NASA

Technology for Large Space Systems

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A Bibliography
with Indexes

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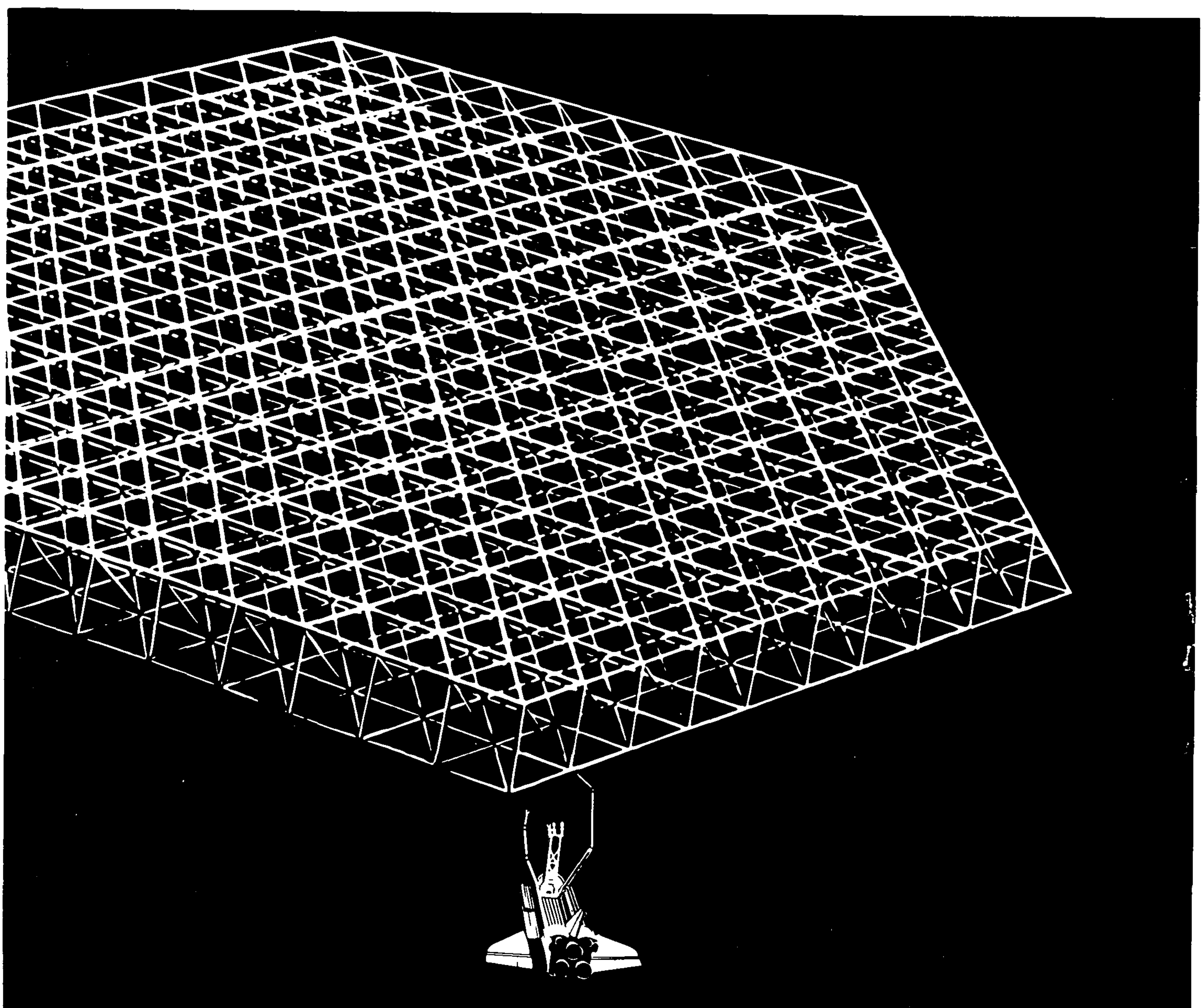

NASA SP-7046(08)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A SPECIAL BIBLIOGRAPHY WITH INDEXES

Supplement 8

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, 1982 in

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

NASA Scientific and Technical Information Branch 1983
National Aeronautics and Space Administration
Washington, DC

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. 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 414 reports, articles and other documents announced between July 1, 1982 and December 31, 1982 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 General category completes the list of subjects addressed by this document.

The selected items are grouped into ten categories as listed in the Table of Contents with notes regarding the scope of each category. These categories were especially selected for this publication and differ from those normally found in *STAR* and *IAA*.

Each entry consists of a standard bibliographic citation accompanied by an abstract where available, and appears with the original accession numbers from the respective announcement journals.

Under each of the ten categories, the entries are presented in one of two groups that appear in the following order:

1) *IAA* entries identified by accession number series A82-10,000 in ascending accession number order;
2) *STAR* entries identified by accession number series N82-10,000 in ascending accession number order.

After the abstract section there are six indexes - subject, personal author, corporate source, contract number, report number, and accession number.

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NASA ACCESSION NUMBER

N82-12091*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SHUTTLE CONSIDERATIONS FOR THE DESIGN OF LARGE SPACE STRUCTURES
J. A. ROEBUCK, JR. Nov. 1980 411 p refs
(Contract NAS9-15718)
(NASA-CR-160861; SSD-80-0183) Avail: NTIS HC A18/MF A01 CSCL 22A

Shuttle related considerations (constraints and guidelines) are compiled for use by designers of a potential class of large space structures which are transported to orbit and, deployed, fabricated or assembled in space using the Space Shuttle Orbiter. Considerations of all phases of shuttle operations from launch to ground turnaround operations are presented Design of large space structures includes design of special construction fixtures and support equipment, special stowage cradles or pallets, special checkout maintenance, and monitoring equipment, and planning for packaging into the orbiter of all additional provisions and supplies chargeable to payload. Checklists of design issues, Shuttle capabilities constraints and guidelines, as well as general explanatory material and references to source documents are included S.L.

TITLE

AUTHOR

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REPORT NUMBERS

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TYPICAL CITATION AND ABSTRACT FROM *IAA*

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AIAA ACCESSION NUMBER

A82-17939*# Rockwell International Corp., Downey, Calif.
SPACE OPERATIONS CENTER ORBIT ALTITUDE SELECTION STRATEGY
J. INDRIKIS and H. L. MYERS (Rockwell International Corp., Downey, CA) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 9 p.
(Contract NAS9-16153)
(AIAA PAPER 82-0420)

The strategy for the operational altitude selection has to respond to the Space Operation Center's (SOC) maintenance requirements and the logistics demands of the missions to be supported by the SOC. Three orbit strategies are developed: two are constant altitude, and one variable altitude. In order to minimize the effect of atmospheric uncertainty the dynamic altitude method is recommended. In this approach the SOC will operate at the optimum altitude for the prevailing atmospheric conditions and logistics model, provided that mission safety constraints are not violated. Over a typical solar activity cycle this method produces significant savings in the overall logistics cost. (Author)

AUTHORS

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TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 8)

FEBRUARY 1983

01

SYSTEMS

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

A82-29251* Santa Clara Univ., Calif.
ADVANCED AUTOMATION FOR SPACE MISSIONS
R. A. FREITAS, JR. (XRI, Santa Clara, CA), T. J. HEALY (Santa Clara, University, Santa Clara, CA), and J. E. LONG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) (International Joint Conference of Artificial Intelligence, 7th, Vancouver, Canada, Aug. 24-28, 1981.) Journal of the Astronautical Sciences, vol. 30, Jan.-Mar. 1982, p. 1-11. NASA-supported research. refs

A NASA/ASEE Summer Study conducted at the University of Santa Clara in 1980 examined the feasibility of using advanced artificial intelligence and automation technologies in future NASA space missions. Four candidate applications missions were considered: (1) An intelligent earth-sensing information system, (2) an autonomous space exploration system, (3) an automated space manufacturing facility, and (4) a self-replicating, growing lunar factory. The study assessed the various artificial intelligence and machine technologies which must be developed if such sophisticated missions are to become feasible by century's end. (Author)

A82-29799
ASTRONOMY AND ASTROPHYSICS FOR THE 1980S
G. B. FIELD (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) Physics Today, vol. 35, Apr. 1982, p. 46-52.

The frontiers of astrophysics include the big bang and evolution of galaxies, the existence of hidden mass in the universe, quasars and active galactic nuclei, stars being born in molecular clouds, the origin and dissipation of solar and stellar magnetic fields, the solar neutrino flux, X-ray and gamma-ray bursts, and extraterrestrial intelligence. The NASA Astronomy Survey Committee has stated the four top priorities for the 1980s are, in order of importance, (1) the Advanced X-ray Astrophysics Facilitiy; (2) a very long baseline array of radio telescopes; (3) a new technology telescope of the 15-meter class on the ground; and (4) a large deployable reflector of the 10-meter class in space. Ongoing activities include the Space Telescope, the Gamma-Ray Observatory, and the Spacelab Infrared Telescope Facility. C.D.

A82-29874
CONCEPTS FOR LARGE TELECOMMUNICATIONS PLATFORMS OF THE FUTURE [KONZEPTE GROSSER TELEKOMMUNIKATIONSPLATTFORMEN DER ZUKUNFT]
G. SCHNEIDER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) (Hermann-Oberth-Gesellschaft, Symposium ueber Entwicklungstrends der Weltraum-Nachrichtentechnik, Berlin, West Germany, Sept. 4, 1981.) Astronautik, vol. 19, no. 1, 1982, p. 12-16. In German.

Services and concepts of telecommunications satellite systems are discussed, including fast availability through relatively short installation time, universally exchangable features, and flexibility of connections on the ground. Limiting conditions and their influence on future telecommunications platforms are reviewed, and trends in the platforms are discussed with emphasis on transport, costs, and the platform as a solution to problems such as coordinating and optimizing geostationary orbits, enhancing work load capabilities, and reducing system procurement costs. Future concepts include platform assembly in a low earth orbit and in a geostationary orbit, and the assembly of an operable telecommunications platform with the transport of individual elements by the Space Shuttle in a low earth orbit. A cost analysis is also performed. D.L.G.

A82-30288
DESIGN, STUDIES OF THE VOSTOK-J AND SOYUZ SPACECRAFT
C. WACHTEL British Interplanetary Society, Journal (Soviet Astronautics), vol. 35, Feb. 1982, p. 92-94.

A82-31348#
SPACE 2020 - THE TECHNOLOGY, THE MISSIONS LIKELY 20-40 YEARS FROM NOW
R. F. BRODSKY (TRW, Inc., Space and Technology Group, Cleveland, OH) and B. G. MORAIS (Lockheed Missiles and Space Co., Space Systems Div., Sunnyvale, CA) Astronautics and Aeronautics, vol. 20, May 1982, p. 54-73.

The hardware and missions in space which are in development or have been approved to take place in the next 20-40 yr are reviewed. Reduced-instrument load planetary probes are foreseen due to fiscal restraints, while a LEO space station followed by construction of a GEO facility are likely directions for near term development. The Shuttle is intended as the vehicle intrinsic to the erection of large space structures, for military, scientific, and civilian applications. The moon offers opportunities for raw materials for the space-based construction activities, while suitable construction materials will require advances in better composites and ceramics. Space structures are characterized as pressure vessels for fluid storage and living conditions and open frame structures for large antennas and extended platforms. Future propulsion systems are described, and the improvement of reliability of all space-based electronics is stressed as necessary for successful development of the space frontier. Finally, advanced communications systems are discussed, as well as the feasibility of robots for construction and maintenance of space platforms and equipment. M.S.K.

A82-33911*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE PLATFORMS/STATIONS
C. C. PRIEST (NASA, Marshall Space Flight Center, Advanced Systems Office, Huntsville, AL) AIAA Student Journal, vol. 19, Fall 1981, p. 16-23. refs

Platforms in low-earth orbit are examined as simple and cost-effective solutions to the problem of long-duration space flight, providing stability, utilities and access for a variety of Shuttle-tended replaceable payloads over extended periods of time. The requirements for space platforms, which will encompass the advantages of both the free-flying and Shuttle-Spacelab operational modes, are discussed, with consideration given to payloads, operations and platform systems, and the status of the space platform concept, which is expected to begin development in early 1983 following definition studies and design selection, is noted. Possible paths in the evolution of space platform facilities to more advanced concepts are then outlined. Finally, the concept of the Science and Applications Manned Space Platform is examined as the first step toward a permanent manned United States presence in space. A.L.W.

