is very large. Author

A84-41366#
DYNAMICS OF GRAVITY STABILIZED STRUCTURALLY DAMPED LARGE FLEXIBLE SPACECRAFT MODELED AS ELASTIC CONTINUA
S. K. SHRIVASTAVA and P. K. MAHARANA (Indian Institute of Science, Bangalore, India) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 11 p. refs
(AIAA PAPER 84-2004)

Longitudinal vibration of gravity stabilized structurally damped large flexible satellites undergoing pitching librations in circular and elliptic orbits is studied. Stability analysis of the linearized system indicates that (1) the vibrational stability is ensured if (structural frequency/orbital rate) is greater than the square root of 3, and (2) structural damping plays a role in exciting the pitch

motion in eccentric orbits. Analytical expressions are derived for stability boundary and response of vibration in even numbered modes in circular orbits using perturbation methods. They indicate that parametric resonance can occur at two additional frequencies and that the minimum (critical) damping, necessary to avoid vibrational instability, is sensitive to satellite inertia ratio. An attempt is made next to establish the stability of the nonlinear system using the Hamiltonian of the corresponding conservative system. The stability criterion thus obtained gives a conservative estimate of the stability boundary. Numerical simulation verifies the results of the stability analysis and indicates that parametric resonance occurs only with the even numbered modes. It is also found that the nonlinear effects arising out of vehicle flexibility do not seem to produce significant deviation either in the rigid body motion or in stable vibrations. Author

A84-41367#
IDENTIFICATION OF VIBRATING FLEXIBLE STRUCTURES
S. RAJARAM and J. L. JUNKINS (Virginia Polytechnic Institute, Blacksburg, VA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 11 p. refs
(Contract F4920-83-K-0032)
(AIAA PAPER 84-2005)

This paper presents novel identification schemes to determine the parameters of vibrating structures. A time domain identification method using transient response is discussed first. Next, a steady state response method using nonresonant harmonic excitations is considered. An especially attractive method for uniquely identifying the parameters of a structure using both free and forced response is also discussed. Numerical results show that the methods are relatively immune to the presence of damping and many low frequency modes with repeated or closely spaced frequencies. Author

A84-41368#
AUTONOMOUS MOMENTUM MANAGEMENT FOR THE SPACE PLATFORM
E. HAHN, R. KACZYNSKI (Allied Bendix Aerospace, Guidance Systems Div., Teterboro, NJ), and D. BARROWS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 7 p. refs
(AIAA PAPER 84-2006)

The design of a momentum management system is described as applied to the Space Platform. The external torques on the vehicle are assumed to be gravity gradient and aerodynamic with both having bias and cyclic terms. The integrals of the cyclic torques are the cyclic momenti which will be stored in the momentum storage actuator. The bias torque will be counteracted by a combination of magnetic and gravity gradient desaturation torques. These are generated using a control law developed during this program and operating at orbital frequency. Author

A84-41369*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FUNCTIONAL EVALUATION OF THE GALILEO ATTITUDE AND ARTICULATION CONTROL SUBSYSTEM USING FUNSIM
M. K. NAMIRI (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 10 p. NASA-sponsored research. refs
(AIAA PAPER 84-2008)

The functional performance of the Galileo spacecraft's attitude and articulation control subsystem is evaluated. The tests are performed utilizing the simulation program developed on an IBM 370 system known as the Functional Simulation (FUNSIM). FUNSIM is an entirely software-based simulation which uses the actual flight software in HAL/S and simulated spacecraft dynamics in FORTRAN language. A description of how the test cases were selected to verify that the algorithms perform functionally correctly, and a summary of the problems encountered are included in the paper. The benefits of having an alternative test bed such as FUNSIM to the real-time simulation test beds which utilize the spacecraft hardware components in discovering the problems are described. A sample test case which shows that the desired tasks were performed functionally correctly is included in the paper. The commands in this test are selected to start the dual-spin spacecraft initially in launch mode and lead it all the way to inertial mode. Major attitude control algorithms such as rotor and platform attitude estimators, clock and core platform attitude estimators, clock and core platform controllers, and the command turn and burn are examined. Author

A84-41371*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN ATTITUDE REORIENTATION ALGORITHM FOR THE GALILEO SPACECRAFT
H.-S. LIN (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 10 p.
(AIAA PAPER 84-2010)

This paper presents an onboard closed loop attitude reorientation algorithm for a dual-spin spacecraft, Galileo. The basic concept for the design uses the despun stator as a reference and fires a sequence of fixed duration thruster pulses to precess the angular momentum vector to its commanded orientation. The error signals used to despin the stator and to perform the turn are derived from the stator error quaternion which is computed using gyro outputs. Constraints considered in the design include gyro rate saturation, plume impingement effects, system parameter variations, as well as software reliability and flexibility. The performance of the algorithm was predicted by analysis and confirmed by computer simulation results. It was concluded that a reorientation accuracy of better than 1 milliradian with a nutation angle of less than 1 degree during the turn can be achieved. Author

A84-41387#
IDENTIFICATION OF VEHICLE RIGID BODY ATTITUDE BY ADAPTIVE FILTERING
K. XIE and Y. CAI (Chinese Aeronautics and Astronautics Society, Beijing, People's Republic of China) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 5 p.
(AIAA PAPER 84-2060)

A method for identifying rigid body attitude information by means of adaptive filtering of elastic vibration interferences is described. The method is shown to be feasible, simple, and economical (in terms of computer run-time). Experimental analysis of the method shows that it could easily satisfy the requirements of an attitude control system for large vehicles under elastic vibration. I.H.

A84-42462* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
ELECTRODYNAMIC COUPLING IN MAGNETICALLY CONFINED STELLAR X-RAY LOOPS
J. A. IONSON (NASA, Goddard Space Flight Center, Laboratory for Astronomy and Solar Physics, Greenbelt, MD) IN: Solar and stellar magnetic fields: Origins and coronal effects; Proceedings of the Symposium, Zurich, Switzerland, August 2-6, 1982 . Dordrecht, D. Reidel Publishing Co., 1983, p. 391-395; Discussion, p. 395, 396. refs

The solar coronal complex X-ray structure is now known to involve radiation loops that coincide spatially with the magnetic loops confining the radiating plasma. An effort is presently made to identify primary submodels involved in the global coupling between a mechanical energy reservoir of beta value greater than 1 and a contiguous site of X-ray activity whose beta value is lower than 1. The 'dynamo' model invoked establishes a quantitative connection between mechanical driver properties and

the dimensions, field strength, and number density distribution of elemental magnetic loops. O.C.

A84-43447#
PERFORMANCE OF REDUCED-ORDER ADAPTIVE IDENTIFIERS FOR OSCILLATORY DISTRIBUTED PARAMETER SYSTEMS
K. TSUCHIYA, K. YAMADA, and S. AKISHITA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 415-419. refs
(AIAA PAPER 84-1904)

Asymptotic behaviors of adaptive identifiers are examined for a oscillatory system. A modeling error is caused by neglected vibration modes. Two types of identifier, parallel and series-parallel identifiers, are considered and reduced equations for these identifiers are derived by the adiabatic approximation and the method of averaging. The stability properties of the reduced equations are found to be different for these two schemes. For the parallel identifier, the reduced equations are nonlinear and several steady states can occur. The proper choice of the frequency components of the input signal becomes crucial in this case. For the series-parallel identifier, the reduced equations are linear and only one steady state exists. The reduced equations are verified by numerical simulations and these equations express well the asymptotic behaviors of the identifiers. Author

A84-43448#
STRUCTURAL MODIFICATIONS OF LARGE FLEXIBLE STRUCTURES TO IMPROVE CONTROLLABILITY
N. S. KHOT, V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and F. E. EASTEP (Dayton, University, Dayton, OH) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 420-430. refs
(AIAA PAPER 84-1906)

Results are presented of an investigation on the effect of structural modifications on the dynamic response of a structure with active controls. The finite element idealization of ACOSS FOUR is used for this study. The structure is modified by using structural optimization algorithms to minimize the weight with constraints on the displacements and the frequency distribution. Two sets of weighting matrices were used for the state variables and the controls in the definition of the performance index. Author

A84-43451#
1CAT (ONE CONTROLLER AT A TIME) - A FREQUENCY DOMAIN MULTI-INPUT MULTI-OUTPUT DESIGN APPROACH
J. R. MITCHELL (Control Dynamics Co., Huntsville, AL; Mississippi State University, Mississippi State, MS), S. M. SELTZER, and D. K. TOLLISON (Control Dynamics Co., Huntsville, AL) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 445-457. refs
(Contract F29601-83-C-0031)
(AIAA PAPER 84-1912)

The main thrust of this paper is the introduction and illustration of the One Controller at a time (1CAT) methodology for designing digital controllers for Large Space Structures (LSS's). In the first section, desirable features of an LSS control system design methodology are delineated. Then the 1CAT approach is presented, along with numerical techniques for carrying out the 1CAT process. Next, 1CAT is used to design digital controllers for the proposed Space Based Laser (SBL). Finally, the SBL design is evaluated for dynamical performance, noise rejection, and robustness. Author

A84-43455*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MULTIVARIABLE CONTROL OF A SOFT COUPLED SPACE STATION
J. W. SUNKEL (NASA, Johnson Space Center, Houston, TX) and A. F. HOTZ (Purdue University, West Lafayette, IN) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 487-499. refs
(AIAA PAPER 84-1920)

The paper discusses a multivariable controller design for a control configured space station concept. The space station concept is novel in that mechanical filters (soft couplers) are used to reduce structural interaction between adjacent modules. The primary objective of this study is to provide stability augmentation to the soft coupled configuration. The control objective is achieved by a state feedback compensator design. To obtain the desired feedback gains, a modified LQR technique is developed which provides prescribed close-loop frequencies and damping ratios. Author

A84-43456#
FLIGHT CONTROL SIMULATION IN LOW-EARTH ORBIT FOR A SPACE FACILITY USING AN STS EXTERNAL TANK
W. KELLY (Martin Marietta Aerospace, Denver, CO) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 500-509. refs
(AIAA PAPER 84-1921)

The flight in low-earth orbit of the STS External Tank is considered as part of a space platform with an attached module with articulating solar panels. Gravity-gradient stabilized earth orientation is examined with solar panel tracking by cone and clock motions defined in the paper. Upper atmosphere drag and gravitational effects are considered as well as change in the beta angle due to seasonal advance and orbit nodal regression. For varied mass properties due primarily to solar panel size, and for tracking mechanism, some perturbation effects are shown, including induced torques and deflections in passively stabilized flight. Some required control torques are shown with sample feedback schemes to obtain steady state errors. Author

A84-43457#
FLEXIBLE SPACECRAFT CONTROLLER DESIGN USING THE INTEGRATED ANALYSIS CAPABILITY (IAC)
J. A. BOSSI (Washington, University, Seattle, WA), G. A. PRICE, and S. A. WINKLEBLACK (Boeing Aerospace Co., Seattle, WA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 510-519. refs
(AIAA PAPER 84-1924)

Dynamic analysis and controls design for flexible spacecraft involves high order dynamic systems with multiple inputs and outputs. Computer tools are essential for such analysis. This paper describes the controls/structures interaction analysis capability of an interdisciplinary computer software system, called the Integrated Analysis Capability (IAC), which is being developed for NASA/Goddard Space Flight Center. An overview of IAC components and procedures is presented, and an example of a preliminary space station controls design is shown. Author

A84-43458#
ORBIT AND ATTITUDE CONTROL OF A GEOSTATIONARY EARTH ORIENTED FLEXIBLE PLATE-LIKE SPACECRAFT
S. K. SHRIVASTAVA (Indian Institute of Science, Bangalore, India), C. K. RAJASINGH, and A. S. PRAKASA RAO (Indian Space Research Organization, Mission Operations Planning Div., Bangalore, India) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 520-528. refs
(AIAA PAPER 84-1925)

The paper presents design of a near optimal orbit and attitude control system for a large rectangular flat plate-like spacecraft in

geostationary orbit, with its normal along the local vertical and its long axis perpendicular to the orbital plane. Assuming the satellite to be rigid, an orbit and attitude control system is designed and optimized first. The interaction of structural dynamics with the control system is studied next. The mechanism by which the interaction takes place, its effect on stability of the total system and the severity of iteration at various levels of flexibility and damping are investigated. It is shown that the structural dynamics destabilizes the system, when the lowest natural frequency is less than ten times the control frequency. Damping reduces this detrimental effect. The control design is modified to reduce the interactions, by including three flexural modes into the control logic and by relocating the thrusters a little away from the corners. Such a design is shown to significantly reduce the control structure interaction which is measured in terms of residual flexural energy after an orbit or attitude correction, thereby avoiding the need for separate shape controllers. The study gives an insight into the problem of controlling a class of future flexible satellites. Author

A84-43461*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SOLUTION OF MX(DOUBLE DOT) + CX(DOT) + KX = 0 APPLICABLE TO THE DESIGN OF ACTIVE DAMPERS
G. A. THURSTON (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers New York, American Institute of Aeronautics and Astronautics, 1984, p. 544-553. refs
(AIAA PAPER 84-1932)

A solution is presented for the equations of motion for the damped linear oscillator, Mx(double dot) + Cx(dot) + Kx = 0. The algorithm solves a transformed set of equations in terms of the modal variables of the undamped system and, at the same time, solves the adjoint equation of the transformed problem. The adjoint solution is normalized to give the inverse of the solution matrix of the transformed problem. The normalized inverse is useful in design for direct computation of sensitivity derivatives of damping ratios with respect to damping rates. The algorithm is programmed to reduce storage requirements by a factor of three-fourths compared to standard complex eigenvalue subroutines. A numerical example is included. Author

A84-43463#
NUMERICAL SOLUTION OF THE OPTIMAL MODEL REDUCTION EQUATIONS
D. S. BERNSTEIN (MIT, Lexington, MA) and D. C. HYLAND (Harris Corp., Melbourne, FL) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 560-562. USAF-sponsored research. refs
(AIAA PAPER 84-1934)

An algorithm is proposed for numerically solving optimal model reduction equations. These equations are in the form of a pair of modified Lyapunov equations coupled by an oblique projection that is a consequence of optimality, which determines the optimal reduced-order model. This form of the necessary conditions considerably simplifies previous results of Wilson (1970) and clearly demonstrates the suboptimality of the balancing method of Moore (1981). Author

A84-43470*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ON THE IMPLEMENTATION OF MODAL FILTERS FOR CONTROL OF STRUCTURES
L. MEIROVITCH and H. BARUH (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 624-636. refs
(Contract NAG1-225)
(AIAA PAPER 84-1949)

The most common technique for the control of structures is modal control. In modal control, the differential equations in terms of actual coordinates are replaced by a set of ordinary differential equations in terms of the modal coordinates known as modal equations. In designing feedback controls in conjunction with the modal equations, one must know the modal states for the modes targeted for control. The sensors measure actual states, however. The modal states can be estimated by means of a Luenberger observer or modal filters. The modal filters produce estimates of the modal states from distributed measurements of the states. If distributed measurements are not available, then they can be reconstructed from measurements at discrete points via interpolation. This paper examines various questions associated with the implementation of modal filters, such as the effect of choice of interpolation functions and sensors locations, as well as of measurement errors, on the state estimation process. The method is demonstrated by means of two numerical examples. Author

A84-43471#
MANEUVER OF DISTRIBUTED SPACECRAFT
H. BARUH (Rutgers University, New Brunswick, NJ) and L. M. SILVERBERG (TRW, Inc., Space and Technology Group, Redondo Beach, CA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers New York, American Institute of Aeronautics and Astronautics, 1984, p. 637-647. refs
(AIAA PAPER 84-1952)

A method is described for the simultaneous large angle maneuver and vibration suppression of flexible spacecraft. The control action is carried out in two independent systems, one system performing the maneuvers and the other system controlling the elastic motion. The vibration is suppressed using Natural Control. It is shown that Natural Control of the elastic modes does not distort the maneuver because Natural Control conserves the spacecraft linear and angular momenta. Thus, the maneuver can be designed and performed independent of the flexible mode control. The method applies to control forces generated by either discrete (in space) actuators or distributed actuators. Author

A84-43472#
ON THE STABILITY OF MULTIDIMENSIONAL LINEAR TIME VARYING SYSTEMS
S. K. SHRIVASTAVA and S. PRADEEP (Indian Institute of Science, Bangalore, India) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 648-654. refs
(AIAA PAPER 84-1954)

This paper focusses attention on the stability of multidimensional linear second order systems with time varying coefficients. Five theorems on stability and two theorems on instability of such systems and ten corollaries are derived based on Liapunov's second method. Unlike many stability theorems which involve determination of the characteristic equations and their roots, or transformation to a system of first order equations (thereby often losing sight of the physical parameters of the system), in this paper conditions are imposed directly on the physical parameters of the system. The theorems derived generalize many existing theorems on the stability of linear constant coefficient systems. Author

A84-43474#
ROLL/YAW CONTROL OF FLEXIBLE SPACECRAFT USING SKEWED BIAS MOMENTUM WHEELS
B. WIE, J. A. LEHNER, and C. T. PLESCIA (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 666-673. refs
(AIAA PAPER 84-1962)

On-orbit roll/yaw control of a bias momentum stabilized flexible spacecraft is presented. The normal mode utilizes a nonminimum phase controller because of its insensitivity to the structural flexibility. If the normal mode controller is switched on at the termination of a thruster-controlled stationkeeping maneuver, it can't by itself provide sufficient nutation damping to guarantee

that the initial transients will remain within specifications. Consequently, a roll/yaw transition controller has been designed to damp out the spacecraft residual rates to levels that the normal controller can handle. The transition controller design requires consideration of the solar array flexibility, because a compensation logic, designed to stabilize the nutation mode neglecting the solar array flexibility, could destabilize the structural mode. Author

A84-43475*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
THE IMPACT OF REMOTE MANIPULATOR STRUCTURAL DYNAMICS ON SHUTTLE ON-ORBIT FLIGHT CONTROL
D. G. SARGENT (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 674-680. refs
(Contract NAS9-16023)
(AIAA PAPER 84-1963)

The performance of the Space Shuttle on-orbit flight control system during payload operations with the remote manipulator system is described. The changing mass and inertia distribution associated with payload manipulation can have a significant effect on the control authority provided by the orbiter's reaction control jets. Commanded payload motion and jet firings can excite significant flexure in the orbiter/manipulator/payload structure. These effects combine to stress the control capabilities of the flight control system. Data from recent flight tests is presented to illustrate these effects. Author

A84-43476*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VALIDATION OF THE GALILEO SCAN PLATFORM CONTROL DESIGN USING DISCOS
J. L. CHODAS and G. A. MACALA (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 681-692.
(Contract NAS5-11996)
(AIAA PAPER 84-1964)

The flexibility of the Galileo spacecraft's scan platform control system stator structure, which lies between the scan platform and one of the control actuators, has been a major design consideration. Tests have been conducted to verify the prevention of undesirable interactions between the structure and the control loop, by means of the Dynamic Interaction Simulation of Controls and Structure (DISCOS) program. The scan platform's control design has been validated for the achievement of 140-microradians maximum position deviation and 50 microradians of jitter over 1-sec intervals. O.C.

A84-44203#
VARIABLE STRUCTURE SYSTEM CONTROL OF FLEXIBLE SPACECRAFT
H. OZ and U. OZGUNER (Ohio State University, Columbus, OH) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 12 p. refs
(Contract NSF MEA-82-04920)
(AIAA PAPER 84-2002)

Variable structure system control is a technique which uses different forms of control laws in different regions of the state space of a dynamic system. The basic objective of the technique is to force the trajectory to switching surfaces in the state-space so that the trajectory will be regulated to the origin along the 'sliding modes' characterized by the switching surfaces. The control laws are designed variably such that conditions for reaching the sliding modes and maintaining the sliding modes are guaranteed. In general, the technique has superior properties regarding insensitivity to parameter changes, computability and versatility in eliciting desired transient responses which are otherwise difficult to obtain with fixed-form control laws. The parameters of the switching surfaces can be chosen by the designer so as to satisfy certain optimality conditions. An attractive application of variable structure control can be affected in conjunction with the Independent-Modal-Space Control. This has the added advantage that the problem reduces to designing switching controls for a collection of independent phase planes for which the switching surfaces become switching lines. The technique is illustrated for the control of a Dual-Spin spacecraft configuration. Author

A84-44213#
CONTROL OF FLEXIBLE SYSTEMS AND PRINCIPLES OF STRUCTURAL MECHANICS
H. OZ (Ohio State University, Columbus, OH) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 16 p. refs
(Contract NSF MEA-82-04920)
(AIAA PAPER 84-2001)

Common control approaches for flexible systems are evaluated in regards to their compatibility with the fundamentals of mechanics of structural systems. It is shown that depending on the formulation, control problems may be ill-posed leading to incompatibilities with the basic laws of mechanics. In an effort to eliminate the incompatibilities constructively, it is found that a unique well-posed method of control that is fully in compliance with the fundamentals of structural mechanics exists. Author

A84-44641*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
OPTIMUM PLACEMENT OF CONTROLS FOR STATIC DEFORMATIONS OF SPACE STRUCTURES
R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg, VA) AIAA Journal (ISSN 0001-1452), vol. 22, Sept. 1984, p. 1293-1298. refs
(Contract NAG1-224)

Many large space structures, such as large antennas, have to maintain a fairly exact shape to operate satisfactorily. Such structures require active and passive controls to maintain their accurate shape under disturbances. The present paper is concerned with optimum placement of controls for correcting static deformations. Both force actuators and heaters are considered for controls. A formulation of design against the worst disturbance is derived. A beam example is employed to demonstrate the procedure. Author

A84-45582#
ATTITUDE STABILIZATION OF FLEXIBLE SPACECRAFT DURING STATIONKEEPING MANEUVERS
B. WIE and C. T. PLESCIA (Ford Aerospace and Communications Corp., Systems Analysis Dept., Palo Alto, CA) (Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers, p. 457-465) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, July-Aug. 1984, p. 430-436. Previously cited in issue 19, p. 2815, Accession no. A83-41706. refs

A84-45583*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
NONLINEAR NATURAL CONTROL OF AN EXPERIMENTAL BEAM
L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg, VA), H. BARUH (Virginia Polytechnic Institute and State University, Blacksburg, VA; Rutgers University, New Brunswick, NJ), R. C. MONTGOMERY, and J. P. WILLIAMS (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 2, p. 185-192) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, July-Aug. 1984, p. 437-442. Previously cited in issue 12, p. 1770, Accession no. A83-29828. refs
(Contract NAG1-225)

A84-45594#
AN EXACT EXPRESSION FOR COMPUTING THE DEGREE OF CONTROLLABILITY
W. E. SCHMITENDORF (Northwestern University, Evanston, IL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, July-Aug. 1984, p. 502-504. refs
(Contract NSF ECS-82-10284)

The 'degree of controllability' concept has been introduced in order to study control systems associated with large, flexible spacecraft, and may be characterized as a measure of the set of initial states that can be steered to the desired region in a prescribed time. An exact expression for the degree of controllability is presently obtained for a constant, linear system when there are magnitude constraints on the control, and the target is the origin. Attention is given to several examples which illustrate how this expression may be used in degree of controllability computation. O.C.

A84-45598*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DYNAMICS AND CONTROL OF LARGE SPACE STRUCTURES
G. S. NURRE, R. S. RYAN, H. N. SCOFIELD, and J. L. SIMS (NASA, Marshall Space Flight Center, Huntsville, AL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 514-526. refs

An attempt is made to gather data useful to investigators in the fields of large space structure dynamics and control modeling, design and testing. Attention is given to structural dynamics and its relationship to such allied engineering fields as flutter analysis, as well as to problems in the prediction of atmospheric density at orbital altitude. The first challenge posed by large space structure control is the design of control systems with natural frequencies above several major structural frequencies. The establishment of a sufficiently accurate structural model, plant excitation, and shape maintenance, are noted to be additional problems. O.C.

A84-45599*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXPERIMENTAL DEMONSTRATION OF THE CONTROL OF FLEXIBLE STRUCTURES
D. B. SCHAECHTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; Lockheed Missile and Space Co., Inc., Palo Alto, CA) and D. B. ELDRED (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 527-534. NASA-supported research. refs

The Large Space Structure Technology Flexible Beam Experiment employs a pinned-free flexible beam to demonstrate such required methods as dynamic and adaptive control, as well as various control law design approaches and hardware requirements. An attempt is made to define the mechanization difficulties that may inhere in flexible structures. Attention is presently given to analytical work performed in support of the test facility's development, the final design's specifications, the control laws' synthesis, and experimental results obtained. O.C.

A84-45600#
STRUCTURAL CONTROL FOR A CIRCULAR PLATE
J.-N. AUBRUN, M. J. RATNER (Lockheed Guidance and Control Laboratory, Palo Alto, CA), and M. G. LYONS (Integrated Systems, Inc., Palo Alto, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 535-545.

In the present experimental study of methods for the control of both the rigid body and the structural modes of a 1.2-m diameter circular plate, an attempt is made to combine many of the features and requirements of large space structure control problems. These include low natural damping and closely distributed modal frequencies, colocated and nocolocated modal control, real time digital mechanization, and optical figure sensing methods. Attention is given to hardware mechanization, using optical sensing together with electromagnetic and electrodynamic actuators to control five structural bending modes. O.C.

A84-45601*# Stanford Univ., Calif.
EXPERIMENTS IN CONTROL OF FLEXIBLE STRUCTURES WITH NONCOLOCATED SENSORS AND ACTUATORS
R. H. CANNON, JR. and D. E. ROSENTHAL (Stanford University, Stanford, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 546-553. NASA-supported research. refs

While the stable control of such flexible structures as limber spacecraft is easily achieved through the colocation of control actuators with sensors, noncolocation renders this extremely difficult. The most difficult case in point is that in which structural damping is low and spacecraft stiffness and inertia values are uncertain and changing. Attention is presently given to an apparatus in which each basic sensor/actuator noncolocation configuration is available, and inertias can be abruptly halved or doubled during control maneuvers. This feature can impose a sudden reversal in the plant's pole-zero sequence, which is a very difficult condition for the controller. Test results obtained to date demonstrate the inherent difficulty of achieving robustness in the case of noncolocation. It is noted that there may be very simple configurations in which there is no alternative to adaptive control. O.C.

A84-45602*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
AN ON-ORBIT EXPERIMENT FOR DYNAMICS AND CONTROL OF LARGE STRUCTURES
H. J. BUCHANAN, R. W. SCHOCK, and H. B. WAITES (NASA, Marshall Space Flight Center, Systems Dynamics Laboratory, Huntsville, AL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 554-562. refs

Attention is given to the definition of the on-orbit dynamic testing that is currently being planned for the flight of a large solar array test article, the Solar Array Flight Experiment (SAFE 1), which consists of a coilable longeron mast that deploys a large solar array blanket. Also discussed is the design of an additional experiment employing this structure in conjunction with a two- or three-axis gimbal system, in order to demonstrate control techniques applicable to such large structures. SAFE 1 experiment objectives, hardware, software, and the experimental operations foreseen are discussed. O.C.

A84-45603#
A GENERAL FORMULATION FOR LIBRATIONAL DYNAMICS OF SPACECRAFT WITH DEPLOYING APPENDAGES
V. J. MODI (British Columbia, University, Vancouver, Canada) and A. M. IBRAHIM Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 563-569. Sponsorship: Natural Sciences and Engineering Research Council of Canada. Previously cited in issue 05, p. 600, Accession no. A83-16711. refs
(Contract NSERC-67-0662)

A84-45610*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
FRICTION ESTIMATION TECHNIQUE FOR GALILEO SCAN PLATFORM CONTROL
J. L. CHODAS (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 7, Sept.-Oct. 1984, p. 608-614. NASA-supported research. Previously cited in issue 19, p. 2995, Accession no. A82-38887.

A84-48004
DYNAMIC-CONTROLLER STABILIZATION OF THE ANGULAR POSITION OF A SPACECRAFT WITH ELASTIC SOLAR-BATTERY PANELS [STABILIZATSIIA UGLOVOGO POLOZHENIIA KOSMICHESKOGO APPARATA S UPRUGIMI PANELIAMI SOLNECHNYKH BATAREI DINAMICHESKIM REGULIATOROM]
V. A. TKACHENKO Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 22, July-Aug. 1984, p. 520-530. In Russian. refs

The paper demonstrates observability and controllability for the motions of a spacecraft with respect to the center of mass with allowance for an arbitrary number of tones of the elastic oscillations of the solar panels; it is assumed that the angles and angular velocities are measured by sensors installed on the spacecraft and that control is effected by attitude engines. A determination is made of the necessary and sufficient conditions which must be satisfied by the minimum order of the dynamic controller which assures a prescribed range of the closed stabilization system given independent control with respect to the stabilization axes. A method for choosing the gain factors of the dynamic controller is indicated. B.J.

A84-48982*#
DYNAMIC CHARACTERISTICS OF LARGE REPETITIVE FRAMELIKE STRUCTURES
A. H. NAYFEH and M. S. HARTLE (Yarmouk University, Irbid, Jordan) ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 51, Sept. 1984, p. 510-518. refs
(Contract NSG-1185)
(ASME PAPER 84-APM-35)

Using a building block approach and starting with a single element, expressions for the energy of various two-dimensional frametype gridwork configurations are derived. These are then used to develop energy equivalent continua for the gridworks. Equations of motion and associated boundary conditions are obtained for the continua. Some dynamic characteristics of these continua are investigated and compared with corresponding results obtained from finite element codes and also with some available theoretical predictions. Author

A84-49110*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
OPTIMUM PLACEMENT OF CONTROLS FOR STATIC DEFORMATIONS OF SPACE STRUCTURES
R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Developments in mechanics. Volume 12 - Midwestern Mechanics Conference, 18th, Iowa City, IA, May 16-18, 1983, Proceedings . Iowa City, IA, University of Iowa, 1983, p. 149-152.
(Contract NAG1-224)

The placement of thermal or force actuators to control slowly varying disturbances in the shape of large space structures is investigated analytically. Expressions are derived based on disturbances defined as the worst linear combination of a given set of functions and minimized numerically using the NEWSUMT optimization package. Results are presented in tables and graphs for a free-free beam with equidistant controls and polynomial-form (order 2-6) disturbances. Control placement is found to be of greater importance for force actuators, but is also of significance for thermal actuators. T.K.

A84-49127#
A CONVOLUTION INTEGRAL APPROACH TO THE OPTIMAL CONTROL OF FLEXIBLE DYNAMIC SYSTEMS
S. B. SKAAR (Iowa State University of Science and Technology, Ames, IA) IN: Developments in mechanics. Volume 12 - Midwestern Mechanics Conference, 18th, Iowa City, IA, May 16-18, 1983, Proceedings . Iowa City, IA, University of Iowa, 1983, p. 467-470.

The application of a single controller function for controlling an elastic dynamic system such as a flexible spacecraft is described. The response of the system geometries is characterized by a convolution integral. The integral covers the responses of rigid and flexible components, such as booms and hubs, in terms of partial differential equations for the response of each subsystem. A performance index is defined, together with necessary conditions for minimization. A sample problem is provided in the form of a rigid mass attached to an axially flexible appendage in axial translation. The method can be extended for controlling the final position and velocity of a finite number of points along the flexible member and the absolute position and velocity of the rigid component. M.S.K.

A84-49158
GUIDANCE AND CONTROL 1984; PROCEEDINGS OF THE SEVENTH ANNUAL ROCKY MOUNTAIN CONFERENCE, KEYSTONE, CO, FEBRUARY 4-8, 1984
R. D. CULP, ED. (Colorado, University, Boulder, CO) and P. S. STAFFORD, ED. (Martin Marietta Aerospace, Denver, CO) Conference sponsored by the American Astronautical Society. San Diego, CA, Univelt, Inc. , 1984, 500 p. For individual items see A84-49159 to A84-49185.

Papers are presented on such topics as the development of the attitude and orbit control subsystem for the OLYMPUS satellite; the EUROSTAR multimission platform attitude and orbit control subsystem; the Marine Observation Satellite-1 system and control concepts; attitude determination and control of the Hipparcos satellite; and the PLANET-A attitude and orbit control system. Also considered are: direct quaternion determination from BARS measurements; artificial intelligence and computer vision for advanced manipulator systems; strapdown inertial guidance performance in space; rendezvous and docking with remotely piloted vehicles; the Laser Docking System; and the docking of a spacecraft with an unrestrained orbiting structure. An integrated design for IUS propulsion, guidance, and control; guidance and control for the Transfer Orbit Stage; the Inertial Upper Stage/Tracking Data Relay Satellite; the in-flight rescue of the stranded TDRS-1 spacecraft; and a protective method against RAM upsets due to cosmic particles. L.M.

A84-49160
EUROSTAR MULTIMISSION PLATFORM ATTITUDE AND ORBIT CONTROL SUBSYSTEM
R. OSKIAN, J.-F. POUSSIN, and B. GOVIN (Matra, S.A., Velizy-Villacoublay, Yvelines, France) IN: Guidance and control 1984; Proceedings of the Seventh Annual Rocky Mountain Conference, Keystone, CO, February 4-8, 1984 . San Diego, CA, Univelt, Inc., 1984, p. 37-53.
(AAS PAPER 84-002)

An overview of the EUROSTAR platform is presented, and associated requirements on the attitude and orbit control system (AOCS) are described. Also considered are the main design features of the AOCS, the operational modes, and the electronic architecture and equipment. The AOCS requirements cover a large number of applications with minimum modifications and follow a design-to-cost approach. The AOCS employs spin stabilization with active nutation control during parking and transfer orbit operations. During all geosynchronous operations, the AOCS operates as a biased momentum three-axis control system. In addition, a digital decentralized architecture with permanent microprocessor and digital data bus is provided. L.M.

A84-49163
ATTITUDE DETERMINATION AND CONTROL OF THE HIPPARCOS SATELLITE
D. P. VILAIN (Matra, S.A., Velizy-Villacoublay, Yvelines, France) and R. S. HARRIS (British Aerospace, PLC, Space and Communications Div., Bristol, England) IN: Guidance and control 1984; Proceedings of the Seventh Annual Rocky Mountain Conference, Keystone, CO, February 4-8, 1984 . San Diego, CA, Univelt, Inc., 1984, p. 93-120.
(AAS PAPER 84-005)

The Hipparcos satellite is an ESA program dedicated to astrometry. The AOCS requirements derived from the scientific mission specifications lead to an AOCS concept based on an opto-inertial attitude estimator of 1 arcsec class and a cold gas

actuator system with control action optimized to minimize the number of actuations. The AOCS design is described and the mission phases and operational modes are detailed. The simulation results demonstrating the ability of the baseline design to comply with the most critical requirements are presented. Author

A84-49505*# Stanford Univ., Calif.
ON PASSIVE DAMPING MECHANISMS IN LARGE SPACE STRUCTURES
H. ASHLEY (Stanford University, Stanford, CA) (Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2, p. 56-67) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 21, Sept.-Oct. 1984, p. 448-455. Previously cited in issue 13, p. 2109, Accession no. A82-30136. refs
(Contract AF-AFOSR-0062; NAG1-97)

A84-49506*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYTICAL AND EXPERIMENTAL VIBRATION AND BUCKLING CHARACTERISTICS OF A PRETENSIONED STAYED COLUMN
W. K. BELVIN (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1, p. 456-463) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 21, Sept.-Oct. 1984, p. 456-462. Previously cited in issue 13, p. 2108, Accession no. A82-30122. refs

A84-49507*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RESPONSE OF LARGE SPACE STRUCTURES WITH STIFFNESS CONTROL
J.-C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 21, Sept.-Oct. 1984, p. 463-467. Previously cited in issue 13, p. 1844, Accession no. A84-30550. refs
(Contract NAS7-100)

N84-22598*# Texas Univ., Austin. Dept. of Aerospace Engineering and Engineering Mechanics.
DYNAMICS ANALYSIS OF ELECTRODYNAMIC SATELLITE TETHERS. EQUATIONS OF MOTION AND NUMERICAL SOLUTION ALGORITHMS FOR THE TETHER Final Report
P. E. NACOZY 31 Jan. 1984 46 p
(Contract NAS9-16744)
(NASA-CR-171777; NAS 1.26:171777) Avail: NTIS HC A03/MF A01 CSCL 22B

The equations of motion are developed for a perfectly flexible, inelastic tether with a satellite at its extremity. The tether is attached to a space vehicle in orbit. The tether is allowed to possess electrical conductivity. A numerical solution algorithm to provide the motion of the tether and satellite system is presented. The resulting differential equations can be solved by various existing standard numerical integration computer programs. The resulting differential equations allow the introduction of approximations that can lead to analytical, approximate general solutions. The differential equations allow more dynamical insight of the motion. M.A.C.

N84-22617 Virginia Polytechnic Inst. and State Univ., Blacksburg.
APPLICATION OF CONTROL THEORY TO LARGE FLEXIBLE STRUCTURES USING THE INDEPENDENT MODAL-SPACE CONTROL METHOD Ph.D. Thesis
J. SHENHAR 1983 215 p
Avail: Univ. Microfilms Order No. DA8402806

The control problem of a large order flexible system in the form of a beam-lattice is presented using the Independent Modal-Space Control (IMSC) method. The method is based on a transformation of the system equations of motion to modal space, yielding internally independent modal equations of motion. The control laws are designed in the modal space, permitting independent control of each mode, providing complete decoupling of the equations of motion. Linear optimal control with quadratic performance index is designed to control the response of the elastic as well as the rigid body modes, using the IMSC method. Actuators placement is of fundamental importance in the control of two dimensional domains if IMSC is used. A method is presented as to the selection of actuators configuration in order to avoid singularity in the mode participation matrix, guaranteeing system controllability. Dissert. Abstr.

N84-22618 Virginia Polytechnic Inst. and State Univ., Blacksburg.
ACTIVE CONTROL OF DISTRIBUTED STRUCTURES Ph.D. Thesis
L. M. SILVERBERG 1983 127 p
Avail: Univ. Microfilms Order No. DA8402807

The partial differential equations of motion for an uncontrolled distributed structure can be transformed into a set of independent modal equations by means of the system eigenfunctions. In vibration analysis, the modal coordinates are referred to as natural coordinates. Active control forces generally recouple the modal equations so that the natural coordinates for the open-loop (uncontrolled) system cease to be natural coordinates for the closed-loop (controlled) system. Control of this form is known as coupled control. In contrast, it is shown that a method known as the independent modal-space control method is a natural control method; i.e., the natural coordinates of the open-loop system and of the closed-loop system are identical. Furthermore, it is shown that natural control provides a unique and globally optimal closed-form solution to the linear optimal control problem for the distributed structure. The optimal control forces are ideally distributed. If implementation of distributed control is not feasible, then the distributed control forces can be approximated by finite-dimensional control forces. Dissert. Abstr.

N84-23091 Howard Univ., Washington, D. C.
ATTITUDE AND SHAPE CONTROL OF LARGE SPACE STRUCTURES Ph.D. Thesis
A. S. S. R. REDDY 1982 289 p
Avail: Univ. Microfilms Order No. DA8404050

The nonlinear equations of motion of flexible bodies such as free-free beams, plates and shallow spherical shells in circular orbits are taken as a basis to study the uncontrolled dynamics and to design the control systems to maintain the attitude and shape of large flexible space systems. The nonlinear equations of motion are linearized around nominal orientations, nominal motions and also nondimensionalized with respect to orbital period and characteristic dimensions of the structure. The point actuators that are utilized for control purposes are modelled and are incorporated into the linear dynamic models of the beams, plates and shells. As the mass and stiffness matrices that are encountered in modelling large space structures are very sparse, a graphical interpretation of the matrices and determinants are utilized to reduce the larger original state matrix in lower ordered sub matrices and then to evaluate the eigenvalues of the original matrix as a union of the eigenvalues of the sub matrices. Dissert. Abstr.

N84-23675*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DECOUPLED CONTROL ANALYSIS OF A LARGE FLEXIBLE SPACE ANTENNA WITH LINEAR QUADRATIC REGULATOR COMPARISONS
J. W. YOUNG, H. A. HAMER, and K. G. JOHNSON May 1984 82 p
(NASA-TP-2293; L-15696; NAS 1.60:2293) Avail: NTIS HC A05/MF A01 CSCL 22B

A decoupled-control analysis was performed for a large flexible space antenna. Control involved commanding changes in the rigid-body modes or nulling disturbances in the flexible modes. The study provides parametric-type data which could be useful in the final design of a large space antenna control system. Results are presented to illustrate the effect on control requirements of

(1) the number of modes controlled; (2) the number, type, and location of control actuators; and (3) variations in the closed-loop dynamics of the control system. Comparisons are given between the decoupled-control results and those obtained by using a linear quadratic regulator approach. Time history responses are presented to illustrate the effects of the control procedures. Author

N84-24477*# Howard Univ., Washington, D. C.
MEGAMECHANICS RESEARCH CONSORTIUM
T. H. BROOME, JR. *In its* NASA/Howard Univ. Large Space Structures Inst. p 28-56 22 Mar. 1984
Avail: NTIS HC A12/MF A01 CSCL 05I

The mechanical behavior of large space lattice systems is investigated. Continuum modeling methods such as the Load Correction Method (LCM) and finite element operations aid in solving structural analysis problems. Static analysis of frames and trusses, dynamic analysis of trusses, analysis of thermal and mechanical loads on frames and trusses, and load corrections for three dimensional complex geometries is possible by using the LCM. The finite element method and the LCM are used to extend Saint-Venant's principle via the Boussinesq problem into the regime of large repetitive lattice systems. M.A.C.