A82-35082*# TRW, Inc., Redondo Beach, Calif.
SHUTTLE TO GEO PROPULSION TRADEOFFS
C. L. DAILEY (TRW, Inc., Redondo Beach, CA) and R. M. LOVBERG (California, University, La Jolla, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA 7 p.
(Contract NAS3-22661)
(AIAA PAPER 82-1245)

An analysis has been made over a range of thruster, spacecraft and mission parameters to determine optimum electric propulsion requirements for LEO to GEO transfer missions. For this mission solar cell cover thicknesses of four to six mils each side appear to be an optimum compromise between mass and power loss due to radiation damage. The optimum range of thruster specific impulse for this mission is roughly from 1500 to 3000 seconds. Thrusters limited to much lower values of specific impulse and those requiring much higher specific impulse for good efficiency require substantially greater transfer times. (Author)

A82-35198
ELECTROSTATICALLY FIGURED REFLECTING MEMBRANE ANTENNAS FOR SATELLITES
J. H. LANG and D. H. STAELIN (MIT, Cambridge, MA) IEEE Transactions on Automatic Control, vol. AC-27, June 1982, p. 666-670. refs
(Contract DAAG29-78-C-0020)

A design concept is described which may permit the construction of very large high-precision low-mass reflecting antennas for use in space. The concept utilizes electrostatic forces to actively shape a flexible membrane reflector, a method which appears to substantially reduce the number of reflector figure actuators required to achieve a specified reflector surface precision. The concept presents a challenging control problem, however, because the equilibrium reflector figure may exhibit several open-loop Rayleigh-Taylor modal instabilities. The origin and essential elements of this control problem are described and a control approach is proposed. A laboratory demonstration of three successfully stabilized modes on a meter-square membrane is also described which suggests that electrostatically figured satellite antennas with diameters reaching several hundred meters, and ratios of focal length to diameter as small as one, could achieve beamwidths of several arc seconds. (Author)

A82-37806*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE TELESCOPE DESIGN STATUS AND OPERATIONS
F. A. SPEER (NASA, Marshall Space Flight Center, Space Telescope Project Office, Huntsville, AL) American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium on Spacelab, Space Platforms and the Future, 20th, Greenbelt, MD, Mar. 17-19, 1982, AAS 27 p.
(AAS PAPER 82-121)

The Space Telescope design concept is described in the context of the basic mission objectives. The orbiting telescope is designed to have 10 times better resolution, to see 50 times fainter stars and to have a much broader spectral range than the best existing ground observatories. The project is on schedule for launch in early 1985. Hardware assembly and test has started on the optical system, and the primary and secondary mirrors have been polished and coated. The five scientific instruments are beginning hardware assembly. The last major design review for the spacecraft has been completed, and good progress has been accomplished with the implementation of the pointing control system. The mission operations ground system has been defined and is under development. Control center design is complete and the science institute is under construction. The Space Telescope is designed to be serviceable in orbit and will be capable of return to the ground for refurbishment. (Author)

A82-38736* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SPACE INFRARED ASTRONOMY - OVERVIEW OF NASA PLANNING
M. G. HAUSER (NASA, Goddard Space Flight Center, Laboratory for Extraterrestrial Physics, Greenbelt, MD) Optical Engineering, vol. 21, July-Aug. 1982, p. 758-763. refs

The present status and potential future direction of the NASA space infrared astronomy program is reviewed. Projects and project concepts discussed include the Infrared Astronomy Satellite, Small Infrared Telescope on Spacelab 2, Cosmic Background Explorer, Shuttle Infrared Telescope Facility, Space Telescope, large deployable reflector, molecular line survey, and infrared interferometer in space. Needs for continued engineering development in critical technology areas such as detectors, cryogenics, optics, and space structures are indicated. (Author)

A82-42789*# National Aeronautics and Space Administration, Washington, D. C.
CURRENT NASA SPACE STATION PLANNING
P. E. CULBERTSON (NASA, Washington, DC) Astronautics and Aeronautics, vol. 20, Sept. 1982, p. 36-43, 59.

Design considerations, trials, and actions both taken and necessary in the future which lead to the establishment of a space station by NASA are reviewed. Human performance on board Skylab demonstrated the feasibility and benefits of continuous operation of a space station. The manned orbital systems concept (MOSC) program, keeping in close contact with potential users, resulted in station requirements which included support for 720 day missions, up to four specialists per payload, 8-10 kW power, a 230 x 200 n mi altitude orbit, orbit change capability of 28.5 deg, all attitude orientation, and stability to within 1,100,000 g. Although the concept will not be funded, it provides a guide for incremental growth of a manned station from previously unmanned science platforms. Initiation of hardware development is projected for 1984-85. The agencies, both domestic and international, and missions for which the station will be built, are discussed. M.S.K.

A82-43265* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CAPTURE-EJECTOR SATELLITES
I. O. MACCONOCHIE, C. H. ELDRED, and J. A. MARTIN (NASA, Langley Research Center, Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 41st, San Jose, CA, May 17-19, 1982, 18 p. refs
(SAWE PAPER 1455)

A satellite in the form of a large rotating rim is described which can be used to boost spacecraft from low-Earth orbit to higher orbits. The rim rotates in the plane of its orbit such that the lower portion of the rim is travelling at suborbital velocity, while the upper portion is travelling at greater than orbital velocity. Ascending spacecraft or payloads arrive at the lowest portion of the rim at suborbital velocities, attach to the perimeter, and remain until they reach the highest point, where the payloads are released on a trajectory for higher orbits; descending payloads employ the reverse procedure. Electric thrusters placed on the rim maintain rim rotational speed and altitude. From the standpoint of currently known materials, the capture-ejector concept may be useful for relatively small velocity increments. A.B.

A82-44653*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE TETHERED RETRIEVABLE PLATFORM CONCEPT AND UTILIZATION
J. H. LAUE (NASA, Marshall Space Flight Center, Huntsville, AL) and G. MANARINI (CNR, Rome, Italy) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p.
(IAF PAPER 82-13)

Main components of the current configuration of a proposed tethered satellite system (TSS) for deploying instrumentation up to 100 km upward or downward from the Orbiter in LEO are described. The TSS consists of the Deployer Module, the Tether, and the Satellite Module, and remains connected to the equipment in the Orbiter bay for the entire mission. The Deployer Module is mounted on a pallet, and has a boom, a tether control mechanism, and a tether control capability, in addition to data acquisition and control systems. The Satellite Module features a thermal control, electrical power and distribution, data management and communication, attitude determination, propulsion, and payload capability. Deployment is unpowered, taking advantage instead of gravity gradients to move the payload from the Orbiter. Safety features include a cutter mechanism to disengage the tether from the Orbiter if retrieval of the payload is judged to endanger the crew and the Orbiter. M.S.K.

A82-44660#
M.E.G.A.L.O.S. - A NEW TELECOMMUNICATION PLATFORM CONCEPT TO MEET THE 1990-1995 EUROPEAN DEMAND
M. T. RAVAZZOTTI (Aeritalia S.p.A., Turin, Italy) and A. FESTA (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p. European Space Research and Technology Centre refs
(Contract ESTEC-4750/81-NL-AK)
(IAF PAPER 82-52)

The concept of a Multimission European Geostationary Ariane Launched Orbital Station (MEGALOS) has been developed to provide a platform for a modular grouping of independent payloads which may be tailored to meet European demands in the next decade. Baseline requirements have been determined by nine reference missions, including national intercity telephony for 2-3 countries, national television broadcasting for 2-6 countries, and European Regional Trunk Service. Modules launched by Ariane are to be assembled in geostationary orbit. With an anticipated 10-15 year lifetime, technological developments which can be clearly identified and reasonably envisaged for this period must be adopted. Outlines of the modular configuration and of the rendez-vous and docking operations for assembly are given. A.B.

A82-44668#
INTELSAT - NEW FRONTIERS, NEW CHALLENGES
S. ASTRAIN (International Telecommunications Satellite Organization, Washington, DC) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p.
(IAF PAPER 82-89)

The growth of Intelsat since its establishment in 1964 and future technological programs are presented. Charts of growth in four areas are included: volume of ocean region traffic (4,000 half circuits in 1970 to 51,000 in 1982), number of earth stations (51 antennas in 30 countries in 1970 to 396 antennas in 135 countries in 1981), number of preassigned pathways (approximately 120 in 1970 to 980 in 1981), and number of countries, territories, and independent possessions using Intelsat (60 in 1970 to about 165 in 1981). New aims include increased satellite size and capacity, and improved cost-efficiency and reliability. Proposed methods of achieving these goals are the use of multibeam antennas and space platforms, advanced launch vehicle capabilities, and improved digital communications techniques. New services are being researched such as videoconferencing and videophone services, business related services, and rural communications services. R.K.R.

A82-44692#
MESA - A NEW APPROACH TO LOW COST SCIENTIFIC SPACECRAFT
G. W. KEYES and C. M. CASE (Boeing Aerospace Co., Seattle, WA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 11 p.
(IAF PAPER 82-205)

Today, the greatest obstacle to science and exploration in space is its cost. The present investigation is concerned with approaches for reducing this cost. Trends in the scientific spacecraft market are examined, and a description is presented for the MESA space platform concept. The cost drivers are considered, taking into account planning, technical aspects, and business factors. It is pointed out that the primary function of the MESA concept is to provide a satellite system at the lowest possible price. In order to reach this goal an attempt is made to benefit from all of the considered cost drivers. It is to be tried to work with the customer early in the mission analysis stage in order to assist in finding the right compromise between mission cost and return. A three phase contractual arrangement is recommended for MESA platforms. The phases are related to mission feasibility, specification definition, and design and development. Modular kit design promotes flexibility at low cost. G.R.

A82-44746#
MULTIPURPOSE COMMUNICATION SATELLITE SOLAR ARRAY
J. L. BASTARD and R. LAGET (Societe Nationale Industrielle Aerospatiale, Cannes, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 7 p.
(IAF PAPER 82-402)

The construction and operation of the solar array for the Multipurpose Communication Satellite is described. Employing high efficiency cells with a back surface reflector, the solar array consists of two wings with four panels each. The favorable 21.4 W/kg power mass ratio makes this system fully adapted to telecommunications missions. Primary power ranging from 1.3 to 1.5 kW is to be provided over the expected orbital lifetime of seven years. During the transfer orbit, the array is designed to be partially deployed and to provide a minimum average power of 400 W. Features of the mechanical design of the array, such as the hold-down mechanisms, linkage and the centrifugal brake are discussed. A.B.

A82-45016* Rockwell International Corp., Downey, Calif.
A PENTAHEDRAL PYRAMIDAL CONCENTRATOR DESIGN FOR SPACE SOLAR ARRAY
L. HSU (Rockwell International Corp., Space Operations and Satellite Systems Div., Downey, CA) In: Photovoltaic Specialists Conference, 15th, Kissimmee, FL, May 12-15, 1981, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1981, p. 560-564.
(Contract NAS8-32988)

A truncated pentahedral pyramidal solar concentrator configuration has been selected as the most favorable candidate capable of providing low-cost multi-hundred-kilowatts (kW) solar array in low earth orbit. This concentrator has the advantages of: commonality for applications using either gallium arsenide (GaAs) or silicon (Si) solar cells, cost effectiveness, structural simplicity, and compatibility with the Shuttle. Results of concentrator optical ray trace, benefit of radiator, deployment mechanism, array power, and cost analysis are discussed. (Author)

A82-45252#
FUTURE SPACE TELESCOPES
H. GURSKY (U.S. Navy, E. O. Hulburt Center for Space Research, Washington, DC) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 1-6. refs
(AIAA 82-1824)
The design features and technology development requirements of three future space based telescope configurations are assessed. These designs are (1) the Very Large Space Telescope, which employs the Space Shuttle External Tank as a housing and support structure for an 8.0 m-diameter primary mirror and the required focal plane instrumentation, (2) the Coherent Optical System of Modular Imaging Collectors, which incorporates four independent mirrors arranged in interferometer configuration and yields a pronounced central maximum whose width corresponds to the diffraction limit of the full array width, and (3) a 100-m, Thinned Aperture Telescope which maximizes collecting area at the expense of angular resolution. Attention is given to the point response functions of the latter two configurations, and to the schematic arrangement of the optical elements of all three. O.C.