N84-24478*# Howard Univ., Washington, D. C. Dept. of Electrical Engineering.
STABILIZATION OF A FLEXIBLE BODY (HOOP-COLUMN) ANTENNA BY FEEDBACK CONTROL LAW
A. CHOUDHURY *In its* NASA/Howard Univ. Large Space Structures Inst. p 57-68 22 Mar. 1984 refs
Avail: NTIS HC A12/MF A01 CSCL 05I

Feedback control laws are presented for stabilization models of a hoop/column antenna. A brief review of linear and nonlinear feedback control laws is included. A method that is computable on a microprocessor and assures closed loop stability is explained and compared to a linear control law model. M.A.C.

N84-24481*# Howard Univ., Washington, D. C.
DYNAMICS AND CONTROL OF FLEXIBLE ORBITING SYSTEMS
P. M. BAINUM, K. PANDE, R. KRISHNA, A. S. SIVARAMACHANDRAN, and S. ANANTHAKRISHNAN *In its* NASA/Howard Univ. Large Space Structures Inst. p 97-134 22 Mar. 1984 refs
Avail: NTIS HC A12/MF A01 CSCL 05I

Mathematical modeling and design analysis is carried out for large flexible spacecraft and antenna systems. Modeling topics include inertially fixed attitude stabilization, solar radiation pressure effects, control systems for space mast structures, and optimal control of a hoop/column space antenna system. Each subject includes a brief overview of the pertinent literature and details of the proposed solutions for the specific modeling tasks. M.A.C.

N84-24482*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
MICROPROCESSOR BASED IMPLEMENTATION OF ATTITUDE AND SHAPE CONTROL OF LARGE SPACE STRUCTURES
A. S. S. R. REDDY *In its* NASA/Howard Univ. Large Space Structures Inst. p 138-146 22 Mar. 1984 refs
Avail: NTIS HC A12/MF A01 CSCL 05I

The feasibility of off the shelf eight bit and 16 bit microprocessors to implement linear state variable feedback control laws and assessing the real time response to spacecraft dynamics is studied. The complexity of the dynamic model is described along with the appropriate software. An experimental setup of a beam, microprocessor system for implementing the control laws and the needed generalized software to implement any state variable feedback control system is included. M.A.C.

N84-24603# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
GUIDANCE AND CONTROL TECHNIQUES FOR ADVANCED SPACE VEHICLES
Loughton, England Jan. 1984 348 p refs In ENGLISH and FRENCH Symp. held in Florence, 27-30 Sep. 1983
(AGARD-CP-350; ISBN-92-835-0349-X; AD-A141969) Avail: NTIS HC A15/MF A01

This symposium dealt with spacecraft problems, the topic being guidance and control techniques for advanced space vehicles. Military applications of space for navigation, communication and intelligence impose increasing requirements on spacecraft capacity, orbit control and pointing accuracy. To meet the requirements for future spacecraft the performance of existing components, such as actuators and sensors, is improved or new concepts are developed. In particular the use of microprocessors and other data distribution systems permits multifunctional use of various sensors or information sources to produce effective, survivable systems at low cost. Increasing on-board computing capacity enables the use of sophisticated software for effective complex spacecraft control. A unique aspect of large spacecraft is the control of the structural configuration in order to achieve a specific pointing accuracy. Large structures, with their mechanical flexibility, present particular problems to the control engineer and control/structure interaction (CSI) is a driving force in many current programs and figured largely in the papers presented.

N84-24604*# National Aeronautics and Space Administration, Washington, D. C.
SPACECRAFT CONTROL RESEARCH AT NASA
J. B. DAHLGREN and L. W. TAYLOR, JR. (NASA. Langley Research Center) *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 14 p Jan. 1984 refs
Avail: NTIS HC A15/MF A01 CSCL 22B

Future missions is space will require controlling spacecraft which are both large and flexible. The limited inherent damping and the uncertain and changing dynamic characteristics of many of these vehicles, such as manned space stations and large antennas, will revolutionize spacecraft control requirements. In preparation for the time that such control systems are required, considerable research and technology development is necessary. A program is in place at NASA for the development of active control technology to support major initiatives for space station and advanced spacecraft. A number of key control technology program needs are cited in the paper as required for these and other future NASA missions together with an integrated controls/structures technology flight experiment to demonstrate and validate technology for large flexible structures. Author

N84-24608# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (West Germany). Engineering Dept. for Gyroscopic and Space Products.
A DOUBLE GIMBALLED MOMENTUM WHEEL FOR PRECISION 3-AXIS ATTITUDE CONTROL
W. AUER *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 8 p Jan. 1984 refs
Avail: NTIS HC A15/MF A01

For precision three-axis attitude control of space vehicles, a Double Gimballed Momentum Wheel (DGMW) as attitude actuator is a favorable approach. A high reliability DGMW of modular design with two momentum wheels and two direct drive ultra high resolution stepper motors plus pick-offs per gimbal axis (full redundancy; no caging during launch) was designed, built and qualification tested, together with an associated wheel and gimbal drive electronics. In addition, extensive system tests were performed on a three-axis air bearing table which proved the excellent control capabilities of this DGMW. Besides the measurement under stationary conditions with an accuracy of 18 sec of arc, also the transient behavior was studied. Due to the high torque capability (up to 0.2 Nm around the momentum wheel axis and up to 1 Nm around the gimbal axes) rapid and accurate pointing and repointing of spacecraft are possible. Therefore, the DGMW system can be designed into tracking loops to assure

continuous pointing of spacecraft instruments with a rapid assignment capability. Author

N84-24611# MATRA Espace, Paris-Velizy (France). Space Branch.
MULTIFUNCTION SPACECRAFT ATTITUDE ESTIMATION AND NAVIGATION SYSTEM
J. C. AMIEUX and B. CALUDINON *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 17 p Jan. 1984
Avail: NTIS HC A15/MF A01

The primary function of a spacecraft attitude control subsystem is the attitude determination and, more generally, the state estimation (attitude of the main body, appendages and flexible modes). The so-called optico-inertial concept is first described with application to a number of modern spacecraft; an example of implementation using space-qualified microprocessors is given in detail; the state estimation of a flexible spacecraft is then considered, a technique which can be readily implemented on existing hardware. The extension of this concept to autonomous orbit control of an orbiting spacecraft is then considered for future development. Author

N84-24619# Honeywell, Inc., Minneapolis, Minn. Systems and Research Center.
CHARACTERIZATION OF UNCERTAINTY FOR LARGE SPACE STRUCTURE CONTROL PROBLEMS
J. C. DOYLE and J. E. WALL *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 19 p Jan. 1984 refs Sponsored in part by Honeywell Internal Research and Development Funding
(Contract F49620-82-C-0090)
Avail: NTIS HC A15/MF A01

A new formulation of the feedback control problem that captures both its performance and robustness aspects is reviewed. The basic analysis tool in this formulation is the structured singular value. The methods are potentially applicable to Large Space Structure Control Problems since they allow for uncertainty in a very natural way. Author

N84-24620# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ATTITUDE CONTROL ON LARGE FLEXIBLE SPACECRAFT
G. THIEME *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 15 p Jan. 1984 refs Sponsored in part by ESA
Avail: NTIS HC A15/MF A01

Some results found during the investigation of control problems of large flexible spacecraft are presented. A triple plate configuration of such a spacecraft is defined and studied. The model is defined by modal data derived from finite element modelling. The order reduction methods applied are briefly described and results of order reduction are presented. An attitude control concept with low and high authority control was used to design an attitude controller for the reduced model. The stability and response of the original system together with the reduced controller is analyzed. Author

N84-24621# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Dynamik der Flugsysteme.
LOW AUTHORITY CONTROL OF FLEXIBLE SPACECRAFT VIA NUMERICAL OPTIMIZATION
G. SCHULZ *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 16 p Jan. 1984 refs
Avail: NTIS HC A15/MF A01

For the design of low authority controllers for attitude control of flexible spacecraft a new method based on numerical optimization is presented. Thereby a dominant criterion to be optimized is determined, and the design requirements are formulated as constraints. Two different criteria are investigated: first a dissipation energy criterion is maximized and second a control energy criterion is minimized. The method is applied for attitude controller design of two models, the 'Draper Model No. 1 and the Purdue Model'. The first represents a flexible tetrahedral truss structure while the latter can be considered as model of a solar power satellite. Damping requirements for these models are formulated as design objectives and the controllers are determined using the proposed method. The achieved results show that due to the now existing efficient optimization software, controller design via numerical optimization is a useful and flexible tool for system design. This flexibility arises from the fact that arbitrary design criteria can be implemented. Author

N84-24622# Rome Univ. (Italy). Dept. of Aerospace.
A DECENTRALIZED ACTIVE CONTROL SYSTEM FOR A LARGE FLEXIBLE STRUCTURE IN SPACE
A. DANESI *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 15 p Jan. 1984 refs
Avail: NTIS HC A15/MF A01

A new strategy in controlling the modal shapes of large structure in space is presented. An active low authority modal control system, consisting of a discrete number of servo system units (M.C.U.) distributed along flexible masts supporting RF radiators, is provided to measure and control the local structural deformations in order to obtain a modal shapes resulting in acceptable pointing error for the RF radiators. Each servo unit is conceived as a model following control system implementing a strategy based on fast fourier transformation (F.F.T.) pairs computations. The control efforts applied by the M.C.U.s to the mast control points are made proportional to the spectral error function generated by a real time F.F.T. dedicated microprocessor as the difference between the measured and desidered modal spectra relative to the antenna angular deflections in respect to a fixed set point. The decentralized control system organized by a central controller residing in the master M.C.U., will force the antenna to match the model dynamical behavior which is expected to improve the antenna pointing accuracy within the large space structure design requirements. Author

N84-24623# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Flight Dynamics Lab.
DESIGN AND ROBUSTNESS ANALYSIS OF REDUCED ORDER CONTROLLERS FOR LARGE FLEXIBLE SPACE VEHICLES
S. S. BANDA, D. B. RIDGELY, H. H. YEH, and D. V. PALMER *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 25 p Jan. 1984 refs
Avail: NTIS HC A15/MF A01

In the control design of a large flexible space vehicle, a finite element model is truncated and the control system is designed on the basis of the reduced order model. The step-by-step application of frequency-shaped Linear - Quadratic - Gaussian methodology is discussed, as well as payoffs and costs of this method. The procedure for choosing and forming both state and control frequency - weightings is shown. Treating the unmodelled dynamics of the structure as a source of plant uncertainty, stability robustness evaluation is discussed. Practical usefulness of the singular-valued closed-loop performance analysis and its possible improvement are also discussed. Author

N84-24701# TRW Defense and Space Systems Group, Redondo Beach, Calif.
VIBRATION CONTROL OF SPACE STRUCTURES VCOSS B: MOMENTUM EXCHANGE AND TRUSS DAMPENING Final Report, Aug. 1981 - Jul. 1983
L. BRADY, G. FRANCO, L. KERANEN, J. KERN, and R. NEISWANDER Wright-Patterson AFB, Ohio AFWAL Jul. 1983 110 p
(Contract F33615-81-C-3235; AF PROJ. 2401)
(AD-A139910; AFWAL-TR-83-3075) Avail: NTIS HC A06/MF A01 CSCL 20K

This report presents the final technical results of the TRW Vibration Control of Space Structures (VCOSS) program. Subtasks include: (1) Dynamic performance studies of a vibration controlled structure, (2) Design iterations, (3) Graphic representation of system performance (LOS errors), (4) Comparison of active controlled to stiffness controlled model. During this phase an emphasis was

placed on development of control hardware and its impact on spacecraft power and weight budgets. A preliminary estimate of the implementation costs associated with the chosen design was also made. An evaluation of the selected hardware is presented. It was determined that mission requirements could be met and that the hardware necessary to achieve these requirements is essentially existing and the state of the art in nature. Based on the presented comparison between the active and the stiffness controlled models, it appears that there is a substantial payoff in active control. Author (GRA)

N84-24702# Lockheed Missiles and Space Co., Sunnyvale, Calif.
VIBRATION CONTROL OF SPACE STRUCTURES VCOSS A: HIGH AND LOW-AUTHORITY HARDWARE IMPLEMENTATIONS Final Technical Report, 15 Sep. 1981 - 15 Apr. 1983
J. N. AUBRUN, C. Z. GREGORY, M. G. LYONS, R. L. KOSUT, and A. A. J. WOODS Wright-Patterson AFB, Ohio AFWAL *Jul. 1983 277 p Prepared in cooperation with Integrated Systems, Inc., Palo Alto, CA*
(Contract F33615-81-C-3220; AF PROJ. 2401)
(AD-A139931; LMSC-D883019; AFWAL-TR-83-3074) Avail: NTIS HC A13/MF A01 CSCL 20K

The report considers some hardware aspects of large space structure control implementations. Hardware and system performance requirements are overviewed, principally in the context of vibration suppression. Analytical models based on soft and stiff versions of CSDL (Charles Stark Draper Lab.) no. 2 structure are used to evaluate vibration suppression performance for actively controlled and passive structures. The effects of hardware bandwidth limitations and system modeling errors are evaluated for the active controls case. It is shown that hardware bandwidth limitations do not pose significant control design problems. The basic elements for a hardware demonstration program to evaluate these results is given. GRA

N84-24703# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS ELEVEN (ACTIVE CONTROL OF SPACE STRUCTURES), VOLUME 1 Interim Report, Nov. 1982 - Apr. 1983
T. H. BROOKS, V. MAHAJAN, D. R. HEGG, G. J. KISSEL, and H. MCCLAMROCH Griffiss AFB, N.Y. RADC Dec. 1983 57 p
(Contract F30602-81-C-0180; ARPA ORDER 3655; AF PROJ. C655)
(AD-A140025; CSDL-R-1648-VOL-1; RADC-TR-83-261-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 17E

The overall objective of the Simulation Extensions project is to identify and quantify those generic mission, scenario and sensor parameters (as well as their interactions) which drive the performance of space-based starting IR surveillance systems. The approach taken to achieve their overall objective has proceeded along two main avenues; Simulation Enhancements, and Simulation Applications. Efforts in the Simulation Enhancements areas are directed toward generalized those models in the Draper Integrated Simulations which are too limited in scope or perhaps restricted to one particular system. In support of the Simulation Enhancements effort, work was performed (or is in progress) on models for the platform, sensor (including focal plane and signal processor), and scene. Utilizing the tools developed as a result of the Simulation Enhancements work, the Simulation Applications effort studies issues related to generic surveillance system performance drivers. Results are reported from a study which examines the effects of spectral band selection and scene local time of day on line-of-sight jitter-induced clutter leakage through the signal processor of a generic surveillance system. The CSDL prepared a deconvolution test to validate Itek's deconvolution algorithm for correcting a deformed HALO optical system. The algorithm uses the wavefront errors measured by a wavefront sensor to determine the actuator signals. This report describes a limited blind test and concludes that the algorithm successfully determines the actuator displacements from the wavefront errors provided in this test. GRA

N84-25747# Aeritalia S.p.A., Torino (Italy). Space Sector
STUDY OF ERS-1 DYNAMIC INTERACTION. VOLUME 1: THEORETICAL NOTES Final Report
G. CORRADO and M. DUMONTEL Paris ESA Dec. 1982 116 p refs
(Contract ESA-4759/81/NL-PP(SC))
(ER-RP-A1-002-VOL-1; ESA-CR(P)-1849-VOL-1) Avail: NTIS HC A06/MF A01

Through the use of a reduced mathematical model, a preliminary analysis and performance assessment of the ERS-1 control system is described. The derivation of the simulation model and the associated software, important simulation results, and additional investigations to support the analysis are presented. M.A.C.

N84-25758*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC CHARACTERISTICS OF A SPACE-STATION SOLAR WING ARRAY
J. T. DORSEY and H. G. BUSH Jun. 1984 32 p refs
(NASA-TM-85780; L-15752; NAS 1.15:85780) Avail: NTIS HC A03/MF A01 CSCL 22B

A solar-wing-array concept is described which meets space-station requirements for minimum fundamental frequency (0.4 Hz), component modularity, and growth potential. The basic wing-array design parameters are varied, and the resulting effects on the array vibration frequencies and mode shapes are assessed. The transient response of a free-free space station (incorporating a solar-wing-array point design) to a load applied at the space-station center is studied. The use of the transient response studies in identifying critically loaded structural members is briefly discussed. The final 150-kW space-station configuration has a fundamental elastic frequency of 0.403 Hz. Author

N84-26185# Air Force Geophysics Lab., Hanscom AFB, Mass.
PROCEEDINGS OF THE AIR FORCE GEOPHYSICS LABORATORY WORKSHOP ON NATURAL CHARGING OF LARGE SPACE STRUCTURES IN NEAR EARTH POLAR ORBIT Scientific Interim Report
R. C. SAGALYN, ed., D. E. DONATELLI, ed. (Boston Coll., Chestnut Hill, Mass.), and I. MICHAEL, ed. 25 Jan. 1983 402 p refs Workshop held at Hanscom AFB, Mass., 14-15 Sep. 1982
(Contract F19628-81-K-0011)
(AD-A134894; AFGL-TR-83-0046; ERP-825) Avail: NTIS HC A18/MF A01 CSCL 04A

The causes and effects of vehicle charging in near Earth orbit and the problems encountered in developing models or codes to adequately deal with the charged vehicle environment are reviewed.

N84-26201# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE INTERACTION OF LARGE SPACE STRUCTURES WITH THE NEAR-EARTH ENVIRONMENT
U. SAMIR *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 235-251 25 Jan. 1983 refs Prepared in cooperation with Michigan Univ., Ann Arbor
(AD-P002115) Avail: NTIS HC A18/MF A01 CSCL 04A

The interaction between natural plasmas and satellites orbiting the planets is one aspect of the more general problems of the interaction between collisionless plasma flows and bodies in the solar system. Examples of body plasma interactions relevant to the solar system are given. The detailed structures, that is, the detailed particle and field distributions in space and time around the bodies, are expected to differ for different types of interactions. However, the basic patterns could be similar since the basic physical processes acting in such interactions are probably similar. Planetary magnetospheres and shocks for example are to be seen as effects whose cause is the interaction between the body (planet's intrinsic and/or induced magnetic field) and plasma (solar wind). GRA

N84-26352*# Bendix Corp., Teterboro, N.J. Guidance Systems Div.
MODULAR DESIGN ATTITUDE CONTROL SYSTEM Final Report, 1 Nov. 1982 - 30 Sep. 1983
F. D. CHICHESTER 1983 71 p refs
(Contract NAS8-33979)
(NASA-CR-173684; NAS 1.26:173684) Avail: NTIS HC A04/MF A01 CSCL 12A

The problem of applying modular attitude control to a rigid body - flexible suspension model of a flexible spacecraft with some state variables inaccessible was addressed by developing a sequence of single axis models and generating a series of reduced state linear observers of minimum order to reconstruct those scalar variables that were inaccessible. The specific single axis models treated consisted of two, three and four rigid bodies, respectively, interconnected by a flexible shaft passing through the mass centers of the bodies. Reduced state linear observers of all orders up to one less than the total number of scalar state variables were generated for each of the three single axis models cited. Author

N84-26738*# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
SPACE STRUCTURE VIBRATION MODES: HOW MANY EXIST? WHICH ONES ARE IMPORTANT?
P. C. HUGHES Apr. 1984 24 p refs Sponsored by JPL, Natural Sciences and Engineering Research Council of Canada, and Canadian Department of Communications
(NASA-CR-173442; NAS 1.26:173442; UTIAS-TN-252; ISSN-0082-5263; AD-B083791) Avail: NTIS HC A02/MF A01 CSCL 22B

This report attempts to shed some light on the two issues raised in the title, namely, how many vibration modes does a real structure have, and which of these modes are important? The surprise-free answers to these two questions are, respectively, an infinite number and the first several modes. The author argues that the absurd subspace (all but the first billion modes) is not a strength of continuum modeling, but, in fact, a weakness. Partial differential equations are not real structures, only mathematical models. This note also explains (1) that the PDE model and the finite element model are, in fact, the same model, the latter being a numerical method for dealing with the former, (2) that modes may be selected on dynamical grounds other than frequency alone, and (3) that long slender rods are useful as primitive cases but dangerous to extrapolate from. B.W.

N84-26741*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SELECTION OF ACTUATOR LOCATIONS FOR STATIC SHAPE CONTROL OF LARGE SPACE STRUCTURES BY HEURISTIC INTEGER PROGRAMING
R. T. HAFTKA (Virginia Polytechnic Inst. and State Univ.) and H. M. ADELMAN Mar. 1984 29 p refs Presented at the GWU/LaRC Symp. on Advan. and Trends in Struct. and Dyn., Washington, D.C., 22-25 Oct. 1984
(NASA-TM-85769; NAS 1.15:85769) Avail: NTIS HC A03/MF A01 CSCL 22B

Orbiting spacecraft such as large space antennas have to maintain a highly accurate space to operate satisfactorily. Such structures require active and passive controls to mantain an accurate shape under a variety of disturbances. Methods for the optimum placement of control actuators for correcting static deformations are described. In particular, attention is focused on the case were control locations have to be selected from a large set of available sites, so that integer programing methods are called for. The effectiveness of three heuristic techniques for obtaining a near-optimal site selection is compared. In addition, efficient reanalysis techniques for the rapid assessment of control effectiveness are presented. Two examples are used to demonstrate the methods: a simple beam structure and a 55m space-truss-parabolic antenna. Author

N84-28538*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
REGIONS OF ATTRACTION AND ULTIMATE BOUNDEDNESS FOR LINEAR QUADRATIC REGULATORS WITH NONLINEARITIES
S. M. JOSHI Jul. 1984 34 p refs
(NASA-TP-2322; L-15739; NAS 1.60:2322) Avail: NTIS HC A03/MF A01 CSCL 09C

The closed-loop stability of multivariable linear time-invariant systems controlled by optimal linear quadratic (LQ) regulators is investigated for the case when the feedback loops have nonlinearities N(sigma) that violate the standard stability condition, sigma N(sigma) or = 0.5 sigma(2). The violations of the condition are assumed to occur either (1) for values of sigma away from the origin (sigma = 0) or (2) for values of sigma in a neighborhood of the origin. It is proved that there exists a region of attraction for case (1) and a region of ultimate boundedness for case (2), and estimates are obtained for these regions. The results provide methods for selecting the performance function parameters to design LQ regulators with better tolerance to nonlinearities. The results are demonstrated by application to the problem of attitude and vibration control of a large, flexible space antenna in the presence of actuator nonlinearities. M.G.

N84-28541# Wisconsin Univ., Madison. Dept. of Mathematics.
CONTROL THEORY OF PARTIAL DIFFERENTIAL EQUATIONS Final Report, 1 Nov. 1981 - 31 Oct. 1982
D. L. RUSSELL 1984 87 p
(Contract AF-AFOSR-0018-79; AF PROJ. 2304)
(AD-A140945; AFOSR-84-0391TR) Avail: NTIS HC A05/MF A01 CSCL 12A

During the period November 1, 1981 to October 31, 1982, the principal investigator, in co-operation with several research assistants, carried out a program of mathematical research in the general area of control theory of partial differential equations. The program involved two distinct phases: an effort aimed specifically at the development and improvement of control strategies in connection with the wing flutter problem and a more general program in the area of distributed parameter control problems of hyperbolic type. This work resulted in two scientific papers which form the greater part of this report. The first of these, Some Remarks on the Current Status of the Control Theory of Single Space Dimension Hyperbolic Systems, was presented at the NASA JPL Symposium on Control and Stabilization of Large Space Structures, Pasadena, California, July 1982. The second, Admissible Input Elements for Systems in Hilbert Space and a Carleson Measure Criterion, by L.F. Ho and the principal investigator, is a paper which largely resulted from Dr. Ho's thesis work.
Author (GRA)

N84-28892*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES, PART 7 Final Report
P. M. BAINUM, A. S. S. R. REDDY, R. KRISHNA, C. M. DIARRA, and S. ANANTHAKRISHNAN Jun. 1984 113 p refs
(Contract NSG-1414)
(NASA-CR-173781; NAS 1.26:173781) Avail: NTIS HC A06/MF A01 CSCL 22B

A preliminary Eulerian formulation of the in-plane dynamics of the proposed spacecraft control laboratory experiment configuration is undertaken when the mast is treated as a cantilever type beam and the reflector as a lumped mass at the end of the beam. Frequency and mode shapes are obtained for the open loop model of the beam system and the stability of closed loop control systems is analyzed by both frequency and time domain techniques. Environmental disturbances due to solar radiation pressure are incorporated into models of controlled large flexible orbiting platforms. Thermally induced deformations of simple beam and platform type structures are modelled and expressions developed for the disturbance torques resulting from the interaction of solar radiation pressure. Noise effects in the deterministic model of the hoop/column antenna system are found to cause a degradation

in system performance. Appropriate changes in the ratio of plant noise to the measurement noise and/or changes in the control weighting matrix elements can improve transient and steady state performance. A.R.H.

N84-28896# California Univ., Berkeley. Electronics Research Lab.
AN INTEGRATED, OPTIMIZATION-BASED APPROACH TO THE DESIGN AND CONTROL OF LARGE SPACE STRUCTURES Annual Scientific Report, 1 Oct. 1983 - 1 May 1984
E. POLAK, K. S. PISTER, and R. L. TAYLOR 1 May 1984 21 p
(Contract AF-AFOSR-0361-83; AF PROJ. 2304)
(AD-A141856; AFOSR-84-0448TR) Avail: NTIS HC A02/MF A01 CSCL 12A

The investigators proposed to consider the design of large space structures which are required to perform large amplitude maneuvers at the end of which they are required to remain locked on a target. They proposed to deal with the pointing of the LSS in two stages. In the first stage, the control task is to rapidly redirect the pointing direction of the LSS reference axis, e.g., the line-of-sight of a telescope or antenna, by open loop optimal control, the large motions of the LSS induced by the maneuver must quiet down so that the control of the LSS can be transferred to a linear, closed loop control system. The task of the latter is to damp out the induced structural vibrations, and, finally, to lock the pointing direction on the target. For the purpose of obtaining a tractable model problem for the research, the investigators shall initially assume that the LSS is a beam. The investigators shall use a nonlinear beam model for the large motions, and they shall use a linear beam model to describe the small displacements as a perturbation around the equilibrium rigid body configuration. In fully developing the model problem, described within the investigators shall first develop the equations of motion for a beam under large and small displacement conditions. They shall then use the resulting equations in transcribing sample design specifications into infinite systems of inequalities. Author (GRA)

N84-29903*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPROXIMATION TECHNIQUES FOR PARAMETER ESTIMATION AND FEEDBACK CONTROL FOR DISTRIBUTED MODELS OF LARGE FLEXIBLE STRUCTURES Final Report
H. T. BANKS and I. G. ROSEN Jun. 1984 22 p refs
(Contract NAS1-17070; NAS1-17130)
(NASA-CR-172411; NAS 1.26:172411; ICASE-84-26) Avail: NTIS HC A02/MF A01 CSCL 22B

Approximation ideas are discussed that can be used in parameter estimation and feedback control for Euler-Bernoulli models of elastic systems. Focusing on parameter estimation problems, ways by which one can obtain convergence results for cubic spline based schemes for hybrid models involving an elastic cantilevered beam with tip mass and base acceleration are outlined. Sample numerical findings are also presented. B.W.

N84-29904# European Space Agency, Paris (France).
DYNAMIC SYNTHESIS AND EVALUATION OF SPACECRAFT STRUCTURES
C. STAVRINIDIS (European Space Research and Technology Center, Noordwijk, Netherlands) Mar. 1984 111 p refs
(ESA-STR-208; ISSN-0379-4067) Avail: NTIS HC A06/MF A01

A general procedure for coupling dynamical equations is outlined. Fixed and free boundary modal synthesis procedures are described. Mode sets for dynamic synthesis are discussed. Author (ESA)

N84-31262 Stanford Univ., Calif.
ATTITUDE DYNAMICS OF THE GALILEO SPACECRAFT Ph.D. Thesis
M. G. WARD 1984 330 p
Avail: Univ. Microfilms Order No. DA8408375

A model of the attitude dynamics of the Galileo spacecraft has been developed for purposes of simulating various spacecraft attitudes controlled maneuvers. Because of complex mission requirements, the Galileo spacecraft structure includes components whose flexibility is important to the spacecraft attitude behavior and which must be considered in the development of a stable attitude control system. The model formulation is based on an efficient procedure for deriving equations of motion, and the resulting equations of motion form the basis for a flexible body dynamics simulation which can provide controls analysts with a means of testing various control algorithms. Dissert. Abstr.

N84-31267*# Virginia Univ., Charlottesville. Dept. of Mechanical and Aerospace Engineering.
DIGITAL CONTROL SYSTEM FOR SPACE STRUCTURAL DAMPERS Annual Report
J. K. HAVILAND Jul. 1984 59 p refs
(Contract NAG1-349)
(NASA-CR-173867; NAS 1.26:173867; UVA/528224/MAE85/102)
Avail: NTIS HC A04/MF A01 CSCL 22B

Digital control systems for space structural dampers, also referred to as inertia or proof-mass dampers are investigated. A damper concept is improved by adding a small taper to the proof-mass, and using a proximeter to determine position. Another damper using a three inch stroke rather than the standard one inch stroke is described. Provisions are made for a relative velocity feedback. In one approach, the digital controller is modified to accept the signal from a linear velocity transducer. In the other, the velocity feedback is included in the digital program. An overall system concept for the use of the dampers is presented. M.A.C.

N84-31715# Sandia Labs., Albuquerque, N. Mex. Engineering Analysis Dept.
COMBINED EXPERIMENTAL/ANALYTICAL MODELING USING COMPONENT MODE SYNTHESIS
D. R. MARTINEZ, T. G. CARNE, and A. K. MILLER Apr. 1984 16 p refs
(Contract DE-AC04-76DP-00789)
(DE84-013147; SAND-83-1889) Avail: NTIS HC A02/MF A01

The accuracy of computed modal frequencies and mode shapes obtained from a combined experimental/analytical model for a simple beam structure was evaluated. The structure was divided into two subsystems, and one subsystem was tested to obtain its free/free modes. Using a component mode synthesis (CMS) technique, the experimental modal data base for one subsystem was directly coupled with a finite element model of the other subsystem to create an experimental/analytical model of the total structure. Both the translational and rotational elements of the residual flexibilities and mode shapes at the interface of the experimental subsystem were measured and used in the coupling. The modal frequencies and mode shapes obtained for the combined experimental/analytical model are compared to those for a reference finite element model of the entire structure. The sensitivity of the CMS model predictions to errors in the modal parameters and residual flexibilities, which are required to define a subsystem, are also examined. DOE

N84-32423*# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.
LINEARIZED DYNAMICAL MODEL FOR THE NASA/IEEE SCOLE CONFIGURATION Interim Report
A. F. HOTZ, E. COLLINS, and R. E. SKELTON Hampton, Va. NASA. Langley Research Center Sep. 1984 34 p refs
(Contract NAG1-468)
(NASA-CR-172394; NAS 1.26:172394) Avail: NTIS HC A03/MF A01 CSCL 22B

The linearized equation of motion for the NASA/IEEE SCOLE configuration are developed. The derivation is based on the method of Lagrange and the equations are assembled into matrix second order form. Author

N84-33457# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
OPTIMIZING PARAMETERS AND CONTROLS FOR MANEUVERING FLEXIBLE STRUCTURES Ph.D. Thesis - Illinois Univ., Urbana-Champaign
R. J. LISOWSKI 1984 92 p
(AD-A143726; AFIT/CI/NR-84-1) Avail: NTIS HC A05/MF A01 CSCL 12A

The combined problem of optimizing both the parameters and the control for maneuvering flexible structures is addressed. The necessary conditions for the general problem are defined and a numerical technique for the solution is discussed. Implementing the numerical solutions is shown to be practical using reduced-order structural models. Optimal controls are smoothed by including control derivative penalties in order to allow terminal values for the controls to be specified. The optimization leads to the investigation of structures that require only simple rigid body controls for accomplishing the maneuver while ensuring minimal modal excitation at the maneuver's completion. Numerical examples are presented for single axis slew maneuvers of a symmetric four boom flexible structure. Author (GRA)

N84-33458# Lockheed Missiles and Space Co., Sunnyvale, Calif.
ACOSS TWELVE (ACTIVE CONTROL OF SPACE STRUCTURES) Final Technical Report, Sep. 1981 - May 1982
J. N. AUBURN, J. A. BREAKWELL, N. K. GUPTA, and M. G. LYONS Griffiss AFB, N.Y. RADC Feb. 1984 255 p
(Contract F30602-81-C-0260; ARPA ORDER 3654)
(AD-A143829; LMSC-D883023; RADC-TR-84-28) Avail: NTIS HC A12/MF A01 CSCL 22B

The theory of steady state and broad band random disturbance rejection for large space structures is developed and tested analytically on a complex optical strawman configuration. It is shown that active control is potentially feasible for micro-vibration stabilization of precision large structures. A number of brassboard experiments have been carried out to illustrate the theory and to address implementation and mechanization of active control systems with both analog and digital approaches. Author (GRA)

N84-34467*# Old Dominion Univ., Norfolk, Va. Dept. of Electrical Engineering.
CONTROL METHODOLOGIES FOR LARGE SPACE STRUCTURES Final Report, period ending Sep. 1983
G. J. MCREE and E. ALTONJI Aug. 1984 38 p
(Contract NAG1-318)
(NASA-CR-173987; NAS 1.26:173987) Avail: NTIS HC A03/MF A01 CSCL 22B

The objectives of this research were to develop techniques of controlling a dc-motor driven flywheel which would apply torque to the structure to which it was mounted. The motor control system was to be implemented using a microprocessor based controller. The purpose of the torque applied by this system was to dampen oscillations of the structure to which it was mounted. Before the work was terminated due to the unavailability of equipment, a system was developed and partially tested which would provide tight control of the flywheel velocity when it received a velocity command in the form of a voltage. The procedure followed in this development was to first model the motor and flywheel system on an analog computer. Prior to the time the microprocessor development system was available, an analog control loop was replaced by the microprocessor and the system was partially tested. B.W.

N84-34491*# Industrieanlagen-Betriebsgesellschaft m.b.H., Ottobrunn (West Germany).
DISTORTION MEASUREMENT OF ANTENNAS UNDER SPACE SIMULATION CONDITIONS WITH HIGH ACCURACY AND HIGH RESOLUTION BY MEANS OF HOLOGRAPHY
H. U. FREY *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 309-319 1984 refs
Avail: NTIS HC A13/MF A01 CSCL 14E

The use of laser holography for measuring the distortion of antennas under space simulation conditions is described. The subject is the so-called double exposure procedure which allows to measure the distortion in the order of 1 to 30/micrometers + or - 0.5 per hologramme of an area of 4 m diameter max. The method of holography takes into account the constraints of the space simulation facility. The test method, the test set up and the constraints by the space simulation facility are described. The results of the performed tests are presented and compared with the theoretical predictions. The test on the K-Band Antenna e.g., showed a distortion of approximately 140/micrometers + or - 5/micrometers measured during the cool down from -10 C to -120 C. Author

06

ELECTRONICS

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

A84-30030* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ENERGY CONVERSION FOR MEGAWATT SPACE POWER SYSTEMS
R. EWELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 1 . New York, American Institute of Chemical Engineers, 1983, p. 87-93. USAF-sponsored research. refs

Large nuclear space power systems capable of continuously producing over one megawatt of electrical power for a several year period will be needed in the future. This paper presents the results of a study to compare applicable conversion technologies which were deemed to be ready for a time period of 1995 and beyond. A total of six different conversion technologies were studied in detail and compared on the basis of conversion efficiency, radiator area, overall system mass, and feasibility. Three static, modular conversion technologies were considered; these include: AMTEC, thermionic, and thermoelectric conversion. The other three conversion technologies are heat engines which involve dynamic components. The dynamic systems analyzed were Brayton, Rankine, and the free piston Stirling engine. Each of the conversion techniques was also examined for limiting characteristics and an attempt was made to identify common research needs and enabling technologies. Author

A84-30102
IECEC '83; PROCEEDINGS OF THE EIGHTEENTH INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, ORLANDO, FL, AUGUST 21-26, 1983. VOLUME 3 - ELECTRICAL POWER SYSTEMS
Conference sponsored by AIChE, ANS, SAE, ACS, AIAA, ASME, and IEEE. New York, American Institute of Chemical Engineers, 1983, 523 p.

Among the topics discussed are manned and unmanned spacecraft electrical power systems, aircraft and missile electrical power, high voltage power technology for aerospace applications, automated spacecraft electrical systems, spacecraft electrical power distribution and control, solar cell systems for space

applications, terrestrial photovoltaics development and applications, the use of wind turbines for electrical generation, and electric vehicles and their subsystems. Specific issues addressed within these categories include future military space power systems, energy storage for manned space stations, laser and solar space power systems, radioisotope thermoelectric generators for space use, high frequency dc/dc converters, high voltage equipment failures, Galileo spacecraft computer memory power control, photovoltaic conversion of laser power to electrical power, manufacturing trends in space cells, spacecraft solar array design, photovoltaic power supplies for remote and rural areas, silicon material processing technology status, effects of clusters and arrays on wind turbine output, and the development status of electric automobiles. O.C.

A84-30104
ELECTRICAL POWER SUBSYSTEM DESIGNS FOR AN INITIAL LOW-COST FACILITY (LCF) SPACE STATION
A. A. NUSSBERGER (Rockwell International Corp., Shuttle Integration and Satellite Systems Div., Pittsburgh, PA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 941-946.

Attention is given to the results of conceptual studies concerned with the identification of subsystems having a critical influence on the development of an 'evolutionary growth' space station meeting scientific experimentation mission requirements. The three low cost facility (LCF) concepts considered involve low development cost through the use of existing Space Shuttle Orbiter or Spacelab hardware. Electrical power subsystem design features are presented and comparative advantages for the LCF concepts considered are assessed. O.C.

A84-30105
POWER SUBSYSTEMS FOR A LOW EARTH ORBIT STATION
Y. DUBOIS (Matra, S.A., Toulouse, France) and M. ESPACE IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 947-951.

A performance evaluation is conducted for the electrical power subsystems of a space station, with a view to the requirements of two scenarios: the assembly of spacecraft elements that will subsequently be launched into geostationary orbit, and the supply of required facilities to a habitable module which can be visited by manned spacecraft at intervals of several months. The electrical power system chosen employs minimum risk/low cost technology and encompasses a solar array and an Ni/H2 battery. A series switching parallel array concept is applied to solar array power conversion, regulation and distribution. Also considered are the power system requirements of a 'tug' spacecraft for transfering payloads from Ariane orbit to the 600-km circular equatorial orbit of the space station. O.C.

A84-30106
ELECTRICAL POWER SYSTEM REQUIREMENTS FOR MANNED SPACE STATIONS
S. W. SILVERMAN and G. R. WOODCOCK (Boeing Aerospace Co., Seattle, WA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 952-956.

Analyses of manned space station missions show that the electrical power requirements will be from 25kW to more than 100kW, depending upon the number of astronauts aboard. For military applications the electrical loads can be much higher even though the load operating time may be short and intermittent. Studies have examined solar cell/battery, solar cell/regenerative fuel cell, and nuclear systems. This paper will summarize the power requirements, the tradeoffs, including how the electrical power systems can be integrated with other functions and nuclear concepts. The influence of mission applications on selection of the power system will be discussed. Author

A84-30107
COMPARATIVE ANALYSIS OF ENERGY STORAGE SYSTEMS FOR SPACE STATIONS
L. HSU and J. E. OPPENHEIM (Rockwell International Corp., Shuttle Integration and Satellite Systems Div., Pittsburgh, PA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 957-962. refs

Nickel-hydrogen batteries, open-loop fuel cells, and regenerative fuel cells were subjected to tradeoff analyses, in order to ascertain the optimum evolutionary development approach in the construction sequence of the space station that would employ one of them as an electrical power subsystem (EPS). The analyses extended to all the interfacing subsystems that can be readily integrated with the EPS, such as the environmental control and life support subsystem, the thermal control subsystem, and the reaction control subsystem. Space station evolutionary stage matching with EPSs is notably influenced by new technology, life cycle costs, and space station developmental expansion methods. O.C.

A84-30109* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE POWER SYSTEM UTILIZING FRESNEL LENSES FOR SOLAR POWER AND ALSO THERMAL ENERGY STORAGE
R. H. TURNER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 971-976.

A solar power plant suitable for earth orbits passing through Van Allen radiation belts is described. The solar-to-electricity conversion efficiency is estimated to be around 9 percent, and the expected power-to-weight ratio is competitive with photovoltaic arrays. The system is designed to be self-contained, to be indifferent to radiation belt exposures, store energy for periods when the orbiting system is in earth shadow (so that power generation is contant), have no moving parts and no working fluids, and be robust against micrometeorite attack. No electrical batteries are required. Author

A84-30114
EFFECT OF MOON'S SHADOW ON GEOSTATIONARY SATELLITE POWER SYSTEMS
G. D. GORDON (COMSAT Laboratories, Clarksburg, MD) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 1002-1007. Research supported by the International Telecommunications Satellite Organization.