A82-45253*# General Research Corp., McLean, Va.
ASTROPHYSICS SPACE SYSTEMS CRITICAL TECHNOLOGY NEEDS
C. F. GARTRELL (General Research Corp., McLean, VA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 7-18. refs
(Contract NASW-2973)
(AIAA 82-1828)
This paper addresses an independent assessment of space system technology needs for future astrophysics flight programs contained within the NASA Space Systems Technology Model. The critical examination of the system needs for the approximately 30 flight programs in the model are compared to independent technology forecasts and possible technology deficits are discussed. These deficits impact the developments needed for spacecraft propulsion, power, materials, structures, navigation, guidance and control, sensors, communications and data processing. There are also associated impacts upon in-orbit assembly technology and space transportation systems. A number of under-utilized technologies are highlighted which could be exploited to reduce cost and enhance scientific return. (Author)

A82-45261*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CONCEPTS FOR LARGE INTERFEROMETERS IN SPACE
S. H. MORGAN, M. E. NEIN, B. G. DAVIS, E. C. HAMILTON (NASA, Marshall Space Flight Center, Huntsville, AL), D. H. ROBERTS (Brandeis University, Waltham, MA), and W. A. TRAUB (Smithsonian Astrophysical Observatory, Cambridge, MA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 78-87. refs
(AIAA 82-1851)
Very high angular resolution can be achieved in optical and radio astronomy through interferometers in space. Evolutionary approaches and required technological advances are presented. In the optical region a phase-coherent array, (COSMIC) starting as a four-element linear array is discussed. Combining several modules results in greatly improved resolution with a goal of combining images to obtain a single field of view with 0.004 arcsecond resolution. The angular resolution, detail and temporal coverage of radio maps obtained by ground-based Very Long Interferometry (VLBI) can be greatly improved by placing one of the stations in earth orbit. An evolutionary program leading to a large aperture VLBI observatory in space is discussed. (Author)

A82-45266*# Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
CONCEPTS FOR AN OPTIMIZED KIRKPATRICK-BAEZ MIRROR MODULE FOR A HIGH THROUGHPUT LAMAR FACILITY
L. M. COHEN and P. GORENSTEIN (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 112-120.
(Contract NAS5-26024)
(AIAA 82-1863)
Alternative concepts are proposed for the design and fabrication of Kirkpartick-Baez nested crossed plate reflectors applicable to a high throughput, moderate resolution X-ray facility composed of a Large Area Modular Array of Reflectors (LAMAR). Numerical, structural and optical analyses are used to quantify the performance characteristics of the concepts proposed. It is found that the theoretical performance of certain concepts approaches the 0.2-min resolution of a perfect parabola of translation. The instrument under consideration has about 1000 sq cm of effective area, or five times greater area than that of the Einstein Observatory. O.C.

A82-45270#
RADIO ANTENNAS IN SPACE - THE NEXT 30 YEARS
B. F. BURKE (MIT, Cambridge, MA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 138-143.
(AIAA 82-1825)
The technique of Very Long Baseline Interferometry (VLBI), which employs a synchronization of independent radio telescopes by accurate frequency standards so that Michelson interferometers of arbitrarily large size can be constructed, has been constrained by the size of the earth. Consideration is given to the possibility of extending VLBI to orbiting radio telescopes. Near-earth orbiting VLBI systems allow the mapping of complex radio source distributions with large dynamic range, and may be deployed from the Space Shuttle. It is anticipated that future systems could be developed with angular resolutions of the order of one microarcsec. O.C.

A82-45273*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A TECHNOLOGY PROGRAM FOR THE DEVELOPMENT OF THE LARGE DEPLOYABLE REFLECTOR FOR SPACE BASED ASTRONOMY
M. K. KIYA, W. P. GILBREATH (NASA, Ames Research Center, Moffett Field, CA), and P. N. SWANSON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 156-163.
(AIAA 82-1850)
Technologies for the development of the Large Deployable Reflector (LDR), a NASA project for the 1990's, for infrared and submillimeter astronomy are presented. The proposed LDR is a 10-30 diameter spaceborne observatory operating in the spectral region from 30 microns to one millimeter, where ground observations are nearly impossible. Scientific rationales for such a system include the study of ancient signals from galaxies at the edge of the universe, the study of star formation, and the observation of fluctuations in the cosmic background radiation. System requirements include the ability to observe faint objects at large distances and to map molecular clouds and H II regions. From these requirements, mass, photon noise, and tolerance budgets are developed. A strawman concept is established, and some alternate concepts are considered, but research is still necessary in the areas of segment, optical control, and instrument technologies. R.K.R.

A82-45500#
RADIO TELESCOPES BIGGER THAN THE EARTH
B. F. BURKE (MIT, Cambridge, MA) Astronautics and Aeronautics, vol. 20, Oct. 1982, p. 44-52.

The very long baseline interferometer (VLBI) method for observing the universe, and the possibility of putting radio antennas in space to increase power capabilities, are presented. The VLBI (with an angular resolution one thousand times better than that of a 200 in. telescope) is based on the Michelson interferometer, with improvements to obtain better results. VLBI can reveal naturally occurring masers in space, and resolves structures with an angular size smaller than 0.0001 arcsec. VLBI observations also reveal structures in quasar nuclei which expand at many times the speed of light. To improve VLBI observations, space-borne radiotelescopes are being examined, and the Space Shuttle is being considered for a platform and a test facility. In the future, a free-flying satellite for VLBI observations may be developed.
R.K.R.

A82-46915*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION TECHNOLOGY
P. F. HOLLOWAY (NASA, Langley Research Center, Hampton, VA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 21 p.
(IAF PAPER 82-15)

A status report is given concerning the technology assessment and implementation effort begun by NASA to provide the basis for a 'permanent' manned space station. NASA's space station technology discipline working groups are identified, and the groups' ground rules and technology and design goals are outlined. Selected examples of high-priority technology tasks are examined to delineate the extent to which space station design and use depend on advanced technology developments of the future. Attention is devoted to working group programs dealing with data management, power and thermal systems, auxiliary propulsion, attitude control and stabilization, communications, structural elements and mechanisms, environmental control and life-support systems, human capabilities, and systems and operations analysis.
F.G.M.

A82-46921#
COST REDUCTIONS IN SPACE OPERATIONS
E. FREUNDT (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 14 p.
(IAF PAPER 82-34)

The operations and cost effectiveness of the EUropean REtrievable CArrier (EURECA) are explored. EURECA will be launched and retrieved by the Shuttle, will weigh 3500 kg, have a solar panel array furnishing 5.5 kW, and will be in a 300 km, 28.5 deg orbit. Later orbits will extend from 500-1000 km and up to 6 mos, with ground turnaround expected to be 18 mos. The spacecraft will carry materials processing/microgravity experiments, and will move into its operational orbit after deployment, then transfer back to a lower orbit, months later, for retrieval. In-flight monitoring will comprise a 600 bps uplink and a 250 kbps downlink for 9 mins every 24 hrs. Configuring the equipment and software for largely autonomous operation is discussed, a conservative approach using a centralized architecture, smart controllers for telemetry and remote control, a data bus, and standardized peripherals is outlined. Costs comparisons for each of five missions are presented.
M.S.K.

A82-46997#
ECONOMY OF MODULARIZED COMMUNICATION PLATFORMS AND SATELLITE CLUSTERS
W. KLEINAU (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany), J. NAUCK (Logica, Ltd., London, England), and P. HANSELL (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 12 p. European Space Research and Technology Centre
(Contract ESTEC-4817/81/NL/MD)
(IAF PAPER 82-224)

Results from an ESA cost-benefits analysis of modularized communication platforms and satellite clusters are reviewed. Attention was given to a reference satellite based on current technology, and advanced candidates for television broadcasting from a 19 deg W GEO modularized units and clusters. Both the Ariane and the Shuttle were considered as the launch vehicles for large, autonomous satellites, co-orbiting cluster units, or modular platofrms to be assembled in GEO. The analyses included development of performance and specific requirements, and cost comparison. Cost components comprised the spacecraft, constant costs, space segment costs, operations, and total system costs for a direct television broadcast system for Europe. An Ariane-launched modular platform was projected to cost 60% of the reference system, with break-even occurring at the addition of the third payload module.
M.S.K.

A82-47254
SPACE PLATFORM
L. P. MORATA (McDonnell Douglas Astronautics Co., Huntington Beach, CA) and M. W. NOVICK (TRW Space and Technology Group, Redondo Beach, CA) In: Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982, p. 1-13 to 1-26.

The Space Platform (SP) will provide a cost effective long-term host vehicle for scientific and applications payloads beginning in the late 1980's. SP will take advantage of STS capabilities for delivery to orbit, assembly, check-out, maintenance and servicing. Services provided to multiple payloads include electrical power, heat rejection, attitude control and high-rate data handling communications. The system includes self-contained altitude maintenance and is designed for indefinite orbital operation. Space Platform for NASA/MSFC is currently being studied to develop optimum configurations for the eventual development-phase competition. Included in the study is development of plans for evolution into an eventual Science and Applications Manned Space Platform.
(Author)

A82-47255
SPACE PLATFORM SOLAR ARRAY - A PROGRESS REPORT
M. GERBASI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) and P. GOLDSMITH (TRW Space and Technology Group, Redondo Beach, CA) In: Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982, p. 1-27 to 1-38.

Technological requirements for the Space Platform Solar Array are discussed, presenting a summary of key aspects of the solar array design, identifying technological issues, and assessing testing efforts currently under way to resolve these issues. The performance of different types of arrays and the special requirements of future arrays, such as retraction and redeployment, are discussed, and the projected array for the Space Platform is shown and discussed. Recent test efforts include an extension/retraction mast test, KC-135 zero 'g' testing, plasma testing of solar panels, and temperature cycling of panel designs.
C.D.

A82-47281
30/20 GHZ TECHNOLOGY AT TRW
W. M. HOLMES (TRW Defense and Space Systems Group, Redondo Beach, CA) In: Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982, p. 9-1 to 9-7A.

The design characteristics and early test results are presented for two types of 20 GHz solid state power amplifiers, an integrated 30 GHz receiver complex with both fixed and scanning beams, and an electric power conditioner for a dual-mode 7.5 and 75 watt 20 GHz travelling wavtube amplifiers, all of which are being developed as part of NASA's proof of concept technology development activity for the 30/20 GHz program. The solid state amplifiers utilize FET amplifiers to provide a 7.5 watt output and IMPATT diodes to provide a 20 watt output, while the IMPATT unit uses a 12 diode combiner with a combining efficiency of 80%. The current breadboard provides 17.18 watts output in the injection-locked mode. The antenna uses an 80.5 inch carbon-filament-reinforced plastic offset parabola to produce 0.3 degree beams. The feeds are polarization-diplexed, with both polarizations being utilized to provide fixed and scanning beams, and the feed-sets are interspersed to solve the feed crowding problem. N.B.

A82-47282
LARGE MESH DEPLOYABLE ANTENNA TECHNOLOGY STATUS AND PERFORMANCE ASSESSMENT
B. C. TANKERSLEY and B. E. MCINTOSH (Harris Corp., Melbourne, FL) In: Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982, p. 9-2 to 9-22. refs

User surveys and the results from an Industry Workshop on Large Space Structures indicate future needs for deployable antennas in the 30 to 100 meter diameter range. In general, these needs are related to applications in communications, earth observations, and radio astronomy. There are two broad antenna categories, including deployable and erectable antennas. The deployable category has been further divided into precision deployable and mesh deployable antennas. Present mesh deployable antenna designs are discussed, taking into account a radial-rib concept in flight hardware for the 4.8 meter Tracking and Data Relay Satellite System (TDRSS), the wrap-rib antenna, and the parabolic, erectable truss antenna. An investigation is conducted regarding concept designs for very large mesh deployable antennas, giving attention to the hoop/column reflector antenna and the maypole antenna. A description of RF performance projections is also provided. G.R.