A geostationary satellite enters the moon's shadow, at unevenly spaced intervals, on the average of twice a year. Such events occur when the moon moves between the sun and the satellite. The present investigation has the objective to provide some understanding of such eclipses. The geometrical relations involved are examined, and data regarding the eclipses for a geostationary satellite at 270 deg E and 90 deg W for the time from 1980 to 1999 are presented. Most of the eclipses are found to be partial, and last less than an hour. The effect of an eclipse on a solar array is to reduce power. Some satellites, such as those for TV broadcast, are not designed to continue operations during an eclipse. However, reduced operations should be possible with a smaller number of channels. G.R.

A84-30136
CONSIDERATIONS IN THE SELECTION OF DC VS AC POWER SYSTEMS FOR HIGH POWER SPACE APPLICATIONS
R. E. CORBETT (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 1164-1169. refs

The use of alternating current (ac) in satellite power systems has been the subject of occasional study for a number of years. Recent studies have considered the advantages of ac power for high-power space systems such as the NASA multi-hundred kilowatt (MHKW) platform technology area. The definitive comparative evaluation has not been performed to date, principally due to the breadth and depth of the technical issues involved and the strong opinions often held by advocates of one position or another. An attempt is made at examination of the technical issues and the motivations for the technologists' opinions. A summary is made of the issues and relative strength of the arguments on each side. It is concluded that the relative quantity of load rating versus source rating and the load voltage regulation requirement are key factors in the suitability of a specific ac or dc power system for a specific mission. Areas requiring further study to settle the technical arguments are reviewed. Author

A84-30137
BUS ARRANGEMENTS FOR SYNCHRONOUS ORBIT SPACECRAFT
J. H. HAYDEN and J. R. KETTLER (Hughes Aircraft Co., Space and Communications Group, Los Angeles, CA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 1170-1173.

The communications satellites considered are spin stabilized and consists of a spinning cylinder and a despun antenna section with its associated RF equipment. A photovoltaic power source is employed to support spacecraft system needs and battery charging during sunlit periods. Aspects of bus arrangement selection are discussed. Both the single bus and the dual bus have been brought to a level of maturity which makes each technically acceptable. The single bus approach results generally in a lower cost system. It has been found that the single bus system is just as reliable as the dual bus approach. The impact of bus arrangement on the electrical power subsystem is considered, taking into account the battery system, the solar array, battery discharge control, battery charge/reconditioning control, telemetry and command, reliability, and load accommodation. G.R.

A84-30140* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PHOTOVOLTAIC CONVERSION OF LASER TO ELECTRICAL POWER
G. H. WALKER (NASA, Langley Research Center, Hampton, VA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 1194-1199. refs

Transmission of power in space using lasers will require devices for converting the laser power to electrical power. One such type of device for accomplishing this is the photovoltaic converter. This paper reviews photovoltaic converters and their application for conversion of monochromatic laser power to electrical power. Laser power densities greater than 1000 W/sq cm are considered. For a converter operated at 300 K a lower bandgap limit of 0.67 eV (1.80 micron) is defined. For ideal conditions, an efficiency of 47.8 percent is calculated for Nd/Liquid laser radiation incident on an Si converter. Several types of photovoltaic converters are discussed. Series resistance is identified as a major problem. Vertical multijunction converters are the most promising photovoltaic devices for use as laser to electric power converters. Author

A84-30146
SOLAR ARRAY POWER TO WEIGHT PERFORMANCE OF 1- TO 10-KILOWATT, FLAT-FOLDED FLEXIBLE WINGS
P. A. DILLARD and M. L. CAMPELL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 3 . New York, American Institute of Chemical Engineers, 1983, p. 1232-1236.

Flexible solar array technology developed for 25-100 kW power levels has been applied to wings with nominal output of 1, 4, and 10 kW, enough to meet the power requirements of most near-term missions. The wing design model is described, and information is presented on blanket size, blanket densities and relative electrical performance, wing weight versus aspect ratio, frequency versus aspect ratio, electrical performance, radiation equivalence, and GEO performance. C.D.

A84-30174
CONCEPTUAL DESIGN OF A LARGE SPACECRAFT POWER SYSTEM UTILIZING A SODIUM-SULFUR BATTERY
L. MARCOUX (Hughes Aircraft Co., El Segundo, CA) and D. M. ALLEN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 4 . New York, American Institute of Chemical Engineers, 1983, p. 1470-1475.
(Contract F33615-79-C-2044)

In order to assess the suitability of high temperature secondary batteries for future spacecraft with large power system requirements, a limited spacecraft design study was performed utilizing an advanced design sodium-sulfur cell as the basic unit of the battery. As well as evaluating the feasibility of the concept of utilizing high temperature batteries in spacecraft power systems, the basic design was also used as a vehicle for the comparison of state-of-the-art and advanced concept nickel-hydrogen batteries with one another and with the high temperature battery system. The design and operation of the conceptual sodium-sulfur battery will be discussed, as will be the comparison with the various nickel-hydrogen battery concepts. Author

A84-30214* TRW, Inc., Redondo Beach, Calif.
AUTOMATED DISTRIBUTION SYSTEM MANAGEMENT FOR MULTICHANNEL SPACE POWER SYSTEMS
G. W. FLECK, D. K. DECKER (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA), and J. GRAVES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 5 . New York, American Institute of Chemical Engineers, 1983, p. 2275-2280.
(Contract NAS8-33198)

A NASA sponsored study of space power distribution system technology is in progress to develop an autonomously managed power system (AMPS) for large space power platforms. The multichannel, multikilowatt, utility-type power subsystem proposed presents new survivability requirements and increased subsystem complexity. The computer controls under development for the power management system must optimize the power subsystem performance and minimize the life cycle cost of the platform. A distribution system management philosophy has been formulated which incorporates these constraints. Its implementation using a TI9900 microprocessor and FORTH as the programming language is presented. The approach offers a novel solution to the perplexing problem of determining the optimal combination of loads which should be connected to each power channel for a versatile electrical distribution concept. Author

A84-30536* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
QUATERNIONS FOR GALILEO SCAN PLATFORM CONTROL
W. G. BRECKENRIDGE and G. K. MAN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 171-184. NASA-supported research.
(AAS PAPER 83-321)

The application of quaternions for the articulation control of the Galileo scan platform is presented in this paper. The purpose of selecting quaternions is to minimize onboard computation time and program size. Attention has been focused on performing inertial pointing while the spacecraft is in a dual spin configuration. Target quaternion and relative target quaternion are introduced and used to specify the target position of the scan platform for point-to-point absolute slews and mosaic relative slews, respectively. The pointing error of the platform is represented by an error quaternion which is converted into gimbal angular errors defining the attitude change. For path control, a moving target quaternion is generated; the corresponding tracking error quaternion and the related spacecraft motion compensation capability are also addressed. A sample slew case is used to demonstrate the implementation of these concepts. Author

A84-34013*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE POWER TECHNOLOGY INTO THE 21ST CENTURY
K. A. FAYMON and J. S. FORDYCE (NASA, Lewis Research Center, Space Power Technology Div., Cleveland, OH) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 80-88. refs
(AIAA PAPER 84-1136)

This paper discusses the space power systems of the early 21st century. The focus is on those capabilities which are anticipated to evolve from today's state-of-the-art and the technology development programs presently in place or planned for the remainder of the century. The power system technologies considered include solar thermal, nuclear, radioisotope, photovoltaic, thermionic, thermoelectric, and dynamic conversion systems such as the Brayton and Stirling cycles. Energy storage technologies considered include nickel hydrogen biopolar batteries, advanced high energy rechargeable batteries, regenerative fuel cells, and advanced primary batteries. The present state-of-the-art of these space power and energy technologies is discussed along with their projections, trends and goals. A speculative future mission model is postulated which includes manned orbiting space stations, manned lunar bases, unmanned earth orbital and interplanetary spacecraft, manned interplanetary missions, military applications, and earth to space and space to space transportation systems. The various space power/energy system technologies anticipated to be operational by the early 21st century are matched to these missions. Author

A84-36799#
HIGH POWER FOR SPACE SYSTEMS
C. C. BADCOCK (Aerospace Corp., El Segundo, CA) Aerospace America (ISSN 0740-722X), vol. 22, June 1984, p. 68-72.

In order to generate 10 to 100 times more electrical power than present systems, novel techniques are being sought in spacecraft solar array design and fabrication. GaAs cells nearing flight readiness have higher efficiencies than Si cells and are more tolerant of heat and radiation. A new generation of such cells having multiple cascaded junctions may achieve 30 percent conversion efficiencies. Flexible substrate arrays, coupled with ultrathin Si cells, may also yield over 100 W/kg, and GaAs or multibandgap cells are expected to raise this value. Attention is also given to the performance improvement prospects of Ni-H2 batteries, regenerative fuel cells, Na-S batteries, and LiAl/Fe batteries, and the findings of the Systems for Nuclear Auxiliary Power program. It is noted that all high power systems considered will require advanced power processing technology. O.C.

A84-38481#
CANADIAN SOLAR ARRAY DEVELOPMENTS FOR SPACE APPLICATIONS
S. AHMED (Department of Communications, Communications Research Centre, Ottawa, Canada), H. BORDUAS, G. MARKS, and E. QUITTNER (Spar Aerospace, Ltd., Toronto, Canada) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 30, March 1984, p. 3-14. refs

Attention is given to Canadian design and development activity concerned with solar arrays for spacecraft. The L-SAT array project will lead to the qualification of solar blanket lengths surfficiently great to provide up to 7.8 kW of power after as much as 10 years' deployment, using two array wings. A partial array deployment capability will be demonstrated by the L-SAT program, and minor design modifications of this array are expected to make feasible the construction of arrays that provide higher power, such as will be required by future space stations. Present development efforts are concerned with on-orbit retraction and restowage. O.C.

A84-42719
OPTIMIZATION OF APERTURE ILLUMINATION FOR RADIO WAVE POWER TRANSMISSION
T. UNO and S. ADACHI (Tohoku University, Sendai, Japan) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. AP-32, June 1984, p. 628-632. refs

Fundamental design indices are presented for a satellite microwave power transmission antenna, with account taken of the electromagnetic environment. The work was performed to quantify the maximum power levels that could be transmitted from a satellite to earth without producing harmful environmental effects. An optimized aperture illumination is calculated to obtain maximized power transmission efficiency with acceptable radiation peaks in the sidelobes. The constrained optimization is determined in terms of sequential unconstrained minimiation techniques. Maximum power transmission and receivable power densities are calculated for various spilled power levels. A small decrease in transmission efficiency is demonstrated to permit maximized received power. M.S.K.

A84-48434#
COMPUTATION OF NEAR AND FAR FIELD RADIATION PATTERNS OF DISTORTED REFLECTOR ANTENNAS
R. POKULS and T. J. F. PAVLASEK (McGill University, Montreal, Canada) IN: Canadian Domestic and International Satellite Communications Conference, 1st, Ottawa, Canada, June 14-17, 1983, Proceedings . Amsterdam and New York, North Holland Publishing Co., 1984, p. 11.6.1-11.6.3.

Two common methods used for calculating far field radiation patterns of reflector antennas are current integration and aperture plane integration. Calculations using these are generally limited to perfect parabolic reflectors with in-focus feeds. This paper describes the extension of an existing aperture plane integration code to allow calculations with out of focus feeds and reflectors of arbitrary shape. The reflector surface may be specified in analytic form or by discrete points using Taylor's series expansions to define the surface. The aperture integration calculates the field for angles close to boresight while the GTD is used for angles further out to take into account the edge diffraction contributions. This technique is particularly useful for studying the behavior of large antennas subject to distortion by thermal and gravitational stress. Author

A84-48461#
COMMUNICATIONS EXPERIMENTS AND DEMONSTRATIONS AT 20/30 GHZ USING L-SAT
S. E. DINWIDDY (ESA, Communications Satellite Dept., Noordwijk, Netherlands) IN: Canadian Domestic and International Satellite Communications Conference, 1st, Ottawa, Canada, June 14-17, 1983, Proceedings . Amsterdam and New York, North Holland Publishing Co., 1984, p. 17.1.1-17.1.4.

The payload contents and potential applications of the ESA's L-SAT communications satellite are described. L-SAT will carry

four communications payloads for experiments, demonstrations of propagation, television broadcasting and fixed satellite services at 12/14 GHz and at 20/30 GHz. The 20/30 GHz payload consists of two repeater chains and two independent fully steerable spot beam antennas, as well as a flexible vehicle for a wide range of experimental investigations. Some of these experiments include: tests of a videoteleconferencing system for business and a tele-education system; and wide and narrow band experiments. A schematic diagram describing the L-SAT satellite and its ground support systems is provided. I.H.

N84-22615*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH VOLTAGE-HIGH POWER COMPONENTS FOR LARGE SPACE POWER DISTRIBUTION SYSTEMS
D. D. RENZ 1984 16 p refs To be presented at the 19th Intersoc. Energy Conversion Eng. Conf., San Francisco, 19-24 Aug. 1984
(NASA-TM-83648; E-2093; NAS 1.15:83648) Avail: NTIS HC A02/MF A01 CSCL 22B

Space power components including a family of bipolar power switching transistors, fast switching power diodes, heat pipe cooled high frequency transformers and inductors, high frequency conduction cooled transformers, high power-high frequency capacitors, remote power controllers and rotary power transfer devices were developed. Many of these components such as the power switching transistors, power diodes and the high frequency capacitor are commercially available. All the other components were developed to the prototype level. The dc/dc series resonant converters were built to the 25 kW level. S.L.

N84-22891*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ADVANCES IN SOLID STATE SWITCHGEAR TECHNOLOGY FOR LARGE SPACE POWER SYSTEMS
G. R. SUNDBERG 1984 20 p refs To be presented at the 19th Intersoc. Energy Conversion Eng. Conf., San Francisco, 19-24 Aug. 1984
(NASA-TM-83652; E-2096; NAS 1.15:83652) Avail: NTIS HC A02/MF A01 CSCL 09C

High voltage solid state remote power controllers (RPC's) and the required semiconductor power switches to provide baseline technology for large, high power distribution systems in the space station, all electric airplane and other advanced aerospace applications were developed. The RPC's were developed for dc voltages from 28 to 1200 V and ac voltages of 115, 230, and 440 V at frequencies of 400 Hz to 20 kHz. The benefits and operation of solid state RPC's and highlights of several developments to bring the RPC to technology readiness for future aerospace needs are examined. The 28 V dc Space Shuttle units, three RPC types at 120 V dc, two at 270/300 V dc, two at 230 V ac and several high power RPC models at voltages up to 1200 V dc with current ratings up to 100 A are reviewed. New technology programs to develop a new family of (DI)2 semiconductor switches and 20 kHz, 440 V ac RPC's are described. E.A.K.

N84-23021*# TRW Space Technology Labs., Redondo Beach, Calif.
STUDY OF SOLAR ARRAY SWITCHING POWER MANAGEMENT TECHNOLOGY FOR SPACE POWER SYSTEM Progress Report, Oct. 1980 - Sep. 1981
J. E. CASSINELLI Sep. 1982 33 p
(Contract NAS3-22656)
(NASA-CR-167890-EXEC-SUM; NAS 1.26:167890-EXEC-SUM; TRW-37243-EXEC-SUM) Avail: NTIS HC A03/MF A01 CSCL 10A

This report documents work performed on the Solar Array Switching Power Management Study. Mission characteristics for three missions were defined to the depth necessary to determine their power management requirements. Solar array switching concepts were identified that could safisfy the mission requirements. These switching concepts were compared with a conventional buck regulator system on the basis of cost, weight and volume, reliability, efficiency and thermal control. For the missions reviewed, solar array switching provided significant advantages in all areas of comparison. Author

N84-23022*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A 37.5-KW POINT DESIGN COMPARISON OF THE NICKEL-CADMIUM BATTERY, BIPOLAR NICKEL-HYDROGEN BATTERY, AND REGENERATIVE HYDROGEN-OXYGEN FUEL CELL ENERGY STORAGE SUBSYSTEMS FOR LOW EARTH ORBIT
M. A. MANZO and M. A. HOBERECHT 1984 11 p Proposed for presentation at the 19th Intersoc. Energy Conversion Eng. Conf., San Francisco, 19-24 Aug. 1984; sponsored by ANS, ASME, SAE, IEEE, AIAA, ACS, and American Inst. for Chemical Engineering
(NASA-TM-83651; E-2016; NAS 1.15:83651) Avail: NTIS HC A02/MF A01 CSCL 10C

Nickel-cadmium batteries, bipolar nickel-hydrogen batteries, and regenerative fuel cell storage subsystems were evaluated for use as the storage subsystem in a 37.5 kW power system for space station. Design requirements were set in order to establish a common baseline for comparison purposes. The storage subsystems were compared on the basis of effective energy density, round trip electrical efficiency, total subsystem weight and volume, and life. Author

N84-24704# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS ELEVEN (ACTIVE CONTROL OF SPACE STRUCTURES), VOLUME 2 Interim Report, Nov. 1982 - Apr. 1983
T. H. BROOKS, V. MAHAJAN, D. R. HEGG, G. J. KISSEL, and H. MCCLAMROCH Griffiss AFB, N.Y. RADC Dec. 1983 110 p
(Contract F30602-81-C-0180; ARPA ORDER 3655; AF PROJ. C655)
(AD-A140026; CSDL-R-1648-VOL-2; RADC-TR-83-261-VOL-2)
Avail: NTIS HC A06/MF A01 CSCL 17E

Volume 2 presents theoretical advances and demonstrations in vibration control against broadband disturbances and in large-angle linear tracking control for flexible optical support structures. Stability results for discrete-time vibration control are also given. The importance of active transducer selection for broadband disturbance accommodation is emphasized. An algorithm for systematically selecting actuators with high influence on the regulated variables is described, together with its theoretical foundation. The algorithm is demonstrated on the ACOSS Model No. 2 structure, obtaining minimal selections with substantially fewer actuators than controlled modes. Disturbance-rejection control designs based on these selections exhibit stability in the presence of residual modes over a frequency range well beyond that of the design model. Sampled-data control for flexible structures is examined using second-order difference equations. A sufficient condition for geometric stability with velocity output feedback requiring non-colocation of actuators and sensors is obtained. Non-colocation reduces to colocation as the sampling period converges to zero. Optimal large-angle slew for linear tracking and terminal convergence is considered. Explicit solutions as a function of matrices satisfying linear algebraic equations are obtained. Demonstrations on a rotating rigid hub with four flexible appendages exhibit the computational efficiency of the solution techniques. Author (GRA)

N84-25089*# Martin Marietta Corp., Denver, Colo.
PASSIVE SUN SEEKER/TRACKER AND A THERMALLY ACTIVATED POWER MODULE
C. J. SIEBERT and F. A. MORRIS *In* NASA. Goddard Space Flight Center The 18th Aerospace Mech. Symp. p 171-185 May 1984
Avail: NTIS HC A14/MF A01 CSCL 20K

Development and testing of two mechanisms using a shape memory alloy metal (NITINOL) as the power source are described. The two mechanisms developed are a passive Sun Seeker/Tracker and a generic type power module. These mechanisms use NITINOL wire initially strained in pure torsion which provides the greatest

mechanical work capacity upon recovery, as compared to other deformation modes (i.e., tension, helical springs, and bending).
Author

N84-25761# JAYCOR, San Diego, Calif.
LITERATURE REVIEW OF SPACECRAFT CHARGING
R. LEADON and M. TREADWAY 20 Oct. 1983 49 p
(Contract F19628-83-C-0147; AF PROJ. 7661)
(AD-A140543; JAYCOR-J200-83-635/2322; AFGL-TR-83-0294)
Avail: NTIS HC A03/MF A01 CSCL 22B

A literature review has been performed on spacecraft electrical anomalies, arc discharges on spacecraft and laboratory simulations of spacecraft materials, and measurements of electrical transients on spacecraft. Analyses in the literature of the probable causes of the observed anomalies are summarized along with the data on measured electrical transients on operating spacecraft. An arc type is tentatively selected for further laboratory investigations of its radiated RF and other characteristics. A brief description of the proposed test plan is given. Author (GRA)

N84-26186# California Univ., San Diego, La Jolla. Center for Astrophysics and Space Science.
AN OVERVIEW OF CHARGING OF LARGE SPACE STRUCTURES IN POLAR ORBIT
E. C. WHIPPLE *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 11-28 25 Jan. 1983 refs
(AD-P002100) Avail: NTIS HC A18/MF A01 CSCL 04A

This paper gives an overview of some of the important questions regarding charging effects on large space structures in the polar ionosphere. The ionosphere as a rule is a rather benign environment as far as charging of spacecraft is concerned. The ionospheric plasma is relatively cool and dense in comparison with other plasmas in space. The plasma density ranges from values on the order of 1000000/cu cm down to values as low as or even below 100/cu cm, with temperatures well below 1 eV (11600 K). However, there can be large fluxes of energetic electrons in the polar ionosphere. This subject is a matter of concern because these auroral fluxes could charge a spacecraft to large potentials. Author

N84-26187# Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div.
IONOSPHERIC CHARACTERISTICS: A REVIEW
F. J. RICH *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 29-56 25 Jan. 1983 refs
(AD-P002101) Avail: NTIS HC A18/MF A01 CSCL 04A

The ionosphere is important to spacecraft charging because the thermal ions and electrons provide a significant current to a spacecraft surface. Low, mid, and high altitude ionospheric characteristics are discussed. B.G.

N84-26188# York Univ., Downsview (Ontario). Dept. of Physics.
IS THERE A GOOD WAY TO MODEL SPACECRAFT CHARGING IN THE PRESENCE OF SPACE-CHARGE COUPLING, FLOW AND MAGNETIC FIELDS?
J. G. LAFRAMBOISE *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 57-78 25 Jan. 1983 refs
(AD-P002102) Avail: NTIS HC A18/MF A01 CSCL 12A

The development of realistic numerical simulations of spacecraft-environment interactions in low-orbit conditions appears likely to be a more difficult task than it has been in high-orbit conditions. At the same time, carefully chosen combinations of existing simulation methods show some promise of being able to cope with this situation, at least in two dimensions and possibly in three dimensions. Simple large-voltage symmetric-sheath probe theories, which have been used to provide preliminary estimates of spacecraft voltages, contain serious limitations for use in making more precise calculations. Author

N84-26189*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHARGED PARTICLE EFFECTS ON SPACE SYSTEMS
W. N. HALL and N. J. STEVENS *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 79-106 25 Jan. 1983 refs Prepared in cooperation with AFGL, Hanscom AFB, Mass.
(AD-P002103) Avail: NTIS HC A18/MF A01 CSCL 20H

There is a growing tendency to plan space missions that will incorporate very large space power systems. These space power systems must function in a space plasma environment that can impose operational limitations. As the power output increases, the operating voltage must also increase and this voltage, exposed at solar array interconnects, interacts with the local plasma. The implications of such interactions are considered here. The available laboratory data for biased array segment tests are reviewed to demonstrate the basic interactions considered. A data set for a test of a floating high voltage array illuminated in a solar simulator test is used to generate approximate relationships for positive and negative current collection from plasma. These relationships are applied to a hypothetical 100 kW power system operating in a 400 lm, near-equatorial, orbit. It is found that discharges from the negative regions of the array are the most probable limiting factor for array operation. Author

N84-26190*# Utah State Univ., Logan.
SPACE SHUTTLE CHARGING RESULTS
W. J. RAITT *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 107-118 25 Jan. 1983
(Contract NAS5-24455)
(AD-P002104) Avail: NTIS HC A18/MF A01 CSCL 20C

The vehicle charging and potential experiment (V CAP) was accepted by NASA as part of the OSS-1 payload to be flown on a test flight of the space shuttle. The V CAP eventually flew on the third shuttle flight at the end of March, 1982. This shuttle flight, designated STS-3, flew a circular orbit with an inclination of 37 deg, an altitude of 250 km, and an orbital plane approximately dawn/dusk. The V CAP experiment consisted of four plasma diagnostic instruments, two of which were duplicated, a fast pulse electron generator (FPEG) and a digital control and interface unit. The prime objective of the V CAP experiment was to study the electrical charging of the orbiter under conditions of passive orbiting, and under conditions of active charge emission by an electron generator. These measurements were to be made under a variety of conditions, such as orientation of the B vector, ram vector, solar direction, varying ambient plasma density, and sunlit/darkness conditions. In order to better understand the mechanisms of vehicle charging, experiments were also made on the interaction of the beam with its environment. Author

N84-26192*# Stanford Univ., Calif. Space, Telecommunications, and Radioscience Lab.
ELECTRON BEAM EXPERIMENTS AND OTHER OBSERVATIONS FROM STS-3
P. M. BANKS *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 125-131 25 Jan. 1983 refs
(Contract NAS5-24455)
(AD-P002106) Avail: NTIS HC A18/MF A01 CSCL 20H

The Vehicle Charging and Potential Experiment (V CAP) experiment was one of six major experiments flown on the OSS-1 pallet aboard STS-3 in March, 1982. The V CAP flight objectives were both scientific and technological and included studies of natural electrical charging of the Orbiter, the effects of artificial electron beam emissions on the Orbiter electrical characteristics, and measurements of plasma phenomena. To determine plasma conditions, wave phenomena associated with pulsed and dc electron beam operations, the nature of the plasma environment within the payload bay, the feasibility of making ionospheric measurements from the Orbiter, and the characteristics of vehicle return currents to different parts of the Orbiter were measured.
Author

N84-26194# Air Force Geophysics Lab., Hanscom AFB, Mass.
THE WORST CASE CHARGING ENVIRONMENT
D. A. HARDY *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 141-155 25 Jan. 1983
(AD-P002108) Avail: NTIS HC A18/MF A01 CSCL 20C

Whether a spacecraft will charge in the auroral zone is crucially dependent on the magnitude of the current to the spacecraft from the precipitating and backscattered electrons and on how that current is distributed over the electron spectrum. To provide theorists and modelers with some initial input on these aspects of the spacecraft charging problem a survey was conducted to find examples of electron precipitation where the total integral number flux over the electron spectrum exceeded 10 to the 10th power electrons/sq cm. sec sr and the average energy of the electrons was approximately equal to or exceeded 1 keV. Author

N84-26195# Boston Coll., Chestnut Hill, Mass. Dept. of Physics.
ESTIMATES OF PRECIPITATING ELECTRON POWER FLUX FROM SIMULTANEOUS DMSP AURORAL IMAGE AND ISEE-1 AKR OBSERVATIONS
N. A. SAFLEKOS and R. E. SHEEHAN *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 157-162 25 Jan. 1983 refs
(AD-P002109) Avail: NTIS HC A18/MF A01 CSCL 20H

This report describes the first attempt to associate the area of discrete aurora observed in a DMSP image with simultaneous measurements of auroral kilometric radiation (AKR) power flux at 178 and 311 kHz. Author

N84-26196# Air Force Geophysics Lab., Hanscom AFB, Mass.
ENVIRONMENTAL INTERACTIONS OF POLAR ORBITING SATELLITES
W. J. BURKE *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 163-173 25 Jan. 1983 refs
(AD-P002110) Avail: NTIS HC A18/MF A01 CSCL 22B

Addressed are questions concerning how large, and/or high-power, polar-orbiting spacecraft will interact with auroral environments. This paper discusses some experiences of spacecraft charging, vehicle shadowing, and current leakage encountered by AFGL measuring systems on small, polar-orbiting satellites. Because spacecraft charging at ionospheric altitudes does not seriously threaten the operation of present systems this subject has not received the widespread attention given to it at geostationary altitudes. As a matter of economics it is desirable to transfer as much as possible of what we have learned about spacecraft interactions at geostationary orbit to the auroral oval. Economics must not however blind us to the real differences between the two problems. Author

N84-26198# University Coll., London (England). Dept. of Physics and Astronomy.
OBSERVATIONS OF DIFFERENTIAL CHARGING WITH METEOSAT
A. D. JOHNSTONE and G. L. WRENN *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 185-195 25 Jan. 1983 refs
(AD-P002112) Avail: NTIS HC A18/MF A01 CSCL 20C

The behavior of the geosynchronous METEOSAT spacecraft in the Earth's shadow throws new light on the topic of the influence of secondary electron emission on differential charging, which could assist understanding of these processes in more general situations. METEOSAT F1, a geosynchronous meteorological satellite operated by the European Space Agency, suffered from a number of non-damaging operational anomalies that were attributed to electrostatic discharges caused by differential charging. The second flight model F2 was modified in several ways to reduce its susceptibility to arcing. In addition, two new sensors were included in the payload to monitor the plasma environment and to detect the electrical effects of discharges. Since launch in June 1981 the spacecraft has experienced only a few anomalies attributable to arcing and no electrostatic discharges have been detected by the monitor although that could be a matter of sensitivity. So far the only evidence for the spacecraft charging to significant potentials occurs during eclipse and comes from the plasma environment monitor. Author

N84-26200# IRT Corp., San Diego, Calif.
SPACE ELECTRON-INDUCED DISCHARGE COUPLING INTO SATELLITE ELECTRONICS
J. WILKENFELD *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 215-234 25 Jan. 1983 refs
(AD-P002114) Avail: NTIS HC A18/MF A01 CSCL 20C

The USAF and NASA began the Spacecraft Charging at High Altitude (SCATHA) program because indirect evidence indicated that discharges induced by space electrons in spacecraft dielectrics could generate sufficient electromagnetic energy to cause spacecraft malfunction or failure. The ultimate cause must be related to the coupling of energy from the discharge into circuits that then malfunction: either an upset (uncommanded change of state of electrical burnout of components) occurs. The draft of this document contains information that designers need to develop spacecraft that are resistant to electron-induced discharges. Author

N84-26202# Air Force Geophysics Lab., Hanscom AFB, Mass.
SHUTTLE ORBITER CHARGING IN POLAR EARTH ORBIT
A. G. RUBIN and A. L. BESSE *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 253-263 25 Jan. 1983 refs
(AD-P002116) Avail: NTIS HC A18/MF A01 CSCL 20C

Spacecraft in polar orbit are subject to charging by the intense electron stream that comprises the aurora. Charging is computed according to the Laframboise theory of plasma probes in which the variation of sheath thickness with potential is taken into account. In this environment spacecraft charge to potentials that depend on their size. It is shown that large spacecraft charge to higher potentials than small spacecraft. The shuttle orbiter being a large spacecraft, may charge to more than 6 kV passing through an intense beam of auroral electrons. Because of the deficiency of ambient ions in the near wake region, the rear of the vehicle will have the lowest threshold auroral current for charging and will charge to the highest potential. GRA

N84-26203# Air Force Geophysics Lab., Hanscom AFB, Mass.
POTENTIAL BARRIERS AND MULTIPLE ROOTS IN SPACECRAFT CHARGING
A. L. BESSE *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 267-276 25 Jan. 1983 refs
(AD-P002117) Avail: NTIS HC A18/MF A01 CSCL 20C

This paper considers two phenomena that may be demonstrated with considerable rigor by computer modeling using a code such as NASCAP. The computer modeling, however, fails to give insight into the physics involved. This paper attempts to furnish such insight by use of simple barrier models and by sketching the history of multiple roots with emphasis on the necessary conditions. GRA

N84-26204# Systems Science and Software, La Jolla, Calif.
MECHANISMS THAT LIMIT POTENTIALS ON IONOSPHERIC SATELLITES
D. E. PARKS and I. KATZ *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 277-281 25 Jan. 1983 Previously announced in IAA as A84-12899
(Contract F19628-82-C-0081)
(AD-P002118) Avail: NTIS HC A18/MF A01 CSCL 12A

For spinning satellites with dielectric coatings it is shown that the currents of rotating charge embedded in the dielectric surface can play a role in limiting the spacecraft ground potential of an ionospheric satellite relative to the surrounding plasma. Such currents, as well as small concentrations of H(+), can account

for previous discrepancies of more than a factor of 2 between measured and calculated potentials of satellites in the region of the ionosphere where O(+) is dominant. More generally, dielectric conduction can also limit the satellite potential. The importance of such small currents as result from spin and conduction stems from the extremely small ion currents impinging on the wakeside of the satellite. Finally, theoretical estimates based on a newly described constant of the motion of a particle indicate that accounting for small concentrations of H(+) remove the major discrepancy between calculated and measured currents on the wakeside of the AE-C satellite. D.E.P. (IAA)

N84-26205# Science Applications, Inc., La Jolla, Calif.
THE IMPORTANCE OF NEUTRALS, TRANSIENT EFFECTS, AND THE EARTH'S MAGNETIC FIELD ON SHEATH STRUCTURE
L. M. LINSON *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 283-292 25 Jan. 1983 refs
(AD-P002119) Avail: NTIS HC A18/MF A01 CSCL 20I

Several aspects of theoretical treatments of the thickness of the sheath surrounding a large structure in low Earth orbit are examined. It is suggested that the ionization of neutrals should be considered for potentials much greater than 15 V even though the mean free path for ionization in the ambient atmosphere is much greater than the structure size. The effects of an enhanced local neutral density, the trapping of electrons in the magnetic field, and modification of the sheath space charge density due to ionization are estimated to support this suggestion. The importance of time scales associated with fluctuations in auroral fluxes, motion through inhomogeneous regions at orbital velocity, the motion of ions, ionization rates, and the response of the ionosphere is emphasized in terms of demonstrating understanding of fundamental physical processes. Criteria for determining when magnetic fields cannot be neglected when estimating the sheath thickness are derived and discussed. GRA

N84-26206# York Univ., Downsview (Ontario). Center for Research in Experimental Space Sciences.
THE THRESHOLD TEMPERATURE EFFECT IN HIGH-VOLTAGE SPACECRAFT CHARGING
J. G. LAFRAMBOISE and M. KAMITSUMA *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 293-308 25 Jan. 1983 refs
(AD-P002120) Avail: NTIS HC A18/MF A01 CSCL 20C

A property of spacecraft surface materials, the threshold temperature for high-voltage charging, is defined. A table of threshold temperatures, calculated for various spacecraft surface materials, is presented. This property explains and unifies several recently identified phenomena affecting spacecraft charging, including: the existence of multiple floating potentials for certain spacecraft surfaces in certain external environments; sensitivity effects in the numerical prediction of spacecraft potentials; sudden jumps in both observed and simulated spacecraft potentials in slowly varying environments; and observed threshold effects in high voltage charging. In addition, knowledge of the threshold temperature for proposed or existing surface materials provides a simple, effective way to evaluate their charging behavior when exposed to various space environments. GRA

N84-26208# Systems Science and Software, La Jolla, Calif.
POLAR CODE DEVELOPMENT
I. KATZ, D. L. COOKE, M. J. MANDELL, D. E. PARKS, J. R. LILLEY, J. H. ALEXANDER, and A. G. RUBIN *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 321-332 25 Jan. 1983
(Contract F19628-82-C-0081)
(AD-P002122) Avail: NTIS HC A18/MF A01 CSCL 09B

Possible charging of large space structures in polar orbit is examined analytically for simple spherical objects. The major questions of the probability of such events and the magnitude of charging given a particular vehicle in a specified auroral flux remain unanswered. The POLAR code is being developed to address the latter question. This paper outlines the physical models being incorporated in the program and the status of the code development. The phenomena of charging may be divided into three processes: (1) the accumulation of charge on the object resulting from collection of charged particles from the space environment; (2) the resultant change in overall and differential potentials on the vehicle; and (3) the formation of a sheath and wake due to the presence of charged objects. GRA

N84-26209*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HIGH VOLTAGE SOLAR ARRAY MODELS AND SHUTTLE TILE CHARGING
A. G. RUBIN and N. J. STEVENS *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 333-336 25 Jan. 1983 Prepared in cooperation with AFGL, Hanscom AFB, Mass.
(AD-P002123) Avail: NTIS HC A18/MF A01 CSCL 09B

This paper described NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) a 3-D computer code that simulates the interaction of space plasma with high-voltage solar arrays in the thin plasma sheath regime. The code requires information about the object and the ambient plasma. The geometric description, the material composition and the voltage distribution versus time of a solar array are the data required about the object. The plasma properties needed are the composition, density, and temperature. NASCAP/LEO will then provide the time-dependent current to each element of area of the array from the external plasma. The NASCAP/LEO output is provided in both three dimensional computer graphics and in numerical form. NASCAP/LEO is user oriented and will provide potential distributions around the object, the currents to each of the conductors, and graphical details of the sheaths and particle trajectories. GRA

N84-26210*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SHEATH SHAPES: A 3-D GENERALIZATION OF THE CHILD-LANGMUIR SHEATH MODEL FOR LARGE HIGH-VOLTAGE SPACE STRUCTURES IN DENSE PLASMAS
L. W. PARKER, E. G. HOLEMAN, and J. E. MCCOY *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 337-389 25 Jan. 1983 refs Prepared in cooperation with Parker (Lee W.), Inc., Concord, Mass.
(AD-P002124) Avail: NTIS HC A18/MF A01 CSCL 12A

A new approach to computing sheaths of large high voltage space structures in dense Low Earth Orbit/Polar Earth Orbit plasmas is described. The method solves the Poisson equation numerically, using a flexible finite element mesh that allows sheath shapes to be described through an extension of the Child Langmuir Blodgett 1D sheath model to three dimensions. Space charge is computed by following trajectories. This approach is potentially more efficient for 3D sheath and wake problems than other approaches presently available. GRA

N84-26211# Air Force Geophysics Lab., Hanscom AFB, Mass.
SPACE SYSTEMS ENVIRONMENTAL INTERACTIONS TECHNOLOGY PROGRAM
C. P. PIKE, D. A. GUIDICE, R. A. DAVIS, A. L. CHESLEY, W. N. HALL, and B. M. SHUMAN *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 391-398 25 Jan. 1983
(AD-P002125) Avail: NTIS HC A18/MF A01 CSCL 22A

The technology program described here addresses space environmental interactions on large dimension high power satellites to provide technology solutions that will insure against potential system failure. Topics under investigation include auroral plasma interaction with high voltage solar arrays, effects of polar magnetic fields on large space structures, electromagnetic interference with space communications and surveillance, and systems failures during extravehicular activity that threaten the astronaut. GRA

N84-26212# Aerospace Corp., Los Angeles, Calif. Space Sciences Lab.
SUMMARY OF EXPERIMENTAL RESULTS
J. F. FENNELL *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 399-405 25 Jan. 1983
(Contract F04701-82-C-0083)
(AD-P002126) Avail: NTIS HC A18/MF A01 CSCL 20C

This session on experimental results provided both a review of satellite charging and laboratory results plus a discussion of new data with emphasis on the recent shuttle test flights. This panel provided, in essence, the type of basic input data required for modeling efforts. Most of the results were new to the modeling community and some of them are not understood even at a rudimentary level at this point. Some results require only changes in data bases of existing models. Discussions covered materials charging, vehicle charging effects, optical observation of electron beams from the space shuttle bay, beam/plasma interactions, electronic circuit damage, and differential charging and noise generation. GRA

N84-26213# Air Force Geophysics Lab., Hanscom AFB, Mass.
QUESTIONS THAT NEED TO BE ANSWERED
H. A. COHAN *In its* Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 403-405 25 Jan. 1983
(AD-P002127) Avail: NTIS HC A18/MF A01 CSCL 20C

By using the space charge limited flow theory large vehicles in a low polar orbit can charge to high potentials due to auroral energetic electrons. The implications of high potentials on spacecraft are serious. A series of questions are presented about large potentials on spacecraft in low polar orbit. Topics include large space vehicle charging, plasma/surface interactions, time scales for large differential charging, arcing from large dielectric surfaces, and resource allocation for continued research. GRA

N84-28903# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systemes Balistiques et Spatiaux.
STUDY OF CONCENTRATION FOR SPACE PHOTOVOLTAIC GENERATOR: EXECUTIVE SUMMARY
Paris ESA 13 Dec. 1983 24 p
(SNIAS-2726-CA/EM/G; ESA-CR(P)-1872) Avail: NTIS HC A02/MF A01

Space photovoltaic generator concentration solutions which meet the requirements of low Earth orbit, and deep space applications, and the possibility of using concentration on geosynchronous orbit missions were studied. For distributed concentration, metallization of composite reflector materials; SSM bonding; reflective coatings; procurement of cold mirror; and design and sizing of heat dissipating devices were investigated. For global concentration, reflector deployment mechanism and tensioning system; optical quality; and electrical discharge were studied. An electro-thermal study and study of protection system of the electrical network were performed. Use of concentration is always foreseeable, and at times necessary to improve the general performances of the solar array subsystems. This change does not put excessive demands on other subsystems such as attitude control and power conditioning. Author (ESA)

N84-29307*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE PHOTOVOLTAIC RESEARCH AND TECHNOLOGY 1983. HIGH EFFICIENCY, RADIATION DAMAGE, AND BLANKET TECHNOLOGY
Washington, D.C. 1984 266 p refs Conf. held in Cleveland, 18-20 Oct. 1983
(NASA-CP-2314; E-2005; NAS 1.55:2314) Avail: NTIS HC A12/MF A01 CSCL 10A

This three day conference, sixth in a series that began in 1974, was held at the NASA Lewis Research Center on October 18-20, 1983. The conference provided a forum for the discussion of space photovoltaic systems, their research status, and program goals. Papers were presented and workshops were held in a variety of technology areas, including basic cell research, advanced blanket technology, and radiation damage.

N84-29336*# Astro Research Corp., Santa Barbara, Calif.
DEVELOPMENT AND SUPPORT STRUCTURES FOR HIGH-POWER SOLAR ARRAYS
K. KNAPP *In* NASA. Lewis Research Center Space Photovoltaic Res. and Technol. 1983 p 193-204 1984
Avail: NTIS HC A12/MF A01 CSCL 10A

A number of structurally efficient configurations for wing-type solar arrays are developed by a combination of deepening the planform of the blanket and structure and by partitioning the blanket with battens and frequent attachments to the support structure. This technique reduces the tension required to avoid a low natural frequency for the blanket, and the load reduction results in a lighter structure. The use of three different structures are investigated: the Astromast, the Extendible Support Structure (ESS), and a new beam called the STACBEAM (Stacking Triangular Articulated Compact Beam) and their relative performances are compared. The investigation of the STACBEAM is emphasized because its sequential deployment is more reliable for very long systems, and its linear deployment facilitates local attachments to the blanket and the development of a low mass deployer. M.A.C.

N84-29343*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SOLAR ARRAY: PLASMA INTERACTIONS Abstract Only
C. K. PURVIS *In its* Space Photovoltaic Res. and Technol. 1983 p 236 1984
Avail: NTIS HC A12/MF A01 CSCL 10A

Interactions between space systems and their orbital particle and field environments have significant impact on the system's operation and life. Interactions such as radiation damage and aerodynamic drag are considered in designing space systems. There are, however, a number of orbital environmental interactions which become important design considerations only for large or high power systems. Their impact is assessed to ensure successful design. Interactions between higher voltage solar arrays and the space plasma which are of critical concern in designing large orbital photovoltaic power systems are outlined. E.A.K.

N84-30529*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
MULTI-100KW: PLANAR LOW COST SOLAR ARRAY DEVELOPMENT Final Report
Jul. 1984 62 p
(Contract NAS8-32981)
(NASA-CR-171119; NAS 1.26:171119; LMSC-D973431) Avail: NTIS HC A04/MF A01 CSCL 10A

Seven low cost multi-100 kW planar solar array modules were fabricated and tested. Two different designs were used, demonstrating advanced solar array construction practices. Both module types utilized second generation gridded back cells featuring high efficiency and IR transparency. A silicon dioxide AR coating optimized for transmission at gamma = 1.7 microns was applied to the back surface. Two interconnect types, a single sheet printed circuit and a roll type, with alternate approaches to increasing transparency and reducing cost were designed and fabricated. Hinge stress and electrical power optimization were also examined. Two point designs were studied. The first design used a coilage longeron mast and is autonomously deployable. The second design used a Stac Beam for high natural frequency response and required astronaut assistance and assembly on orbit. It was conclusively demonstrated that planar arrays are the most cost effective design for use on the space station or other high power applications. E.R.

N84-31272*# 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 1984 12 p refs Presented at the 14th Intern. Symp. on Space Technol. and Sci., Tokyo, 28 May - 1 Jun. 1984; sponsored by Inst. of Space and Astronautical Science
(NASA-TM-83770; E-2261; NAS 1.15:83770) Avail: NTIS HC A02/MF A01 CSCL 21H

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 is 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

N84-31462*# Harris Corp., Melbourne, Fla. Government Electronic Systems Div.
HOOP/COLUMN ANTENNA RF VERIFICATION MODEL. VOLUME 2: ANALYSIS AND CORRELATION Final Report
W. F. CROSWELL, ed., M. D. VANSTRUM, R. J. SCHRIMPF, R. C. TAYLOR, and R. L. MOYE Aug. 1984 78 p refs
(Contract NAS1-15763)
(NASA-CR-172413; NAS 1.26:172413) Avail: NTIS HC A05/MF A01 CSCL 20N

As part of the Large Space System Technology Program, the theoretical and experimental results of the RF characteristic of a hoop/column, quad aperture antenna using an RF verification model are presented. To satisfy the primary purposes of the model, experimental pattern data is provided for the quad aperture configuration at different reflector edge illumination levels, from which the geometry and edge effects can be assessed, and experimental data which can be compared with calculations using various theoretical reflector scattering formulae are provided. It also experimentally determines the effects upon secondary patterns of scale model quartz cables, as used in the hoop/column design, upon secondary patterns in order to assess the importance of developing a scattering theory to predict such effects. In addition, a comprehensive theoretical study and the experimental pattern results of quad aperture antenna feeds, a discussion of the fundamental affect of parasitic side lobes, their amplitude, and location in space. Author

N84-31463*# Harris Corp., Melbourne, Fla. Government Electronic Systems Div.
HOOP/COLUMN ANTENNA: RF VERIFICATION MODEL. VOLUME 1: TEST RESULTS Final Report
W. F. CROSWELL, ed., M. D. VANSTRUM, R. J. SCHRIMPF, R. G. TAYLOR, and R. L. MOYE Hampton, Va. NASA. Langley Research Center Aug. 1984 324 p 2 Vol.
(Contract NAS1-15763)
(NASA-CR-172412; NAS 1.26:172412) Avail: NTIS HC A14/MF A01 CSCL 17B

As part of the Large Space System Technology Program, this report, in two volumes, presents the theoretical and experimental results of the RF characteristic of a hoop/column, quad aperture antenna using an RF verification model. To satisfy the primary purposes of the model it provides experimental pattern data for the quad aperture configuration at different reflector edge illumination levels, from which the geometry and edge effects can be assessed, and provides experimental data which can be compared with calculations using various theoretical reflector scattering formulae. It also experimentally determines the effects upon secondary patterns of scale model quartz cables, as used in the hoop/column design, upon secondary patterns in order to assess the importance of developing a scattering theory to predict such effects. In addition, this report contains a comprehensive theoretical study and the experimental pattern results of quad aperture antenna feeds, a discussion of the fundamental affect of parasitic side lobes, their amplitude, and location in space. Author

N84-32783*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTURAL DESIGN OF A VERTICAL ANTENNA BORESIGHT 18.3 BY 18.3-M PLANAR NEAR-FIELD ANTENNA MEASUREMENT SYSTEM
G. R. SHARP, P. A. TRIMARCHI, and J. S. WANHAINEN 1984 26 p refs Proposed for presentation at the Meeting of the Antenna Measurement Techniques Association, San Diego, Calif., 2-4 Oct. 1984
(NASA-TM-83781; E-2274; NAS 1.15:83781) Avail: NTIS HC A03/MF A01 CSCL 14B

A large very precise near-field planar scanner was proposed for NASA Lewis Research Center. This scanner would permit near-field measurements over a horizontal scan plane measuring 18.3 m by 18.3 m. Large aperture antennas mounted with antenna boresight vertical could be tested up to 60 GHz. When such a large near field scanner is used for pattern testing, the antenna or antenna system under test does not have to be moved. Hence, such antennas and antenna systems can be positioned and supported to simulate configuration in zero g. Thus, very large and heavy machinery that would be needed to accurately move the antennas are avoided. A preliminary investigation was undertaken to address the mechanical design of such a challenging near-field antenna scanner. The configuration, structural design and results of a parametric NASTRAN structural optimization analysis are contained. Further, the resulting design was dynamically analyzed in order to provide resonant frequency information to the scanner mechanical drive system designers. If other large near field scanners of comparable dimensions are to be constructed, the information can be used for design optimization of these also. Author

N84-33169# Florida Inst. of Tech., Melbourne.
SPACE REACTORS: WHAT IS A KILOGRAM?
D. BUDEN, J. ANGELO, JR., D. EK (AFWL), and S. VOSS (AFWL) 1984 13 p refs Presented at the 19th Ann. IECEC Meeting, San Francisco, 19-24 Aug. 1984 Submitted for publication
(Contract W-7405-ENG-36)
(DE84-012656; LA-UR-84-1378; CONF-840804-20) Avail: NTIS HC A02/MF A01

The use of nuclear electric propulsion can triple payloads to GEO for a single Shuttle launch. Life orbits of 300 years can be used to allow most of the fission and activation products to decay before a reactor reenters the biosphere. Enough radioactive materials remain with very long lifetimes to make it desirable to design the reactor to disperse upon reentry and little additional risk to the biosphere is introduced by initiating NEP operations from 300 km. DOE

N84-33452*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN GUIDELINES FOR ASSESSING AND CONTROLLING SPACECRAFT CHARGING EFFECTS
C. K. PURVIS, H. B. GARRETT (JPL), A. C. WHITTLESEY (JPL), and N. J. STEVENS (Hughes Aircraft Co., El Segundo, Calif.) Sep. 1984 48 p refs
(NASA-TP-2361; E-2073; NAS 1.60:2361) Avail: NTIS HC A03/MF A01 CSCL 22B

The need for uniform criteria, or guidelines, to be used in all phases of spacecraft design is discussed. Guidelines were developed for the control of absolute and differential charging of spacecraft surfaces by the lower energy space charged particle environment. Interior charging due to higher energy particles is not considered. A guide to good design practices for assessing and controlling charging effects is presented. Uniform design practices for all space vehicles are outlined. E.A.K.

N84-33722# Department of the Air Force, Washington, D.C.
FEED DISPLACEMENT CORRECTION IN A SPACE FED LENS ANTENNA Patent Application
R. L. HAUPT, inventor (to Air Force) 2 May 1984 24 p
(AD-D011155; US-PATENT-APPL-SN-616325) Avail: NTIS HC A02/MF A01 CSCL 09E

A space fed microwave lens antenna for deployment in outer space or other remote, hazardous or unattended location is described. Electronic means are provided for compensating for errors in the mechanical displacement of the phased array feed elements from the phased array lens elements. Author (GRA)

N84-34708*# Aerojet Electrosystems Co., Azusa, Calif.
CONCEPTUAL DESIGN OF A HYBRID GE:GA DETECTOR ARRAY
C. M. PARRY Jul. 1984 136 p refs
(Contract NAS2-10740)
(NASA-CR-166605; NAS 1.26:166605; REPT-6907) Avail: NTIS HC A07/MF A01 CSCL 14B

For potential applications in space infrared astronomy missions such as the Space Infrared Telescope Facility and the Large Deployable Reflector, integrated arrays of long-wavelength detectors are desired. The results of a feasibility study which developed a design for applying integrated array techniques to a long-wavelength (gallium-doped germanium) material to achieve spectral coverage between 30 and 200 microns are presented. An approach which builds up a two-dimensional array by stacking linear detector modules is presented. The spectral response of the Ge:Ga detectors is extended to 200 microns by application of uniaxial stress to the stack of modules. The detectors are assembled with 1 mm spacing between the elements. Multiplexed readout of each module is accomplished with integration sampling of a metal-oxide-semiconductor (MOS) switch chip. Aspects of the overall design, including the anticipated level of particle effects on the array in the space environment, a transparent electrode design for 200 microns response, estimates of optical crosstalk, and mechanical stress design calculations are included. Author

07

ADVANCED MATERIALS

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

A84-31699#
IDENTIFICATION OF STRUCTURAL PROPERTIES OF A CONTINUOUS LONGERON SPACE MAST
Y. SOUCY and F. R. VIGNERON (Department of Communications, Communications Research Centre, Ottawa, Canada) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 130-139. refs
(AIAA PAPER 84-0930)

This paper describes test and modal parameter identification results for a deployable coilable continuous longeron space mast of a type planned for several space missions. Four different types of tests were needed to obtain good results over the range of natural frequencies 0-60 Hz. Modal damping factors were in the range 0.02-0.09 and were essentially the same in air and vacuum. Experimental frequencies are compared to results generated by an equivalent continuum beam model and a finite element model. The models correlate with test data for lower frequency modes, but fall short for higher modes. Author

A84-32475#
FIBRE COMPOSITES FOR AEROSPACE STRUCTURES SUBJECT TO LOW TEMPERATURES
H. BANSEMIR and W. WEISS (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Cryogenic Engineering Conference, Colorado Springs, CO, Aug. 15-19, 1983, Paper. 17 p.
(MBB-UD-406-83-OE)

The application of carbon, glass, and aramid fiber epoxy composites in aerospace structures which sustain loads due to both external forces and high temperature differences is reviewed. Attention is given to carbon fiber composite solar arrays as used on Intelsat V and EXOSAT, an antenna truss structure, and a suspension chain with carbon and glass epoxy lugs for a liquid helium tank. Load introduction elements, such as bonded joints and lugs, and stresses in carbon fiber composites are discussed. Results of low-temperature testing of lugs are in accordance with composite material tests which usually show better properties at low temperatures. J.N.

A84-35547#
SELECTION AND CONTROL OF MATERIALS FOR SPACE APPLICATIONS
J. DAUPHIN (ESA, Product Assurance Div., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 8, no. 1, 1984, p. 53-59. refs

Materials used in spacecraft applications are subjected to a high vacuum environment pervaded by high UV and particle radiation fluxes, as well as wide temperature variations. Because on-orbit maintenance is still in its infancy, this environment's effects on materials must be carefully assessed. Addtional considerations are the effects of erosion and surface reactions with hot residual atoms in low orbits, abrasion and sputtering of optical surfaces by micrometeorites, and the severity in the case of planetary probes, of such environments as that of the Venus atmosphere. O.C.

A84-35920#
SURVEY LECTURE AND SPECIAL EXPERIENCES IN FRG
K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) International Conference on Carbon Fibre Application, Brazil, Dec. 5-9, 1983, Paper. 40 p.
(MBB-UD-410-83-OE)

An overview of experience gained in the development of carbon fiber composite (CFC) structures for aerospace application is presented. Consideration is given to materials, the use of CFC structures in the solar arrays of Intelsat V, thermal expansion molding for transportation aircraft components, military aircraft, and the use of CFC to regulate torsional stiffness in helicopter rotor blades. For cost-effectiveness, small volume production of aerospace CFC structures indicates a well balanced mix of automated and manual processing. Various testing techniques for quality control of composite components are briefly reviewed. J.N.

A84-36812
EFFECT OF GEOSYNCHRONOUS ALTITUDE RADIATION ON PERFORMANCE OF NI/H2 CELLS
C. K. DYER (Bell Telephone Laboratories, Inc., Murray Hill, NJ) Journal of Power Sources (ISSN 0378-7753), vol. 12, July-Aug. 1984, p. 323-334. refs

Nickel/hydrogen cells are under consideration as eclipse season power sources for long-life communications satellites in geosynchronous orbit (GEO). There is concern that damage to polymers in key components of these cells may arise from irradiation with high energy protons and electrons at the fluxes present at GEO altitudes. Nickel/hydrogen cells have been subjected to fluences of electrons and protons which simulate exposure to the GEO environment for more than 10 years. The cells show promise for considerable radiation tolerance in this new application. Author

A84-37499#
REQUALIFICATION OF S13G/LO
R. A. CULL, G. STEVENSON (USAF, Materials Laboratory, Wright-Patterson AFB, OH), Y. HARADA, and R. MELL (IIT Research Institute, Chicago, IL) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 19th, Snowmass, CO, June 25-28, 1984. 9 p. USAF-supported research. refs
(AIAA PAPER 84-1775)

The results of a program to develop a new binder for the thermal control coating S-13G/LO are reported. The new binder is needed because production of the old binder, RTV 602, was discontinued by the manufacturer. The ZnO pigment in S-13G/LO has exhibited low solar absorptance and high emissivity as the standard coating for unmanned and manned spacecraft for a decade and a half. A high resistance to oxidation commends its use as a coating for a LEO-situated space station. Test procedures for qualification of a new binder resin are outlined, noting that dimethylsiloxanes have yielded the best results to date, and are composed similar to RTV 602. Immediate transition to operational use without extensive on-orbit experience will be necessitated due to the shortage of the remaining supply of RTV 602. M.S.K.

A84-42726
NATIONAL TECHNICAL CONFERENCE, 15TH, CINCINNATI, OH, OCTOBER 4-6, 1983, PROCEEDINGS
Conference sponsored by the Society for the Advancement of Material and Process Engineering. Azusa, CA, Society for the Advancement of Material and Process Engineering (National SAMPE Technical Conference Series. Volume 15), 1983, 794 p. For individual items see A84-42727 to A84-42783.

The present conference discusses Space Shuttle Orbiter beryllium applications, lubrication, and unique Main Engine materials requirements, novel pultrusion processing developments, high performance composites, linear composite materials for guyless tower structures, the containerless melting of glass in low gravity, the interfacial behavior of aramid and graphite fibers in an epoxy matrix, the viscoelastic fracture behavior of polymers in a composite system, temperature, moisture, and radiation effects on composite mechanical properties, composite aircraft applications, and strength and thermal stability improvements of fibrous ceramic composites. Also considered are filamentary composite structure manufacturing advancements, vapor phase heating systems and their applications, solid state humidity sensors, the use of shape memory alloys as engineering materials, planning for the use of robots, cure monitoring for adhesives and prepregs, conductive composite materials for electronics packages, dynamic radiography for fiber-reinforced composites, automated measurement in robotic grinding operations, metal shell technology, and Kevlar ropes and cables. O.C.

A84-42731* Rockwell International Corp., Canoga Park, Calif.
UNIQUE MATERIAL REQUIREMENTS IN THE SPACE SHUTTLE MAIN ENGINES
D. L. FULTON, M. C. SHOEMAKER, and S. BASHIR (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: National Technical Conference, 15th, Cincinnati, OH, October 4-6, 1983, Proceedings . Azusa, CA, Society for the Advancement of Material and Process Engineering, 1983, p. 39-50. refs
(Contract NAS8-27980)

Components operating in staged-combustion cycle liquid fuel rocket engines such as the Space Shuttle Main Engines (SSMEs) are subjected to severe temperature changes during start/stop transients, together with extremely high pressures, corrosive gases, high fluid velocities, demanding weight-control criteria, etc. Attention is given to the selection and application of metallic and nonmetallic materials for high temperature resistance, cryogenic properties, and hydrogen and oxygen compatibility. The materials in question include polyimides, Kel-F, Armalon, and Teflon among plastics, and gold and copper platings, weld-overlays and heat treatment modifications among metals and metallic processing techniques. The polymeric materials are oxygen-resistant, and the metallic ones hydrogen-resistant. O.C.

A84-42754
GLASS IN THE SPACE AGE
A. F. SHOEMAKER (Corning Glass Works, Corning, NY) IN: National Technical Conference, 15th, Cincinnati, OH, October 4-6, 1983, Proceedings . Azusa, CA, Society for the Advancement of Material and Process Engineering, 1983, p. 342-346.

State-of-the-art glass components in aerospace applications must retain structural reliability under the influence of hostile environments. The glasses that have been developed to satisfy these exacting specifications involve novel compositions, static fatigue containment processing methods and nondestructive inspection techniques. There are three basic design-driving criteria for flight vehicle glasses: the lightest possible weight, flight reliability, and, in such cases as that of the Space Shuttle Orbiter, the ability to withstand reentry temperatures and thermal shock. O.C.

A84-42762
ADHESIVE BONDING OF A STABLE SPACE STRUCTURE
K. S. H. WESTPHAL (McDonnell Douglas Astronautics Co., St. Louis, MO) IN: National Technical Conference, 15th, Cincinnati, OH, October 4-6, 1983, Proceedings . Azusa, CA, Society for the Advancement of Material and Process Engineering, 1983, p. 449-452.

A bonding process for achieving dimensional stability in space structures is described. Adhesive bonding is used with composite tubes joined to composite or Ti blades with split shell or clamshell splices. The splices are made of the same material as the tubes (graphite-reinforced epoxy). The adhesive is a thixotropic paste which cures at room temperature yet functions in the -60 to 160 F space environment. The Ti surface must be primed and the GRE tube grit-blasted in preparation. Excess paste is squeezed out by a finger-tight torque. The bond meets all current structural requirements and work will continue on reducing weight and reaching higher efficiencies. M.S.K.

A84-46121#
LIGHT-INDUCED CHANGES IN DARK CONDUCTIVITY OF KAPTON
M. S. LEUNG, M. B. TUELING, and P. F. MIZERA (Aerospace Corp., Los Angeles, CA) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 22nd, Reno, NV, Jan. 9-12, 1984. 25 p. refs
(Contract F04701-83-C-0084)
(AIAA PAPER 84-0452)

The light-induced increase in dark conductivity of Kapton in space and simulated space environments has been investigated. It was found that the increase in conductivity is caused by an accumulation of electrically active centers generated in the bulk of the material in the presence of solar radiation. An analysis of the increase in conductivity as a function of exposure time indicates that the dark conductivity of Kapton can be raised to a level where the film can become sufficiently conductive to be antistatic by simply exposing it to solar radiation in orbit. Author

A84-46575
INFLUENCE OF A SIMULATED SPACE ENVIRONMENT ON THE BEHAVIOR OF CARBON-FIBER-REINFORCED PLASTICS WITH + OR - 45 DEG PLY ORIENTATIONS. - I
W. HARTUNG and H. W. BERGMANN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Strukturmechanik, Brunswick, West Germany) Composites Technology Review, vol. 6, Summer 1984, p. 82-90.

The structural properties of graphite/epoxy and grapite/polyimide composites recommend their use in the primary structures of large future spacecraft, which pose new challenges in such respects as mass, dynamic behavior, dimensional stability, and reliability. In order to assess the effects of severe thermal cycling and electron radiation on the mechanical properties of representative carbon fiber-reinforced composites, a test program was conducted which emphasized the comparison of initial and residual material properties in view of ultrasonic inspection, radiograph, and SEM results. By contrast to predictions based on computational analyses of the maximum stress state achieved during thermal cycling, only minor cracking could be observed in epoxy-matrix laminates even when high curing temperatures were applied, indicating physical property nonlinearities. In the polyimide-based matrix laminates, severe cracking and delaminations were caused by an insufficient breaking strain. O.C.

A84-46774#
AN IMPROVED MATERIAL FOR SPACECRAFT THERMAL AND CHARGING PROTECTION - TCC KAPTON
J. P. BOUCHEZ (ESA, Mechanical Systems Div., Noordwijk, Netherlands) and F. LEVADOU (ESA, Product Assurance Div., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 8, no. 2, 1984, p. 163-168. refs

The occurrence of electrical charging on spacecraft external surfaces can be avoided by adding a transparent conductive layer of aluminized TCC kapton. Study and test programs, which have been conducted by ESTEC to improve the mechanical behavior and electrical conductivity of these layers, are discussed. TCC kapton, which has displayed greater resistance to mechanical handling and lower electrical conductivity after heat treatment, satisfies the stringent specifications for the International Solar-Polar Mission, and is being used in the flight-unit spacecraft. Although the material may be used for applications requiring good electrical conductivity and electrical discharge protection, a modified material is yet to be fully characterized, and the integrated effects of exposure to the low-earth-orbit environment have to be better understood. J.P.

A84-48522* Mississippi Univ., University.
SPACECRAFT CONTAMINATION: SOURCES AND PREVENTION; THERMOPHYSICS CONFERENCE, 18TH, MONTREAL, CANADA, JUNE 1-3, 1983, SELECTED PAPERS
J. A. ROUX, ED. (Mississippi, University, University, MS) and T. D. MCCAY, ED. (NASA, Marshall Space Flight Center, Huntsville, AL) Conference sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics (Progress in Astronautics and Aeronautics. Volume 91), 1984, 347 p. No individual items are abstracted in this volume.

Results of current research in the field of spacecraft contamination are presented. An overview of the various sources of contamination is given, showing the many and diverse mechanisms associated with the degradation of thermal and optical performance of spacecraft surfaces and optics. Some of the causes of contamination are discussed, including spallation of foam insulation on cryogenic fuel tanks, dispersion of particle contamination about a spacecraft, particle contamination of optical sensors, and the influence of the location of venting systems. Contamination prevention is addressed. Infrared transmittance and infrared optical properties of contaminants are considered along with the effects and properties of mixtures of exhaust species, of plume boundary layer flow, and of the contamination associated with bipropellant attitude control thrusters proposed for the Galileo spacecraft. Also discussed are: degradation of 'clean' thermal control surfaces over four years in orbit, in-orbit measurement of solar absorptance, and contamination from postfire efflux of a solid-propellant rocket motor. C.D.

A84-48568* Virginia Polytechnic Inst. and State Univ., Blacksburg.
INFLUENCE OF DAMAGE ON THE THERMAL RESPONSE OF GRAPHITE-EPOXY LAMINATES
D. S. ADAMS and C. T. HERAKOVICH (Virginia Polytechnic Institute and State University, Blacksburg, VA) Journal of Thermal Stresses (ISSN 0149-5739), vol. 7, no. 1, 1984, p. 91-103. refs
(Contract NCC1-15)

A constrained-displacement finite-element approach for studying the influence of transverse cracks and delaminations on the thermal response of laminated composites is presented. Typical results are given in the form of percent-retention curves for the coefficient of thermal expansion as a function of crack density. Cross-ply and quasi-isotropic T300/5208 graphite-epoxy laminates are considered. It is shown that transverse cracks can have a significant influence on the coefficient of thermal expansion, but delaminations located symmetrically about the laminate midplane have no influence on thermal expansion. Author

A84-49346
CONSIDERATIONS IN THE UTILIZATION OF SEMICRYSTALLINE THERMOPLASTIC ADVANCED COMPOSITES
A. LUSTIGER (Battelle Columbus Laboratories, Columbus, OH) SAMPE Journal (ISSN 0091-1062), vol. 20, Sept.-Oct. 1984, p. 13-16. refs

The introduction of advanced composites based on semicrystalline thermoplastic matrices, such as PEEK (polyetheretherketon) and Ryton (polyphenylene sulfide), requires that the fundamental uncertainties relating to the service life of such composites in aerospace applications be understood. Here, the relationships between the processing conditions, the morphology, and the properties of semicrystalline thermoplastics are examined. In particular, attention is given to the tradeoffs between the chemical resistance and the mechanical properties of these materials. It is noted that the ability to manipulate the cooling or subsequent annealing of semicrystalline thermoplastics may provide a way to tailor morphological variables for the unique requirements of each individual part. The memory effect observed in semicrystalline thermoplastics, the maximum use temperature, and the phenomenon of physical aging are discussed. V.L.

A84-49515#
ULTRALIGHT REACTIVE METAL FOAMS IN SPACE - A NOVEL CONCEPT
F. H. COCKS (Duke University, Durham, NC) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 21, Sept.-Oct. 1984, p. 510-512. refs

The paper discusses the possibility of the application of in-orbit foaming techniques to ultralight reactive metals (Li, Na, K, and Ca) to produce stiff structural units of exceptionally low weight (such as are suitable for large-scale engineering projects). It is noted, as an example, that the use of preformed solid shapes composed of Mg-14Li-1Al admixed and compacted together with a foaming agent such as barium hydride would enable this material to be handled in a compact form while in the terrestrial environment as well as during launch. In orbit, these solid compact shapes could be foamed by heating them in a chamber whose inner dimensions were those of the desired structural unit. The advantages of the ultralight reactive metal foams are considered, including resistance to degradation by UV radiation, resistance to hypervelocity impacts by small particles, and heat-transfer advantages. B.J.

N84-23698*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SOLAR ABSORPTANCE AND THERMAL EMITTANCE OF SOME COMMON SPACECRAFT THERMAL-CONTROL COATINGS
J. H. HENNINGER Apr. 1984 47 p refs
(NASA-RP-1121; REPT-84F0248; NAS 1.61:1121) Avail: NTIS HC A03/MF A01 CSCL 11D

Solar absorptance and thermal emittance of spacecraft materials are critical parameters in determining spacecraft temperature control. Because thickness, surface preparation, coatings formulation, manufacturing techniques, etc. affect these parameters, it is usually necessary to measure the absorptance and emittance of materials before they are used. Absorptance and emittance data for many common types of thermal control coatings, are together with some sample spectral data curves of absorptance. In some cases for which ultraviolet and particle radiation data are available, the degraded absorptance and emittance values are also listed. M.A.C.

N84-23703# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
EXPERIMENTAL MEASUREMENT OF MATERIAL DAMPING FOR SPACE STRUCTURES IN SIMULATED ZERO-G M.S. Thesis
R. L. SHEEN Dec. 1983 120 p
(AD-A139215; AFIT/CI/NR-83-84T) Avail: NTIS HC A06/MF A01 CSCL 11D

An experimental apparatus for measuring the material damping properties of a beam specimen is described. The apparatus, called Tuneable Excitation Launch Mechanism (TELM) measures the free decay of free-free beams launched into free-fall in a vacuum. Aluminum 2024-T3 specimens are tested with results following the Zener model for specimens with a fundamental free-free frequency above the relaxation frequency. However, specimens with a fundamental free-free frequency below the relaxation frequency show a high degree of stress dependence. Frequency range was 17 Hz to 358 Hz and stress range was 0.5 KSI to 17 KSI. Graphite/epoxy ASI/3501-6 laminates were also tested. For (o) sub 8 laminates, material damping ratio of approximately .000555 was found for frequencies varying from 45 Hz to 237 Hz. The damping was neither stress on frequency dependent. For (90 sub 8) laminates, the damping ratio ranged from .0055 to .0066 as frequency ranged from 42 Hz to 143 Hz. Damping ratios for (90 sub 8) specimens with graphite fibers, magnesium matrix, and either titanium or magnesium foil were also tested. Damping ratios ranged from .00039 to .00099 depending upon the lay up, frequency, and possibly the stress range involved. Author (GRA)

N84-24637*# Michigan Univ., Ann Arbor.
INFLUENCE OF EXTENDED EXPOSURE IN SPACE ON MECHANICAL PROPERTIES OF HIGH-TOUGHNESS GRAPHITE-EPOXY COMPOSITE MATERIAL (A0019)
D. K. FELBECK *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 19-20 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

Graphite-epoxy composites are promising candidates for structural use in space vehicles because of their high strength and elastic modulus properties. The problem of low fracture toughness was solved by use of recently developed techniques of intermittent interlaminar bonding. Before this material can be adapted for space use, however, confidence must be gained that its mechanical properties are not degraded by exposure to the space environment. The objective of this experiment is to test the effect of extended exposure to a space environment on the mechanical properties of a specially toughened T300/5208 graphite-epoxy composite material. Specimens made by recently developed techniques of intermittent interlaminar bonding will be exposed and afterward tested for fracture toughness, tensile strength, and elastic modulus. The approach of this experiment is to provide a frame on which the specimens can be mounted with their flat sides normal to the Long Duration Exposure Facility radius, each specimen with an unobstructed exposure of about 2 pi sr. The specimens will be mounted so that they neither fracture from high stress nor fail from excessive heating during launch and return. R.J.F.

N84-24638*# Grumman Aerospace Corp., Bethpage, N.Y.
EFFECT OF SPACE ENVIRONMENT ON SPACE-BASED RADAR PHASED-ARRAY ANTENNA (A0133)
R. J. DELASI, M. L. ROSSI, J. B. WHITESIDE, M. KESSELMAN, R. L. HEUER, and F. J. KUEHNE *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 21-23 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 20N

Kapton polyimide film was selected as the baseline material for the Grumman spce based radar (SBR) concept. To gain the requisite confidence for long-term service durability, it is desirable to subject material specimens as well as a portion of the SBR antenna directly to the combined space environment and compare property degradation to that caused by laboratory simulation. The overall objective of this program is to evauate the effect of the space environment on polymeric materials currently being considered for the Grumman SBR Phased-Array Antenna. Degradation mechanisms caused by thermal cycling, ultraviolet and charged-particle irradiation, applied load, and high-voltage plasma interaction will be evaluated. The experiment occupies a 6-in.-deep end corner tray located on the space end of the Long Duration Exposure Facility and consists of both passive and active parts. The passive part addresses the effect of environment and stress on the dimensional stability spliced and continuous Kapton, both plain and reinforced. The active part will study the interaction of high voltage and low-Earth-orbit plasma. R.J.F.

N84-24639*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE EXPOSURE OF COMPOSITE MATERIALS FOR LARGE SPACE STRUCTURES (A0134)
W. S. SLEMP *In its* Long Duration Exposure Facility (LDEF) p 24-26 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

The objective of this experiment is to evaluate the effects of the near-Earth orbital environment on the physical and chemical properties of laminated continuous-filament composites and composites resin films for use in large space structures and advanced spacecraft. The experiment is passive and occupies about one-half of a 6-in.-deep peripheral tray. Specimens of composite materials and polymeric and resin films are arranged above and below the experiment mounting plate to enable both

exposure and nonexposure to sunlight. This provides a comparison of the effects of ultraviolet plus vacuum plus thermal cycling and those of vacuum plus thermal cycling on these materials. The experiment tray is thermally isolated from the Long Duration Exposure Facility structure to allow the material specimens to experience a wide range of thermal cycles. Tensile and compression specimens will be used to evaluate the laminated composite materials. A number of the specimens are precut and ready for testing after space exposure, whereas other specimens will be prepared from larger samples. R.J.F.

N84-24640*# MATRA Service Aerodynamique, Le Chesnay (France). Space Div.

EFFECT OF SPACE EXPOSURE OF SOME EPOXY MATRIX COMPOSITES ON THEIR THERMAL EXPANSION AND MECHANICAL PROPERTIES (A0138-8)

R. ELBERG *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 27-31 Feb. 1984

Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

This experiment has three objectives. The first and main objective is to detect a possible variation in the coefficient of thermal expansion of composite samples during a 1-year exposure to the near-Earth orbital environment. A second objective is to detect a possible change in the mechanical integrity of composite products, both simple elements and honeycomb sandwich assemblies. A third objective is to compare the behavior of two epoxy resins commonly used in space structural production. The experimental approach is to passively expose samples of epoxy matrix composite materials to the space environment and to compare preflight and postflight measurements of mechanical properties. *The experiment will be located in one of the three* FRECOPA (French cooperative payload) boxes in a 12-in.-deep peripheral tray that contains nine other experiments from France. The FRECOPA box will protect the samples from contamination during the launch and reentry phases of the mission. The coefficients of thermal expansion are measured on Earth before and after space exposure. R.J.F.

N84-24641*# Aerospatiale Etablissement des Mureaux (France).

THE EFFECT OF THE SPACE ENVIRONMENT ON COMPOSITE MATERIALS (A0138-9)

M. PARCELIER *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 32-34 Feb. 1984

Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

The objective is to test different types of materials (laminates, thermal coatings, and adhesives) to determine their actual useful lifetime. These experiments will also make is possible to integrate the histories of the thermal and mechanical characteristics into models of the composite structures. The experiment is passive and is located in one of the boxes in a 12-in.-deep peripheral tray with nine other experiments from France. The box will provide protection for the samples from contamination during the launch and reentry phases of the Long Duration Exposure Facility mission. The experiment revolves around four themes of study: thermal coatings, adhesives, dimensional stability, and mechanical characteristics. *The various materials will be arranged in six levels* within the box, so only the first level will be subjected to direct solar radiation. Each level will consist of plates from which test specimens will be cut after the mission. R.J.F.

N84-24642*# Societe Nationale Industrielle Aerospatiale, Cannes (France).

MICROWELDING OF VARIOUS METALLIC MATERIALS UNDER ULTRAVACUUM (A0138-10)

J. P. ASSIE *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 35-37 Feb. 1984

Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11F

In the space vacuum environment, the spacecraft mechanisms are liable to sustain damaging effects from microwelds due to molecular diffusion of the spacecraft constituent metals. Such microwelds result in a continuing increase in the friction factors and are even liable to jam the mechanisms altogether. The object of this experiment is to check the metal surfaces representative *of the mechanism constituent metals (treated or untreated,* lubricated or unlubricated) for microwelds afater an extended stay in the space environment. The experimental approach is to passively expose inert metal specimens to the space vacuum and to conduct end-of-mission verification of the significance of microwelds between various pairs of metal washers. The experiment will be located in one of the FRECOPA boxes in a 12-in. -deep peripheral tray that contains nine other experiments from France. R.J.F.

N84-24643*# Rockwell International Corp., Tulsa, Okla.

EVALUATION OF LONG-DURATION EXPOSURE TO THE NATURAL SPACE ENVIRONMENT ON GRAPHITE-POLYIMIDE AND GRAPHITE-EPOXY MECHANICAL PROPERTIES (A0175)

J. H. POWELL and D. W. WELCH *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 38-40 Feb. 1984

Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

The primary objective of this experiment is to accumulate the needed operational data associated with the exposure of graphite-polyimide and graphite-epoxy material to the environments of space. The experiment will be mounted in two 3-in.-deep *peripheral trays. Graphite-polyimide specimens will occupy 1 1/3* trays and the graphite-epoxy specimens will occupy two-thirds of a tray. The experiment approach requires two matched sets of specimens with traceable records that are maintained for materials processing and specimen quality. After fabrication, one set of each test specimen will be sectioned and structurally tested to serve as a data baseline. After the flight, the other set of specimens will undergo extensive measurements of mechanical properties for comparison with the original data baseline. Structural testing of the graphite-polyimide specimens will provide strength and elastic data in tension, compression, and shear. Transverse tension microcracking and crack propagation will be evaluated by photomicroscopy. Structural testing of the graphite-epoxy specimens will include verification of laminate, core, adhesive, and fatigue properties as applied to the design and analysis of the payload bay door. Microcracking and crack propagation will also be analyzed by photomicroscopy. R.J.F.

N84-24644*# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.

THE EFFECT OF SPACE ENVIRONMENT EXPOSURE ON THE PROPERTIES OF POLYMER MATRIX COMPOSITE MATERIALS (A0180)

R. C. TENNYSON and J. S. HANSEN *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 41-43 Feb. 1984

Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

The objective of this experiment is to determine the effect of various lengths of exposure to a space environment on the mechanical properties of selected commercial polymer matrix composite materials. Fiber materials will include graphite, boron, S-glass, and PRD-49. The mechanical properties to be investigated are orthotropic elastic constants, strength parameters (satisfying *the tensor polynomial relation), coefficients of thermal expansion,* impact resistance, crack propagation, and fracture toughness. In addition, the effect of laminate thickness on property changes will also be investigated. R.J.F.

N84-24645*# Aerospace Corp., El Segundo, Calif.
SPACE ENVIRONMENT EFFECTS ON SPACECRAFT MATERIALS (M0003)
P. SCHALL *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 44-48 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11D

The immediate objectives of this experiment are to understand changes in the properties and structure of materials after exposure to the space environment and to compare these changes with predictions based on laboratory experiments. The experiment consists of 19 subexperiments involving a number of DOD laboratories and contractor organizations. In general, the experimental approach with each of the subexperiments will involve comparison of preflight and postflight analyses. Typical analyses will include the measurement of optical properties (reflectance, transmittance, and refractive index), and macrophysical properties. In addition to measuring changes in the macroscopic properties of the returned specimens, microstructural properties will also be examined. Thus, it may be possible to increase our understanding of the changes induced by the environment. This increased understanding can then be used to predict the performance of materials based on knowledge of the space environment and the results of laboratory tests. This experiment will be a coopperative effort and will provide an opportunity for DOD space programs and laboratories to evaluate materials and components after long exposures to the space environment. R.J.F.

N84-24646*# Texas A&M Univ., College Station.
BALLOON MATERIALS DEGRADATION (S1006)
D. H. ALLEN *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 49-51 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11G

The objective of this experiment is to assess the effects of long-term exposure of candidate balloon films, tapes, and lines to the hostile environment above the Earth's atmosphere. Degradation of mechanical and radiometric properties will be observed by a series of tests on exposed materials. The experiment is passive and will test candidate balloon films, tapes, and lines. The experiment will occupy one-third of a 3-in.-deep peripheral tray. Two additional identical sets of material will be prepared. The first set will be tested immediately and the second will be held in a controlled environment until the recovery of the samples placed on orbit. Tests will then be performed on this second set to determine any effects of aging. The specimens that are recovered from the Long Duration Exposure Facility will also be tested and the effects of long-duration exposure noted. In addition to these specimens, another set of specimens will be exposed at an accelerated exposure facility and the results will be compared with those of specimens exposed in situ. R.J.F.

N84-24647*# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France).
THERMAL CONTROL COATINGS EXPERIMENT (A0138-6)
A. PAILLOUS and J. C. GUILAUMON (CNES) *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 52-53 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11G

The objectives of this LDEF experiment are to verify the validity of space environment simulation performed in the laboratory in order to measure the stability of the thermo-optical properties of thermal control coatings, and to compare the behavior in space of some materials for which the available ultraviolet solar simulation is inadequate (especially in the far ultraviolet). The experimental approach is to passively expose samples of the thermal coatings of interest. These coatings include black paint, aluminum paint, white paint, a solar absorber, an optical surface reflector, second surface mirrors, metal coatings, and silica fabrics. Preflight and postflight measurements of thermo-optical properties will be compared to determine the effects of space environment exposure. M.G.

N84-24648*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPOSURE OF SPACECRAFT COATINGS (S0010)
W. S. SLEMP *In its* Long Duration Exposure Facility (LDEF) p 54-56 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11G

The objectives of this LDEF experiment are to determine the effects of both the Shuttle-induced environment and the space radiation environment on selected sets of spacecraft thermal control coatings. The experimental approach is to passively expose samples of thermal control coatings to Shuttle-induced and space radiation environments and to return the samples for postflight evaluation and comparison with preflight measurements to determine the effects of the environmental exposure. Optical measurements of the samples will include total normal emittance and spectral reflectance. The experiment will utilize a 6 in. deep peripheral tray and an experiment exposure control canister (EECC). The EECC will provide protection for some of the samples against exposure to the launch and reentry environments. The EECC will be programmed to open about 2 weeks after LDEF deployment and close pior to LDEF retrieval by the Shuttle and reentry. Some samples will not be housed in the EECC and will be exposed to the Shuttle-induced environment during launch and reentry. Comparison of the data from these samples with data from samples in the EECC will yield information about possible contamination induced degradation effects. M.G.