A83-11932
ADVANCED OPERATIONAL EARTH RESOURCES SATELLITE SYSTEMS
S. W. MCCANDLESS (User Systems Engineering, Annandale, VA) and P. M. MAUGHAN (COMSAT General Corp., Washington, DC) In: Spacelab, space platforms and the future; Proceedings of the Fourth Joint AAS/DGLR Symposium and Twentieth Goddard Memorial Symposium, Washington, DC, March 17-19, 1982. San Diego, CA, Univelt, Inc., 1982, p. 293-308.
(AAS 82-128)

Spacecraft instrumentation and design, business objectives, and space technologies being developed and used by various nations in the near term are reviewed. The French are preparing the SPOT satellite for earth resouces mapping, while the ERS-1 spacecraft are being developed by both ESA and Japan, with capabilities similar to SEASAT and the GOES satellites. Communications satellites will implement the 30/20 GHz bands, multiple spot beam antennas, and large unmanned multiservice satellite systems. Predicted space missions in the period 1982-1991 are provided, including mention of satellite business communication services, direct broadcast television services, electronic mail, and international information services. At least four U.S. environmental monitoring satellites will be in orbit at any one time. Finally, the use of multisensor platforms is noted to potentially reduce the launch volume demands on the Shuttle and ballistic missile systems. M.S.K.

N82-22715*# Rhode Island Univ., Kingston. Dept. of Electrical Engineering.
PASSIVE SOLAR REFLECTOR SATELLITE REVISITED
C. POLK and J. C. DALY *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 231-233 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

Passive light weight reflectors in space which direct the incident solar energy to a specified location on the Earth surface are proposed as an alternative system for the solar power satellite to overcome conversion losses and to avoid the need for photovoltaic cells. On Earth, either photovoltaic cells or a steam turbine alternator on a solar tower, or a similar conventional, relatively high efficiency cycle are used for electricity generation. The constraints which apply to the design of the optical system if a single satellite is placed in geostationary orbit are outlined. A single lens and a two lens system are discussed. J.M.S.

N82-22740*# Rice Univ., Houston, Tex.
MICROWAVE POWER TRANSMISSION WORKSHOP SUMMARY
J. W. FREEMAN *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 345-347 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The assumptions, methodologies, and conclusions of the NASA SPS studies were assessed and criticized to identify critical issues and to make recommendations for follow-on works. An assessment of the following items was made: beam forming and control, microwave amplifiers, radiating elements, and the rectenna. It was concluded that top priority should be given to determining an upper limit for permissible microwave power density which can be sent through the ionosphere. M.D.K.

N82-23144# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Div.
A MODULAR GEOPLATFORM CONCEPT FOR INTELSAT 7 AND OTHER APPLICATIONS
D. E. KOELLE and W. KLEINAU *In its* Res. and Develop. at MBB. Tech. and Sci. Publ., 1981 11 p 1981 refs Presented at DGLR Symp. on Nachrichtensatelliten-heute u. Morgen, Munich, 15 Oct. 1981
(MBB-UR-517-81-OE) Avail: NTIS HC A09/MF A01

A geoplatform design with the special features of modularity and integrated transfer propulsion, optimized for launching by space shuttle, is described. Technical results, regarding the geoplatform and its performance in terms of communication payload and mission lifetime, are presented. The reference system design has a total mass of 14,300 kg, including 10,900 kg transfer propellants mass. The initial mass is 3400 kg, allowing for 400 to 700 kg of communication equipment, depending on power level, eclipse capability requirements (batteries) and mission lifetime. As examples, the platform design is shown with a typical Intelsat 7 payload (including and intersatellite link), a German national services payload (TVBS and 20/30 GHz data service), and a multinational direct TV broadcasting payload. The platform propels itself from low Earth orbit to geosynchronous orbit with a 6 impulse transfer, provided by a 5 kN engine (1100 lbs thrust level). This launching mode, although not being the optimum from the performance standpoint, proves to be the most economic.
Author (ESA)

N82-24137*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
RESEARCH AND TECHNOLOGY ANNUAL REPORT FY-1981
Nov. 1981 100 p
(NASA-TM-84199; NAS 1.15:84199) Avail: NTIS HC A05/MF A01 CSCL 05A

Space transportation systems are summarized: space shuttle enhancement, a space operations center, the space platform, and geostationary activites are discussed. Aeronautics and space technology are summarized: experiments, energy systems, propulsion technology, synthetic aperture radar, large space systems, and shuttle-launched vehicles are discussed. Space sciences are summarized: lunar, planetary, and life sciences are discussed. Space and terrestrial applications are summarized. The AgRISTARS program, forest and wildland resource, and Texas LANDSAT applications are discussed. N.W.

N82-24787*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE PLATFORMS AND METEOROLOGICAL APPLICATIONS
K. L. MITCHELL and G. S. WILSON *In its* Meteorol. Satellites p 43-51 May 1982 refs
Avail: NTIS HC A04/MF A01 CSCL 04B

An overview of past, current, and future space platform activities, with emphasis on implementation of the initial space platform is presented. Utilization of the space platform for meteorological purposes is examined and shown to be practical for both research and operational payloads. R.J.F.

N82-25286# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensbereich Raumfahrt.
THE DEVELOPMENT OF GEOSTATIONARY COMMUNICATION SATELLITES
D. E. KOELLE 13 Jul. 1981 10 p refs Repr. from Rundfunktech. Mitt. Jahrgang 25, no. 5, 1981 p 219-226 In GERMAN; ENGLISH summary Presented at Kongr. Kommunikation ueber Satelliten des Muenchner Kreis, Munich, 23-24 Oct. 1980
(MBB-UR-530-81-O) Avail: Issuing Activity

The development of communication satellites is surveyed. Major satellite systems are described. Their data handling characteristics are mentioned and physical parameters are given. With increasing demand for communication services via satellites and limited orbital positions in geosynchronous orbit, there is a trend to larger communication satellite platforms (3000 kg mass or more). An advanced U.S. platform concept (approximately 10,000 kg satellite mass) and the European Geoplatform are shown as examples of future systems. Author (ESA)

N82-25610*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RADIOMETER MISSION REQUIREMENTS FOR LARGE SPACE ANTENNA SYSTEMS
L. S. KEAFER, JR., P. SWANSON, and J. ECKERMAN May 1982 64 p refs
(NASA-TM-84478; NAS 1.15:84478) Avail: NTIS HC A04/MF A01 CSCL 20N

Requirements are defined for Earth observational microwave radiometry using large space antenna systems with apertures in the 50 to 200 meter range. General Earth observational needs, specific measurement requirements, orbital mission guidelines and constraints, and general radiometric requirements are defined. Specific measurements include soil moisture, water surface temperature, water roughness, ice boundaries, salinity, and water pollutants. Measurements with 10 to 1 km spatial resolution and 3 to 1 day temporal resolution are required. Author

N82-25655# British Aerospace Dynamics Group, Bristol (England). Space and Communications Div.
SOLA: SOLAR ARRAY TECHNOLOGY DEVELOPMENT FOR SHUTTLE LAUNCHED MISSIONS Final Report
R. A. HENDERSON Paris ESA Mar. 1981 110 p refs
(Contract ESA-4148/79/NL-JS)
(ESS/SS-1039; ESA-CR(P)-1535) Avail: NTIS HC A06/MF A01

A 60 kW solar power array was designed. It features a multiple deployment/retraction capability and a multiple stowage/restowage capability. It allows for power growth and can provide a wide voltage range. Blanket construction is modular. It is compatible with orbiters, power module-type vehicles and the free flying pallet. It has remote manipulator system and extravehicular activity interfaces. Author (ESA)

N82-26357*# Harris Corp., Melbourne, Fla. Government Systems Group.
LSST (HOOP/COLUMN) MAYPOLE ANTENNA DEVELOPMENT PROGRAM, PHASE 1, PART 1 Final Report
M. R. SULLIVAN Jun. 1982 244 p
(Contract NAS1-15763)
(NASA-CR-3558-PT-1; NAS 1.26:3558) Avail: NTIS HC A11/MF A01 CSCL 22B

The first of a two-phase program was performed to develop the technology necessary to evaluate, design, manufacture, package, transport and deploy the hoop/column deployable antenna reflector by means of a ground based program. The hoop/column concept consists of a cable stiffened large diameter hoop and central column structure that supports and contours a radio frequency reflective mesh surface. Mission scenarios for communications, radiometer and radio astronomy, were studied. The data to establish technology drivers that resulted in a specification of a point design was provided. The point design is a multiple beam quadaperture offset antenna system wich provides four separate offset areas of illumination on a 100 meter diameter symmetrical parent reflector. The periphery of the reflector is a hoop having 48 segments that articulate into a small stowed volume around a center extendable column. The hoop and column are structurally connected by graphite and quartz cables. The prominence of cables in the design resulted in the development of advanced cable technology. Design verification models were built of the hoop, column, and surface stowage subassembilies. Model designs were generated for a half scale sector of the surface and a 1/6 scale of the complete deployable reflector. Author

N82-26358*# Harris Corp., Melbourne, Fla. Government Systems Group.
LSST (HOOP/COLUMN) MAYPOLE ANTENNA DEVELOPMENT PROGRAM, PHASE 1, PART 2 Final Report
M. R. SULLIVAN Jun. 1982 296 p 2 Vol.
(Contract NAS1-15763)
(NASA-CR-3558-PT-2; NAS 1.26:3558) Avail: NTIS HC A13/MF A01 CSCL 22B

Cable technology is discussed. Manufacturing flow and philosophy are considered. Acceptance, gratification and flight tests are discussed. Fifteen-meter and fifty-meter models are considered. An economic assessment is included. N.W.

N82-26376*# Martin Marietta Aerospace, Denver, Colo.
CONCEPTUAL DESIGN AND ANALYSIS OF A LARGE ANTENNA UTILIZING ELECTROSTATIC MEMBRANE MANAGEMENT Report, Sep. 1980 - Sep. 1981
A. L. BROOKS, J. V. COYNER, W. J. GARDNER, and D. J. MIHORA Washington NASA May 1982 312 p refs
(Contract NAS1-16447)
(NASA-CR-3522; NAS 1.26:3522; MCR-81-1334) Avail: NTIS HC A14/MF A01 CSCL 22B

Conceptual designs and associated technologies for deployment 100 m class radiometer antennas were developed. An electrostatically suspended and controlled membrane mirror and the supporting structure are discussed. The integrated spacecraft including STS cargo bay stowage and development were analyzed. An antenna performance evaluation was performed as a measure of the quality of the membrane/spacecraft when used as a radiometer in the 1 GHz to 5 GHz region. Several related LSS structural dynamic models differing by their stiffness property (and therefore, lowest modal frequencies) are reported. Control system whose complexity varies inversely with increasing modal frequency regimes are also reported. Interactive computer-aided-design software is discussed. Author

N82-27359*# National Aeronautics and Space Administration, Washington, D. C.
OVERVIEW OF LARGE SPACE SYSTEMS/PROPULSION INTERACTIONS
R. F. CARLISLE *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 1-6 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22A

Large space structure characteristics, antenna controller design, the attitude control system, mission grouping, propulsion system/large space structure interactions, structural mass impact for start transient effects, box truss multiple thrust point effects, and large space structure/propulsion issues are illustrated. J.D.

N82-27360*# General Research Corp., McLean, Va.
NASA SPACE SYSTEM TECHNOLOGY MODEL FUTURE MISSION SYSTEM NEEDS
T. G. REESE *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 7-18 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22A

The overall technology model is outlined and the objectives and descriptions of the primary and secondary propulsion drives presented. The primary propulsion driver missions are the geostationary platform; the coherent optical system of modular imaging collectors (COSMIC); the 100 meter thinned aperature telescope; and the orbiting deep space relay station (ODSRS). The secondary propulsion driver missions are space platform alpha, the space station, and the automated planetary station. J.D.