N84-24650*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ION-BEAM-TEXTURED AND COATED SURFACES EXPERIMENT (S1003)
M. J. MIRTICH, JR. *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 62-65 Feb. 1984
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 11G

The objective of this LDEF experiment is to measure the effects of exposure to the shuttle launch and near Earth space environments on the optical properties of ion beam textured high absorptance solar thermal control surfaces, the optical and electrical properties of ion beam sputtered conductive solar thermal control surfaces, and the weight loss of ion beam deposited oxide polymer films. The various types of surfaces to be tested include six major categories: (1) ion beam textured surfaces suitable for space solar thermal (solar concentration) application; (2) painted and/or state of the art solar thermal surfaces; (3) ion beam sputtered conductive coatings for thermal and space charge control (e.g., indium-oxide coated metalized FEP Teflon); (4) ion beam sputtered conductive coated solar sail materials for space charge control and cooling through emittance; (5) micrometeoroid sensitive samples whose optical properties change only as a result of micrometeoroid impact; and (6) Kapton coated with oxide polymer films to minimize oxygen degradation at near Earth orbit altitudes. M.G.

N84-24656*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR-ARRAY-MATERIALS PASSIVE LDEF EXPERIMENT (A0171)
A. F. WHITAKER, C. F. SMITH, JR., L. E. YOUNG, H. W. BRANDHORST, JR., A. F. FORESTIERI, E. M. GADDY, J. A. BASS, and P. M. STELLA *In* NASA. Langley Research Center Long Duration Exposure Facility (LDEF) p 86-87 Feb. 1984 Prepared in cooperation with NASA. Lewis Research Center and NASA. Goddard Space Flight Center and JPL
Avail: NTIS HC A09/MF A01; also available SOD HC CSCL 10A

The objective of this experiment is to evaluate the synergistic effects of the space environment on various solar-array materials, including solar cells, cover slips with various antireflectance coatings, adhesive, encapsulants, reflector materials, substrate strength materials, mast and harness materials, structural composites, and thermal control treatments. The experiment is

passive and consists of an arrangement of material specimens mounted in a 3-in.-deep peripheral tray. The effects of the space environment on the specimens will be determined by comparison of preflight and postflight measurements of mechanical, electrical, and optical properties. M.G.

N84-24807*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
COATED FLEXIBLE LAMINATE AND METHOD OF ITS PRODUCTION Patent Application
J. J. PARK, inventor (to NASA) 2 May 1984 9 p
(NASA-CASE-GSC-12913-1; US-PATENT-APPL-SN-606430)
Avail: NTIS HC A02/MF A01 CSCL 11B

The use of silicone as a protective coating on Kapton (trademark), a polyimide film, is described. Because of its flexibility, Kapton is considered the material best suited for use in fabrication of large, rollable, and foldable solar cells needed for spacecraft. Silicone adhesive coatings protect the emissivity and absorptivity characteristics of a Kapton layer solar array so that they change less than 0.01%, even when subjected to a high concentration of oxygen atoms in a space atmosphere. A method of applying the silicone coating is also described. R.S.F.

N84-25787# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Product Assurance Div.
FLAMMABILITY TESTING FOR THE SCREENING OF SPACE MATERIALS
Oct. 1982 42 p
(ESA-PSS-01-721-ISSUE-1; ISSN-0379-4059) Avail: NTIS HC A03/MF A01

The test-process selection criteria for the flammability testing of materials proposed for use in manned and unmanned European Space Agency spacecraft and associated equipment are defined. The applicable test methods are included. R.J.F.

N84-26199# Aerospace Corp., Los Angeles, Calif. Space Sciences Lab.
LABORATORY AND SPACE MEASUREMENTS OF MATERIALS
J. F. FENNELL, P. F. MIZERA, and M. S. LEUNG *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 197-213 25 Jan. 1983 refs
(Contract F04701-82-C-0083)
(AD-P002113) Avail: NTIS HC A18/MF A01 CSCL 09A

The SCATHA (Spacecraft Charging at High Altitude) data has shown that several dielectric materials responded to the space environment differently than was expected prior to launch. For example, there was a marked increase in the bulk conductivity of Kapton samples that were exposed to the Sun in the space vacuum. Teflon accumulated a permanent charge, which resulted in a potential difference that increased with time between it and the satellite frame. A quartz cloth thermal control material was observed to charge to higher levels on orbit than was obtained in pre-launch laboratory tests. Some of the differences between the expected and observed data have been explained by laboratory tests that more accurately model the space environment. Author

N84-26751*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
OUTGASSING DATA FOR SELECTING SPACECRAFT MATERIALS
W. A. CAMPBELL, JR., R. S. MARRIOTT, and J. J. PARK Jun. 1984 280 p refs
(NASA-RP-1124; REPT-84B0271; NAS 1.61:1124) Avail: NTIS HC A13/MF A01 CSCL 11D

Outgassing data, derived from tests at 398 K (125 C) for 24 hours in vacuum as per ASTM E 595-77, were compiled for numerous materials for spacecraft use. The data presented are the total mass loss (TML) and the collected volatile condensable materials (CVCM). The various materials are grouped as: adhesives; cable insulation and shrink tubing; conformal coating; electrical components; electrical shields; films and sheet materials, foams; greases and lubricants; lacing tape and cord cable ties; laminates and circuit boards; marking materials and inks; molding compounds; paints, lacquers, and varnishes; potting compounds; and rubbers and elastomers. The materials are also listed alphabetically. A.R.H.

N84-26803*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPUTTERED COATINGS FOR PROTECTION OF SPACECRAFT POLYMERS
B. A. BANKS, M. J. MIRTICH, S. K. RUTLEDGE, and D. M. SWEC 1983 13 p refs Presented at the 11th Intern. Conf. on Met. Coatings, San Diego, Calif., 9-13 Apr. 1984; sponsored by Am. Vacuum Soc.
(NASA-TM-83706; E-2092; NAS 1.15:83706) Avail: NTIS HC A02/MF A01 CSCL 11B

Kapton polyimide oxidizes at significant rates (4.3x10(-24) gram/incident oxygen atom) when exposed in low Earth orbit to the ram atomic oxygen flux. Ion beam sputter deposited thin films of Al2O3 and SiO2 as well as a codeposited mixture of predominantly SiO2 with a small amount of polytetrafluoroethylene were evaluated and found to be effective in protecting Kapton from oxidation in both laboratory plasma ashing tests as well as in space on board shuttle flight STS-8. A protective film of or = 96 percent SiO2 and or = 4 percent polytetrafluoroethylene was found to be very flexible compared to the pure metal oxide coatings and resulted in mass loss rates that were 0.2 percent of that of the unprotected Kapton. The optical properties of Kapton for wavelengths investigated between 0.33 and 2.2 microns were not significantly altered by the presence of the coatings or changed by exposure of the coated Kapton to the low Earth orbital ram environment. M.G.

N84-28887*# Goodyear Aerospace Corp., Akron, Ohio.
SYSTEM DEFINITION STUDY OF DEPLOYABLE, NON-METALLIC SPACE STRUCTURES
F. J. STIMLER Jun. 1984 156 p refs
(Contract NAS8-35498)
(NASA-CR-171090; NAS 1.26:171090; GAC-19-1615) Avail: NTIS HC A08/MF A01 CSCL 22B

The state of the art for nonmetallic materials and fabrication techniques suitable for future space structures are summarized. Typical subsystems and systems of interest to the space community that are reviewed include: (1) inflatable/rigidized space hanger; (2) flexible/storable acoustic barrier; (3) deployable fabric bulkhead in a space habitat; (4) extendible tunnel for soft docking; (5) deployable space recovery/re-entry systems for personnel or materials; (6) a manned habitat for a space station; (7) storage enclosures external to the space station habitat; (8) attachable work stations; and (9) safe haven structures. Performance parameters examined include micrometeoroid protection; leakage rate prediction and control; rigidization of flexible structures in the space environment; flammability and offgassing; lifetime for nonmetallic materials; crack propagation prevention; and the effects of atomic oxygen and space debris. An expandable airlock for shuttle flight experiments and potential tethered experiments from shuttle are discussed. A.R.H.

N84-31266*# General Electric Co., Philadelphia, Pa. Space Div.
ON ORBIT SURFACING OF THERMAL CONTROL SURFACES Monthly Progress Report
G. W. RACETTE May 1984 12 p
(Contract NAS8-35342)
(NASA-CR-171121; NAS 1.26:171121; MPR-7) Avail: NTIS HC A02/MF A01 CSCL 22B

Substrates to be contaminated and contamination source were prepared. Additional information on paint spray method apparatus was obtained. Silver teflon second surface mirror samples and S 13 GLO paint samples were mounted, photographed under the microscope and measured to establish baseline data. Atomic oxygen cleaning and spray painting are being considered.

Electrostatic powder and plasma spray coating systems appear to have serious drawbacks. A.R.H.

N84-31269# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Space Div.
TESTING OF COATINGS IN SPACE, LONG DURATION EXPOSURE FACILITY (LDEF) Final Report, Oct. 1981
H. BAUER, P. GOEDTKE, K. GROH, O. K. HUSMANN, L. PREUSS, W. SCHAEFER, C. WITA, and J. ZWIEGEL Bonn Bundesministerium fuer Forschung und Technologie May 1984 326 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-84-017; ISSN-0170-1339) Avail: NTIS HC A15/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 49

Thermal coatings of the flexible second surface mirrors type, and conductive coatings on solar cell covers were qualified for operation in 24 hr orbit. The coatings are exposed to the low Earth orbit space environment for a longer period by means of the LDEF. Accompanying laboratory experiments supplement the flight experiment. The flight experiment was developed, especially the establishment of test and functional specifications, materials and weight lists, temperature prediction for thermal tests, the defined stowage, and the completion of three accompanying ground experiments (near UV solar simulation, contamination experiment, and charging experiment). Author (ESA)

N84-34351*# Auburn Univ., Ala. Dept. of Physics.
SURFACE ANALYSIS OF SPACE TELESCOPE MATERIAL SPECIMENS Monthly Report
A. T. FROMHOLD 31 Jul. 1984 70 p
(Contract NAS8-35914)
(NASA-CR-171163; NAS 1.26:171163) Avail: NTIS HC A04/MF A01 CSCL 03A

Surface analysis by electron spectroscopy for chemical analysis (ESCA) was used to characterize a number of the material samples for the space telescope. With ESCA, the sample is irradiated with monoenergetic soft X-rays and the resulting emitted electrons are energy analyzed to determine the binding energy of electrons to the surface atoms. The major peaks were used in the quantitative determination of the surface composition. The presence of trace elements (impurities below 1% atomic composition) was also detailed. Initially a survey scan was run for each sample to deduce the elemental composition. Then the major peaks of interest and those of the trace elements were individually examined. After this, the samples were argon sputtered to etch away surface layers, and then additional measurements were carried out in order to obtain depth profile information. In this way it was possible for those species present only on the surface to be distinguished from those having a significant depth distribution within the sample. Author

N84-34481*# Aerospace Corp., El Segundo, Calif. Chemistry and Physics Lab.
A FACILITY FOR INVESTIGATING INTERACTIONS OF ENERGETIC ATOMIC OXYGEN WITH SOLIDS
G. S. ARNOLD and D. R. PEPLINSKI *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 150-168 1984 refs Sponsored in part by the Aerospace Research Program
Avail: NTIS HC A13/MF A01 CSCL 20H

A facility for the investigation of the interactions of energetic atomic oxygen with solids is described. The facility is comprised of a four-chambered, differentially pumped molecular beam apparatus which can be equipped with one of a variety of sources of atomic oxygen. The primary source is a dc arch-heated supersonic nozzle source which produces a flux of atomic oxygen in excess of 10 to the 15th power/cu cm/sec at the target, at a velocity of 3.5 km/sec. Results of applications of this facility to the study of the reactions of atomic oxygen with carbon and polyimide films are briefly reviewed and compared to data obtained on various flights of the space shuttle. Author

N84-34482*# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
AN ATOMIC OXYGEN FACILITY FOR STUDYING POLYMER MATERIALS FOR SPACECRAFT APPLICATIONS
R. C. TENNYSON, J. B. FRENCH, L. J. KOK, J. KLEIMAN, and D. G. ZIMCIK (Communications Research Centre, Canada) *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 169-192 1984 refs Sponsored in part by the Communications Research Centre
Avail: NTIS HC A13/MF A01 CSCL 11B

A nozzle beam facility utilizing microwave discharge on a helium carrier gas seeded with oxygen to produce atomic oxygen fluxes of the order of 10 to the 15th power atoms/cu cm/sec is described. In addition, limited test results obtained from exposing a graphite/epoxy composite and Kapton (H) film are presented in terms of mass loss measurements and changes in surface morphology. Author

N84-34484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE ENERGY DEPENDENCE AND SURFACE MORPHOLOGY OF KAPTON (TRADEMARK) DEGRADATION UNDER ATOMIC OXYGEN BOMBARDMENT
D. C. FERGUSON *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 205-221 1984 refs
Avail: NTIS HC A13/MF A01 CSCL 20H

Data from laboratory simulations and from samples returned from STS-8 are used to derive the energy dependence of the mass loss rate of Kapton under atomic oxygen bombardment and to discuss the development of surface structure and its effect on erosion rates. It is concluded that all the laboratory data from discharge and flow tubes and from accelerated beams, along with the orbital data from STS-3 through STS-8, can be accommodated by a rate of mass loss that varies with impact energy normal to the surface. It is hypothesized that increases of mass loss rate with exposure time may be due to trapping of the incoming atoms by the surface structure which develops. Author

N84-34506*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LEO ATOMIC OXYGEN EFFECTS ON SPACECRAFT MATERIALS: STS-5 RESULTS
A. F. WHITAKER Aug. 1984 22 p refs
(NASA-TM-86463; NAS 1.15:86463) Avail: NTIS HC A02/MF A01 CSCL 11G

Effects of low Earth orbit (LEO) atomic oxygen were measured on a variety of spacecraft materials which obtained exposure on STS-5. Material degradation dependency on temperature was found in one material. Of the five paints flown, only S13GLO was unaffected. Generally, the glossy paints became Lambertian and the diffuse coatings improved. Scanning electron microscope examinations indicated removal of urethane and epoxy paint binder materials. Reaction products were evident on the surfaces of Z302 paint and Mylar. Thin films showed thickness losses ranging from negligible loss in Teflon to considerable loss in Mylar and Kapton. Glossy films such as black Kapton and white Tedlar became diffused. Kevlar 29 rope lost tensile strength and silver solar cell interconnect material oxidized. Oxidation on the backside of an elevated specimen indicated that reflections of oxygen atoms were occurring and that reflecting surfaces, probably Kapton, were not fully accommodating the incident atoms. Author

08

ASSEMBLY CONCEPTS

Includes automated manipulator techniques, EVA, robot assembly, teleoperators, and equipment installation.

A84-30217* Martin Marietta Aerospace, Denver, Colo.
AUTOMATION CONCEPTS FOR LARGE SPACE POWER SYSTEMS
M. S. IMAMURA, R. MOSER (Martin Marietta Aerospace, Denver, CO), D. AICHELE, and R. LANIER, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 5 . New York, American Institute of Chemical Engineers, 1983, p. 2295-2302.

A study was undertaken to develop a methodology for analyzing, selecting, and implementing automation functions for multi-hundred-kW photovoltaic power systems intended for manned space station. The study involved identification of generic power system elements and their potential faults, definition of automation functions and their resulting benefits, and partitioning of automation functions between power subsystem, central spacecraft computer, and ground. Automation to a varying degree was concluded to be mandatory to meet the design and operational requirements of the space station. The key drivers are indefinite lifetime, modular growth, high performance flexibility, a need to accommodate different electrical user load equipment, on-orbit assembly/maintenance/servicing, and potentially large number of power subsystem components. Functions that are good candidates for automation via expert system approach includes battery management and electrical consumables management. Author

A84-30606#
SATELLITE SERVICING BY TELEOPERATORS
R. FRENCH and B. BOYCE (Vought Corp., Dallas, TX) American Society of Mechanical Engineers, Winter Annual Meeting, Boston, MA, Nov. 13-18, 1983. 7 p. refs
(ASME PAPER 83-WA/AERO-9)

A Teleoperator Maneuvering System (TMS) is considered which will initially be a Shuttle-launched ground-based satellite servicing vehicle controlled by man-in-the-loop. During Space Station implementation in the 1990's, TMS will assist the Shuttle in the assembly and placement of Space Station elements. The TMS will require approximately 1.6 million pound seconds of total impulse energy to propel its 12,000 lb weight and will use N2O4/NMH bipropellant. Following implementation of the Space Station, TMS's applications are expected to include: support for the retrieval and servicing of space observatories; support for commercial and government free-flying materials processing platforms; satellite refueling and maintenance; and support for contingency operations including rescue, debris control and emergency personnel transfer. Diagrams are provided which describe some tentative basing options for the TMS with respect to the number and arrangement of TMS vehicles on board the Space Station, but it is pointed out that specific station applications must await definition of emerging station configurations. I.H.

A84-34008#
DEVELOPING ADVANCED ORBITAL MAINTENANCE/SERVICING TECHNIQUES FOR EVA APPLICATIONS
S. M. CHUCKER and R. J. DELLACAMERA (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 32-39.
(AIAA PAPER 84-1114)

It is pointed out that increased activity planned for the Space Transportation System (STS) can provide services to earth orbiting payloads which were not previously available. Thus, on-orbit maintenance servicing by manned extravehicular activity (EVA) can accomplish contingency/restorative repair activities. Implementation of an orbital maintenance concept could provide extended life to orbiting systems for operational cost effectivity. The present investigation is concerned with the development of EVA techniques associated with a recent space platform study. Attention is given to aspects of aft payload port deployment, a large replaceable unit exchange, manual appendage deployment, large item exchange, and the examination of fine motor activities. G.R.

A84-38624#
EXTENDABLE AND RETRACTABLE MAST (ERM)
M. SCHMID Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1984, p. 79-82.

The Extendable and Retractable Mast (ERM) telescopic model demonstrates high structural stiffness, good pointing accuracy, high reliability, low mass, low power consumption and small stowage volume. The 85-kg ERM can reach a maximum deployment of 40 m, and its mode of operation relies on a rotating spindle and sliding nut arrangement. A maximum tube diameter of 480 mm, a wall thickness of 0.5 mm and a maximum length of about 2850 mm make up the structure of the solar array mast. A drive-unit with gear, bearing and spindle, a cable follow-up mechanism, a latching mechanism, an angle-encoder and a launch locking device are the necessary mechanisms for ERM operation. The ERM requirements are discussed with reference to the necessity of positioning large folding structures in orbit, mainly in the framework of the Shuttle program. J.P.

A84-40609* Spar Aerospace Ltd., Toronto (Ontario).
THE SHUTTLE REMOTE MANIPULATOR SYSTEM AND ITS USE IN ORBITAL OPERATIONS
S. S. SACHDEV and B. R. FULLER (Spar Aerospace, Ltd., Remote Manipulator Systems Div., Toronto, Canada) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IC-29 to IC-49. Research supported by the Spar Aerospace, Ltd., National Research Council of Canada, and NASA.

It is pointed out that the Shuttle Remote Manipulator System (RMS) is a key element in the Space Transportation System's ability to deploy, retrieve, and handle payloads in space. In addition, the RMS has the capability of performing other critical tasks such as inspection, construction, and satellite servicing. The present investigation is concerned with various end of arm tool concepts which could augment the RMS's capability enabling it to perform functions such as pushing/holding (applying pressure), prying, clamping (nonimpulse release) and shearing. Attention is also given to a tool for satellite servicing, a method for augmenting the operator's 'feel' for the job by force/moment sensing, and a possible four phase program for implementation of the tool system. A description is given of the key elements of RMS flight testing carried out to date. G.R.

A84-41082
MANNED REMOTE WORK STATIONS - MACHINES TO ENHANCE MAN'S SPACE PRESENCE
C. A. NATHAN (Grumman Aerospace Corp., Bethpage, NY) IN: Behavioral Objectives in Aviation Automated Systems Symposium; Proceedings of the Aerospace Congress and Exposition, Anaheim, CA, October 25-28, 1982 . Warrendale, PA, Society of Automotive Engineers, Inc., 1982, p. 329-341.

The evolution of the Manned Remote Work Station (MRWS). The MRWS is a series of EVA platforms and crew cabins that perform roles which are common on the ground such as cherry pickers, crane turrets, emergency repair vehicles and short haul transporters. Concepts and their space applications are delineated for near term applications in support of the Space Shuttle and future applications in support of the Space Station. Results of man-in-the-loop simulations that demonstrate man's role in

maintaining satellites are also discussed as are test results on the use of manipulators, a key element of the MRWS. Author

A84-43440*# Massachusetts Inst. of Tech., Cambridge.
RESULTS OF THE M.I.T. BEAM ASSEMBLY TELEOPERATOR AND INTEGRATED CONTROL STATION
J. R. SPOFFORD and D. L. AKIN (MIT, Cambridge, MA) IN: Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 351-359. refs
(Contract NAGW-21)
(AIAA PAPER 84-1890)

To examine the issues of optimum human-machine mixtures for orbital assembly operations, a full six degree-of-freedom teleoperator system for assembly of large space structures has been developed by the Space Systems Laboratory. This consists of a free-flying neutrally buoyant Beam Assembly Teleoperator (BAT) with two manipulators, and a modular Integrated Control Station (ICS). The design and configuration of both the BAT and the ICS are described in some detail in this paper. In addition, qualitative results from early tests of the system are presented. These tests concentrated mostly on free-flying operations and grasping. Future tests will involve complete teleoperated assembly. Author

A84-49173
CONTROL OF A FLEXIBLE ROBOT FOR SPACE APPLICATIONS
R. GRAN (Grumman Research and Development Center, Bethpage, NY) IN: Guidance and control 1984; Proceedings of the Seventh Annual Rocky Mountain Conference, Keystone, CO, February 4-8, 1984 . San Diego, CA, Univelt, Inc., 1984, p. 269-274.
(AAS PAPER 84-035)

The interactions expected to occur between a control system of a robot device for space applications and the structural dynamics of the robot are discussed. The robot may be used for satellite retrieval, berthing, and other purposes. The structural dynamics are modeled in terms of the actuators and sensors, the disturbances, and the dynamics. Areas needing further study include the controller bandwidth, vibration modes, and techniques for adapting the controller to alterations in the robot geometry caused by, e.g., movement of the robot arm. A set of transfer functions would be used for the combined rigid body and structural dynamics model. The level of the control/structure interaction is governed by the speed of robot motion. The interaction will be stable or unstable, the latter occurring at the structural eigenfrequency. It is recommended that control theory developed for large space structures be adapted for robot control laws. M.S.K.

N84-24614# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
DOCKING MECHANISM FOR IN-ORBIT ASSEMBLY AND SPACECRAFT SERVICING
F. GAMPE *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 12 p Jan. 1984
Avail: NTIS HC A15/MF A01

Future in-orbit infrastructure requires the usage of a Docking Mechanism Subsystem (DMS) for in-orbit assembly and spacecraft servicing. As a first entry for European applications unmanned, autonomous docking missions are foreseen as well in low Earth orbit (processing platforms) as in geostationary orbit (communication satellite clustering). The Rendezvous and Docking (RVD) operation is a key technology to realize such type of mission. The DMS is imbedded in a system performing the 'last meters' problem, where specially the Attitude and Orbit Control Subsystem (AOCS) closely cooperates with the DMS. The DMS itself is composed of the Docking Mechanism itself and the Docking Mechanism Electronics. Dependent on the initial separation conditions two docking concepts are considered: the DMS- and the AOCS - controlled closure. A first docking demonstration is envisaged during the EURECA-2 mission in 1989/90. Author

N84-25063*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LATCHING MECHANISM FOR DEPLOYABLE-RESTOWABLE COLUMNS Patent Application
E. L. AHL, JR., inventor (to NASA) 2 May 1984 21 p
(NASA-CASE-LAR-13169-1; US-PATENT-APPL-SN-606431)
Avail: NTIS HC A02/MF A01 CSCL 13I

A column longeron latch assembly provides the securing mechanism for the deployable, telescoping column of a hoop/column antenna. The column is an open lattice structure with three longerons disposed 120 deg apart as the principle load bearing member and is deployed from a pair of eleven nested bays disposed on opposite sides of a center section under the influence of a motor-cable-pulley system. The longeron latch is a four bar linkage mechanism using the over-center principle for automatically looking the longeron sections into position during deployment and serves to unlock the sections when antenna 10 is to be re-stowed. A spring pack, disposed in an end of each longeron, serves to absorb stress forces on the deployed column throught the cam head piston and the abutting latch from an adjacent longeron. NASA

N84-25078*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE 18TH AEROSPACE MECHANISMS SYMPOSIUM
Washington May 1984 321 p refs Symp. held in Greenbelt, Md., 2-4 May 1984; sponsored by NASA, the California Inst. of Tech., and LMSC
(NASA-CP-2311; REPT-84FO235; NAS 1.55:2311) Avail: NTIS HC A14/MF A01 CSCL 20K

Topics concerning aerospace mechanisms, their functional performance, and design specifications are presented. Discussed subjects include the design and development of release mechanisms, actuators, linear driver/rate controllers, antenna and appendage deployment systems, position control systems, and tracking mechanisms for antennas and solar arrays. Engine design, spaceborne experiments, and large space structure technology are also examined.

N84-25079*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE DESIGN AND DEVELOPMENT OF A RELEASE MECHANISM FOR SPACE SHUTTLE LIFE-SCIENCE EXPERIMENTS
H. M. JONES and R. G. DANIELL *In its* The 18th Aerospace Mech. Symp. p 1-14 May 1984 refs
Avail: NTIS HC A14/MF A01 CSCL 13I

The design, development, and testing of a release mechanism for use in two life science experiments on the Spacelab 1, 4, and D1 missions is described. The mechanism is a self latching ball lock device actuated by a linear solenoid. An unusual feature is the tapering of the ball lock plunger to give it a near constant breakout force for release under a wide range of loads. The selection of the design, based on the design requirements, is discussed. A number of problems occurred during development and test, including problems caused by human factors that became apparent after initial delivery for crewtraining sessions. These problems and their solutions are described to assist in the design and testing of similar mechanisms. M.A.C.

N84-25081*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A PASSIVELY CONTROLLED APPENDAGE DEPLOYMENT SYSTEM FOR THE SAN MARCO D/L SPACECRAFT
W. E. LANG, H. P. FRISCH, and D. A. SCHWARTZ *In its* The 18th Aerospace Mech. Symp. p 29-48 May 1984 refs
Avail: NTIS HC A14/MF A01 CSCL 13I

The analytical simulation of deployment dynamics of these two axis concepts as well as the evolution of practical designs for the add on deployable inertia boom units is described. With the boom free to swing back in response to Coriolis forces as well as outwards in response to centrifugal forces, the kinematics of motion are complex but admit the possibility of absorbing deployment energy in frictional or other damping devices about the radial axis, where

large amplitude motions can occur and where the design envelope allows more available volume. An acceptable range is defined for frictional damping for any given spin rate. Inadequate damping allows boom motions which strike the spacecraft; excessive damping causes the boom to swing out and latch with damaging violence. The acceptable range is a design parameter and must accommodate spin rate tolerance and also the tolerance and repeatability of the damping mechanisms. M.A.C.

N84-25084*# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
EVOLUTION FROM A HINGE ACTUATOR MECHANISM TO AN ANTENNA DEPLOYMENT MECHANISM FOR USE ON THE EUROPEAN LARGE COMMUNICATIONS SATELLITE (L-SAT/OLYMPUS)
M. D. DEATH *In* NASA. Goddard Space Flight Center The 18th Aerospace Mech. Symp. p 79-91 May 1984 refs
Avail: NTIS HC A14/MF A01 CSCL 13I

The evolution of an Antenna Deployment Mechanism (ADM) from a Hinge Actuator Mechanism (HAM) is described as it pertains to the deployment of large satellite antennas. Design analysis and mechanical tests are examined in detail. M.A.C.

N84-28894*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONCEPTUAL DESIGN OF A MOBILE REMOTE MANIPULATOR SYSTEM
H. G. BUSH, M. M. MIKULAS, JR., R. E. WALLSOM (Kentron International, Inc., Hampton, Va.), and J. K. JENSEN Jul. 1984 16 p refs
(NAS 1.15:86262; NASA-TM-86262) Avail: NTIS HC A02/MF A01 CSCL 22B

A mobile remote manipulator system has been identified as a necessary device for space station. A conceptual design for an MRMS is presented which features (1) tracks on the MRMS and guide pins only on the truss structure, (2) a push/pull drive mechanism which rotates to permit movement in four directions, and (3) spacecrane and mobile foot restraint manipulators (or arms). Operational and design features of the MRMS elements are described and illustrated. Concepts are also presented which permit rotating the operational plane of the MRMS through 90 deg. Such a system has been found to have great utility for initial space station construction, maintenance and repair, and to provide a construction capability for future station growth or large spacecraft assembly and/or servicing. Author

N84-29236# Krupp (Fried.) G.m.b.H., Essen (West Germany). Krupp Forschungsinst.
DESIGN, MANUFACTURE AND TESTS OF A LOCKING AND UNLOCKING MECHANISM, USING MEMORY ELEMENTS (VEM); LAYOUT, MANUFACTURE AND TESTING OF A TRACKING MECHANISM, USING MEMORY ELEMENTS FOR LOCKING/UNLOCKING AND DRIVING AND BEING SUITABLE FOR QUALIFICATION (NFMM) Final Report, Jan. 1979
J. JORDE and H. G. REISS Bonn Bundesministerium fuer Forschung und Technologie Apr. 1984 61 p In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
(BMFT-FB-W-84-012; ISSN-0170-1339) Avail: NTIS HC A04/MF A01; Fachinformationszentrum, Karlsruhe, West Germany DM 13

A locking/unlocking mechanism and a tracking mechanism using NiTi alloy memory elements as drives are presented. The power supply components, the drives, and the active parts were designed, manufactured and tested for spacecraft applications. Advantages in terms of simplicity, reliability and cost are emphasized. The memory elements are inexpensive to replace and can be reconditioned repeatedly at low cost. Author (ESA)

N84-32424*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
FOLDABLE SELF-ERECTING JOINT Patent Application
T. E. PELISCHEK, inventor (to NASA) 9 Mar. 1984 11 p
(NASA-CASE-MSC-20635-1; NAS 1.71:MSC-20635-1; US-PATENT-APPL-SN-588039) Avail: NTIS HC A02/MF A01 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 biased toggle links in the unfolded position. The members are nested against one of the members in substantial alignment and overcenter for securely locking the joint in the unfolded position. E.R.

09

PROPULSION

Includes propulsion concepts and designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.

A84-30182
DEVELOPMENT STATUS OF A REGENERATIVE FUEL CELL SYSTEM FOR ORBITAL ENERGY STORAGE
A. C. ERICKSON and L. J. NUTTALL (General Electric Co., Wilmington, MA) IN: IECEC '83; Proceedings of the Eighteenth Intersociety Energy Conversion Engineering Conference, Orlando, FL, August 21-26, 1983. Volume 4 . New York, American Institute of Chemical Engineers, 1983, p. 1519-1524.

The system design and operation of a NASA sponsored breadboard regenerative fuel cell (RFC) system is described (with a block diagram), and the results of testing are reviewed. Also presented are estimated system weights as a function of overall energy storage efficiency for space station-type requirements. The RFC system consists of an electrolysis subsystem for oxygen and hydrogen gas generation, a fuel cell subsystem for power generation, an oxygen/hydrogen gas storage subsystem, and a remote control console. The study designed to assess the RFC system potential for space station applications was based on a 39.23 kW output power rating with sufficient reactant storage for 44 minutes of operation at full load, and on a 92 minute orbit duty cycle. It is concluded that the RFC system is a viable future energy source for space stations. C.M.

A84-30570
IMPLEMENTATION OF A MINIMUM TIME AND FUEL ON/OFF THRUSTER CONTROL SYSTEM FOR FLEXIBLE SPACECRAFT
A. M. FLOYD, M. E. BROWN, J. D. TURNER, and W. E. V. VANDER VELDE (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 2 . San Diego, CA, Univelt, Inc., 1984, p. 759-775.
(AAS PAPER 83-376)

A nonlinear feedback control algorithm (Vander Velde's algorithm) which optimizes between response time and fuel consumption is implemented on an example structure consisting of a rigid hub on which four flexible appendages are attached. Simulations are run with both single and multiple inputs controlling one rigid-body and two flexible modes. It is shown that the above algorithm can successfully control a flexible structure during a large-angle slew if a sufficient number of control inputs are available. Refinements are made, and several problems with the algorithm are noted which indicate a need for further study. B.J.

A84-32062#
APPLIED-FIELD MAGNETOPLASMADYNAMIC THRUSTERS FOR ORBIT-RAISING MISSIONS
G. R. SEIKEL (SeiTec., Inc., Cleveland, OH), T. M. YORK (Pennsylvania State University, University Park, PA), and W. C. CONDIT (Westinghouse Research and Development Center, Pittsburgh, PA) IN: Orbit-raising and maneuvering propulsion: Research status and needs . New York, American Institute of Aeronautics and Astronautics, 1984, p. 260-286. refs

An important type of space mission will involve the transfer of large payloads from low earth orbit (LEO) to geosynchronous orbit (GEO). Studies concerned with the optimum specific impulse for such missions have shown that electromagnetic thrusters would be very attractive if high performance could be obtained with a compact, lightweight thruster system (thruster plus necessary power conditioning). As a result of an investigation of a large variety of electromagnetic thrusters, the applied-field magnetoplasmadynamic (MPD) arc thruster emerged as the most attractive contender in the mid-sixties. A review is presented of the results of studies concerning noncondensable propellant applied-field MPD, taking into account also the impact of recent developments in energy storage technology. It is pointed out that performance levels already demonstrated, 34 percent at 2500 s specific impulse for a 25 kW argon MPD thruster with a 1 T applied magnetic field, make the thrusters potentially attractive for LEO-GEO transfer missions. G.R.

A84-34011*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROGRESS IN SPACE NUCLEAR REACTOR POWER SYSTEMS TECHNOLOGY DEVELOPMENT - THE SP-100 PROGRAM
H. S. DAVIS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 59-66. NASA-supported research. refs
(AIAA PAPER 84-1132)

Activities related to the development of high-temperature compact nuclear reactors for space applications had reached a comparatively high level in the U.S. during the mid-1950s and 1960s, although only one U.S. nuclear reactor-powered spacecraft was actually launched. After 1973, very little effort was devoted to space nuclear reactor and propulsion systems. In February 1983, significant activities toward the development of the technology for space nuclear reactor power systems were resumed with the SP-100 Program. Specific SP-100 Program objectives are partly related to the determination of the potential performance limits for space nuclear power systems in 100-kWe and 1- to 100-MW electrical classes. Attention is given to potential missions and applications, regimes of possible space power applicability, safety considerations, conceptual system designs, the establishment of technical feasibility, nuclear technology, materials technology, and prospects for the future. G.R.

A84-35141#
OLYMPUS COMBINED PROPULSION SUBSYSTEM
R. W. DEVEY (British Aerospace PLC, Space and Communications Div., Stevenage, Herts., England) AIAA, SAE, and ASME, Joint Propulsion Conference, 20th, Cincinnati, OH, June 11-13, 1984. 5 p.
(AIAA PAPER 84-1232)

The paper presents the salient features of the propulsion subsystem of the Olympus satellite. A brief outline is given of the overall spacecraft capability followed by a detailed description of the elements which make up the propulsion subsystem. The factors which were the prime influences on the design of the subsystem are discussed and the modes of operation are described. Finally, the major elements of the development program are presented. Author

A84-36985#
ASSESSMENT METHODOLOGY FOR SPACE TRANSPORTATION PROPULSION TECHNOLOGIES
C. J. MEISL (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 20th, Cincinnati, OH, June 11-13, 1984. 12 p.
(AIAA PAPER 84-1468)

A two-step technology assessment method is illustrated for the case of advanced rocket engine design, where the first step consists of the engine concept's selection and the second is the choosing of its technological implementation. This process yields technological priorities. Attention is given to the evaluation of assessment criteria and to the numerical evaluation process itself. The method is applicable to technologically complex subsystems in transportation, space power, space station support, and advanced weapons systems. O.C.

N84-26193*# Minnesota Univ., Minneapolis. School of Physics and Astronomy.
FLOATING POTENTIALS AND THE HOT PLASMA GENERATED BY AN ELECTRON-BEAM-EMITTING ROCKET IN THE IONOSPHERE
J. R. WINCKLER *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 133-140 25 Jan. 1983 refs
(Contract NSG-5088)
(AD-P002107) Avail: NTIS HC A18/MF A01 CSCL 20H

This paper summarizes some recent experimental results concerning the potentials of a large vehicle emitting a powerful electron beam in the ionosphere. Many such experiments have been conducted in the last decade (see Winckler 1) and these experiments indicate that if a constant electron beam is emitted in the ionosphere from a large rocket or other space vehicle, a return current may be drawn from the ionospheric plasma that will stabilize the potential of the vehicle in the range of a few tens of volts to perhaps several hundred volts. Author

N84-27825*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE CAPABILITIES OF THE 12-CENTIMETER XENON ION THRUSTER
M. MANTENIEKS and M. SCHATZ 1984 18 p refs Presented at the 17th Intern. Elec. Propulsion Conf., Tokyo, 28-31 May 1984
(NASA-TM-83674; E-2022; NAS 1.15:83674) Avail: NTIS HC A02/MF A01 CSCL 21H

The 8- and 12-cm mercury ion thruster systems were developed primarily to provide N-S station keeping of satellites with masses up to about 1800 to 3600 kg respectively. The on-orbit propulsion requirements of recently proposed Large Space Systems (LSS) are beyond the thrust capabilities of the baseline 8- and 12-cm thruster systems. This paper presents a characterization of the performance capabilities of the 12-cm Xenon ion thruster to enable an evaluation of its application to LSS auxiliary propulsion requirements. With minor thruster modifications and simplifications the thrust was increased to 64 mN, a factor of six over the baseline 12-cm mercury thruster performance. The thruster was operated over a range of specific impulse of about 2000 to 4000 seconds and at total efficiencies up to 68.0 percent. The operating levels reached in this study were found to be close to the operating limits of the thruster design in terms of perveance, grid breakdown voltage and thruster component temperatures such as those of the magnets and cathode baffle. Author

N84-29906# Applied Physics Lab., Johns Hopkins Univ., Laurel, Md. *Chemical Propulsion Information Agency.*
THE 1984 JANNAF PROPULSION MEETING, VOLUME 1
K. L. STRANGE, ed. Feb. 1984 384 p refs Meeting held in New Orleans, 7-9 Feb. 1984 5 Vol.
(Contract N00024-83-C-5301)
(AD-A142852; CPIA-PUBL-390-VOL-1) Avail: NTIS HC A17/MF A01 CSCL 21H

Topics covered include Space Shuttle propulsion, liquid propellant booster engines, satellite and space station attitude

control systems, liquid oxidizer compatibility, and electric propulsion. Author and source indexes to this volume are included.

N84-29910*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERY LOW THRUST AND LOW CHAMBER PRESSURE GO2/GH2 THRUSTER TECHNOLOGY
R. A. BJORKLUND and M. A. APPEL *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 29-38 Feb. 1984 refs
(Contract NAS7-918)
Avail: NTIS HC A17/MF A01 CSCL 21H

An experimental program was conducted to evaluate very low thrust and low chamber pressure thruster technology using gaseous oxygen (GO2) and gaseous hydrogen (GH2) propellants for spacecraft and satellite reaction control system (RCS) application. This program is a continuation of the GO2/GH2 ignition technology study, wherein both electric spark and catalytic igniters were evaluated. A nominal 2.2-N (0.5-lb (sub f)) thruster with a coaxial-type injector and a rhenium metal thrust chamber was used to develop design data and evaluate the use of a hydrogen film-barrier to prevent the high-temperature oxidation of the rhenium. Initial tests of this configuration have been very encouraging, with delivered vacuum specific impulse ranging up to 4098 N-s/kg (418 lb(sub f)/s/lb(sub m) at an O/F ratio of 3.5:1 and chamber pressure of 485 kN/sq m (70 psia). Successful ignitions have been obtained using an experimental low-energy inductive-type spark exciter delivering 0.2 mJ per spark at test cell pressure as low as 0.014 kN/sq m (5.0 psia). Total engine operating time to date with a rhenium chamber has exceeded one hour of combined steady-state and multiple-starts (pulse-mode) operations without measurable thrust chamber deterioration.
Author

N84-29912# Marquardt Corp., Van Nuys, Calif.
LOW THRUST BIPROPELLANT ENGINE DEVELOPMENT
T. E. HUDSON, J. G. CAMPBELL, and R. C. STECHMAN *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 47-53 Feb. 1984
Avail: NTIS HC A17/MF A01 CSCL 21H

A 1.0 lbf thrust level earth storable bipropellant rocket engine was developed to meet the operational requirements of the next generation of three axis and spin stabilized controlled military and commercial satellites. This radiation-cooled engine design is capable of meeting all duty cycles, including long steady-state burn requirements. The engine uses torque motor or solenoid valves without compromising its operational or performance capabilities.
Author

N84-29931*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FACTORS THAT INFLUENCE SPACE STATION PROPULSION REQUIREMENTS
W. W. SMITH (Rocket Research Co., Redmond, Wash.), C. L. WILKINSON (Boeing Aerospace Co., Kent, Wash.), and M. E. VALGORA *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 303-318 Feb. 1984 refs
(Contract NAS3-23353)
Avail: NTIS HC A17/MF A01 CSCL 21H

The manned space station major propulsion system requirements were outlined and the important influencing factors were defined. To accomplish these objectives, a range of configuration designs were defined and subjected to an environmental perturbation analysis over a range of altitudes. Sensitivities to design and operation were identified and top level propulsion system requirements defined. Conclusions and recommendations regarding operational altitude, configuration design, and ways to minimize the propellant requirements for the space station mission were discussed. A principal finding is that station modules and, more importantly, solar array configuration design, must be limited to strictly balanced or gravity gradient stable designs, otherwise propulsion and momentum system requirements will be unacceptably large.
Author

N84-33462*# Rocket Research Corp., Redmond, Wash.
RADIATIVE RESISTOJET PERFORMANCE CHARACTERIZATION TESTS Final Report
C. I. MIYAKE Sep. 1984 55 p refs
(Contract NAS3-23868)
(NASA-CR-174763; NAS 1.26:174763; REPT-84-R-958) Avail: NTIS HC A04/MF A01 CSCL 21H

The test article, test approach, data analysis and results of a study undertaken to characterize performance of the augmentation section of the Rocket Research Company Augmented Catalytic Thruster as a gas resistojet using hydrogen, nitrogen and ammonia as propellants are described. This renewed interest in resistojets is a result of propulsion systems definition studies which indicate potential application to space station auxiliary propulsion.
Author

N84-34474*# Dayton Univ., Ohio.
THE SCEPTRE FACILITY: IMPROVED SIMULATION OF THE SPACE ENVIRONMENT THROUGH THE APPLICATION OF ADVANCED TECHNOLOGY
J. D. RULEY *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 57-71 1984 refs
(Contract F33615-82-C-5039)
Avail: NTIS HC A13/MF A01 CSCL 14B

SCEPTRE (Space Combined Effects Primary Test Research Equipment) is the Air Force Materials Laboratory's primary device for performance testing of spacecraft thermal control materials. It has been undergoing a major upgrade in the last two years aimed at making it capable of simulating the synergistic effects of vacuum, ultraviolet radiation, and electron radiation. In the course of this work, a number of advances have been made in the areas of computer data processing, solar simulation, and the analysis of test results.
Author

N84-34479*# Aerospace Corp., El Segundo, Calif. Chemistry and Physics Lab.
INTRODUCTION TO SIMULATION OF UPPER ATMOSPHERE OXYGEN SATELLITE EXPOSED TO ATOMIC OXYGEN IN LOW EARTH ORBIT
D. R. PEPLINSKI, G. S. ARNOLD, and E. N. BORSON *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 133-145 1984 refs
Avail: NTIS HC A13/MF A01 CSCL 04A

A brief review of atmospheric composition in low Earth orbit is presented. The flux of ambient atomic oxygen incident on a surface orbiting in this environment is described. Estimates are presented of the fluence of atomic oxygen to which satellite surfaces in various orbits are exposed.
Author

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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.

A84-30528
GENERATION OF SYMBOLIC EQUATIONS OF MOTION FOR COMPLEX SPACECRAFT USING FORMALISM NEWEUL
E. J. KREUZER and W. O. SCHIEHLEN (Stuttgart, Universitaet, Stuttgart, West Germany) IN: Astrodynamics 1983; Proceedings of the Conference, Lake Placid, NY, August 22-25, 1983. Part 1 . San Diego, CA, Univelt, Inc., 1984, p. 21-36. refs
(AAS PAPER 83-302)

In this paper it is demonstrated that an existing program for the computerized generation of symbolic equations of motion of terrestrial multibody systems may easily be extended to include orbiting spacecraft. The necessary dynamical background of the NEWEUL program is presented in detail along with the extensions

needed for the description of the spacecraft motion. Two examples using spacecraft models from the literature are included. Author

A84-31734*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CLOSED-FORM SOLUTIONS FOR A CLASS OF OPTIMAL QUADRATIC REGULATOR PROBLEMS WITH TERMINAL CONSTRAINTS
J.-N. JUANG (NASA, Langley Research Center, Hampton, VA), J. D. TURNER, and H. M. CHUN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: 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 . New York, American Institute of Aeronautics and Astronautics, 1984, p. 449-456. refs
(AIAA PAPER 84-1047)

Closed-form solutions are derived for coupled Riccati-like matrix differential equations describing the solution of a class of optimal finite time quadratic regulator problems with terminal constraints. Analytical solutions are obtained for the feedback gains and the closed-loop response trajectory. A computational procedure is presented which introduces new variables for efficient computation of the terminal control law. Two examples are given to illustrate the validity and usefulness of the theory. Author

A84-35172#
OPTIMIZING THE SPACE TRANSPORTATION SYSTEM WITH A SPACE FUELING STATION AND TUG
J. M. SPONABLE (USAF, Space Div., Los Angeles Air Force Station, CA) and A. R. DEWISPELARE (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, SAE, and ASME, Joint Propulsion Conference, 20th, Cincinnati, OH, June 11-13, 1984. 12 p. refs
(AIAA PAPER 84-1324)

Nonlinear optimization techniques are used to quantify the impact of adding a space fueling station and reusable tug to the Space Transportation System (STS). The Shuttle deploys all space traffic to the station at which a tug is used to launch a representative satellite fleet across the entire gamut of inclinations and altitudes. Annual Shuttle launches are calculated by summing the total mass required to deploy and operate the system, and dividing by the Shuttle cargo mass capacity. The station altitude and inclination are variables specified when Shuttle launches are minimized. Launch rates for one, two and three station scenarios are compared to the author's estimate of the corresponding rates for current STS operations. The use of both chemically and ion propelled tugs are evaluated. Applying vector optimization to the latter minimizes both the average tug flight time and annual Shuttle launches. The resulting efficient operating frontier specifies a set of optimal inclinations, altitudes and tug sizes. The Shuttle launch rates for the chemical and ion systems are potentially less than for current STS projections. Equally important, for existing ion thruster technology the round trip flight time of the tug to geosynchronous orbit can be less than 60 days. Author

A84-35535
OPTIMIZATION OF LARGE COMPOSITE STRUCTURES WITH STRENGTH AND LOCAL STABILITY RESTRICTIONS [OPTIMIZATSIIA BOL'SHIKH KOMPOZITNYKH KONSTRUKTSII S OGRANICHENIIAMI PO PROCHNOSTI I LOKAL'NOI USTOICHIVOSTI]
R. I. NEPERSHIN, I. B. GINKO, and V. G. PILOSIAN (Akademiia Nauk SSSR, Institut Mashinovedeniia, Moscow, USSR) (Vsesoiuznaia Konferentsiia po Mekhanike Polimernykh i Kompozitnykh Materialov, 5th, Riga, Latvian SSR, Oct. 1983) Mekhanika Kompozitnykh Materialov (ISSN 0203-1272), Mar.-Apr. 1984, p. 313-319. In Russian. refs

A computer program is developed for the optimization of large three-dimensional composite structures using the energy criterion of optimality with restrictions on thickness, strength, and local stability of the elements of the finite-element model of the structure. This technique involves various strength criteria and the local stability of both continuous and three-layer membrane elements with a honeycomb filler and composite carrying layers. Optimization examples are given for a composite cellular cantilever beam and for a carbon-plastic aerodynamic fin structure. The respective finite-element models contained 108 and 580 independent design variables. The spars and ribs of the fin are modeled as shear and rod elements, and the web material is considered to be uniform and orthotropic. J.N.

A84-36944
PRESENT-DAY SPACE AND SPACECRAFT MECHANICS PROBLEMS
F. RIMROTT (Toronto, University, Toronto, Canada) Canadian Society for Mechanical Engineering, Transactions (ISSN 0315-8977), vol. 8, no. 1, 1984, p. 6-15. refs

Mechanical problems in the design of large flexible-body spacecraft are discussed and illustrated in a general review based primarily on NASA experience and planning. The requirements for future large spacecraft are summarized, and topics such as response to the centrifugal field and the atmosphere, deployable elements, open-section tubing, blankets, substructuring and ground testing, material properties, structural control and damping, tethered and interacting spacecraft, space robotics, and dissipative dynamics are examined. Drawings, diagrams, and graphs are provided. T.K.

A84-37656#
POTENTIAL ROLE OF TETHERS IN SPACE TRANSPORTATION
J. A. CARROLL and A. H. CUTLER (California, University, La Jolla, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 20th, Cincinnati, OH, June 11-13, 1984. 8 p. refs
(AIAA PAPER 84-1448)

The utility of tethers in space transportation is described. Tethers allow rendezvous between spacecraft in substantially different orbits without using propellant. They allow co-orbiting spacecraft to exchange momentum and separate, thus allowing momentum from a re-entering spacecraft (such as the Shuttle) to be given to one remaining on orbit (such as the space station). This momentum exchange also allows a high impulse thruster at one location to efficiently boost many payloads. Mechanical pumping of the tether can couple to orbital eccentricity or nonspherical terms in the gravitational field allowing changes in the orbital energy and angular momentum without expending propellant. Electrically conducting tethers which carry a current couple to the earth's magnetic field. In low earth orbit there is sufficient plasma density to allow large currents to flow through the tether and close the loop efficiently through the plasma. The tether can be used as a highly energy efficient electric thruster (2-8 KW/N) which expends no propellant. Practical vehicles with an electrodynamic tether propulsion system can go from any arbitrary low earth orbit to any other arbitrary low earth orbit in a few months. Tethers can allow low thrust vehicles to take surface samples from bodies such as the moon. The above systems could all be in use by 1995. Author

A84-38127
INTERNATIONAL SYMPOSIUM ON SPACE TECHNOLOGY AND SCIENCE, 13TH, TOKYO, JAPAN, JUNE 28-JULY 3, 1982, PROCEEDINGS
I. WADA, ED. Symposium sponsored by the National Space Development Agency of Japan, Nippon Telegraph and Telephone Public Corp., Mitsubishi Corp., et al. Tokyo, AGNE Publishing, Inc., 1982, 1746 p.

The progress of various space technologies as a result of national and international efforts is explored. The space programs of ten nations are described, as are advanced propulsion systems, propellants and testing techniques, materials and structures for spacecraft, and the legal implications of space activities. Flight dynamics, astrodynamics, and fluid dynamics of spacecraft within and beyond the atmosphere are investigated. Thermophysics and thermochemical problems for space materials research and spacecraft materials, power sources, and heat radiators are examined. Space communications technologies, particularly for

telemetry and telecommunications, are surveyed. Guidancg and control applications are discussed, together with systems engineering for spacecraft. Attention is also given to balloons and recovery technology, earth and planetary observations, scientific exploration, space science astronomy, space medicine and biology, and materials processing. M.S.K.

A84-38184
ON THE OPTIMAL TRANSFER ORBIT AS A TERMINAL RENDEZVOUS PHASE
M. KURIHARA, Y. KOSAKA (Fujitsu, Ltd., Tokyo, Japan), and T. TADAKAWA (National Space Development Agency of Japan, Sakura, Ibaraki, Japan) IN: International Symposium on Space Technology and Science, 13th, Tokyo, Japan, June 28-July 3, 1982, Proceedings . Tokyo, AGNE Publishing, Inc., 1982, p. 451-456.

A study was made of a relative motion of two vehicles near a geostationary altitude, using a computer code for a motion simulation. An energy optimal condition was also studied as to a transfer angle and a phase angle of a maneuvering vehicle. The energy optimum pair of angles that satisfies some tentative requirements on a line of sight condition was found to be around 160 and 1.08 deg (when a relative altitude is taken to be -400 km) respectively. Author

A84-38549
ASCENT TO ORBIT: A SCIENTIFIC AUTOBIOGRAPHY
A. C. CLARKE New York, Wiley-Interscience, 1984, 234 p. refs

A collection of the scientific articles of the author is presented. The papers are on a variety of subjects, including waves and circuits, satellite communications, rockets and warfare, amateur astronomy, astronautics, electronics and spaceflight, interstellar robot probes, and mathematical recreation. Each paper is put in a biographical context. C.D.

A84-38890#
IMPROVEMENTS IN SOLAR SIMULATION THROUGH ADVANCED TECHNOLOGY OPTICS
J. D. RULEY and R. L. VISSOC (Dayton, University, Dayton, OH) IN: Annual Mini-Symposium on Aerospace Science and Technology, 10th, Wright-Patterson AFB, OH, March 20, 1984, Proceedings . New York, American Institute of Aeronautics and Astronautics, 1984, p. 6-1-1 to 6-1-3.

Recent advances in high-intensity optical systems have made possible considerable improvements in solar simulator design. At AFWAL's space simulation facility, these advances have been applied to a prototype simulator, resulting in a 100 percent efficiency increase over conventional systems. This increased efficiency will permit more rapid testing of spacecraft materials for resistance to the extraterrestrial solar flux, resulting in a substantially reduced cost of simulation. Author

A84-39063
OVERVIEW OF THE INDUSTRIALIZATION OF SPACE
G. K. C. PARDOE (General Technology Systems, Ltd., Brentford, Middx., England) (Royal Society, Meeting on the Industrialization of Space, London, England, Dec. 7, 8, 1983) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 4, no. 2, 1984, p. 65-76.

The present status of space industrialization is reviewed with attention given to the role played by satellites in education, mobile communications on land, navigation, earth observations and meteorology. Space transportation for the injection of satellites into orbit, and more recently the process of recovering them, is shown to be an area of considerable commercial opportunity and projected as an area of vast importance in the future. The recent flight of Spacelab is considered, along with the deployment of SPAS from a Shuttle in September 1983 and its retrieval by the RMS. SPAS and its onboard observation package MOMS is noted to represent an important operational facility for the future. International industrial collaboration may play an essential role in the consideration of other projects among which the Space Station figures prominently. In conclusion, it is noted that because of its potential for industrialization and extensive commercial activities, space has become an expensive business and there is therefore a need for the interest of nonaerospace industries, particularly in the pharmaceutical sector to get involved. J.P.

A84-40601
SPACE - THE NEXT TWENTY YEARS; PROCEEDINGS OF THE TWENTIETH SPACE CONGRESS, COCOA BEACH, FL, APRIL 26-28, 1983
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, 426 p.

The subjects discussed are related to private enterprise in space, computers and simulators, orbital operations, energy applications in space, STS cargos, future space transportation systems, and a space station. The presence of diamagnetic oxygen in space is considered along with X-ray examination of possible QSO models, the operation of the solar powered Stirling engine in space, cancer observation in zero G, the effects of zero-gravity environment on the crossing over mechanism of yeast chromosomes, planaria regeneration in zero-gravity, the design of microgravity space environments to enhance crew health and productivity, artificial intelligence and man in space, risk and investment decisions, and computer graphics. Attention is given to a comparison of manned and unmanned orbital construction and maintenance, a laboratory in space, biomedical requirements for space cabin environment, hydrogen from renewable energy, and alternative liquid fuels for transportation. G.R.

A84-40606* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE SIMULATION IN THE NEXT 20 YEARS
M. J. KNORRE (NASA, Johnson Space Center, Shuttle Data and Simulation Branch, Houston, TX) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IB-51 to IB-56.

This is a brief overview of logically expected advancements in the area of space simulation over the next twenty years. Current NASA Space Shuttle simulations will be upgraded to support more complex payload and on-orbit tasks. This includes the ability to integrate various remote ground facilities with a real time space mission simulator and an expanded use of efficient part-task simulations. Software compatibilities between simulators will increase and each simulator will have a more combined training and engineering role. Software development processors will be increasingly internetted to an integrated data processing system. Author

A84-40632
DESIGN OF MICROGRAVITY SPACE ENVIRONMENTS TO ENHANCE CREW HEALTH, MORALE, AND PRODUCTIVITY
L. BELL (Houston, University, Houston, TX) IN: Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1984, p. IIIC-1 to IIIC-14.

This paper discusses habitability issues and design concepts which apply to large and small space stations. Special emphasis is placed upon opportunities and constraints posed by microgravity and upon special problems and needs associated with long-term isolation under confined conditions. Design concepts are illustrated through photographs of drawings and models. Types of functional areas addressed include crew quarters, food preparation/dining areas, work areas, and exercise/recreation facilities. Author

A84-43364
SPACE LAW AND PRACTICE IN THE 1980'S AND BEYOND - A PRACTITIONER'S PERSPECTIVE
M. A. ROTHBLATT (George Washington University, Washington, DC) Journal of Space Law, vol. 12, Spring 1984, p. 26-39. refs

Three categories of space law are explored: communications, transportation, and property. Telecommunications activities comprise data transfer to and from the earth, between spacecraft, and from remote sensing and astrophysics spacecraft. Frequency allocations are guided by ITC regulations. Broadcasts between nations are covered by the Intelsat agreement, which serve to inhibit countries from establishing their own international telecommunications networks. Transportation issues arise from the use of launch vehicles, reusable spacecraft, and satellites. Problems arise due to launching nations' liability and authority over all spacecraft, even privately owned, launched from the respective nations. Property issues are associated with artificial (functional or debris) space objects and natural objects like the moon and earth-grazing asteroids. Treaty provisions prohibiting the appropriation of celestial objects by any nation may conflict with the capabilities of some nations to mine asteroids or the moon and build large space structures. Specific fields of law and appropriate organizations before which space law is practiced are delineated. M.S.K.

A84-44134
U.S. ADOPTS NEW SPACE STRATEGY
C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 121, Aug. 27, 1984, p. 14-16.

Features of an administration-approved National Space Policy for the U.S. are described. Among the directives are joint NASA/DoD examinations of concepts for a reconnaissance/bomber to replace the SR-71 and have space capabilities, evaluation of booster requirements for 300,000 lb payloads, and a winged, reusable replacement for the Shuttle with a greater load capability. The vehicles are to be ready after 1995. NASA has been directed to obtain full cost recovery for Shuttle launches by late 1988, although full recovery was not planned until operational status for 12 yr had been achieved. The space station will be an $8 billion international program. A space commercialization office will be opened within NASA and commercial management and marketing of Shuttle payload capabilities will soon begin. Funding will be allocated in 1986 for a research vehicle that will be dropped from the Orbiter and fly hypersonic through the atmosphere in support of advanced vehicle development. It can be noted that the accelerated full-cost recovery status of Shuttle launches is being urged at the same time as are competing commercial and USAF expendable launch vehicles. M.S.K.

A84-44151
SHARING THE GRAND STRATEGY
M. A. G. MICHAUD Space World (ISSN 0038-6332), vol. U-8-248, Aug. 1984, p. 5-9.

The main goals toward which large scale space activities are moving are examined. It is asserted that humans are more realistically assessing the possibilities of living on and exploiting other planets, expanding efforts to contact extraterrestrial intelligence, improving space flight capabilities, and planning space-based macroengineering projects. The latter include mining the moon and asteroids, building space colonies and factories, and terraforming other planets. The funding for the work is subject to political vagaries and competition. It is suggested that the activities competing for funding should be considered as parts of a larger, comprehensive program, a strategy for the human species designed to improve the chances for survival. All data gathering missions are essential for extraplanetary ventures, and space flight serves both data acquisition and operational objectives. A near-term goal, visiting an earth-grazing asteroid, is recommended. M.S.K.

A84-45530
SPACE AND SOCIETY: CHALLENGES AND CHOICES; PROCEEDINGS OF THE CONFERENCE, UNIVERSITY OF TEXAS, AUSTIN, TX, APRIL 14-16, 1982
P. ANAEJIONU, ED., N. C. GOLDMAN, ED. (Texas, University, Austin, TX), and P. J. MEEKS, ED. (Georgia, University, Athens, GA) Conference sponsored by the University of Texas and American Astronautical Society. San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 59), 1984, 438 p. No individual items are abstracted in this volume.

The book discusses the impact of present and future space activity on society, through economic and political effects. The general topics include: the U.S. space structure, policy, and political economics and space industrialization, colonizing, and energy technology; foreign space programs including U.S.-European competition; Soviet spaceflight; Japanese space industrialization; and Third World perspectives; and space applications in the areas of remote sensing, Landsat land monitoring, satellite power stations, and communication satellite social and public policy implications. A section on future space stations and colonies, lunar and asteroid mining, and ecological problems in life support systems is also presented. J.P.

A84-46723
PRECISION CLEANING OF LARGE COMPLEX STRUCTURES. II
S. C. KWAN, R. S. TOMER, and K. D. MASON (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) Journal of Environmental Sciences (ISSN 0022-0906), July-Aug. 1984, p. 27-30. refs

This paper is concerned with a program which has the objective to develop precision cleaning methods for the achievement of MIL-STD-1246A cleanliness levels on large complex structures. Increased spacecraft/payload cleanliness is needed as a result of technology advances and long-life reliability requirements for space systems. Cleaning techniques must, therefore, be devised to reduce particle concentrations and nonvolatile residue (NVR) to acceptable levels on large spacecraft structures and components. A description is given of results obtained from solvent wipe precision cleaning procedures for complex structures which were not readily cleaned by solvent flushing. Attention is given to the three phases involved in the approach to the project, the unhemmed polyester wipers, the solvent, precleaning, and the procedures of precision cleaning. G.R.

N84-22605* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
APPARATUS FOR RELEASABLY CONNECTING FIRST AND SECOND OBJECTS IN PREDETERMINED SPACE RELATIONSHIP Patent
J. A. CHANDLER, inventor (to NASA) 14 Feb. 1984 11 p Filed 14 Apr. 1982
(NASA-CASE-MSC-18969-1; US-PATENT-4,431,333; US-PATENT-APPL-SN-368189; US-PATENT-CLASS-403-322; US-PATENT-CLASS-244-161) Avail: US Patent and Trademark Office CSCL 22B

A releasable apparatus that connects first and second space objects, such as a spacecraft and a space vehicle, in predetermined spaced relationship is described. The apparatus comprises at least one probe member mounted on the first object, having an elongated shank portion, the distal end of which is provided with a tapered nose portion. At least one drogue assembly is mounted on the second space object for releasably capturing the probe member upon the first and second objects being brought into close proximity with each other.

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

N84-22607*# Boeing Aerospace Co., Kent, Wash.
DEFINITION OF TECHNOLOGY DEVELOPMENT MISSIONS FOR EARLY SPACE STATIONS. LARGE SPACE STRUCTURES, PHASE 2, MIDTERM REVIEW
22 Mar. 1984 105 p
(Contract NAS8-35043)
(NASA-CR-171004; NAS 1.26:171004) Avail: NTIS HC A06/MF A01 CSCL 22B

The large space structures technology development missions to be performed on an early manned space station was studied and defined and the resources needed and the design implications to an early space station to carry out these large space structures technology development missions were determined. Emphasis is being placed on more detail in mission designs and space station resource requirements. Author

N84-22610*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
TANKER ORBIT TRANSFER VEHICLE AND METHOD Patent Application
G. G. RYAN, inventor (to NASA) 8 Feb. 1983 23 p
(NASA-CASE-MSC-20543-1; US-PATENT-APPL-SN-580574)
Avail: NTIS HC A02/MF A01 CSCL 22B

A method and apparatus for transportation between orbits are presented. A tanker orbit transfer vehicle includes two stages each of which includes a fuel container. The first stage may be left in an intermediate parking orbit while the second stage goes on to carry out a mission, thereafter to return to rendezvous and dock with the first stage. Fuel carried by the first stage may be utilized for travel of the two stages between the starting orbit and the parking orbit, and for return to the starting orbit. An aerobrake may be included in the system for use in the return to the initial orbit. NASA

N84-23668*# National Aeronautics and Space Administration, Washington, D. C.
FUTURE SPACE TRANSPORT
S. D. GRISHIN and S. V. CHEKALIN Mar. 1984 46 p refs Transl. into ENGLISH of the book "Kosmicheskiy Transport Budushchevo" Moscow, Znaniye Press, 1983 p 1-59 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-3541)
(NASA-TM-77554; NAS 1.15:77554) Avail: NTIS HC A03/MF A01 CSCL 22B

Prospects for the mastery of space and the basic problems which must be solved in developing systems for both manned and cargo spacecraft are examined. The achievements and flaws of rocket boosters are discussed as well as the use of reusable spacecraft. The need for orbiting satellite solar power plants and related astrionics for active control of large space structures for space stations and colonies in an age of space industrialization is demonstrated. Various forms of spacecraft propulsion are described including liquid propellant rocket engines, nuclear reactors, thermonuclear rocket engines, electrorocket engines, electromagnetic engines, magnetic gas dynamic generators, electromagnetic mass accelerators (rail guns), laser rocket engines, pulse nuclear rocket engines, ramjet thermonuclear rocket engines, and photon rockets. The possibilities of interstellar flight are assessed. A.R.H.

N84-23670*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
CONCEPTUAL DESIGN STUDY. SCIENCE AND APPLICATIONS SPACE PLATFORM (SASP). FINAL BRIEFING Final Briefing Report
1980 161 p refs
(Contract NAS8-33592)
(NASA-CR-173520; NAS 1.26:173520; MDC-G9300) Avail: NTIS HC A08/MF A01 CSCL 22B

The modularity, shape, and size of the recommended platform concept offers a low investment, early option to demonstrate the system; flexibility to conservative growth; adaptability to great variety of multi or dedicated payload groups; and good dispersion and viewing freedom for payloads. Platform configuration effectively supports 80 to 85% of the NASA/OSS and OSTA payloads. The subsystem approaches recommended are based on cost effective distribution of functions. B.G.

N84-23672*# Boeing Aerospace Co., Seattle, Wash.
ADVANCED PLATFORM SYSTEMS TECHNOLOGY STUDY. VOLUME 2: TRADE STUDY AND TECHNOLOGY SELECTION Final Report, Jul. 1982 - Apr. 1983
Apr. 1983 181 p refs
(Contract NAS8-34893)
(NASA-CR-173522; NAS 1.26:173522; D180-27487-2-VOL-2)
Avail: NTIS HC A09/MF A01 CSCL 22B

Three primary tasks were identified which include task 1-trade studies, task 2-trade study comparison and technology selection, and task 3-technology definition. Task 1 general objectives were to identify candidate technology trade areas, determine which areas have the highest potential payoff, define specific trades within the high payoff areas, and perform the trade studies. In order to satisfy these objectives, a structured, organized approach was employed. Candidate technology areas and specific trades were screened using consistent selection criteria and considering possible interrelationships. A data base comprising both manned and unmanned space platform documentation was used as a source of system and subsystem requirements. When requirements were not stated in the data base documentation, assumptions were made and recorded where necessary to characterize a particular spacecraft system. The requirements and assumptions were used together with the selection criteria to establish technology advancement goals and select trade studies. While both manned and unmanned platform data were used, the study was focused on the concept of an early manned space station. Author

N84-23673*# Boeing Aerospace Co., Seattle, Wash.
ADVANCED PLATFORM SYSTEMS TECHNOLOGY STUDY. VOLUME 3: SUPPORTING DATA Final Report, Jul. 1982 - Apr. 1983
Apr. 1983 303 p refs
(Contract NAS8-34893)
(NASA-CR-173523; NAS 1.26:173523; D180-27487-3-VOL-3)
Avail: NTIS HC A14/MF A01 CSCL 22B

The overall study effort proceeded from the identification of 106 technology topics to the selection of 5 for detail trade studies. The technical issues and options were evaluated through the trade process. Finally, individual consideration was given to costs and benefits for the technologies identified for advancement. Eight priority technology items were identified for advancement. Supporting data generated during the trade selection and trade study process were presented. Space platform requirements, trade study and cost benefits analysis, and technology advancement planning are advanced. The structured approach used took advantage of a number of forms developed to ensure that a consistent approach was employed by each of the diverse specialists that participated. These forms were an intrinsic part of the study protocol. Author

N84-23674*# Boeing Aerospace Co., Seattle, Wash.
ADVANCED PLATFORM SYSTEMS TECHNOLOGY STUDY. VOLUME 4: TECHNOLOGY ADVANCEMENT PROGRAM PLAN Final Report, Jul. 1982 - Apr. 1983
Apr. 1983 85 p refs
(Contract NAS8-34893)
(NASA-CR-173524; NAS 1.26:173524; D180-27487-4) Avail: NTIS HC A05/MF A01 CSCL 22B

An overview study of the major technology definition tasks and subtasks along with their interfaces and interrelationships is presented. Although not specifically indicated in the diagram, iterations were required at many steps to finalize the results. The development of the integrated technology advancement plan was initiated by using the results of the previous two tasks, i.e., the trade studies and the preliminary cost and schedule estimates for the selected technologies. Descriptions for the development of each viable technology advancement was drawn from the trade

studies. Additionally, a logic flow diagram depicting the steps in developing each technology element was developed along with descriptions for each of the major elements. Next, major elements of the logic flow diagrams were time phased, and that allowed the definition of a technology development schedule that was consistent with the space station program schedule when possible. Schedules show the major milestone including tests required as described in the logic flow diagrams. Author

N84-24605# Engins Matra, Toulouse (France).
THE ROLE OF ONBOARD INTELLIGENCE AND OF ORBITAL SERVICING IN THE INCREASE OF SATELLITE LIFETIME [ROLE DE LINTELLIGENCE DE BORD ET DE LENTRETIEN EN ORBITE DANS LACCROISSEMENT DE LA DUREE DE VIE DES SATELLITES]
P. C. COUGNET and J. P. SOTTA *In* AGARD Guidance and Control Tech. for Advan. Space Vehicles 14 p Jan. 1984 In FRENCH
Avail: NTIS HC A15/MF A01

The continued increase in satellite lifetime is now or is going to become critical with respect to the maintenance of system reliability and the risk of mission obsolescence. Resource to redundant equipment becomes more and more penalizing particularly because of the limited capacities of the launch methods. Futhermore, the classic satellite concept does not permit avoiding mission obsolescence or long duration life. To remedy these problems, two possible complementary methods are presented. One involves the use of satellite onboard intelligence to enable better management of its configuration and platform subsystems in order to assure a high level of availability to he satellite. The other solution is orbital servicing which permits periodic adjustment of reliability and platform autonomy as well as the eventual exchange of the payload. This solution calls for new techniques: rendezvous, assembling, and the space robot. Transl. by A.R.H.

N84-25083*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DESIGN AND TEST OF A LOW-TEMPERATURE LINER DRIVER/RATE CONTROLLER
C. H. LOWRY *In its* The 18th Aerospace Mech. Symp. p 65-77 May 1984
Avail: NTIS HC A14/MF A01 CSCL 13I

The design and testing of a force/rate control device used to deploy an Earth shield on an orbiting satellite is described. Test experience, failure modes, and applications are emphasized. M.A.C.

N84-25091*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
ANTENNA TRACKING MECHANISM FOR GEOSTATIONARY SATELLITES
C. M. FRANCIS *In* NASA. Goddard Space Flight Center The 18th Aerospace Mech. Symp. p 203-214 May 1984
Avail: NTIS HC A14/MF A01 CSCL 13I

The design and development of a continuous duty cycle antenna tracking mechanism (ATM) for geostationary communications satellites is described. The FACC requirements for an ATM and description of the development mechanism designed and built for the program are presented. The mechanism mechanical configuration and component performance is documented along with its launch and operational constraints. The proposed development tests and the results of computer simulations are discussed. The advantages of this mechanism are its simplicity with inherent reliability, low mass, high stiffness, and ability to accurately point a wide range of antenna sizes. Author

N84-25531# Committee on Appropriations (U. S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Dept. of Housing and Urban Develop.-Independent Agencies Appropriation Bill, 1985 p 33-38 Washington GPO 1984
Avail: US Capitol, House Document Room

The appropriations for the National Aeronautics and Space Administration are described. The research and development account includes funding for the space station and various programs involving the application of space capabilities in remote sensing of land resources, ocean and atmospheric conditions; materials processing; and communications. In the area of space science it includes projects designed to explore the solar system and expand man's knowledge of the universe. Also included under this heading are development programs involving aeronautics technology which support the civilian and military capability of the United States in the area of airframe and engine manufacturing. M.G.

N84-25533# Committee on Appropriations (U. S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION RESEARCH AND DEVELOPMENT
In its Dept. of Housing and Urban Develop.-Independent Agencies Appropriations Act, 1985 p 22-26 Washington GPO 1984
Avail: US Capitol, Senate Document Room

The text for an act making appropriations for NASA programs and activities for the fiscal year ending September 30, 1985 is given. Construction, maintenance, research and development, space stations, the Gamma Ray Observatory, the Space Telescope, the Venus radar mapper mission, and the Galileo mission are funded. Money is also appropriated for the National Science Foundation, and the National Credit Union Administration. R.J.F.

N84-25736* National Aeronautics and Space Administration, Washington, D. C.
TECHNOLOGY FOR LARGE SPACE SYSTEMS: A BIBLIOGRAPHY WITH INDEXES
Jan. 1984 115 p refs
(NASA-SP-7046(10); NAS 1.21:7046(10)) Avail: NTIS HC $13.00 CSCL 22A

The bibliography lists 408 reports, articles and other documents introduced into the NASA scientific and technical information system to provide helpful information to the researcher, manager, and designer in technology development and mission design in the area of large space system technology. Subject matter is grouped according to systems, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. M.A.C.

N84-26191*# Iowa Univ., Iowa City. Dept. of Physics and Astronomy.
STS-3/OSS-1 PLASMA DIAGNOSTICS PACKAGE (PDP) MEASUREMENTS OF ORBITER-GENERATED V X B POTENTIALS AND ELECTROSTATIC NOISE
S. D. SHAWHAN and G. B. MURPHY *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 119-123 25 Jan. 1983
(Contract NAS8-32807)
(AD-P002105) Avail: NTIS HC A18/MF A01 CSCL 20I

The Plasma Diagnostics Package (PDP) was flown as part of OSS-1 pallet on the Space Shuttle fight STS-3 in March 1982. During this eight-day mission, the PDP was operated in its pallet position and on the Remote Manipulator System. PDP measurements included dc electric and magnetic fields, ac magnetic fields to 100 kHz; ac electric fields to 800 MHz and at S-band, energetic ions and electrons from 2.5 eV to 50 KeV; total electron flux; the ion mass spectrum, energy distribution, and streaming direction; the electron density and temperature, and the neutral pressure. Author

N84-26197# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Space Sciences Dept.
INTERACTIONS BETWEEN A LARGE BODY AND ITS ENVIRONMENT IN A LOW POLAR ORBIT
R. GRARD, K. KNOTT, and A. PEDERSEN *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 175-184 25 Jan. 1983 refs
(AD-P002111) Avail: NTIS HC A18/MF A01 CSCL 20C

The parameters that characterize the high latitude ionosphere are reviewed. The electron current density collected by a surface is evaluated in typical environments and is compared to the emitted flux of photoelectrons. The polarity and order of magnitude of the relative surface potentials are tentatively estimated for various situations: sunlight, shadow, and eclipse. Other types of interactions encountered by large structures, such as magnetic induction effect and plasma instability triggering, are also discussed. Author

N84-26207# Utah State Univ., Logan. Center for Atmospheric and Space Sciences.
MODELS OF THE IONOSPHERIC ENVIRONMENT
R. W. SCHUNK *In* AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 311-319 25 Jan. 1983 refs
(AD-P002121) Avail: NTIS HC A18/MF A01 CSCL 04A

During the last decade our understanding of the physical processes that control ionospheric behavior has greatly increased. As a consequence, comprehensive, large scale, quasi static models of the high latitude ionospheric are developed to describe the aurora, the E region conductivity and currents, the F region, and the polar wind. In addition, 2 D particles in a cell computer codes are developed to study the microphysics connected with auroral acceleration processes. These studies involve models of double layers and anomalous resistivity to explain auroral electron precipitation as well as models describing the stochastic acceleration of ionospheric ions by both electrostatic ion cyclotron waves and lower hybrid waves to explain ion beams and conics. GRA

N84-26476# Committee on Appropriations (U. S. Senate).
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT-INDEPENDENT AGENCIES APPROPRIATIONS BILL, 1985
Washington GPO 1984 116 p Rept. to accompany H. R. 5713 presented by the Comm. on Appropriations, 98th Congr., 2nd Sess., 7 Jun. 1984
(S-REPT-98-506; GPO-35-356) Avail: US Capitol, Senate Document Room

Federal aappropriations for the Department of Housing and Urban Development and for sundry independent agencies, boards, commissions, corporations, and offices are enumerated and discussed. Recommendations by the House Committee on Appropriations are given along with a detailed description of each program considered. Specific programs discussed include: urban research, urban development, urban planning, solar energy, environmental quality, space stations, space shuttle orbiters, scientific research and education, and selective service. This bill, H.R. 5713, makes appropriations for the fiscal year ending September 30, 1985.

N84-26477# Committee on Appropriations (U. S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Dept. of Housing and Urban Develop.-Independent Agencies Appropriation Bill, 1985 p 63-71 1984
Avail: US Capitol, Senate Document Room

Federal appropriations for various NASA programs are enumerated and discussed. Recommendations by the House Committee on Appropriations are given along with a detailed description of each program considered. This bill, H.R. 5713, makes appropriations for the fiscal year ending September 30, 1985: Specific NASA programs and research projects discussed include: the space station, space shuttle orbiters, spacelab, Gamma Ray Observatory, Galileo project, space telescopes, Atlas Centaur launch vehicles, robotics, Venus probes, and Mars probes. R.S.F.

N84-27560# Arizona Univ., Tucson. Optical Sciences Center.
INNOVATIVE RESEARCH IN THE DESIGN AND OPERATION OF LARGE TELESCOPES FOR SPACE: ASPECTS OF GIANT TELESCOPES IN SPACE
J. R. P. ANGEL, J. M. BECKERS, W. F. HOFFMANN, J. T. MCGRAW, R. E. PARKS, H. S. STOCKMAN, and N. J. WOOLF 1982 7 p refs
Avail: NTIS HC A02/MF A01

Eight areas of research on large space telescopes are identified and discussed. Telescope mirror technology in particular is addressed. Among the research topics described are: mirror substrates, physical optics, geometrical optics, optical surfaces, imagers, spacecraft guidance, and fiber optics. R.S.F.

N84-27604# Committee of Conference (U. S. Congress).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Making Appropriations for the Dept. of Housing and Urban Develop., and for Sundry Independent Agencies, Boards, Comm., Corp., and Offices for the Fiscal Year Ending Sep. 30, 1985, and for Other Purposes p 19-21 1984
Avail: US Capitol, House Document Room

Federal appropriations for NASA programs and research projects for the fiscal year ending September 30, 1985 are enumerated and discussed in the context of the Committee of Conference report on H.R. 5713. Monies for orbital space stations, communication satellites, launch vehicles, space shuttle orbiters, space platforms, turboprop aircraft, and robotics are considered. R.S.F.

N84-30822# Illinois Univ., Urbana. Decision and Control Lab.
A NUMERICAL ALGORITHM FOR CHAINED AGGREGATION AND MODIFIED CHAINED AGGREGATION
H. S. THARP Sep. 1983 129 p
(Contract N00014-79-C-0424; NSF ECS-82-17631)
(AD-A142394; DC-62; UILU-ENG-83-2217; R-996) Avail: NTIS HC A07/MF A01 CSCL 12A

A computer implementation of chained aggregation and modified chained aggregation using orthogonal transformations is presented. The numerical advantages associated with orthogonal matrices are highlighted. The developed algorithm is then employed to identify a reduced-order model of a large space structure. With the reduced-order model, an output feedback design is carried out. The design is shown to produce an acceptable result on the full order model. Author (GRA)

N84-31258*# Martin Marietta Corp., Denver, Colo.
SPACECRAFT SERVICING DEMONSTRATION PLAN Final Report
F. H. BERGONZ, M. A. BULBOACA, and W. L. DEROCHER, JR. Jul. 1984 312 p
(Contract NAS8-35496)
(NASA-CR-171132; NAS 1.26:171132; MCR-84-1866) Avail: NTIS HC A14/MF A01 CSCL 22B

A preliminary spacecraft servicing demonstration plan is prepared which leads to a fully verified operational on-orbit servicing system based on the module exchange, refueling, and resupply technologies. The resulting system can be applied at the space station, in low Earth orbit with an orbital maneuvering vehicle (OMV), or be carried with an OMV to geosynchronous orbit by an orbital transfer vehicle. The three phase plan includes ground demonstrations, cargo bay demonstrations, and free flight verifications. The plan emphasizes the exchange of multimission modular spacecraft (MMS) modules which involves space repairable satellites. Three servicer mechanism configurations are the engineering test unit, a protoflight quality unit, and two fully operational units that have been qualified and documented for use in free flight verification activity. The plan balances costs and risks by overlapping study phases, utilizing existing equipment for ground demonstrations, maximizing use of existing MMS equipment, and rental of a spacecraft bus. E.R.

N84-32317*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
SIMULATION REQUIREMENTS FOR THE LARGE DEPLOYABLE REFLECTOR (LDR) Final Technical Report
K. SOOSAAR Jul. 1984 29 p refs Sponsored in part by NASA. Ames Research Center
(Contract NAS8-34904)
(NASA-CR-171140; NAS 1.26:171140; CSDL-R-1725) Avail: NTIS HC A03/MF A01 CSCL 03A

Simulation tools for the large deployable reflector (LDR) are discussed. These tools are often the transfer function variety equations. However, transfer functions are inadequate to represent time-varying systems for multiple control systems with overlapping bandwidths characterized by multi-input, multi-output features. Frequency domain approaches are the useful design tools, but a full-up simulation is needed. Because of the need for a dedicated computer for high frequency multi degree of freedom components encountered, non-real time smulation is preferred. Large numerical analysis software programs are useful only to receive inputs and provide output to the next block, and should be kept out of the direct loop of simulation. The following blocks make up the simulation. The thermal model block is a classical heat transfer program. It is a non-steady state program. The quasistatic block deals with problems associated with rigid body control of reflector segments. The steady state block assembles data into equations of motion and dynamics. A differential raytrace is obtained to establish a change in wave aberrations. The observation scene is described. The focal plane module converts the photon intensity impinging on it into electron streams or into permanent film records. S.B.