N82-27361*# Analytic Services, Inc., Arlington, Va.
POTENTIAL LARGE SPACE SYSTEMS MISSION OPPORTUNITIES FOR THE POST 1990'S
R. L. CHASE *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 19-24 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22A

Potential mission opportunities outlined and illustrated are missile defense; space defense; command, control, and communications; defense suppression; force support; space transportation; and orbital support. J.D.

N82-27362*# Aerospace Corp., El Segundo, Calif. 22a
ADVANCED SPACE SYSTEM CONCEPTS AND THEIR ORBITAL SUPPORT NEEDS (1980 - 2000)
J. BUTTS *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 25-37 Jun. 1982
Avail: NTIS HC A12/MF A01

Possible uses of satellite technology up to the year 2000 are suggested and discussed. Included are electronic mail transmission, a personal communications capability, quick location of vehicles or shipments, monitoring of disputed territorial borders, upgraded scientific exploration of the universe, providing better maps of the Earth by remote sensing, space solar power stations and the safe transmission of the electrical energy to Earth, night lighting, and a small personal navigation capability. Support requirements are outlined. L.F.M.

N82-27363*# Analytic Services, Inc., Arlington, Va.
MISSIONS PANEL WORKSHOP SUMMARY
R. L. CHASE *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 39-42 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22A

A workshop panel defined missions that would require the potential use of very large, advanced space systems, and ranked them on the basis of need from both a civilian and military perspective. The panel also pointed out those that would need advanced propulsion technology. Surveillance, communications, and defense were given the highest priority, followed by command and control, orbital support, terrestrial support, and space science. L.F.M.

N82-27367*# General Dynamics Corp., San Diego, Calif.
STRUCTURES: PROPULSION INTERACTIONS AND REQUIREMENTS
C. D. PENGELLEY *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 71-79 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 21H

The dynamics of the interaction of space structures and their propellant systems are outlined. Optimization for a platform type of space structure is discussed. Static and transient loads, propellant accelerations, tolerances, attitude control, and distributed thrust are considered. J.D.

N82-27371*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYSTEMS INTEGRATION
J. J. PELOUCH, JR. *In its* Large Space Systems/Propulsion Interactions p 123-126 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

The workings of systems integration, its accomplishments, the influences of its character changes on the STS, propulsion out of the orbiter and LSS, and technological demands are discussed. The task of systems integration is to define, understand, and account for interactions between the major systems on a space mission. The safety and propulsion systems and their reliability are outlined. E.A.K.

N82-27373*# Martin Marietta Aerospace, Denver, Colo.
SYSTEM REQUIREMENTS AND OPERATIONS PANEL WORKSHOP SUMMARY
F. R. SCHWARZBERG *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 135-171 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

The low Earth orbit (LEO) versus the geosynchronous Earth orbit (GEO) deployment systems were discussed. The following items are emphasized: (1) large area systems, such as deployment, altitude, orbit transfer, and on orbit operation; (2) propulsion oriented issues such as the orbit transfer vehicle and the auxiliary propulsion systems; (3) programmatic issues. The LEO versus GEO deployment is a significant driver on propulsion requirements for an orbit transfer vehicle. It is suggested that early systems will be deployed at LEO. The Shuttle remote manipulator system (RMS) will not be involved in early demonstration activities. It is concluded that an integrated large space system/propulsion approach is essential and that propulsion development requirements need to be established. E.A.K.

N82-27374*# Martin Marietta Aerospace, Denver, Colo.
THE 100-METER RADIOMETER SPACECRAFT STUDY
H. F. ZIMBELMAN *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 173-197 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

A rigid body analysis of a baseline Large Space System (LSS) which is to function as a radiometer is presented. The LSS is placed in circular orbit about the Earth at an altitude of 650 km, subjected to environmental and vehicle interaction forces and torques, without an active control system of any type on board. The environment forces and torques are gravity gradient, solar radiation, and aerodynamic. Normal operation is in nadir pointing along the Z-local vertical axis. Orbital velocity is assigned to the x-axis of the spacecraft. The analysis is then used to demonstrate the ability or lack of the gravity gradient torques to stabilize the LSS over one complete orbit. Author

N82-28322# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Information und Dokumentation.
FUTURE COMMUNICATION SATELLITE SYSTEMS AND TECHNOLOGY TRENDS
H. KELLERMEIER and D. E. KOELLE 1981 37 p Presented at TMSA/TTS Conf., Munich and London, Oct. 1981
(MBB-UB-542-81-O) Avail: Issuing Activity

Technological trends in communication satellite design and requirements were identified. The Intelsat program, TDR satellite systems, and the European large GEO platforms project were reviewed. There is a tendency towards modularized satellite buildup, large unfurlable lightweight multiple beam antennas 4 to 10 m for high frequencies (12 to 30 GHz) and up to larger than 100 m for lower frequencies, and large deployable solar arrays. Antenna pointing accuracies of 0.05 deg are required along with three axis stabilization and FR sensors with antenna pointing mechanisms. Use of a B1 propellant integrated propulsion system for injection and attitude control as well as of electric propulsion for N-S stationkeeping and attitude control for large platforms are foreseen. Increasing application of satellite-switched time division multiple access and of large scale frequency reuse by multiple spot beam antennas with large reflectors for point-to-point communication (data transfer and teleconferencing) are noted. More large communication platforms in geosynchronous orbit in order to avoid the 24 hour orbit saturation problem and large size (or = 7 m dia) unmanned, reusable launch systems for cargo transfer are also predicted. Author (ESA)

N82-28325*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LAND MOBILE SATELLITE SERVICE (LMSS): A CONCEPTUAL SYSTEM DESIGN AND IDENTIFICATION OF THE CRITICAL TECHNOLOGIES. PART 1: EXECUTIVE SUMMARY
F. NADERI, ed. 15 Feb. 1982 74 p 2 Vol.
(NASA-CR-169135; JPL-PUB-82-19-PT-1; NAS 1.26:169135)
Avail: NTIS HC A04/MF A01 CSCL 17B

A system design for a satellite aided land mobile service is described. The advanced system is based on a geostationary satellite which employs a large UHF reflector to communicate with small user antennas on mobile vehicles. It is shown that the system through multiple beam antennas and frequency reuse provides for radiotelephone and dispatch channels. It is concluded that the system is technologically feasible to provide service to rural and remote regions.

N82-28326*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LAND MOBILE SATELLITE SERVICE
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. p 6-16 15 Feb. 1982
Avail: NTIS HC A04/MF A01 CSCL 17B

The land mobile satellite service (LMSS) a spacecraft in geostationary orbit which relays radio messages to many land mobile units is reported. The LMSS's feature is its large antenna which enables communication with small mobile equipment. With the large antenna the spacecraft forms multiple coniguous spot beams which provide blanket coverage. The reuse of the available frequency band among the beams gives efficient utilization of the spectrum. E.A.K.

N82-28327*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LMSS TELECOMMUNICATION NETWORK DESIGN
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. p 20-27 15 Feb. 1982
Avail: NTIS HC A04/MF A01 CSCL 17B

The conceptional land mobile satellite service (LMSS) design is discussed. The following requirements are outlined: network design parameters, multiple beam layout, and a LMSS network design summary. The market requirements are as follows: the area to be served, time frame, capacity, type of service, cost considerations, compatibility and quality. E.A.K.

N82-28328*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MSAT DESIGN
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. p 30-67 15 Feb. 1982
Avail: NTIS HC A04/MF A01 CSCL 17B

The design of the communication satellite MSAT which is the central component of a land mobile satellite service (LMSS) system is reviewed. The following topics are discussed: UHF antenna geometry, overlapping cluster feed conept, UHF feed array, cluster feed RF pattern, frequency reuse plan, beam isolation performance, beam forming network, LMSS link budget, UHF feed thermal hardware, UHF antenna structure, MSAT deployed configuration, MSAT attitude control and MSAT stowage. E.A.K.

N82-28331*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTRODUCTION
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 19 p 15 Feb. 1982 refs
Avail: NTIS HC A18/MF A01 CSCL 17B

The concept of land mobile service is reviewed. The conventional terrestrial mobile radio systems, including dispatch and radiotelephone are described. The more advanced cellular system is described, and the way it mitigate the many problems currently plaguing the conventional terrestrial mobile service are discussed. The concept of the Land Mobile Satellite Service is introduced. How a satellite system can augment the terrestrial system for a truly ubiquitous coverage is shown. The operation of a multiple beam satellite system is explained in terms of its similarities with the terrestrial cellular systems. The potential frequency spectrum availability for the LMSS in the United States is included. Author

N82-28333*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SATELLITE SYSTEM DESIGN
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 186 p 15 Feb. 1982 refs
Avail: NTIS HC A18/MF A01 CSCL 17B

The design of the MSAT spacecraft for the LMSS is presented. The most important requirement affecting the design of MSAT is that of producing a prescribed number of multiple beams. A conceptual design for MSAT describing most major subsystem individually is developed. The design of the large UHF multiple beam antenna and its associated feed array which are the most singularly prominent features of MSAT is emphasized. The overall design is outlined, and each subsystem is discussed. The design of the feed array and the RF, control, power, propulsion, and thermal subsystem are included. The RF performace of the UHF antenna, including its beam isolation performance, is discussed. The volume and mass properties of MSAT and its Shuttle launch considerations are also included. Author

N82-28335*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE TECHNOLOGY
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 52 p 15 Feb. 1982 refs
Avail: NTIS HC A18/MF A01 CSCL 17B

The technology development needed to support the satellite system conceptual design is amplified. Activities connected to RF, control, and structure of the MSAT UHF antenna are addressed. The antenna RF activities are considered, and two studies related to the reflector surface tolerance and the microstrip feed technology are described. The software and hardware needed to implement the attitude control conceptual design are reviewed. Antenna structure development for the reflector and the deployable supporting mast is discussed. UHF feed located electronics are addressed. Author

N82-28540# Federal Communications Commission, Washington, D. C. Office of Science and Technology.
A REPORT OF THE TECHNOLOGICAL ASPECTS OF REGULATORY-POLICY ISSUES OF GEOSTATIONARY PLATFORMS
S. DAS Dec. 1981 35 p refs
(PB82-142191; FCC/OST-R81-1) Avail: NTIS HC A03/MF A01 CSCL 17B

Geostationary platforms and their possible application to low cost communication services are discussed. A number of regulatory technology, policy issues related to the introduction of a geostationary platform, e.g., organizational arrangements for platform operation, electromagnetic compatibility at orbit environment, sharing with terrestrial services and other satellites, diversity operation, frequency reuse, small orbit spacing and efficient modulation techniques are considered. Some technological policy issues may require demonstrated results before a commercially viable geostationary platform is implemented by investors and approved by regulators. GRA

N82-29337*# General Dynamics/Convair, San Diego, Calif.
SPACE CONSTRUCTION EXPERIMENT DEFINITION STUDY (SCEDS), PART 2. VOLUME 1: EXECUTIVE SUMMARY Final Report
26 Apr. 1982 32 p refs 2 Vol.
(Contract NAS9-16303)
(NASA-CR-167635; NAS 1.26:167635; GDC-ASP-82-003-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 22A

A baseline Space Construction Experiment (SCE) concept is defined. Five characteristics were incorporated: (1) large space system (LSS) element test, (2) shuttle mission payload of opportunity, (3) attachment to Orbiter with jettison capability, (4) Orbiter flight control capabilities, and (5) LSS construction and assembly operations. N.W.

N82-29338*# General Dynamics/Convair, San Diego, Calif.
SPACE CONSTRUCTION EXPERIMENT DEFINITION STUDY (SCEDS), PART 2. VOLUME 2: STUDY RESULTS Final Report
26 Apr. 1982 148 p refs 2 Vol.
(Contract NAS9-16303)
(NASA-CR-167632; NAS 1.26:167632; GDC-ASP-82-004-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 22A

The Space Construction Experiment (SCE) was defined for integration into the Space Shuttle. This included development of flight assignment data, revision and update of preliminary mission timelines and test plans, analysis of flight safety issues, and definition of ground operations scenarios. New requirements for the flight experiment and changes for a large space antenna feed mask test article were incorporated. The program plan and cost estimates were updated. Revised SCE structural dynamics characteristics were provided for simulation and analysis of experimental tests to define and verify control limits and interactions effects between the SCE and the Orbiter digital automatic pilot. N.W.