N84-32318*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LARGE DEPLOYABLE REFLECTOR SCIENCE AND TECHNOLOGY WORKSHOP. VOLUME 3: SYSTEMS AND TECHNOLOGY ASSESSMENT
C. A. LEIDICH, ed. and R. B. PITTMAN, ed. Jul. 1984 65 p refs Workshop held in Pacific Grove, Calif., 21-25 Jun. 1982 3 Vol.
(NASA-CP-2275-VOL-3; A-9341-VOL-3; NAS 1.55:2275-VOL-3) Avail: NTIS HC A04/MF A01 CSCL 03A

The results of five technology panels which convened to discuss the Large Deployable Reflector (LDR) are presented. The proposed LDR is a large, ambient-temperature, far infrared/submillimeter telescope designed for space. Panel topics included optics, materials and structures, sensing and control, science instruments, and systems and missions. The telescope requirements, the estimated technology levels, and the areas in which the generic technology work has to be augmented are enumerated.

N84-32319*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LARGE DEPLOYABLE REFLECTOR SCIENCE AND TECHNOLOGY WORKSHOP. VOLUME 3: SYSTEMS AND TECHNOLOGY ASSESSMENT. INTRODUCTION
In its Large Deployable Reflector Sci. and Technol. Workshop. Vol. 3: Systems and Technol. Assessment p 1-7 Jul. 1984
Avail: NTIS HC A04/MF A01 CSCL 03A

The Large Deployable Reflector (LDR), a proposed 20 m diameter telescope designed for infrared and submillimeter astronomical measurements from space, is discussed in terms of scientific purposes, capabilities, current status, and history of development. The LDR systems goals and functional/telescope requirements are enumerated. R.S.F.

N84-32320*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TECHNOLOGY PANEL REPORTS
In its Large Deployable Reflector Sci. and Technol. Workshop. Vol. 3: Systems and Technol. Assessment p 8-47 Jul. 1984
Avail: NTIS HC A04/MF A01 CSCL 03A

Results are presented from five technology panels which convened to identify relevant technologies within their discipline for the Large Deployable Reflector (LDR) and to assess the current and projected state of these technologies. The five panels considered the following topics: optics, materials and structure, sensing and control, science instruments, and systems and missions. R.S.F.

N84-32321*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LARGE DEPLOYABLE REFLECTOR SCIENCE AND TECHNOLOGY WORKSHOP. VOLUME 3: SYSTEMS AND TECHNOLOGY ASSESSMENT. CONCLUSIONS
In its Large Deployable Reflector Sci. and Technol. Workshop. Vol. 3: Systems and Technol. Assessment p 48-54 Jul. 1984 refs
Avail: NTIS HC A04/MF A01 CSCL 03A

The physical parameters of the Large Deployable Reflector (LDR) required to achieve the anticipated astronomical objectives are reviewed briefly. System parameters and performance requirements for the LDR are enumerated. The LDR was compared with the Cosmic Background Experiment (COBE), the Infrared Astronomical Satellite (IRAS), and the Space Infrared Telescope Facility (SIRTF). Angular resolution and high resolution spectroscopy requirements for LDR were considered. R.S.F.

N84-32328*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
STUDIES OF LOW-MASS STAR FORMATION WITH THE LARGE DEPLOYABLE REFLECTOR
A. G. G. M. TIELENS and D. J. HOLLENBACH Jul. 1984 28 p refs
(NASA-TM-85960; A-9754; NAS 1.15:85960) Avail: NTIS HC A03/MF A01 CSCL 03B

Estimates are made of the far-infrared and submillimeter continuum and line emission from regions of low mass star formation. The intensity of this emission is compared with the sensitivity of the large deployable reflector (LDR), a large space telescope designed for this wavelength range. The proposed LDR is designed to probe the temperature, density, chemical structure, and the velocity field of the collapsing envelopes of these protostars. The LDR is also designed to study the accretion shocks on the cores and circumstellar disks of low-mass protostars, and to detect shock waves driven by protostellar winds. R.S.F.

N84-33301# Committee on Science and Technology (U. S. House).
THE 1985 NASA AUTHORIZATION, VOLUME 2
Washington GPO 1984 1168 p Hearings before the Subcomm. on Space Sci. and Appl. of the Comm. on Sci. and Technol., 98th Congr., 2d Sess., no. 84, 1, 2, 7, 8, 9, 22, 23, 28, 29 Feb. and 1 Mar. 1984
(GPO-34-202) Avail: Subcommittee on Space Science And Applications

Of the 7.5 billion in the President's budget for NASA, $2.4 billion is allocated for research and development; $160 billion for space flight, control, and data communication; $160 million for construction of facilities; and $1.3 million for research and program management. Space station concepts and capabilities are explored and efforts to improve the shuttle main engine and assure cost effectiveness of the operational space shuttle are examined. Planning for the upper atmosphere research satellite mission, the Mars geoscience/climatology orbiter, and the advanced communications technology satellite is highlighted. The space commercialization, stabilization of number of civil service employees working for NASA, and the agency-wide productivity improvement and quality enhancement program are also discussed. A.R.H.

N84-34457*# Rockwell International Corp., Pittsburgh, Pa. Space Station Systems Div.
GROUND TEST ARTICLE FOR DEPLOYABLE SPACE STRUCTURE SYSTEMS Bimonthly Progress Report
G. D. MALLOY Sep. 1984 21 p
(Contract NAS8-34657)
(NASA-CR-171158; NAS 1.26:171158; BMPR-3) Avail: NTIS HC A02/MF A01 CSCL 14B

The ground test article fabrication and assembly plan was completed by Santek Engineering, Inc. The plan was reviewed and accepted by Rockwell during an on-site visit to the Santek facility. Raw material and hardware orders were placed by Santek in July. Approximately 98% of the raw materials and 10% of the hardware deliveries have been completed. Several material and hardware substitutions were requested by Santek due to no-bid responses from suppliers or excessive costs for limited quantity items. These substitutions were evaluated and approved by Rockwell Engineering and Material and Process and are being incorporated into the drawing package. Santek started fabrication of detail parts in mid-August. Their current resource utilization is at approximately 50% of the planned eventual commitment and is increasing at a rate commensurate with the fabrication and assembly plan. At this writing, Santek's estimate of completion is 03%. During verification testing of the diagonal member joint, in a program funded by Rockwell discretionary funds, the axial load to unlock the joint was found to increase significantly after a few cycles of operation. This was attributed to galling, poor lubrication, and locking pin geometry. A change of materials, lubricant, and modification of the pin geometry reduced the unlocking load and provided repeatability after 50 cycles of operation. This new design is being implemented into the ground test article. Author

N84-34485*# Aerospace Corp., El Segundo, Calif. Aerophysics Lab.
ATOMIC BEAM SYSTEM FOR LABORATORY SIMULATION OF UPPER ATMOSPHERE OXYGEN ATOM IMPACT ON STS SURFACES
P. MAHADEVAN *In* NASA. Goddard Space Flight Center 13th Space Simulation Conf. p 222-227 1984
Avail: NTIS HC A13/MF A01 CSCL 20H

An atomic beam apparatus capable of producing a collimated beam of O atoms or other atmospheric species at the STS impact velocity of 8 km/s is described. A conventional ion beam charge transfer neutralization approach was adopted to produce the projectile beam. The prime considerations favoring this approach are: the ability to vary the velocity of the impacting species at will over a wide range on either side of the optimum required value of 8 km/s; and sample irradiation can be made with species other than O-atoms, such as O2, N, or N2. M.G.

N84-34499# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
OPTIMAL SENSOR/ACTUATOR PLACEMENT ON A LARGE SPACE STRUCTURE M.S. Thesis
R. R. LUTER Mar. 1984 92 p
(AD-A144560; AFIT/GA/AA/82D-6) Avail: NTIS HC A05/MF A01 CSCL 22A

The method of eliminating observation and control spillover is studied by making groups of reduced order controlled modes orthogonal to each other. These modes are the rows and columns of the system matrices which are calculated from the direction cosine matrix and the eigenvector matrix. The direction cosine matrix is determined from the locations and orientations of the sensor/actuators. The eigenvector matrix is determined from the NASTRAN finite element model of large space structure. The decentralized controller can be made stable if the placement of the sensors/actuators cause the spillover to be eliminated. The program ANGLE is developed to calculate the angles between modes. After selecting a possible grouping of modes, problem angles are identified for improvement. These angles are then improved using the ORIENT program by manipulating the sensor/actuator placement model. Finally, the finite element model is changed to see its effect on the angles between the modes. Author (GRA)

N84-35133# Committee on Commerce, Science, and Transportation (U. S. Senate).
NASA AUTHORIZATION FOR FISCAL YEAR 1985
Washington GPO 1984 267 p Hearings before the Subcomm. on Sci., Technol., and Space of the Comm. on Com., Sci., and Transportation, 98th Congr., 2nd Sess., 28 Feb. and 1, 8, and 29 Mar. 1984
(GPO-32-363) Avail: Subcommittee on Science, Technology, and Space

Generally, NASA's budget for fiscal year 1985 is discussed. The President's proposal to build a manned orbiting space station is brought up, and the pros and cons are debated. With the perception that the Japanese and Europeans have moved ahead of the U.S. in the areas of telecommunications, the merits of the Advanced Communication Technology Satellite (ACTS) and it's impact on NASA's budget, are brought out. NASA has delayed ACTS by the decision to limit it to ground testing. The development of the space shuttle is brought out. The Spacelab flight is discussed, as are the issues concerning a fifth orbiter and an extended duration orbiter. Space science, space commercialization, theoretical astrophysics, and trade policies in space, are some of the issues. Artificial intelligence is given weight as an issue, with man-machine interaction also discussed. S.B.

11

SPACE STATION

Includes either state-of-the-art or advanced technology which may apply to Space Stations and does not fit within the previous categories but may be applicable to other large structure programs.

A84-30605#
SERVICING SPACECRAFT FROM THE SPACE STATION
H. T. FISHER and K. J. FORSBERG (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) American Society of Mechanical Engineers, Winter Annual Meeting, Boston, MA, Nov. 13-18, 1983. 8 p.
(ASME PAPER 83-WA/AERO-8)

Space Station roles in spacecraft servicing are assessed. It is anticipated that once the Space Station becomes operational in the 1990s, a complimentary role will still remain for the Space Shuttle Orbiter in various servicing functions. Attention is given to the Space Station's servicing-related orbital mechanics, and the Teleoperator Retrieval and Orbital Maneuvering systems that will be employed in spacecraft retrieval, capture, and/or on-site servicing. O.C.

A84-30607*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AUTONOMY AND AUTOMATION FOR SPACE STATION HOUSEKEEPING AND MAINTENANCE FUNCTIONS
P. R. TURNER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Society of Mechanical Engineers, Winter Annual Meeting, Boston, MA, Nov. 13-18, 1983. 4 p. NASA-supported research. refs
(ASME PAPER 83-WA/AERO-10)

The Space Station crew will be a critical resource for economical operation of science and commercial payloads. Core station housekeeping and maintenance functions should be provided in a manner that requires a minimum of crew interaction. This paper outlines a prospective functional architecture for allocation of autonomous and automated control of these functions and discusses implementation issues arising from safety of manned operations, integration test requirements, and evolution of future station capabilities. Author

A84-30608*# Boeing Computer Services, Inc., Seattle, Wash.
COMPUTER-ASSISTED ENGINEERING DATA BASE
R. P. DUBE and H. R. JOHNSON (Boeing Computer Services, Inc., Seattle, WA) American Society of Mechanical Engineers, Winter Annual Meeting, Boston, MA, Nov. 13-18, 1983. 6 p. refs
(Contract NAS1-14700)
(ASME PAPER 83-WA/AERO-11)

General capabilities of data base management technology are described. Information requirements posed by the space station life cycle are discussed, and it is asserted that data base management technology supporting engineering/manufacturing in a heterogeneous hardware/data base management system environment should be applied to meeting these requirements. Today's commercial systems do not satisfy all of these requirements. The features of an R&D data base management system being developed to investigate data base management in the engineering/manufacturing environment are discussed. Features of this system represent only a partial solution to space station requirements. Areas where this system should be extended to meet full space station information management requirements are discussed. Author

A84-33143#
SPACE STATION ARCHITECTURE AND CONFIGURATIONS
D. C. WENSLEY (McDonnell Douglas Astronautics Co., Huntington Beach, CA) American Institute of Aeronautics and Astronautics, Annual Meeting, Washington, DC, May 1-3, 1984. 36 p.
(AIAA PAPER 84-1089)

The type of architectural process that may be used in designing a Space Station for the 1990s is described, and the key considerations that will be used to narrow the field of candidate concepts are highlighted. This iterative process begins with the definition of missions to be accommodated by this space facility in science and applications, commercial uses, and technology development. Key criteria for allocation of missions to platforms, satellites, STS, and the Space Station are illustrated. Requirements for individual missions are then combined to establish the total list of required support functions and to establish rough subsystem and crew sizing. Subsystem level architecture and technology options are defined and evaluated against requirements. Subsystem technology options are examined and chosen and system geometry options are examined. System geometry influences include power system, structural integrity and stiffness, solar array and radiator orientation, and orbital assembly/dissembly. The final step in the process consists of a detailed comparison of the candidates and the selection of one. J.N.

A84-34004*
SPACE SYSTEMS TECHNOLOGY CONFERENCE, COSTA MESA, CA, JUNE 5-7, 1984, TECHNICAL PAPERS
Conference sponsored by the American Institute of Aeronautics and Astronautics and NASA. New York, American Institute of Aeronautics and Astronautics, 1984, 116 p.

Space station technology is considered along with a shuttle tethered satellite system development program, the development of advanced orbital maintenance/servicing techniques for EVA applications, human systems interfaces for space stations, materials and structures for space applications, progress in space nuclear reactor power systems technology development with the aid of the SP-100 Program, and the design of reliable power systems for communications satellites. Attention is given to problems and concepts of space station guidance and control, spacecraft data management hardware state-of-the-art, progressive autonomy, and automation in teleoperation from a man-machine interface viewpoint. A space exploration outlook is provided, and the space power systems of the early 21st century are discussed. G.R.

A84-34006*# National Aeronautics and Space Administration, Washington, D. C.
SPACE STATION TECHNOLOGY
W. T. TUMULTY (NASA, Washington, DC) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 10-20.
(AIAA PAPER 84-1105)

In an evaluation of the current technological basis for a space station, the Space Station Technology Steering Committee (SSTSC) came to the conclusion that a space station could certainly be made with existing technology. It was, however, found that state-of-the-art technology would not provide for the evolutionary growth aspects of a long life system. In the process of its reviews, the SSTSC identified 10 specific disciplines to categorize the technology which was found to be relevant or potentially applicable to a future space station design. Attention is given to the objectives for the advanced development program, systems and operations, data management, crew and life support, power, thermal management, human capability, auxiliary propulsion, fluid management systems, attitude control and stabilization, structures and mechanisms, and communications. G.R.

A84-34009#
HUMAN SYSTEMS INTERFACES FOR SPACE STATIONS
B. J. BLUTH (California State University, Northridge, CA) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 40-49. refs
(AIAA PAPER 84-1115)

The Space Station is to be primarily an operational vehicle which has to tend successfully to customer demands. The special position of the Space Station with respect to other spacecraft and the Space Shuttle lead to an important modification in the place and importance of the role of Human Systems in the design, development, and operation of a Space Station. Human productivity is now a far more significant factor than it has been before. Aspects of human productivity are considered along with the context of human productvity, the effects of weightlessness on the physiological status of the human body, food as an important biochemical variable and a psychological and social factor, human systems interfaces, preliminary results, and the implementation of human productivity. G.R.

A84-34016*# National Aeronautics and Space Administration, Washington, D. C.
PROGRESSIVE AUTONOMY
J. L. ANDERSON (NASA, Washington, DC) IN: Space Systems Technology Conference, Costa Mesa, CA, June 5-7, 1984, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1984, p. 100-107. refs
(AIAA PAPER 84-1112)

The present investigation is concerned with the evolution of a space station in terms of the progression of autonomy, as systems perspectives and architectural concepts permit. The distinction between automation and autonomy is considered along with the evolution of autonomy, and the evolution of automation in station operations. Attention is given to the startup of a complex technological system, aspects of station control, questions of crew operational support, factors regarding the habitability of a space station, system design philosophy for autonomy, evolvability, latent capability, stage commonality, and multiple modularity. It is concluded that an evolutionary space station operating over a period of 10-20 years with a great increase in capability over that time will require a design philosophy which is more flexible and open-ended than for previous space systems. G.R.

A84-34573#
LONG-TERM PLANNING FOR SPACE STATIONS [LANGE-TERMIJN PLANNEN VOOR RUIMTESTATIONS]
R. C. MEINER (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) Ruimtevaart, vol. 32, Dec. 1983, p. 283-292. In Dutch.

Current NASA/ESA plans for space-station development are summarized, with an emphasis on the incorporation of Spacelab technology in the NASA manned-space-station concept. Previous studies are reviewed, current designs are illustrated with drawings, tables, and diagrams; and the importance of the ESA development of an independent launching system based on Ariane is indicated. The question of man's roles in space is briefly considered, stressing the need to evaluate the capabilities of robots and humans in conducting experiments and maneuvers and the costs involved.
T.K.

A84-35272
NASA'S SPACE STATION TO MIDWIFE MODULAR SATELLITES
M. KACHMAR Microwaves and RF (ISSN 0745-2993), vol. 23, May 1984, p. 29, 32, 35, 36.

It is pointed out that NASA has targeted 1991 as the date for an operational space station. The space station is to include a 195 cu m pressurized habitat, docks for a reusable orbital transfer vehicle (OTV), and storage facilities. The station is to be occupied by about five persons. It is believed that large communication satellite systems will greatly benefit from a permanent manned space station. The Space Shuttle will be used to deliver satellites and needed equipment to NASA's space station. Both NASA and the European Space Agency have considered the development of large space antennas as reasons for building a station. The plans of an American aerospace company go beyond the discussed space station. A second space station permanently based in geosynchronous orbit is envisioned. This station, called 'mobile geoservice station' (MGSS), would serve in the same role in the geostationary equatorial orbit as NASA's space station will serve in low earth orbit.
G.R.

A84-41083
SPACE OPERATIONS CENTER COMMAND AND CONTROL STATION CONCEPTS
K. H. MILLER (Boeing Aerospace Co., Seattle, WA) IN: Behavioral Objectives in Aviation Automated Systems Symposium; Proceedings of the Aerospace Congress and Exposition, Anaheim, CA, October 25-28, 1982 . Warrendale, PA, Society of Automotive Engineers, Inc., 1982, p. 343-348.

This paper discusses the origin of the command station concepts for the Space Operations Center that Boeing Aerospace Company defined for NASA-Johnson Space Center. This discussion includes the description of the mission scenario used to define command and control requirements and the relevant requirements imposed by NASA. These requirements were analyzed to produce command center configurations and control panel layouts. The types of controls and displays to be used are discussed. Author

A84-41084
SPACE OPERATIONS CENTER CREW SKILLS AND SCHEDULING
R. L. OLSON and K. H. MILLER (Boeing Aerospace Co., Seattle, WA) IN: Behavioral Objectives in Aviation Automated Systems Symposium; Proceedings of the Aerospace Congress and Exposition, Anaheim, CA, October 25-28, 1982 . Warrendale, PA, Society of Automotive Engineers, Inc., 1982, p. 349-362.

A summary of the Space Operations Center (SOC) crew skill and scheduling analysis is presented in this paper. The analysis was conducted by Boeing Aerospace Company on contract to NASA-Johnson Space Center. Brief descriptions of the SOC design, projected missions, and mission modeling are presented. The analytical approach is outlined as well as the resulting crew skill allocations and projected crew sizes through the year 2000.
Author

A84-41845
AN ALTERNATIVE SPACE STATION RESUPPLY MODE
S. A. STERN (Colorado, University, Boulder, CO) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 32, Apr.-June 1984, p. 211-219. refs

Conventional resupply scenarios for a Space Station envision the Space Shuttle as the sole earth-to-Station transport vehicle. In this paper, a resupply scheme composed of a Shuttle plus an orbital Teleoperator vehicle is compared to a Shuttle-Only scheme, and a spectrum of representative test cases is subjected to comparative performance analysis. The significant operational differences between the competing resupply scenarios are investigated. Analysis indicates that Teleoperator-Assisted resupply is superior in terms of payload performance and manifest flexibility, in almost every case.
Author

A84-42571
COLUMBUS - A CONCEPT CONCERNING THE COOPERATION OF EUROPE WITH THE U.S. IN THE SPACE STATION PROGRAM [COLUMBUS - EIN KONZEPT ZUR ZUSAMMENARBEIT EUROPAS MIT DEN USA IM RAUMSTATIONSPROGRAMM]
H. SAX (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), vol. 42, June 1984, p. 19-25. In German.

The Space Station Program is related to the development of an orbital infrastructure. It involves a number of mutually dependent, manned, and unmanned elements in different orbits. Salient characteristics of these elements are related to versatility regarding their use, maintenance, and the feasibility of repair. The operational basis for the orbital infrastructure can be a permanent manned space station in low earth orbit. A description is given of European aims in connection with the considered cooperation between the U.S. and Europe regarding this project, taking into account aspects of utilization. The Columbus Concept consists of four elements. One element is a module which can be used as laboratory, workshop, or place of residence for astronauts. Another element is a platform for payloads which must be exposed to the free space environment. A resource module is to provide means and services needed for the support of the first two modules. The fourth element is to provide transportation for materials and people between the Columbus elements and either the Space Station or the Shuttle Orbiter.
G.R.

A84-44179*# National Aeronautics and Space Administration. *Lewis Research Center, Cleveland, Ohio.*
SPACE STATION PROPULSION ANALYSIS STUDY
R. M. DONOVAN, J. S. SOVEY, and N. B. HANNUM (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, and ASME, Joint Propulsion Conference, 20th, Cincinnati, OH, June 11-13, 1984. 22 p. *Previously announced in STAR as N84-25764.*
(AIAA PAPER 84-1326)

This paper summarizes the impacts on the weight, volume and power usage of a manned space station and its 90-day resupply for three integrated, auxiliary propulsion subsystems. The study was performed in coordination with activities of the Space Station Concept Development Group (CDG). The study focused on three space station propulsion high-low thrust options that make use of fluids that will be available on the manned space station. Specific uses of carbon dioxide, water and cryogen boiloff were considered. For each of the options the increase in station hardware mass and volume to accommodate the dual thrust option is offset by the resupply savings, relative to the reference hydrazine system, after one to several resupplies. Over the life of the station the savings in cost of logistics could be substantial. The three options are examples of alternative technology paths that, because of the opportunity they provide for integration with the environmental control life support system (ECLSS) and OTV propellant storage systems, may reduce the scarring which is required on the early station to meet the increasing propulsion requirements of the growth station.
Author

A84-45144#
THE SPACE STATION IS COMING [DIE RAUMSTATION KOMMT]
D. LEMKE (Max-Planck-Institut fuer Radioastronomie, Bonn, West Germany) Sterne und Weltraum (ISSN 0039-1263), vol. 23, Aug.-Sept. 1984, p. 434-439. In German.

Plans for the U.S. Space Station and for European participation in it are reviewed and illustrated with drawings, and the scientific arguments for and against a manned multipurpose orbiting platform are examined from an astronomer's perspective. The problems associated with the Station orbit (400 km, 28-deg inclination) and operation which could affect astronomical observations include limits on sky coverage, relatively short measurement times, radiation-belt effects, complex data-transmission systems, contamination by dust and gases, and vibration and movement caused by crew; advantages include the possibility of instrument repair, cooling-fluid refilling, replacement of focal-plane instruments, and construction of large antennas. It is predicted that, for political and economic reasons, the ESA members will decide both to develop a European semi-manned station of smaller size and to contribute the pressurized modules, platforms, resource modules, and servicing vehicles of the 'Columbus' plan to the NASA effort. Astronomers are urged to adjust their plans for space observations to make the best use of the Station and to participate actively in planning it. T.K.

A84-45688* National Aeronautics and Space Administration, Washington, D. C.
SPACE STATIONS AND THEIR POTENTIAL USES
R. F. FREITAG (NASA, Space Station Task Force, Washington, DC) (Royal Society, Discussion on Technology in the 1990s: The Industrialization of Space, London, England, Dec. 7, 8, 1983) Royal Society (London), Philosophical Transactions, Series A (ISSN 0080-4614), vol. 312, no. 1519, July 26, 1984, p. 119-131.

This paper discusses the status of NASA's efforts to define the scope of a space station program. It presents NASA's rationale for a space station, architectural, technological and operational concepts that would enhance its capabilities, status of planning, how it would be used, opportunities for commercialization, and the potential for international participation in the program.
Author

A84-46480*# National Aeronautics and Space Administration, Washington, D. C.
THE SPACE STATION PROGRAM PLAN
J. D. HODGE (NASA, Space Station Program Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 22, Sept. 1984, p. 56-59.

The strategy that has been adopted for the NASA permanent manned space station development program is to provide a source of different modular components. Virtually any tactical requirements can then be accommodated through the specification of the appropriate inventory of orbitally assembled modular components. Some of the space station's subsystems are common to several elements, and must therefore be generally compatible, offering consistent interfaces with, for example, the Space Shuttle Orbiter. Tethered systems, including small platforms for controlled micro-g experiments, will be incorporated, and the occasional presence of two docked Space Shuttle Orbiters will be allowed for. O.C.

A84-46481*# National Aeronautics and Space Administration, Washington, D. C.
SPACE STATION - TECHNOLOGY DEVELOPMENT
R. F. CARLISLE (NASA, Space Station Systems Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 22, Sept. 1984, p. 60-64, 66.

The NASA manned space station program's systems technology effort involves the development of novel techniques that will reduce the scope of tasks neeeded for design, development, testing and evaluation of the hardware. Operations technology efforts encompass analyses that will define those techniques best able to improve the efficiency and reduce the costs of space station functions. The technology objective for data management calls for a fault-tolerant, distributed, expandable and adaptable, as well as repairable and user-friendly, flight data management system that employs state-of-the-art hardware and software. The space station's power system includes the largest element, a 'solar blanket', and the heaviest component, the batteries, of all the subsystems. A thermal management system for the power system is of paramount importance. Attention is also given to the exacting demands of attitude control and stabilization and a regenerative life support system of the requisite capacity and reliability. O.C.

A84-46482*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION DESIGN - INNOVATION AND COMPROMISE
L. E. POWELL (NASA, Marshall Space Flight Center, Space Station Project Office, Huntsville, AL), A. COHEN, and M. CRAIG (NASA, Johnson Space Center, Houston, TX) Aerospace America (ISSN 0740-722X), vol. 22, Sept. 1984, p. 70-72.

The NASA manned space station will consist of three main elements: habitable modules, solar collectors, and their interconnecting hardware. The most arduous of the requirements to be met by this configuration is the simultaneous integration of terrestrial, solar, and celestial viewing instruments, since omnidirectional simultaneous viewing is made difficult by the station's large solar energy collection devices. The space station also imposes unique design conditions on individual subsystems, such as the power distribution and energy storage hardware. In particular, the thermal control subsystem must be designed to meet a variety of mission, payload, and housekeeping tasks that demand a large heat rejection capacity. Novel environmental control and life support subsystem technology will be indispensable. O.C.

A84-46483*# National Aeronautics and Space Administration, Washington, D. C.
SPACE STATION - THE WORLD CONNECTION
R. F. FREITAG, R. V. LOTTMANN, and L. D. WIGBELS (NASA, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 22, Sept. 1984, p. 76-78, 80.

NASA has expressed an interest in acquiring foreign partners for its upcoming permanent, manned space station program who will participate as builders, operators and users, and will invest a significant portion of the financial and developmental research resources entailed by this ambitious undertaking. Cooperation, then, will not come to an end upon delivery of the hardware developed by a foreign partner, but will continue on the basis of ownership of the hardware and responsibility for its engineering and operational management. Attention is presently given to the prospective contributions of Canada, the European Space Agency, and Japan. O.C.

A84-47869
SPACE STATION - 1984
H. O. RUPPE (Muenchen, Technische Universitaet, Munich, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 8, July-Aug. 1984, p. 271-273.

A brief survey is presented of a possible future space station with European involvement. The basic design consists of four modified Spacelab long modules for habitat, station management, science/technology/commerce, and industrial operations as well as an access and transfer spider. Internal and external special equipment, costs, and a possible time schedule are also addressed. The operation of the station and interorbital pick-up are very briefly discussed. C.D.

A84-49359#
'FLOTILLAS' TO SET SAIL FOR LOW-EARTH ORBIT
L. LERMAN (Stanford University, Stanford, CA) Aerospace America (ISSN 0740-722X), vol. 22, Oct. 1984, p. 74-76.

A system of separate platforms grouped in a 'flotilla' is described as a possible configuration for the Space Station. Some of the important features of such a configuration are described, and an evaluation is made of the relative advantages and possible

disadvantages of such a system. The Pleiades flotilla concept consists of a series of smaller unmanned instrument platforms interconnected through a number of relay satellites. Service vehicles (teleoperators and robots) would shuttle between platforms to perform periodic adjustments and repairs. The data distribution network would be ground-based providing realtime interaction between scientists and instruments. Several of the important military, industrial and scientific applications of this type of configuration are described. I.H.

A84-49360#
SCIENCE - THE SPACE STATION DESIGN DRIVER
H. FRIEDMAN (U.S. National Research Council, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 22, Oct. 1984, p. 78-81.

Some examples are presented of the possible areas of scientific research for the Space Station. Attention is given to the unique advantages presented by the space environment for the observation of deep space objects. A configuration for a VLA radiotelescope is presented which would permit an astronomical resolution of about 10 to the -6th arcsec. Several other devices currently under development are described, including a Gamma Ray Observatory for the Shuttle, a Coded Mask telescope, and the Gravity Probe B experiment which would measure the effect of curved space-time around the earth on the orbital motion of two ultraprecise gyroscopes in order to test Einstein's general theory of relativity. I.H.

N84-18269*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. FINAL EXECUTIVE REVIEW
5 Apr. 1983 126 p refs
(Contract NASW-3680)
(NASA-CR-173335; NAS 1.26:173335; D180-27477-6) Avail: NTIS HC A07/MF A01 CSCL 22B

Identification and validation of missions, the benefits of manned presence in space, attributes and architectures, space station requirements, orbit selection, space station architectural options, technology selection, and program planning are addressed. N.W.

N84-22594*# Science Applications, Inc., Schaumburg, Ill.
PERFORMANCE ASSESSMENT OF PLANETARY MISSIONS AS LAUNCHED FROM AN ORBITING SPACE STATION
A. FRIEDLANDER 27 Jul. 1982 33 p refs Presented at Summer Study Retreat, Snowmass, Colo.
(Contract NASW-3622)
(NASA-CR-173498; NAS 1.26:173498) Avail: NTIS HC A03/MF A01 CSCL 22A

Results presented are intended to assist planners and the mission analysis community in assessing the performance impact (pro or con) of launching planetary missions from an orbiting space station as compared to the usual, ground-based Shuttle launch of such missions. The analyses comprising this assessment include: (1) a basic understanding and description of the space station launch problem; (2) examination of alternative injection strategies and selection of the most appropriate strategy for minimizing performance penalties; and (3) quantitative comparison of station-launched and Shuttle-launched performance over a wide energy/mass range of planetary mission opportunities. Data for each mission covers a full 360 deg of possible nodal location of the space station orbit. The main results are that planetary missions can be launched from a space station within acceptable penalty bounds, and that the station serving as a staging base/propellant depot can benefit some missions requiring large payload mass or high injection energy. S.L.

N84-22612*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION ARCHITECTURE, MODULE, BERTHING HUB, SHELL ASSEMBLY, BERTHING MECHANISM AND UTILITY CONNECTION CHANNEL Patent Application
M. M. COHEN, inventor (to NASA) 9 Mar. 1984 25 p
(NASA-CASE-ARC-11505-1; US-PATENT-APPL-SN-588036)
Avail: NTIS HC A02/MF A01 CSCL 22B

The geometric form of a space station is presented that includes a description of a plurality of modules and berthing hubs, joined by interconnections which are sideways connectable. The modules and hubs are fastened together in a triangular configuration in three dimensions. The interconnections include a pair of opposed, axially aligned, flanged ports and a clamp latch formed from a plurality of sections hinged along their length and extending circumferentially around the flanged ports. A hermetic seal is formed between the ports. A utilities connection channel extends between the ports. The channel has a shell with utilities connectors movable between an extended position to mating connectors in the modules and a withdrawn position. Assembly sequence and common module shell structure is detailed. NASA

N84-22613*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION SYSTEMS TECHNOLOGY STUDY. VOLUME 3: TECHNOLOGY AND ADVANCEMENT PROGRAM PLAN Final Report
Feb. 1984 73 p refs 3 Vol.
(Contract NAS8-34893)
(NASA-CR-171016; NAS 1.26:171016; D180-27935-3) Avail: NTIS HC A04/MF A01 CSCL 22B

The development of the integrated technology advancement plan was initiated with the results of the advanced platform system technology study (APSTS). Descriptions for the development of each viable technology advancement were drawn from the trade studies. Major elements were time-phased, allowing the definition of a development schedule consistent with the space station program when possible. Schedules show the major milestones of the development programs including test required as described in the logic flow diagrams. B.G.

N84-22614*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION SYSTEMS TECHNOLOGY STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report
Feb. 1984 111 p refs 3 Vol.
(Contract NAS8-34893)
(NASA-CR-171014; NAS 1.26:171014; D180-27935-1) Avail: NTIS HC A06/MF A01 CSCL 22B

The four study areas addressed are: (1) attitude control, (2) data management, (3) long-life thermal management, and (4) automated housekeeping integration. The design concepts in each area were refined. The cost benefits, schedules, and life cycle costs for the options were evaluated. Technology advancement plans were prepared for each of the selected items, and documentation was prepared. B.G.

N84-23028*# Boeing Aerospace Co., Seattle, Wash.
STUDY OF FLYWHEEL ENERGY STORAGE FOR SPACE STATIONS Final Report
S. GROSS Feb. 1984 128 p refs
(Contract NAS9-16151)
(NASA-CR-171780; NAS 1.26:171780; D180-27951-1) Avail: NTIS HC A07/MF A01 CSCL 10A

The potential of flywheel systems for space stations using the Space Operations Center (SOC) as a point of reference is discussed. Comparisons with batteries and regenerative fuel cells are made. In the flywheel energy storage concept, energy is stored in the form of rotational kinetic energy using a spinning wheel. Energy is extracted from the flywheel using an attached electrical generator; energy is provided to spin the flywheel by a motor, which operates during sunlight using solar array power. The motor and the generator may or may not be the same device. Flywheel energy storage systems have a very good potential for use in space stations. This system can be superior to alkaline secondary

batteries and regenerable fuel cells in most of the areas that are important in spacecraft applications. Of special impotance relative to batteries, are high energy density (lighter weight), longer cycle and operating life, and high efficiency which minimizes the amount of orbital makeup fuel required. In addition, flywheel systems have a long shelf life, give a precise state of charge indication, have modest thermal control needs, are capable of multiple discharges per orbit, have simple ground handling needs, and have the potential for very high discharge rate. Major disadvantages are noted. R.J.F.

N84-23671*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SECOND INTERIM BRIEFING (D3). EVOLUTIONARY SCIENCE AND APPLICATIONS SPACE PLATFORM. CHARACTERIZATION OF CONCEPTS, TASKS A AND B
Nov. 1981 192 p refs
(Contract NAS8-33592)
(NASA-CR-173521; NAS 1.26:173521; MDC-9744) Avail: NTIS HC A09/MF A01 CSCL 22B

The objectives were to define, evaluate, and select concepts for evolving a space station in conjunction with the Space Platform for NASA science, Applications, Technology and DOD; and a permanently manned presence in space early, with a maximum of existing technology. B.G.

N84-24601*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
SPACE STATION NEEDS ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY COSTING WORKING GROUP BRIEFING Final Report
7 Apr. 1983 21 p Presented at the Mater. Processing in Space Workshop, Redondo Beach, Calif., 27-28 Oct. 1982
(Contract NASW-3681)
(NASA-CR-173517; NAS 1.26:173517) Avail: NTIS HC A02/MF A01 CSCL 22A

Individuals in the United States who understand the promise of materials processing in space and who also are senior technical personnel associated with commercial firms that process materials: (1) endorsed the concept of a space station as a desirable national asset; (2) stated that a commercial MPS research program is mandatory to extend commericalization of space for materials processing; and (3) described in general terms a national research laboratory and free flying facilities that are needed. Participants agreed that industry R&D is motivated largely by market pull rather than by technology push, that initial interest is low-g materials research; and that to farther, commercial market assurance (a salable product) is a must. A.R.H.

N84-24692*# Martin Marietta Aerospace, Denver, Colo. Space and Electronics Systems Div.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. BRIEFING MATERIAL, MID-TERM REVIEW
Nov. 1982 172 p
(Contract NASW-3686)
(NASA-CR-173536; NAS 1.26:173536; SOC-SE-02-01) Avail: NTIS HC A08/MF A01 CSCL 22B

User mission requirements and their relationship to the current space transportation system are examined as a means of assuring the infusion of corporate ideas and knowledge in the space station program. Specific tasks include developing strategies to develop user consistency; determine DOD implication and requirements; and foster industry involvement in the space station. Mission alternatives; accrued benefits; program options; system attributes and characteristics; and a recommended plan for space station evolution are covered. A.R.H.

N84-25764*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION PROPULSION ANALYSIS STUDY
R. M. DONOVAN, J. S. SOVEY, and N. B. HANNUM 1984 15 p refs Presented at the 20th Joint Propulsion Conf., Cincinnati, 11-13 Jun. 1984
(NASA-TM-83715; E-2180; NAS 1.15:83715; AIAA-84-1326)
Avail: NTIS HC A02/MF A01 CSCL 21H

This paper summarizes the impacts on the weight, volume and power usage of a manned space station and its 90-day resupply for three integrated, auxiliary propulsion subsystems. The study was performed in coordination with activities of the Space Staton Concept Development Group (CDG). The study focused on three space station propulsion high-low thrust options that make use of fluids that will be available on the manned space station. Specific uses of carbon dioxide, water and cryogen boiloff were considered. For each of the options the increase in station hardware mass and volume to accommodate the dual thrust option is offset by the resupply savings, relative to the reference hydrazine system, after one to several resupplies. Over the life of the station the savings in cost of logistics could be substantial. The three options are examples of alternative technology paths that, because of the opportunity they provide for integration with the environmental control life support system (ECLSS) and OTV propellant storage systems, may reduce the scarring which is required on the early station to meet the increasing propulsion requirements of the growth station. Author

N84-26740*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
NATURAL ENVIRONMENT DESIGN CRITERIA FOR THE SPACE STATION PROGRAM DEFINITION PHASE
W. W. VAUGHAN Jul. 1984 14 p refs
(NASA-TM-82585; NAS 1.15:82585) Avail: NTIS HC A02/MF A01 CSCL 22B

The natural environment design criteria requirements for use in the Space Station and its Elements (SSPE) definition phase studies are presented. The atmospheric dynamic and thermodynamic environments, meteoroids, radiation, physical constants are addressed. It is intended to enable all groups involved in the definition phase studies to proceed with a common and consistent set of natural environment criteria requirements. E.A.K.

N84-27756*# Booz-Allen and Hamilton, Inc., Arlington, Va.
SPACE STATION COMMERCIAL USER DEVELOPMENT
20 Jan. 1984 51 p
(Contract NASW-3775)
(NASA-CR-173688; NAS 1.26:173688) Avail: NTIS HC A04/MF A01 CSCL 22A

The commercial utilization of the space station is investigated. The interest of nonaerospace firms in the use of the space station is determined. The user requirements are compared to the space station's capabilities and a feasibility analysis of a commercial firm acting as an intermediary between NASA and the private sector to reduce costs is presented. M.A.C.

N84-27788*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Office of Space Station Program.
SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS: COMMERCIAL OPPORTUNITIES IN SPACE
H. L. WOLBERS, JR. Apr. 1983 144 p refs
(Contract NASW-3687)
(NASA-CR-173698; NAS 1.26:173698; MDC-H0532A) Avail: NTIS HC A07/MF A01 CSCL 22B

The roles of government and industry in the commercialization of space are examined and an approach for stimulating the interests of potential users is described. Several illustrative examples of potential commercial developments are presented. The role of manned space systems in space commercialization is discussed as well as some of the issues and opportunities that are likely to be encountered in the commercial exploitation of the unique characteristics of space. Results suggest that interest in space

facilities can be found among a number of commercially oriented users. In order to develop and maintain the involvement of these potential users, however, space demonstrations are required, and commercial growth or evolution depends on the results of the initial in situ experience. Manned facilities are required for the conceptual research and development phases and for maintenance and servicing operations during production or operational missions. Space facilities must be easily accessible by dependable and regularly scheduled means. A.R.H.

N84-27789*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Office of Space Station Program.
SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS: TECHNOLOGY DEVELOPMENT
A. C. ROBERT Apr. 1983 67 p refs
(Contract NASW-3687)
(NASA-CR-173697; NAS 1.26:173697; MDC-H0538) Avail: NTIS HC A04/MF A01 CSCL 22B

The technology development of the space station is examined as it relates to space station growth and equipment requirements for future missions. Future mission topics are refined and used to establish a systems data base. Technology for human factors engineering, space maintenance, satellite design, and laser communications and tracking is discussed. M.A.C.

N84-27790*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Office of Space Station Program.
SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS: SPACE STATION PROGRAM COST ANALYSIS
R. S. COWLS and A. J. GOODWIN Apr. 1983 34 p
(Contract NASW-3687)
(NASA-CR-173696; NAS 1.26:173696; MDC-H0541) Avail: NTIS HC A03/MF A01 CSCL 22B

This report documents the principal cost results (Task 3) derived from the Space Station Needs, Attributes, and Architectural Options study conducted for NASA by the McDonnell Douglas Astronautics Company. The determined costs were those of Architectural Options (Task 2) defined to satisfy Mission Requirements (Task 1) developed within the study. A major feature of this part of the study was the consideration of realistic NASA budget constraints on the recommended architecture. Thus, the space station funding requirements were adjusted by altering schedules until they were consistent with current NASA budget trends. B.W.

N84-27791*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS: BRIEF ANALYSIS
F. H. SHEPPHIRD Apr. 1983 34 p refs
(Contract NASW-3687)
(NASA-CR-173695; NAS 1.26:173695; MDC-H0534) Avail: NTIS HC A03/MF A01 CSCL 22B

A baseline set of model missions is thoroughly characterized in terms of support requirements, demands on the Space Station, operating regimes, payload properties, and statements of the mission goals and objectives. This baseline is a representative set of mission requirements covering the most likely extent of space station support requirements from which architectural options can be constructed and exercised. The baseline set of 90 missions are assessed collectively and individually in terms of the economic, performance, and social benefits. M.A.C.

N84-27792*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS: MIDTERM MAIN BRIEFING Final Report
16 Nov. 1982 182 p
(Contract NASW-3687)
(NASA-CR-173687; NAS 1.26:173687; MDC-H0145; VXF830)
Avail: NTIS HC A09/MF A01 CSCL 22B

Space station missions, their requirements, and architectural solutions are presented. Analyses of the following five mission categories are summarized: (1) science/applications, (2) commercial, (3) national security, (4) operational support, and (5) technology development. R.S.F.

N84-27793*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Space Station Program.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS: ARCHITECTURAL OPTIONS AND SELECTION Final Report
W. G. NELSON Apr. 1983 89 p
(Contract NASW-3687)
(NASA-CR-173694; NAS 1.26:173694; MDC-H0537) Avail: NTIS HC A05/MF A01 CSCL 22B

The approach, study results, and recommendations for defining and selecting space station architectural options are described. Space station system architecture is defined as the arrangement of elements (manned and unmanned on-orbit facilities, shuttle vehicles, orbital transfer vehicles, etc.), the number of these elements, their location (orbital inclination and altitude, and their functional performance capability, power, volume, crew, etc.). Architectural options are evaluated based on the degree of mission capture versus cost and required funding rate. Mission capture refers to the number of missions accommodated by the particular architecture. M.A.C.

N84-27794*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Space Station Program.
SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS: MISSION REQUIREMENTS
F. D. RIEL Apr. 1983 163 p
(Contract NASW-3687)
(NASA-CR-173693; NAS 1.26:173693; MDC-H0533) Avail: NTIS HC A08/MF A01 CSCL 22B

Space station missions and their requirements are discussed. Analyses of the following four mission categories are summarized: (1) commercial, (2) technology, (3) operation, and (4) science and applications. The requirements determined by the study dictate a very strong need for a manned space station to satisfy the majority of the missions. The station is best located at a 28.5-deg inclination and initially (1992 era) requires a crew of four (three for mission payloads) and a mission power of 25 kW. A space platform in a polar orbit is needed to augment the station capability; it initially would be a 15-kW system, located in a sun-synchronous orbit. R.S.F.

N84-27796*# Boeing Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. VOLUME 7-1: DATA BOOK. SCIENCE AND APPLICATIONS MISSIONS Final Report
21 Apr. 1983 508 p 7 Vol.
(Contract NASW-3680)
(NASA-CR-173700; NAS 1.26:173700; D180-27477-7-VOL-7-1)
Avail: NTIS HC A22/MF A01 CSCL 22B

User requirements for space station use are presented for the following areas: space environments, astrophysics, Earth observations, and life science. Also included are a summary of study tasks and final reports, a topical cross reference, key team members, and acronyms and abbreviations. B.G.

N84-27797*# Boeing Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. VOLUME 7-2: DATA BOOK. COMMERCIAL MISSIONS Final Report
21 Apr. 1983 412 p 7 Vol.
(Contract NASW-3680)
(NASA-CR-173719; NAS 1.26:173719; D180-27477-7-VOL-7-2)
Avail: NTIS HC A18/MF A01 CSCL 22B

The history of NASA's materials processing in space activities is reviewed. Market projections, support requirements, orbital operations issues, cost estimates and candidate systems (orbiter sortie flight, orbiter serviced free flyer, space station, space station serviced free flyer) for the space production of semiconductor crystals are examined. Mission requirements are identified for materials processing, communications missions, bioprocessing, and

for transferring aviation maintenance training technology to spacecraft. A.R.H.

N84-27798*# Boeing Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY Final Report
21 Apr. 1983 330 p 7 Vol.
(Contract NASW-3680)
(NASA-CR-173699; NAS 1.26:173699; D180-27477-7-VOL-7-3)
Avail: NTIS HC A15/MF A01 CSCL 22B

All the candidate Technology Development missions investigated during the space station needs, attributes, and architectural options study are described. All the mission data forms plus additional information such as, cost, drawings, functional flows, etc., generated in support of these mission is included with a computer generated mission data form. B.G.

N84-27799*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. VOLUME 7-4A: DATA BOOK, ARCHITECTURE, TECHNOLOGY AND PROGRAMMATICS, PART A Final Report
21 Apr. 1983 454 p
(Contract NASW-3680)
(NASA-CR-173686; NAS 1.26:173686; D180-27477-7-VOL-7-4A)
Avail: NTIS HC A20/MF A01 CSCL 22B

Various parameters of the orbital space station are discussed. The space station environment, data management system, communication and tracking, environmental control, and life support system are considered. Specific topics reviewed include crew work stations, restraint systems, stowage, computer hardware, and expert systems. R.S.F.

N84-27800*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. VOLUME 7-4B: DATA BOOK, ARCHITECTURE, TECHNOLOGY AND PROGRAMMATICS, PART B Final Report
21 Apr. 1983 255 p
(Contract NASW-3680)
(NASA-CR-173685; NAS 1.26:173685; D180-27477-7-VOL-7-4B)
Avail: NTIS HC A12/MF A01 CSCL 22B

The remote manipulating system, the pointing control system, and the external radiator for the core module of the space station are discussed. The principal interfaces for four basic classes of user and transportation vehicles or facilities associated with the space station were examined. R.S.F.

N84-27801*# Boeing Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. VOLUME 7-5A: DATA BOOK. MISSION ANALYSIS PART A Final Report
21 Apr. 1983 647 p 7 Vol.
(Contract NASW-3680)
(NASA-CR-173701; NAS 1.26:173701; D180-27477-7-VOL-7-5A)
Avail: NTIS HC A99/MF A01 CSCL 22B

The mission analysis printouts for the mission driven scenario A-1 are presented. B.G.

N84-27802*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS STUDY. VOLUME 7-5B: DATA BOOK. MISSION ANALYSIS PART B Final Report
21 Apr. 1983 720 p 7 Vol.
(Contract NASW-3680)
(NASA-CR-173711; NAS 1.26:173711; D180-27477-7-VOL-7-5B)
Avail: NTIS HC A99/MF A01 CSCL 22B

The mission analysis printouts for the station driven scenario B-1 are presented. B.G.

N84-27803*# General Dynamics/Convair, San Diego, Calif. Office of Advanced Space Programs.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. VOLUME 1: EXECUTIVE SUMMARY Final Report, 20 Aug. 1982 - 22 Apr. 1983
O. STEINBRONN 22 Apr. 1983 50 p 2 Vol.
(Contract NASW-3682)
(NASA-CR-173705; NAS 1.26:173705; GDC-ASP-83-001) Avail: NTIS HC A03/MF A01 CSCL 22B

Missions that will benefit from the development of a permanent manned space station are examined. The missions that will determine the space station architecture include spaceborne scientific experiments, space industrialization and commercialization, remote space operations, and U.S. national security. Architectural options and economic analysis are also presented. M.A.C.

N84-27804*# General Dynamics/Convair, San Diego, Calif. Office of Advanced Space Programs.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. VOLUME 2: TECHNICAL. BOOK 1: MISSION REQUIREMENTS Final Report
O. STEINBRONN 22 Apr. 1983 245 p 2 Vol.
(Contract NASW-3682)
(NASA-CR-173706; NAS 1.26:173706; GDC-ASP-83-002) Avail: NTIS HC A11/MF A01 CSCL 22B

The following types of space missions were evaluated to determine those that require, or will be benefited materially, by a manned space station: (1) science and applications, (2) commercial, (3) technology development, (4) space operations, and (5) national security. Integrated mission requirements for man-operated and man-tended free-flying missions were addressed. A manned space station will provide major performance and economic benefits to a wide range of missions planned for the 1990s. R.S.F.

N84-27805*# General Dynamics Corp., San Diego, Calif.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. VOLUME 2: TECHNICAL. BOOK 1: MISSION REQUIREMENTS. APPENDIXES 1 AND 2 Final Report
22 Apr. 1983 1000 p
(Contract NASW-3682)
(NASA-CR-173769; NAS 1.26:173769; GDC-ASP-83-002) Avail: NTIS HC A99/MF A01 CSCL 22B

The space station mission requirements data base consists of 149 attached and free-flying missions each of which is documented by a set of three interrelated documents: (1) NASA LaRC Data Sheets - with three sheets comprising a set for each payload element described. These sheets contain user payload element data necessary to drive Space Station architectural options. (2) GDC-derived operations descriptions that supplement the LaRC payload element data in the operations areas such as further descriptions of crew involvement, EVA, etc. (3) Payload elements synthesis sheets used by GDC to provide requirements traceability to data sources and to provide a narrative describing the basis for formulating the payload element requirements. A.R.H.

N84-27807*# General Dynamics/Convair, San Diego, Calif.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS, VOLUME 2, TECHNICAL. BOOK 3: ECONOMIC BENEFITS, COSTS AND PROGRAMMATICS Final Report
22 Apr. 1983 161 p 4 Vol.
(Contract NASW-3682)
(NASA-CR-173689; NAS 1.26:173689; GDC-ASP-83-004) Avail: NTIS HC A08/MF A01 CSCL 22B

The economic benefits, cost analysis, and industrial uses of the manned space station are investigated. Mission payload costs are examined in relation to alternative architectures and projected technological evolution. Various approaches to industrial involvement for financing, development, and marketing of space station resources are described. M.A.C.

N84-27808*# General Dynamics/Astronautics, San Diego, Calif.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. MIDTERM BRIEFING, EXECUTIVE SUMMARY Final Report
14 Dec. 1982 50 p
(Contract NASW-3682)
(NASA-CR-173446; NAS 1.26:173446) Avail: NTIS HC A03/MF A01 CSCL 22B

The approach used to develop a broad interest in the space station within the commercial and DoD communities is outlined. Areas of maximum benefit from a space station were identified and the associated economic benefits were quantified. Results show that the space station can provide major performance benefits for 82 man-operated missions, 18 man-tended free flyer missions, and 46 OTV missions. The man-operated OVT-based benefits are $800 M per year. The cost of shuttle flights of all STS users can be reduced by $7 M per flight. The economic benefits quantified to date exceed 1.3 B per year. Combined NASA/DoD utilization of an initial space station provided economic and technical benefits. Preliminary studies of operational missions indicate a possible need for separate stations. A.R.H.

N84-27809*# General Dynamics Corp., San Diego, Calif. Convair Div.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS, MIDTERM BRIEFING Final Report
17 Nov. 1982 302 p
(Contract NAS2-3682)
(NASA-CR-173714; NAS 1.26:173714) Avail: NTIS HC A14/MF A01 CSCL 22B

The benefits, costs, and mission requirements of the space station are considered. Five mission categories were identified: (1) science, (2) applications, (3) commercial, (4) U.S. national security, and (5) space operations. The orbit transfer vehicle (OTV) is discussed in detail. R.S.F.

N84-27810*# General Dynamics/Convair, Fort Worth, Tex.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. FINAL BRIEFING: COST WORKING GROUP DISCUSSION SESSION Final Report
18 Apr. 1983 60 p
(NASA-CR-173713; NAS 1.26:173713) Avail: NTIS HC A04/MF A01 CSCL 22B

The economic factors involved in the design and utilization of the space station are investigated. Topics include the economic benefits associated with research and production, the orbit transfer vehicle, and satellite servicing. Program costs and design options are examined. The possibilities of financing from the private sector are discussed. M.A.C.

N84-27811*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. VOLUME 3, TASK 1: MISSION REQUIREMENTS Final Report
5 Apr. 1983 482 p
(Contract NASW-3684)
(NASA-CR-173712; NAS 1.26:173712; LMSC-D889718) Avail: NTIS HC A21/MF A01 CSCL 22B

The mission requirements of the space station program are investigated. Mission parameters are divided into user support from private industry, scientific experimentation, U.S. national security, and space operations away from the space station. These categories define the design and use of the space station. An analysis of cost estimates is included. M.A.C.

N84-27812*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. VOLUME 3, ATTACHMENT 1, TASK 1: MISSION REQUIREMENTS Final Report
22 Apr. 1983 483 p
(Contract NASW-3684)
(NASA-CR-173716; NAS 1.26:173716; LMSC-D889718) Avail: NTIS HC A21/MF A01 CSCL 22B

The development and systems architectural requirements of the space station program are described. The system design is determined by user requirements. Investigated topics include physical and life science experiments, commercial utilization, U.S. national security, and remote space operations. The economic impact of the space station program is analyzed. M.A.C.

N84-27813*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. VOLUME 4, TASK 2 AND 3: MISSION IMPLEMENTATION AND COST Final Report
5 Apr. 1983 389 p
(Contract NASW-3684)
(NASA-CR-173715; NAS 1.26:173715; LMSC-D889718) Avail: NTIS HC A17/MF A01 CSCL 22B

An overview of the basic space station infrastructure is presented. A strong case is made for the evolution of the station using the basic Space Transportation System (STS) to achieve a smooth transition and cost effective implementation. The integrated logistics support (ILS) element of the overall station infrastructure is investigated. The need for an orbital transport system capability that is the key to servicing and spacecraft positioning scenarios and associated mission needs is examined. Communication is also an extremely important element and the basic issue of station autonomy versus ground support effects the system and subsystem architecture. M.A.C.

N84-27814*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS: STUDY SUMMARY Final Study Report, 23 Aug. 1982 - 22 Apr. 1983
22 Apr. 1983 48 p
(Contract NASW-3684)
(NASA-CR-173692; NAS 1.26:173692; LMSC-D889718) Avail: NTIS HC A03/MF A01 CSCL 22B

Space station needs, attributes, and architectural options that affect the future implementation and design of a space station system are examined. Requirements for candidate missions are used to define functional attributes of a space station. Station elements that perform these functions form the basic station architecture. Alternative ways to accomplish these functions are defined and configuration concepts are developed and evaluated. Configuration analyses are carried to the point that budgetary cost estimates of alternate approaches could be made. Emphasis is placed on differential costs for station support elements and benefits that accrue through use of the station. M.A.C.

N84-27815*# Rockwell International Corp., Downey, Calif. Shuttle Integration and Satellite Systems Div.
SPACE STATION: COST AND BENEFITS Final Report
11 Apr. 1983 71 p
(NASA-CR-173718; NAS 1.26:173718; SSD-83-0045; RI-33SSV133636) Avail: NTIS HC A04/MF A01 CSCL 22B

Costs for developing, producing, operating, and supporting the initial space station, a 4 to 8 man space station, and a 4 to 24 man space station are estimated and compared. These costs include contractor hardware; space station assembly and logistics flight costs; and payload support elements. Transportation system options examined include orbiter modules; standard and extended duration STS fights; reusable spacebased perigee kick motor OTV; and upper stages. Space station service charges assessed include crew hours; energy requirements; payload support module storage;

pressurized port usage; and OTV service facility. Graphs show costs for science missions, space processing research, small communication satellites; large GEO transportation; OVT launch costs; DOD payload costs, and user costs. A.R.H.

N84-27816*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS. VOLUME 1. EXECUTIVE SUMMARY Final Report
E. B. PRITCHARD 20 Apr. 1983 34 p *Prepared in cooperation* with Communications Satellite Corp., Clarksburg, Md. and General Electric, Philadelphia
(Contract NASW-3685)
(NASA-CR-173710; NAS 1.26:173710; SA-SSP-RP007) Avail: NTIS HC A03/MF A01 CSCL 22B

The initial space station should be manned, placed in 28.5 deg orbit, and provide substantial economic, performance, and social benefits. The most beneficial space station capabilities include: a space test facility; a transport harbor; satellite servicing and assembly; and an observatory. A space industrial park could be added once further development effort validates the cost and expanding commercial market for space processed materials. The potential accrued gross mission model benefit derived from these capabilities is $5.9B without the industrial park, and $9.3B with it. An unclassified overview of all phases of the study is presented. A.R.H.

N84-27817*# McDonnell-Douglas Corp., St. Louis, Mo.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS: MISSION REQUIREMENTS Final Study Report
Apr. 1983 68 p Sponsored by NASA
(NASA-CR-173691; NAS 1.26:173691) Avail: NTIS HC A04/MF A01 CSCL 22B

Various mission requirements for the proposed space station are examined. Subjects include modelling methodology, science applications, commercial opportunities, operations analysis, integrated mission requirements, and the role of man in space station functions and activities. The information is presented through the use of graphs. M.A.C.

N84-27818*# Lockheed Missiles and Space Co., Palo Alto, Calif.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS: MIDTERM REVIEW, EXECUTIVE OVERVIEW
15 Nov. 1982 53 p
(Contract NASW-3687)
(NASA-CR-173707; NAS 1.26:173707) Avail: NTIS HC A04/MF A01 CSCL 22B

An overview of the mission architecture of the space station based on user requirements is presented. Interest from nonaerospace firms is determined and activities such as spaceborne experiments, space commercialization, U.S. national security, and remote space operations are examined. M.A.C.

N84-27819*# KMS Fusion, Inc., Ann Arbor, Mich.
STUDY OF ROBOTICS SYSTEMS APPLICATIONS TO THE SPACE STATION PROGRAM Final Report
J. C. FOX (Michigan Univ.) Oct. 1983 119 p refs
(Contract NASW-3751)
(NASA-CR-173703; NAS 1.26:173703; KTR-108) Avail: NTIS HC A06/MF A01 CSCL 22B

Applications of robotics systems to potential uses of the Space Station as an assembly facility, and secondarily as a servicing facility, are considered. A typical robotics system mission is described along with the pertinent application guidelines and Space Station environmental assumptions utilized in developing the robotic task scenarios. A functional description of a supervised dual-robot space structure construction system is given, and four key areas of robotic technology are defined, described, and assessed. Alternate technologies for implementing the more routine space technology support subsystems that will be required to support the Space Station robotic systems in assembly and servicing tasks are briefly discussed. The environmental conditions impacting on the robotic configuration design and operation are reviewed. R.S.F.

N84-28891*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION SYSTEMS TECHNOLOGY STUDY. VOLUME 2: TRADE STUDY AND TECHNOLOGY SELECTION TECHNICAL REPORT Final Report
Feb. 1984 191 p refs
(Contract NAS8-34893)
(NASA-CR-171015; NAS 1.26:171015; D180-27935-2-VOL-2)
Avail: NTIS HC A09/MF A01 CSCL 22B

High leverage technologies are examined for application to the space station. The areas under investigation include attitude control, data management, long life thermal management, and automated housekeeping integration. M.A.C.

N84-29344*# National Aeronautics and Space Administration, Washington, D. C.
SPACE STATION
A. F. FORESTIERI *In* NASA. Lewis Research Center Space Photovoltaic Res. and Technol. 1983 p 237-250 1984
Avail: NTIS HC A12/MF A01 CSCL 22B

The need for a space station, its cost, its use, and completion are examined. The Space Station Task Force was established by NASA Administrators to answer questions and to provide focus and direction for Space Station planning activities. The task force provides Congress and the Administration with sufficient information to make decisions on whether the United States should proceed with a Space Station as the next major national initiative in space. Current thinking on selected issues, planning guidelines, unique considerations and organization are presented. E.A.K.

N84-29932*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
COST EVALUATION OF SPACE STATION PROPULSION SYSTEM OPTIONS
R. W. KLEMETSON and P. W. GARRISON *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 319-328 Feb. 1984 refs
Avail: NTIS HC A17/MF A01 CSCL 21H

Alternative space station propulsion system options for a range of space station configurational and operational architectures were evaluated. The propulsion system options included H2 resistojets, low pressure gaseous oxygen/hydrogen, bipropellant N2O4/MMH, and augmented hydrazine. The primary evaluation criterion was the life cycle cost of the propulsion system which includes its development and operation in the space station system for ten years. Propulsion system mass, performance, reliability, and other relevant parameters were considered in the comparison of the candidate propulsion technologies. Parametric results are presented for a range of space station propulsion requirements that vary from these representative of a first generation station to those of an advanced station with a space-based orbital transfer vehicle. Space Transportation System costs were treated parametrically and are found to be a major consideration in evaluating the payoff of advanced propulsion system technology for space station. Advanced propulsion systems are shown to reduce space station operations costs by providing higher performance but also to require a larger front end investment for development and qualification. Low cost implementations of advanced technology must be developed if the full potential of such systems is to be realized. R.S.F.

N84-29933*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
AN INTEGRATED SPACE STATION PROPULSION SYSTEM
S. D. ROSENBERG (Aerojet Techsystems Co., Sacramento, Calif.), D. C. JUDD (Aerojet Techsystems Co., Sacramento, Calif.), and P. W. GARRISON *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 329-338 Feb. 1984 refs
Avail: NTIS HC A17/MF A01 CSCL 21H

Oxygen/hydrogen propulsion system options for space station orbit maintenance and attitude control were developed and

evaluated relative to monopropellant and storable bipropellant propulsion systems. Space station propulsion requirements were analyzed with reference to such considerations as station size, altitude, power, crew size, and orbit transfer vehicle and orbital maneuvering vehicle servicing requirements. The evolutionary growth of oxygen/hydrogen bipropellant propulsion as an integral part of several interrelated space station functions, e.g., life support, power, and thermal management was considered. Propellant resupply evolves from resupply based on transport of liquid oxygen and liquid hydrogen to water. The advantages of the operation of the space station based on an oxygen/hydrogen economy are presented and discussed. Author

N84-29934*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OXYGEN/HYDROGEN THRUSTERS FOR THE SPACE STATION AUXILIARY PROPULSION SYSTEMS
M. A. APPEL, L. SCHOENMAN, and D. K. BERKMAN *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 339-350 Feb. 1984 refs
Avail: NTIS HC A17/MF A01 CSCL 21H

The status of a program to determine the feasibility and technology requirements of a low-thrust, high-performance, long-life gaseous oxygen/gaseous hydrogen thruster for space station propulsion was discussed. An existing igniter-injector was coupled with three different thrust chambers to acquire test data for the program. A stainless-steel chamber was used for test stand checkout, calibration, and propellant ignition studies. A regeneratively cooled thrust chamber was used to evaluate the feasibility of utilizing this method of cooling and to determine achievable performance. Because of off-design point operation, the cooling method was not proven. Vacuum performance achieved was 3616 N-s/kg (369 lbf-s/lbm) at the ODK optimum mixture of 2.5:1 and a chamber pressure of 207 kN/ sq m (30 psia). A high temperature rhenium thrust chamber was run at the same operating conditions for a total run duration of 2852 sec during 41 tests with no degradation of the walls. Vacuum performance achieved was 4020 N-s (410 lbf-s/lbm). A total of 115 tests were conducted with no instances of nonignition. Recommendations are presented to advance the feasibility and technology requirements evaluation. Author

N84-29935*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THRUST LEVEL REQUIREMENTS FOR SPACE STATION ON-ORBIT PROPULSION
R. W. KLEMETSON and J. C. SERCEL *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 351-358 Feb. 1984 refs
Avail: NTIS HC A17/MF A01 CSCL 21H

Thrust level requirements for the space station propulsion system were systematically evaluated for a range of possible space station configurations. Requirements addressed include orbit reboost or orbit maintenance and attitude control for disturbance correction. Constraints considered include acceleration limits imposed by structure and payloads, pointing requirements, reboost frequency, and allowable thrusting period. Results are presented parametrically and thrust level requirements for various space station architectures are specified. Author

N84-29937*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROPULSION ISSUES FOR ADVANCED ORBIT TRANSFER VEHICLES
L. P. COOPER *In* APL The 1984 JANNAF Propulsion Meeting, Vol. 1 p 365-378 Feb. 1984 refs Previously announced as N84-25762
Avail: NTIS HC A17/MF A01 CSCL 21H

Studies of the United States Space Transportation System show that in the mid to late 1990s expanded capabilities for orbital transfer vehicles (OTV) are needed to meet increased payload requirements for transporting materials and possibly men to geosynchronous orbit. Discussion and observations relative to the propulsion system issues of space basing, aeroassist compatibility, man ratability, and enhanced payload delivery capability are presented. These issues require resolution prior to the development of a propulsion system for the advanced OTV. The NASA program in support of advanced propulsion for an OTV is briefly described along with conceptual engine design characteristics. Author

N84-31263*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE STATION SYSTEMS ANALYSIS STUDY. VOLUME 1: EXECUTIVE SUMMARY, PART 1 AND 2 Final Report
25 Mar. 1977 119 p refs
(Contract NAS8-31993)
(NASA-CR-161590; NAS 1.26:161590; NSS-SS-RP014-VOL-1-PT-1/2) Avail: NTIS HC A06/MF A01 CSCL 22B

The elements of space station programs required to support an operational base theme, a space laboratory theme, and advanced missions relatable to public needs/national interests are defined. Missions satisfying the foregoing requirements are identified, program scenarios/options are established. System options are evaluated for a selected number of program options. Subsystem analysis and programmatic comparisons are performed for selected primary concepts. A.R.H.

N84-31264*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE STATION SYSTEMS ANALYSIS STUDY. VOLUME 2: PROGRAM REVIEW REPORT Final Report
20 Apr. 1977 105 p refs
(Contract NAS8-31993)
(NASA-CR-161231; NAS 1.26:161231; NSS-SS-RP016-VOL-2)
Avail: NTIS HC A06/MF A01 CSCL 22B

Major growth options for tended and manned space stations in LEO and GEO are examined including increased orbiter augmentation and habitation requirements. Approaches for providing power supplies, construction aids needed to assemble support platforms, transportation system constraints, and the hardware required for various missions categories are defined. Subsystem requirements are analyzed for structure; flight control; power generation and storage; avionic; life support systems; personnel provisions; and environmental control. Tradeoffs are considered. A.R.H.

N84-31265*# Grumman Aerospace Corp., Bethpage, N.Y.
SPACE STATION SYSTEMS ANALYSIS STUDY. VOLUME 2: PROGRAM OPTIONS, BOOK 1, PARTS 1 AND 2 Final Report
25 Mar. 1977 344 p refs
(Contract NAS8-31993)
(NASA-CR-161927; NAS 1.26:161927; NSS-SS-RP014-VOL-2-BK-1-PT-1/2) Avail: NTIS HC A15/MF A01 CSCL 22B

Program options are defined and requirements are determined for integrating crew, mass, volume, and electrical power for a space construction base which incorporates the space shuttle external tanks. Orbits, stabilization, flight control hardware, as well as modules and aids for orbital assembly and servicing are considered. The effectiveness of various program options for life science and radio astronomy missions, for the solar terrestrial observatory, and for public service platforms is assessed. Technology development items are identified and costs are estimated. A.R.H.

N84-31270*# National Academy of Sciences - National Research Council, Washington, D. C. Space Applications Board.
PRACTICAL APPLICATIONS OF A SPACE STATION
1984 104 p refs
(Contract NSR-09-012-106)
(NASA-CR-173672; NAS 1.26:173672; PB84-194794) Avail: NTIS HC A06/MF A01 CSCL 22B

The potential uses of a special station for civil and commercial applications is examined. Five panels of experts representing user-oriented communities, and a sixth panel which dealth with system design considerations, based their studies on the assumption that the station would be a large platform, capable of

housing a wide array of diverse instruments, and could be either manned or unmanned. The Earth's Resources Panel dealt with applications of remote sensing for resource assessment. The Earth's Environment Panel dealt with the Earth's atmosphere and its impact on society. The Ocean Operations Panel looked at both science and applications. The Satellite Communications Panel assessed the potential role of a space station in the evolution of commercial telecommunication services up to the year 2000. The Materials Science and Engineering panel focused on the utility of a space station environment for materials processing.

Author (GRA)

N84-33437*# National Aeronautics and Space Administration, Washington, D. C.

SPACE STATION PROGRAM DESCRIPTION DOCUMENT. BOOKS 1-7 Final Edition, May 1982 - Apr. 1984

Mar. 1984 762 p

(NASA-TM-86652-BK-1-7; NAS 1.15:86652-BK-1-7) Avail: NTIS HC A99/MF A01 CSCL 22B

The Space Station Program Description Document is summarized. The six volumes include: (1) introduction and summary; (2) mission description; (3) systems requirements and characteristics; (4) advanced development; (6) system operations; and (7) program plan. Volume 5 was deleted as a separate book.

N84-33438*# National Aeronautics and Space Administration, Washington, D. C.

SPACE STATION PROGRAM DESCRIPTION DOCUMENT: INTRODUCTION AND SUMMARY, BOOK 1

In its Space Station Program Description Document 99 p Mar. 1984

(NAS 1.15:86652-BK-1; NASA-TM-86652-BK-1) Avail: NTIS HC A99/MF A01 CSCL 22B

Space Station historical perspective; time-phased mission set; mission requirements; user concerns and NASA challenges; system requirements; generic technology base; candidate system architecture; design considerations; operational requirements; program management and procurement approach are discussed.

B.G.

N84-33439*# National Aeronautics and Space Administration, Washington, D. C.

MISSION DESCRIPTION DOCUMENT, BOOK 2

In its Space Station Program Description Document 175 p Mar. 1984

(NAS 1.15:86652-BK-2; NASA-TM-86652-BK-2) Avail: NTIS HC A99/MF A01 CSCL 22B

Realistic science and applications, commercial, and technology development missions appropriate to the Space Station program are identified. Time-phased mission requirements synthesized from the various industry studies and the results from in-house studies are established. Author

N84-33440*# National Aeronautics and Space Administration, Washington, D. C.

SYSTEM REQUIREMENTS AND CHARACTERISTICS, BOOK 3

In its Space Station Program Description Document 193 p Mar. 1984

(NAS 1.15:86652-BK-3; NASA-TM-86652-BK-3) Avail: NTIS HC A99/MF A01 CSCL 22B

The Space Station configuration concepts, architecture, and system requirements as driven by the missions were developed. The requirements address both missions that are carried out on-board the Station and missions that are supported from the Space Station. Author

N84-33441*# National Aeronautics and Space Administration, Washington, D. C.

ADVANCED DEVELOPMENT PROGRAM, BOOKS 4 AND 5

In its Space Station Program Description Document 74 p Mar. 1984

(NAS 1.15:86652-BK-4/5; NASA-TM-86652-BK-4/5) Avail: NTIS HC A99/MF A01 CSCL 22B

The technology and advanced development programs required to support the Space Station are outlined. The technology program identifies the key technology options that have the potential for enhancing the desired operational Space Station. The advanced development program provides the means of advancing selected technologies and demonstrating feasibility and performance before implementing into the Space Station design. The program is designed to support the initial Space Station and the evolutionary growth capability. Author

N84-33442*# National Aeronautics and Space Administration, Washington, D. C.

SYSTEM OPERATIONS, BOOK 6

In its Space Station Program Description Document 175 p Mar. 1984

(NAS 1.15:86652-BK-6; NASA-TM-86652-BK-6) Avail: NTIS HC A99/MF A01 CSCL 22B

The operational philosophies developed and the operational requirements necessary to satisfy the missions outlined in Book 2 are addressed. Author

N84-33443*# National Aeronautics and Space Administration, Washington, D. C.

PROGRAM PLAN, BOOK 7

In its Space Station Program Description Document 46 p Mar. 1984

(NAS 1.15:86652-BK-7; NASA-TM-86652-BK-7) Avail: NTIS HC A99/MF A01 CSCL 22B

The program planning and objectives are defined, and the overall management, technical, and procurement approaches are described. Author

N84-33454*# National Aeronautics and Space Administration, Washington, D. C.

SPACE STATIONS: LIVING IN ZERO GRAVITY, DEVELOPMENTAL TASK FOR PSYCHOLOGISTS AND SPACE ENVIRONMENTAL EXPERTS

E. LUDWIG Sep. 1984 10 p Transl. into ENGLISH from Umschau (West Germany), no. 18, 1984 p 526-527

(NASA-TM-77620; NAS 1.15:77620) Avail: NTIS HC A02/MF A01 CSCL 22B

The recent advances in the psychological aspects of space station design are discussed, including the impact of the increase in awareness of both the public in general as well as space environmental experts of the importance of psychological factors when designing space stations and training astronauts. Author

N84-33455*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

A REVIEW OF MICROMETEOROID FLUX MEASUREMENTS AND MODELS FOR LOW ORBITAL ALTITUDES OF THE SPACE STATION

M. SUSKO Sep. 1984 27 p refs

(NASA-TM-86466; NAS 1.15:86466) Avail: NTIS HC A03/MF A01 CSCL 22B

A review of meteoroid flux measurements and models for low orbital altitudes of the Space Station has been made in order to provide information that may be useful in design studies and laboratory hypervelocity impact tests which simulate micrometeoroids in space for design of the main wall of the Space Station. This report deals with the meteoroid flux mass model, the defocusing and shielding factors that affect the model, the probability of meteoroid penetration of the main wall of a Space Station. Whipple (1947) suggested a meteoroid bumper, a thin shield around the spacecraft at some distance from the wall, as an effective device for reducing penetration, which has been

discussed in this report. The equations of the probability of meteoroid penetration, the average annual cumulative total flux, and the equations for the thickness of the main wall and the bumper are presented in this report. B.W.

N84-33456 Virginia Polytechnic Inst. and State Univ., Blacksburg.
SPACE STATION M.A. Thesis
J. CARTER Jul. 1984 42 p
Avail: NTIS HC A03/MF A01

The disciplines of architecture are used to combine and coordinate space structures and human factors engineering to create a liveable space station environment in which recognizable components keep the man-made space from totally alienating the human occupant. A space station comprising a three-part module that is 14' in diameter with segments that are 9' 2' on center is considered. Three alternatives for orientation within a cylinder are examined. Life support systems, purpose of task, and psychological and spiritual concerns are addressed. A.R.H.

N84-33658# Joint Publications Research Service, Arlington, Va.
STAND ON SPACE STATION PARTICIPATION TO BE SURVEYED
In its Worldwide Rept.: Telecommun. Policy, Res. and Develop. p 20-21 26 Sep. 1984 Repr. from The Toronto Star (Toronto), 25 Jul. 1984 p A19
Avail: NTIS HC A05/MF A01

The building of a permanent orbiting space station which will use the low gravity, near perfect vacuum to produce better, cheaper products than their Earth bound competitors is discussed. The the Canadian government, which is trying to raise the profile of its own space program, is excited at the prospect of an extraterrestrial partnership. Opportunities in areas such as communications, remote sensing, space science and technology are investigated. Tangible commercial benefits the space station could offer are questioned. Benefits the station for Canadian manufacturing are examined, and the potential of each project are considered. The feasibility of joining the space station is studied. E.A.K.

N84-34459*# General Dynamics Corp., St. Louis, Mo.
A STUDY OF SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS Final Briefing Report
5 Apr. 1983 136 p
(Contract NASW-3682)
(NASA-CR-173997; NAS 1.26:173997) Avail: NTIS HC A07/MF A01 CSCL 22B

The mission requirements, economic benefits, and time table of deployment of the space station are discussed. It is concluded that: (1) mission requirements overwhelmingly support the need for a space station; (2) a single space station is the way to begin; (3) the space station must evolve its capability; (4) the orbit transfer vehicle aspect of the space station will provide significant economic benefit; and (5) an early, affordable, effective way to start the space station program is needed. R.S.F.

N84-34460*# TRW, Inc., Cleveland, Ohio.
SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS. CONTRACTOR ORIENTATION BRIEFINGS Final Report
7 Apr. 1983 602 p Meeting held 14-15 Sep. 1982
(Contract NASW-3681)
(NASA-CR-173999; NAS 1.26:173999) Avail: NTIS HC A99/MF A01 CSCL 22B

Requirements are considered for user missions involving life sciences; astrophysics, environmental observation; Earth and planetary exploration; materials processing; Spacelab payloads; technology development; and communications are analyzed. Plans to exchange data with potential cooperating nations and ESA are reviewed. The capability of the space shuttle to support space station activities are discussed. The status of the OAST space station technology study, conceptual architectures for a space station, elements of the space-based infrastructure, and the use of the shuttle external tank are also considered. A.R.H.

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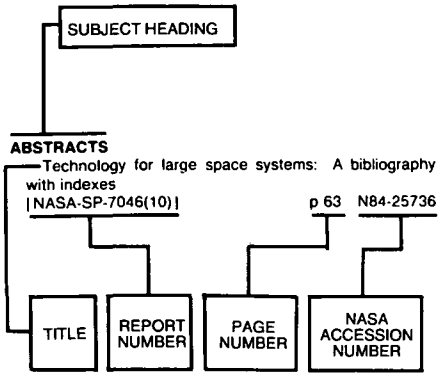

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Space - The next twenty years; Proceedings of the Twentieth Space Congress, Cocoa Beach, FL, April 26-28, 1983 p 60 A84-40601
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Space and society: Challenges and choices; Proceedings of the Conference, University of Texas, Austin, TX, April 14-16, 1982 p 61 A84-45530

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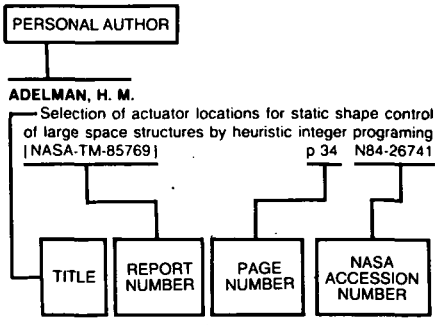

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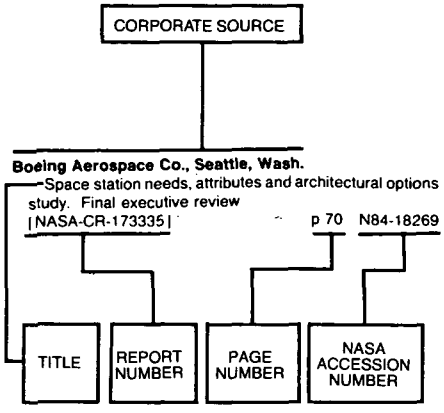

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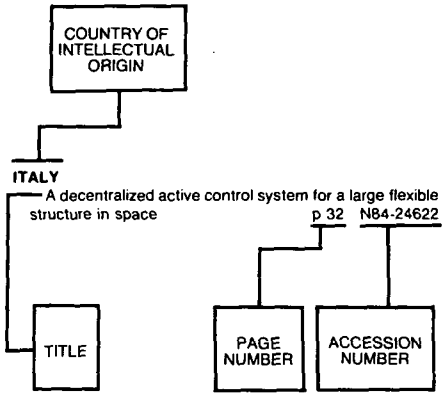

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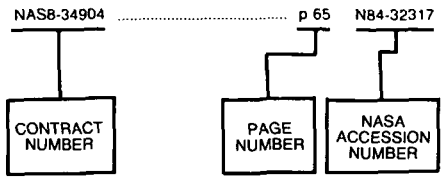

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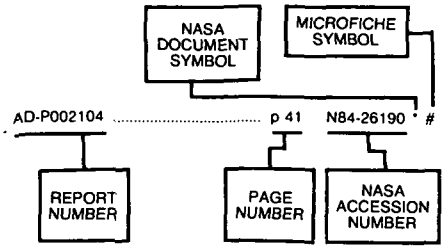

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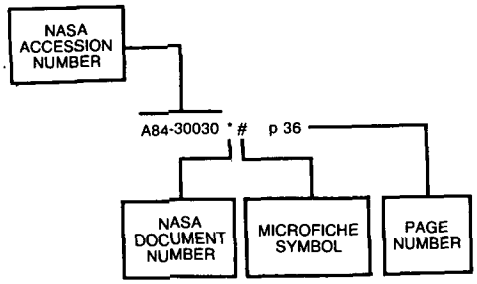

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