N82-31060# Engins Matra, Velizy (France).
STUDY ON MANNED VERSUS AUTOMATED SPACE ACTIVITIES, EXECUTIVE SUMMARY Final Report
L. DOMAU, G. BERGER, J. L. LACOMBE, E. ZEIS, and J. VERTUT (Commissariat a l'Energie Atomique) Paris ESA Dec. 1980 186 p refs
(Contract ESA-4267/80)
(REPT-DX60/0196; ESA-CR(P)-1561) Avail: NTIS HC A09/MF A01

The role of man in space was assessed, and the state of the art of automation relevant to space applications was examined. Major functions in space which can be performed either by man or an automatic system (rendezvous and docking, transfer operations, assembly and deployment) were reviewed. The implications of manned and unmanned approaches to a future material processing mission in low Earth orbit, and a geostationary telecommunication platform project are discussed. Both approaches are possible for future missions, but in the short-term, when experimentation and tests are necessary, human presence is required. In the long-term, when industrialization imposes cost optimization of routine activities, automated processes become pre-eminent. Author (ESA)

N82-33217*# General Research Corp., Santa Barbara, Calif.
PRELIMINARY DESIGN NOTES ON A LOW F-NUMBER EMR
D. J. MIHORA 13 May 1982 39 p refs
(Contract NAS1-16133)
(NASA-CR-165953; NAS 1.26:165953; CR-3-998) Avail: NTIS HC A03/MF A01 CSCL 20F

Conceptual design studies were completed on a new Electrostatic Membrane Reflector, EMR. This new model incorporates both a preformed, curved membrane reflector and membrane control surface. This improved model is the second step toward a high precision large space antenna that could evantually exhibit a performance in terms of aperture diameter to surface quality exceeding 1,000,000. Design trades indicate that the goal of a low ratio of focal length to aperture diameter (f sub n) can be achieved while operating in a humid sea-level environment. A nominal surface quality of 1.0 mm (RMS) is possible using available off-the-shelf commercial membranes. Both the membrane reflector and control electrode surface are fabricated from 12 gore segments and attached to the available 12 sided, 4.88 m diameter rim. The preferred conceptual design has a f sub n = 1.0. The 4.88 m aperture is performed with a centerline displacement of 0.306 m. The nominal spacing between the membrane reflector and the electrode control surface is 50.8 mm. The centerline membrane displacement from its performed to its tensioned, smooth shape is about 3 mm. The membrane tensioning is achieved by application of an electrostatic pressure of 2.6 N/sq cm and a voltage of about 38 kV. Author

N82-33421*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ILLUMINATION FROM SPACE WITH ORBITING SOLAR-REFLECTOR SPACECRAFT
J. E. CANADY, JR. and J. L. ALLEN, JR. Sep. 1982 90 p refs
(NASA-TP-2065; L-15127; NAS 1.60:2065) Avail: NTIS HC A05/MF A01 CSCL 22B

The feasibility of using orbiting mirrors to reflect sunlight to Earth for several illumination applications is studied. A constellation of sixteen 1 km solar reflector spacecraft in geosynchronous orbit can illuminate a region 333 km in diameter to 8 lux, which is brighter than most existing expressway lighting systems. This constellation can serve one region all night long or can provide illumination during mornings and evenings to five regions across the United States. Preliminary cost estimates indicate such an endeavor is economically feasible. The studies also explain how two solar reflectors can illuminate the in-orbit nighttime operations of Space Shuttle. An unfurlable, 1 km diameter solar reflector spacecraft design concept was derived. This spacecraft can be packaged in the Space, Shuttle, transported to low Earth orbit, unfurled, and solar sailed to operational orbits up to geosunchronous. The necessary technical studies and improvements in technology are described, and potential environmental concerns are discussed. S.L.

N82-34315*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SHUTTLE VLBI EXPERIMENT. TECHNICAL WORKING GROUP SUMMARY REPORT
S. H. MORGAN, ed. and D. H. ROBERTS, ed. (Brandeis Univ.) Jul. 1982 53 p
(NASA-TM-82491; NAS 1.15:82491) Avail: NTIS HC A04/MF A01 CSCL 03A

The gain in interferometric resolution of extragalactic sources at radio frequencies which can be achieved by placing a very long baseline interferometry (VLBI) antenna in space is quantitatively described and a VLBI demonstration experiment using a large deployable antenna, which if realized could be a very acceptable first venture for VLBI in space is discussed. A tutorial on VLBI, a summary of the technology available for the experiment, and a preliminary mission scenario are included. A.R.H.

02

ANALYSIS AND DESIGN TECHNIQUES

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

A82-29905

QUALITATIVE STUDY OF THE MOTION OF A SPACECRAFT UNDER CONSTANT RADIAL ACCELERATION [KACHESTVENNOE ISSLEDOVANIE DVIZHENIIA KA PRI POSTOIANNOM RADIAL'NOM USKORENII]

V. A. IVANOV Kosmicheskie Issledovaniia, vol. 20, Mar.-Apr. 1982, p. 191-195. In Russian.

The qualitative theory of dynamic systems of Andronov et al. (1966, 1967) is used to study the trajectories of the controlled motion of a spacecraft under constant radial acceleration. All possible types of trajectories of this class are determined, and attention is given to the application of the qualitative results to the synthesis of various orbital maneuver schemes with low radial thrust. B.J.

A82-29913

FORMATION OF ENERGETIC-ION FLUXES IN THE GEOSTATIONARY ORBIT [FORMIROVANIE POTOKOV ENERGICHNYKH IONOV NA GEOSTATSIONARNOI ORBITE]

M. I. PANASIUK Kosmicheskie Issledovaniia, vol. 20, Mar.-Apr. 1982, p. 277-288. In Russian. refs

A single function is used to represent the averaged differential energy spectra of H (0.1 keV to 1 MeV), He, C, and O (greater than 1 MeV) ions observed in the geostationary orbit. It is suggested that the solar wind is the most probable source of these energetic ions; solar-wind ions are transported to the earth by convection in the large-scale quasi-stationary electric field of the magnetotail. The formation of the dominant ion fluxes by the direct penetration of solar cosmic rays into the magnetosphere is assessed. Theoretical and experimental results on the energy densities of ions of solar and ionospheric origins are compared. B.J.

A82-38863#

INCLINED AND ECCENTRIC GEOSYNCHRONOUS SATELLITE ORBITS

P. NACOZY (Texas, University, Austin, TX) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 4 p. refs

(AIAA PAPER 82-1412)

The orbit of the geostationary satellite is compared with that of the nonstationary, geosynchronous satellite. For the former, the long-term motion characteristics are summarized, while the latter is discussed in terms of its two types: the inclined, eccentric orbit, and the inclined, nearly circular orbit. The long-term motion of the nonstationary, geosynchronous satellite appears to have two characteristics: (1) the motion differs substantially for different initial conditions, even more so than for the geostationary satellite; and (2) more conditions must be considered than for the geostationary satellite case, including groundtrack shape and orientation, the longitude of the satellite at its equator crossings, the maximum latitude, and the ground antennas slewing rates. C.D.

A82-39400#

HIGHLY EFFICIENT, VERY LOW THRUST TRANSFER TO GEOSYNCHRONOUS ORBIT - EXACT AND APPROXIMATE SOLUTIONS

D. C. REDDING American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 29 p.

(AIAA PAPER 82-1484)

Very low thrust minimum fuel orbit transfer for constant specific impulse spacecraft require multiple burns at perigee and apogee to keep gravity losses small. A lengthy iterative computer program has been developed to solve for the optimal thrust-direction histories of such transfers, given specific numbers of burns, for fixed thrust and fixed acceleration cases. Algebraic approximations for total time and loss are presented which provide quick determination of the best numbers of burns versus trip time. Results for the low earth orbit-geosynchronous orbit case show the approximations to be good. Moreover, for long trip times, loss varies as the inverse of maximum acceleration squared for fixed time, and loss varies as the inverse of time-squared for fixed initial acceleration. (Author)

A82-40433#

SOLAR RADIATION PRESSURE GRADIENT DURING ECLIPSE - A SOURCE OF TORQUE FOR VERY LARGE SPACECRAFT

G. B. SINCARSIN and P. C. HUGHES (Toronto, University, Downsview, Ontario, Canada) American Institute of Aeronautics and Astronautics, Guidance and Control Conference, San Diego, CA, Aug. 9-11, 1982, 8 p. Natural Sciences and Engineering Research Council of Canada refs

(Contract NSERC-A-4183)

(AIAA PAPER 82-1612)

A general formulation is developed for calculating penumbral solar-pressure-gradient torque. A literal expression for the dependence of light intensity on position is given and the three-dimensional gradient about any point of interest in the spacecraft computed. Solar-gradient torques are studied, via numerical simulation, for both earth-pointing and sun-pointing planar spacecraft in geostationary orbit. Both specularly reflecting and totally absorbing surfaces are considered. Eclipse conditions are identified for the following critical cases: (1) maximum solar-gradient pitch torque; (2) maximum solar-gradient roll torque; and (3) longest duration within penumbra. The maximum instantaneous torque and angular impulse from solar-gradient torque are compared with those arising from gravity-gradient torque and shown to be significant for some spacecraft orientations. A comparison of equivalent cm-cp offsets for solar-gradient and conventional solar torque indicates that solar-gradient torque may potentially become dominant for very large spacecraft. It is also argued that the symmetry present within an eclipse season permits an attitude control approach based on angular momentum storage. (Author)

A82-44718#

OPTIMUM LOW THRUST TRANSFER TO ATTAIN A GEOSYNCHRONOUS ORBIT

Y. MATOGAWA (Tokyo, University, Tokyo, Japan) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 12 p. refs

(IAF PAPER 82-306)

The low thrust transfer for geosynchronous mission has been studied by many investigators from the view-point of optimization in case of continuous thrust. This paper discusses the possibility of fuel saving to attain a geosynchronous orbit by introducing coast phases during each revolution. In advance of optimizing the whole transfer mission, optimization during a single revolution is treated, and it is shown that the entrance and the exit of optimal coasting arcs are expressed by a sixth order equation, which, in case of coplanar transfer, degenerates into a cubic equation, with respect to the cosine of true longitude. Then an optimum transfer to a geosynchronous orbit, including coast phases in each revolution, is simulated. Computational results for typical initial conditions are shown to be compared with those for all-propulsion cases. (Author)

A82-47015#

STRATEGIES AND SCHEMES FOR RENDEZ-VOUS ON GEOSTATIONARY TRANSFER ORBIT

W. WOLFSBERGER, J. WEISS, and D. RANGNITT (Messerschmitt-Boelkow-Blohm GmbH, Munich; ERNO Raumfahrttechnik GmbH, Bremen, West Germany) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 30 p.
(IAF PAPER 82-310)

Various strategies for achieving rendezvous on high eccentric orbits, including the geostationary transfer orbit, are discussed, and simulation results are presented. Four phases are distinguished in the rendezvous procedure. The first is the guided phase, that is, the ground-controlled 'phasing' strategy. Here, the relative distance reduction is from tens of thousands of km down to about 500 km, the acquisition range. The second phase is the homing phase, where there is autonomously controlled transfer and where the range is reduced to about 5 km. The third phase is the final approach. Here, the trajectory is autonomously controlled on the basis of the channel guidance of proportional navigation. The range is reduced to about 10 m. The last phase is docking, where the trajectory is autonomously controlled up to physical contact. C.R.

A82-47062#

A MODEL FOR THE EVOLUTION OF ON-ORBIT MANMADE DEBRIS ENVIRONMENT

R. C. REYNOLDS, N. H. FISCHER, and D. S. EDGECOMBE (Battelle Columbus Laboratories, Columbus, OH) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, Paper. 41 p. refs

A probabilistic model for the evolution of the man-made debris population in low earth orbit is constructed that accounts for collision processes. Contributions to the population that may arise from on-orbit collisions and explosions are examined, and a method is devised for discriminating between debris injected into short- or long-life orbits. Results are presented for three cases: (1) future space use as an extrapolation of past practices, (2) an era of enhanced space use, and (3) an era in which antisatellite tests contribute to the debris population. In all three cases, a severe hazard to large space systems is found in the altitude region below 1200 km. F.G.M.

N82-22290*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ON-ORBIT FREE MOLECULAR FLOW AERODYNAMIC CHARACTERISTICS OF A PROPOSAL SPACE OPERATIONS CENTER CONFIGURATION

P. O. ROMERE Mar. 1982 162 p
(NASA-TM-58243; NAS 1.15:58243) Avail: NTIS HC A08/MF A01 CSCL 22B

A proposed configuration for a Space Operations Center is presented in its eight stages of buildup. The on orbit aerodynamic force and moment characteristics were calculated for each stage based upon free molecular flow theory. Calculation of the aerodynamic characteristics was accomplished through the use of an orbital aerodynamic computer program, and the computation method is described with respect to the free molecular theory used. The aerodynamic characteristics are presented in tabulated form for each buildup stage at angles of attack from 0 to 360 degrees and roll angles from -60 to +60 degrees. The reference altitude is 490 kilometers, however, the data should be applicable for altitudes below 490 kilometers down to approximately 185 kilometers. Author

N82-23118*# Houston Univ., Tex. Mission Planning and Analysis Div.

NONLINEAR COUPLING BETWEEN THE IN-PLANE AND OUT-OF-PLANE MOTION ABOUT A STATIONARY POINT IN GEOSYNCHRONOUS ORBIT

B. R. FEIRING *In its* The 1981 NASA ASEE Summer Fac. Fellowship Program, Vol. 1 18 p 20 Aug. 1981 refs
Avail: NTIS HC A14/MF A01 CSCL 22A

The range of validity of the solutions in the vicinity of the libration points include significant out-of-plane oscillations by the satellite. The stability of inclined geosynchronous satellites is studied. N.W.

N82-23486*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

INTERACTIVE MODELING, DESIGN AND ANALYSIS OF LARGE SPACECRAFT

L. B. GARRETT *In its* Computational Aspects of Heat Transfer in Struct. p 199-219 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

An efficient computer aided design and analysis capability applicable to large space structures was developed to relieve the engineer of much of the effort required in the past. The automated capabilities can be used to rapidly synthesize, evaluate, and determine performance characteristics and costs for future large spacecraft concepts. The interactive design and evaluation of advanced spacecraft program (IDEAS) is used to illustrate the power, efficiency, and versatility of the approach. The coupling of space environment modeling algorithms with simplified analysis and design modules in the IDEAS program permits rapid evaluation of completing spacecraft and mission designs. The approach is particularly useful in the conceptual design phase of advanced space missions when a multiplicity of concepts must be considered before a limited set can be selected or more detailed analysis. Integrated spacecraft systems level data and data files are generated or subsystems and mission reexamination and/or refinement and for more rigorous analyses. R.J.F.

N82-23489*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

ROLE OF IAC IN LARGE SPACE SYSTEMS THERMAL ANALYSIS

G. K. JONES, J. T. SKLADANY, and J. P. YOUNG *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 253-270 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20C

Computer analysis programs to evaluate critical coupling effects that can significantly influence spacecraft system performance are described. These coupling effects arise from the varied parameters of the spacecraft systems, environments, and forcing functions associated with disciplines such as thermal, structures, and controls. Adverse effects can be expected to significantly impact system design aspects such as structural integrity, controllability, and mission performance. One such needed design analysis capability is a software system that can integrate individual discipline computer codes into a highly user-oriented/interactive-graphics-based analysis capability. The integrated analysis capability (IAC) system can be viewed as: a core framework system which serves as an integrating base whereby users can readily add desired analysis modules and as a self-contained interdisciplinary system analysis capability having a specific set of fully integrated multidisciplinary analysis programs that deal with the coupling of thermal, structures, controls, antenna radiation performance, and instrument optical performance disciplines. R.J.F.

N82-24222# Centre National d'Etudes Spatiales, Toulouse (France).
OUTGASSING AND CONTAMINATION IN SPACE [DEGAZAGE ET CONTAMINATION DANS L'ESPACE]
J. GUILLIN *In its* The Technol. of Spaceborne Sci. Expt. p 215-223 1981 refs In FRENCH
Avail: NTIS HC A99/MF A01

The extent, importance and complexity of contamination problems regarding spacecraft are evoked. Among sources of contamination there are outgassing of materials in vacuum; leaks from pressurized vessels, combustion products from motors and contamination on the ground. Test schemes for parameterizing these sources are explained, including transport phenomena. Experimental measurements are reported. The effects of these contaminants on satellite performance are discussed and methods for reducing contamination are proposed. A program package that calculates the flux of contaminants in a space environment is introduced. The special case of manned spacecraft is brought up, citing Spacelab. Author (ESA)

N82-24269# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
SUMMARY OF ORBIT COMPUTATIONS FROM LASER RANGE OBSERVATIONS OF LAGEOS, STARLETTE, GEOS 3 AND SEASAT
K. F. WAKKER and B. A. C. AMBROSIUS Jan. 1982 42 p refs Presented at ESOC Workshop on Orbit Determination for ERS-1 Altimeter Mission, Darmstadt, West Germany, 11-12 Jan. 1982
(VTH-LR-342) Avail: NTIS HC A03/MF A01

How the spatial, temporal and geographical distribution of laser range measurements, and the selection of satellite and perturbation force model, affect orbital and parameter solutions was investigated. Satellite perturbation due to the Earth gravity field, atmospheric drag, solar and lunar attraction, direct solar radiation pressure and solid Earth tides were considered. Dynamic model errors (not laser range measurement precision) limit the accuracy of a long arc orbital solution. Tailored gravity models are more accurate than GEM-9 or GEM-10B. For low-altitude satellites with large appendages, accurate orbit determination requires precise modeling of the time-dependent variation of the satellite cross sectional area. Density fluctuations due to short period solar and geomagnetic disturbances are modeled relatively poorly. Multiple drag coefficient models eliminate orbital effects of these model errors. Author (ESA)

N82-24276# Communications Research Centre, Ottawa (Ontario). Space Technology and Applications Branch.
THE ATTITUDE DYNAMICS OF HERMES AFTER TERMINATION OF THREE AXIS STABILIZATION
F. R. VIGNERON and W. E. KRAG (MIT) Feb. 1982 28 p refs Presented at the 12th Norad Spacecraft Identification Conf., 13-15 Aug. 1980
(CRC-1354) Avail: NTIS HC A03/MF A01

In late 1979, Hermes, an experimental geostationary communications satellite, experienced an Earth sensor malfunction which resulted in its loss of control and subsequent transition from 2 axis stabilization to spin about its maximum moment of inertia axis. During and after the transition, the Sun's reflections from the satellite were detected and monitored at the experimental test site (ETS) for the ground based electro-optical deep space surveillance system (GEODSS) in New Mexico. The satellite's attitude dynamics are deduced by correlating the GEODSS ETS observations with dynamics analysis and simulation. The transition to spin took about 15 days. Thereafter, the rate of spin decayed to zero in about 70 days due to solar pressure. The GEODSS ETS observations also provide data on the relative misalignment and bending of the two solar sails of the satellite. Author

N82-26132# Los Alamos Scientific Lab., N. Mex.
LOS ALAMOS GEOSTATIONARY ORBIT SYNOPTIC DATA SET: A COMPILATION OF ENERGETIC PARTICLE DATA
D. N. BAKER, P. R. HIGBIE, R. D. BELIAN, W. P. AIELLO, and E. W. HONES, JR. Aug. 1981 213 p refs
(Contract W-7405-ENG-36)
(DE82-004178; LA-8843) Avail: NTIS HC A10/MF A01

Energetic electron (30 to 2000 keV) and proton (145 keV to 150 MeV) measurements made by Los Alamos National Laboratory sensors at geostationary orbit 6.6 R/sub E/ are summarized. The data are plotted in terms of daily average spectra, 3-h local time averages, and in a variety of statistical formats. The data summarize conditions from mid-1976 through 1978 (S/C 1976-059) and from early 1977 through 1978 (S/C 1977-007). The compilations correspond to measurements at 350W, 700W, and 1350W geographic longitude and, thus, are indicative of conditions at 90, 110, and 4.80 geomagnetic latitude, respectively. Most of this report is comprised of data plots that are organized according to Carrington solar rotations so that the data can be easily compared to solar rotation-dependent interplanetary data. As shown in prior studies, variations in solar wind conditions modulate particle intensity within the terrestrial magnetosphere. The effects of these variations are demonstrated and discussed. Potential uses of the Synoptic Data Set by the scientific and applications-oriented communities are also discussed. DOE

03

STRUCTURAL CONCEPTS

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

A82-30189#
DESIGN AND DEVELOPMENT OF THE INTELSAT V GRAPHITE EPOXY CENTRAL THRUST TUBE
N. BARBERIS (Ford Aerospace and Communications Corp., Detroit, MI), M. ZILIANI, and C. GABRIEL (Societe Nationale Industrielle Aerospatiale, Cannes, France) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 594-602. Research sponsored by the International Telecommunications Satellite Organization.
(AIAA 82-0677)

This paper describes the design, development, and testing of a graphite epoxy central thrust tube. The advanced composite structure has been developed for use on the Intelsat V-A spacecraft. The tube is the primary load path for the spacecraft and is a graphite epoxy faceskin aluminum honeycomb structure designed to replace the aluminum cylinder/stringer stiffened tube at a net weight savings in excess of 9 kg. A prototype tube has been fabricated and successfully tested to ultimate static loads and a low level sine vibration test while integrated in the Intelsat V Proto Engineering Model (PEM) spacecraft.

A82-35629#
THE GEOSYNCHRONOUS TIDAL WEB, A METHOD FOR CONSTRUCTING AN ULTRA-LARGE SPACE STRUCTURE
R. E. SIMBERG In: Space manufacturing 4; Proceedings of the Fifth Conference, Princeton, NJ, May 18-21, 1981. New York, American Institute of Aeronautics and Astronautics, 1981, p. 323-329. refs

A method is proposed by which a two dimensional tension structure millions of square kilometers in area may be constructed in geosynchronous orbit, using present materials technology. The structure consists of a ring of cables held taut by gravity-gradient, extended all the way around the planet. Such a ring would be useful for enlarging the effective geosynchronous region, reducing

or eliminating collision hazards, reducing station-keeping thrust pollution in industrial regions, and providing an anchor for orbital towers or 'skyhooks'. A static load analysis is performed and potential drawbacks and stability problems are discussed.
(Author)

A82-39665
ELECTRON BEAM WELDING OF VT6 TITANIUM ALLOY IN AEROSPACE INDUSTRIES
A. DUCROT and S. A. SCIAKY In: Titanium and titanium alloys: Scientific and technological aspects. Volume 2. New York, Plenum Press, 1982, p. 1245-1257.
The three groups into which titanium alloys are classified are listed, together with the mechanical properties of the main alloys. The electron beam (EB) process offers the following advantages: no contamination by gases owing to the vacuum environment during welding operation, low power input, and limited distortion (little or no machining after welding). The areas where EB welding has found application are discussed. It is thought that EB welding may eventually be used with high-strength steels and aluminum and nickel alloys. C.R.

A82-39889
DEVELOPMENT OF GRAPHITE/EPOXY TUBE TRUSS FOR SATELLITE
T. KAWASHIMA (National Space Development Agency of Japan, Tokyo, Japan), Y. SAKATANI, and T. YAMAMOTO (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Nagoya, Japan) In: Composite materials: Mechanics, mechanical properties and fabrication; Proceedings of the Japan-U.S. Conference, Tokyo, Japan, January 12-14, 1981. Barking, Essex, England, Applied Science Publishers, 1982, p. 453-460.
The design and testing of the graphite/epoxy tube trusses that constitute the main structural components of a planned Japanese satellite are briefly discussed. The conceptual model includes an upper adapter, box module, and ACS subsystem; the load condition includes an axial force of 8600 Kgf, bending moment of 57 Kgf-M, and equivalent compressive force of 12,400 Kgf. For the test specimen, the material, specification, type, prepreg property, and laminate property are shown. A flow diagram of the fabrication process is given, as are the method and results of a tensile and a compressive test. The modes of fracture in the latter was buckling at the ends of the tubes. The results showed that the tubes met the strength requirement and that material construction and fabrication process were satisfactory. C.D.

A82-45271*# Boeing Aerospace Co., Seattle, Wash.
REQUIREMENTS AND DESIGN OF THE GRAPHITE/EPOXY STRUCTURAL ELEMENTS FOR THE OPTICAL TELESCOPE ASSEMBLY OF THE SPACE TELESCOPE
C. T. GOLDEN and E. E. SPEAR (Boeing Aerospace Co., Seattle, WA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 144-151. Research supported by the Perkin-Elmer Corp. and NASA.
(AIAA 82-1833)
The production of the Space Telescope's Metering Truss Structure (MTS) and Focal Plane Structure (FPS), which are of graphite/epoxy, is described. Graphite/epoxy laminates were chosen because of their high strength and stiffness, low weight, and a controlled coefficient of thermal expansion approaching zero. Photocopy masters, which are dimensionally accurate and stable photographic reproductions of full size engineering drawings, allowed the exact assembly of bonded or bolted parts by assembly mechanics, cutting costs and speeding production. While moisture absorption, high through-the-thickness coefficient of thermal expansion effects, and labor-intensive layup costs are potentially problematic in some cases, it is expected that solutions can be found through analytical and developmental programs. O.C.

A82-46912#
SOLAR SAIL CONCEPT STUDY
T. SVITEK International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 18 p. refs
(IAF PAPER 82-ST-12)
The materials, equipment, and configuration of a solar sail-powered spacecraft which could be launched by the Ariane 4 rocket are reviewed. A numerical model is developed for the available thrust imparted by the solar wind to sail material. The concept is extended to the provision of attitude control using the same force in rotation about an axis. The three types of solar sail stiffening, i.e., rigid frame, semi-rigid frame, and free sail, are discussed, as are the employment of composites, gas, foil, and wire options for reinforcement. The study areas necessary for defining a viable solar sail configuration are detailed, including control electronics circuitry, platform design, solar array configuration, launch configuration, and development schedule for realization of a flight model. M.S.K.

A82-47008#
TECHNOLOGY OF VERY LARGE SATELLITES DEPLOYABLE IN SPACE APPLICATION TO RADIOTELESCOPE
M. J. FERRONNIERE (Zodiac, Issy-les-Moulineaux, Hauts-de-Seine, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 6 p.
(IAF PAPER 82-267)
The concept of using inflatable structures as very large satellites deployable in space is developed. The possible use of large antennas for the SETI program of radio monitoring for discovery of other civilizations in the universe is discussed, with a recommendation made for such an antenna's size and location. The concept of a satellite using inflatable structures is described, giving its general design characteristics. The feasibility and technological limits related to the process are analyzed, including industrial problems, dimensional limits, service life limits, and geometric tolerances. Finally, the general characteristics of a radiotelescope with a 900 m DIDON are analyzed, including the active and passive subsystems, the configuration of the reflector subsystem, and the satellite's deployment, inflation, and reinflation. C.D.

A82-47023#
THE RETRACTABLE ULTRALIGHTWEIGHT /ULP/ SOLAR ARRAY FOR RETRIEVABLE SPACE PLATFORMS
H. KELLERMEIER, M. ROTH, and K. SCHNEIDER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) International Astronomical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p.
(IAF PAPER 82-334)
Design specifications and performance of a retractable ultralightweight (ULP) solar array mechanism, capable of automatic operational retraction, are presented. The advantages of rigid and flexible solar arrays are combined, resulting in a panel with high stiffness and low mass which demonstrates a performance of 40 to 60 W/kg. Implementation of the retraction mechanism is optimum when the following design aspects are combined: a central actuator with a reduction gear, a rope drive to deploy and retract the array wing, a closed cable loop for simultaneous deployment, and a final stopper. A function scheme diagram is included, and hold-down and release mechanism performance (to accommodate transfer to earth mechanical loads) is shown in a diagram. Retractable array performance has been calculated at 4-6%. R.K.R.

N82-22699*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS STRUCTURES: A 1980 TECHNOLOGY STATUS REVIEW
H. S. GREENBERG *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 172-175 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The classes of major structural components and constructions utilized were considered. A review of the current (SPS) structure technology status was made. The major issues considered pertinent to SPS structures are: Cost effective construction, construction materials, structural design requirements, stress and dimensional integrity of as-built structures, and predictability of strength and dynamic behavior. The feasibility of passive figure control approach to MPTS flatness, of structure stiffness compatible with MPTS pointing, of passive control through damping, and the feasibility of space fabrication of ultra-large reflector surfaces are also considered. Qualification, model verification, inspection are considered of vital concern. M.D.K.

N82-23350*# Lockheed Missiles and Space Co., Sunnyvale, Calif. Mechanisms and Separation Analysis Group.
A BALL TRUNNION CAPTURE LATCH
D. V. ADAMS and B. ALCHORN *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 99-107 May 1982 refs
Avail: NTIS HC A15/MF A01 CSCL 13I

The Ball Trunnion Capture Latch described was developed and designed to restrain a spacecraft deployable appendage in three translational directions. The latch is capable of supporting an appendage during STS ascent and landing events and is capable of releasing and restowing an appendage distorted in three translational directions by thermal growth. The requirements, design, analyses, and tests conducted on a development unit of the latch are discussed. M.D.K.

N82-23365*# Lockheed Missiles and Space Co., Sunnyvale, Calif. RF/Antenna Systems Lab.
DESIGN, DEVELOPMENT AND MECHANIZATION OF A PRECISION DEPLOYABLE TRUSS WITH OPTIMIZED STRUCTURAL EFFICIENCY FOR SPACEBORNE APPLICATIONS
N. D. CRAIGHEAD, T. D. HULT, and R. J. PRELIASCO *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 315-328 May 1982 refs
Avail: NTIS HC A15/MF A01 CSCL 22B

A deployable mast concept which meets the weight, size and stability requirements for a feed support structure for offset antennas up to 100 meters in diameter is discussed. A triangulated truss configuration, the use of tapered tubes which exhibit a high strength-to-weight ratio, and low CTE graphite-epoxy material are seen to provide an efficient, lightweight and stable truss suitable for an antenna feed support. A low stowage ratio of 30:1 is achieved through a unique preloaded hinge located at the center of each longeron and an autonomous deployment cage with a drive mechanism. Initial analysis and proof of concept hardware validated the basic mechanism and design assumptions and provided a basis for further investigation. The concept can readily accept variations in member size and thus lends itself to optimization for other potential uses where a stiff, lightweight deployable truss is needed. Author

N82-26676*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERLOCKING WEDGE JOINT Patent Application
M. J. LONG, inventor (to NASA) 23 Apr. 1982 9 p
(NASA-CASE-LAR-12729-1; US-PATENT-APPL-SN-371353)
Avail: NTIS HC A02/MF A01 CSCL 13I

An interlocking wedge joint is described comprising a male member having a tapered columnar body with an interlocking means on the end thereof, a female member having a tapered columnar body with a receptacle means therein, and a sleeve member having a tapered tubular body. To assemble the joint the male member interlocking means is inserted transversely into the female member receptacle means and the sleeve member is slid over the male member and female member interface thus locking the members into place. NASA

N82-32732* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MECHANICAL END JOINT SYSTEM FOR STRUCTURAL COLUMN ELEMENTS Patent
H. G. BUSH (Vought Corp., Hampton, Va.) and R. E. WALLSOM, inventors (to NASA) (Vought Corp., Hampton, Va.) 20 Jul. 1982 9 p Filed 5 Dec. 1979 Supersedes N80-22704 (18 - 13, p 1719)
(NASA-CASE-LAR-12482-1; US-PATENT-4,340,318; US-PATENT-APPL-SN-100611; US-PATENT-CLASS-403-217; US-PATENT-CLASS-403-317; US-PATENT-CLASS-403-331; US-PATENT-CLASS-403-340; US-PATENT-CLASS-52-81) Avail: US Patent and Trademark Office CSCL 13I

A mechanical end joint system, useful for the transverse connection of strut elements to a common node, comprises a node joint half with a semicircular tongue and groove, and a strut joint half with a semicircular tongue and groove. The two joint halves are engaged transversely and the connection is made secure by the inherent physical property characteristics of locking latches and/or by a spring-actioned shaft. A quick release mechanism provides rapid disengagement of the joint halves.
Official Gazette of the U.S. Patent and Trademark Office

04

STRUCTURAL AND THERMAL ANALYSIS

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

A82-28968#
AN APPROACH TO DETAILED INELASTIC ANALYSIS OF THIN-WALLED PIPELINES
H. D. HIBBITT and E. K. LEUNG (Hibbitt and Karlsson, Inc., Providence, RI) In: Nonlinear finite element analysis of plates and shells; Proceedings of the Winter Annual Meeting, Washington, DC, November 15-20, 1981. New York, American Society of Mechanical Engineers, 1981, p. 83-118. refs

The main objective of the investigation is to provide numerical models for very flexible, thin-walled piping systems. The models must make it possible to accomplish design verification by detailed inelastic analysis, a particular concern being the accurate modeling of the interaction between the pipe bends and adjacent straight pipe runs, since it is well known that this interaction plays a very important role in restricting deformation in the bends, especially during creep holds. A description is presented of a family of Fourier/polynomial interpolation deforming section beam elements, of the type introduced by Ohtsubo and Watanabe (1978). A degenerate version of the element family is also investigated, and errors which can occur are pointed out. G.R.

A82-29135*# Astro Research Corp., Carpinteria, Calif.
INFLUENCE OF FABRICATION TOLERANCES ON THE SURFACE ACCURACY OF LARGE ANTENNA STRUCTURES
J. M. HEDGEPETH (Astro Research Corp., Carpinteria, CA) AIAA Journal, vol. 20, May 1982, p. 680-686. refs
(Contract NAS1-15347)

One of the sources of error in radio frequency antennas is the lack of dimensional precision of the surface. This paper presents an approach for estimating the amount of error caused by random dimensional imperfections of the many structural elements which make up a truss-type antenna. A principle of equivalence between the analyses of statistical errors and of the natural vibration frequencies of the structure is developed. Examples are presented to show the application of this equivalence principle to the determination of average surface errors of several types and proportions of antenna structures. (Author)

A82-29457
NONAXISYMMETRIC DEFORMATION OF FLEXIBLE CIRCULAR LAYERED ORTHOTROPIC PLATES WITH VARIABLE STIFFNESS PARAMETERS [O NEOSESIMMETRICHNOI DEFORMATSII GIBKIKH KRUGLYKH SLOISTYKH ORTOTROPNYKH PLASTIN S PEREMENNYMI ZHESTKOSTNYMI PARAMETRAMI]
IA. M. GRIGORENKO (Akademiia Nauk Ukrainskoi SSR, Institut Mekhaniki, Kiev, Ukrainian SSR) and N. N. KRIUKOV (Kievskii Inzhenerno-Stroitel'nyi Institut, Kiev, Ukrainian SSR) Prikladnaia Mekhanika, vol. 18, Mar. 1982, p. 49-54. In Russian. refs

Analysis of the stress-strain state is carried out for flexible circular plates consisting of a stack of an arbitrary number of orthotropic and isotropic layers whose thickness varies in two directions. The mechanical characteristics and thickness of the layers are such that the Kirchhoff-Love hypothesis is applicable to the stack as a whole. A resolving system of nonlinear partial differential equations is obtained and a numerical solution method is demonstrated. V.L.

A82-30082#
FUNDAMENTAL STUDIES OF THERMAL-STRUCTURAL EFFECTS ON ORBITING TRUSSES
J. MAHANEY and K. B. STRODE (Old Dominion University, Norfolk, VA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, 1982, p. 49-59. refs
(AIAA 82-0650)

Fundamental features of the thermal-structural behavior of orbiting trusses are studied. The paper describes the use of the finite element method in orbital heat load determination and thermal-structural analysis. For composite materials, the thermal analysis uses a single isothermal element per truss member to compute temperature histories for a quasi-static structural analysis. All analyses use the same finite element model with the results of the thermal analysis being used directly in the structural analysis. Effects of orbit altitude and material properties on thermal-structural response are evaluated for flat and parabolic tetrahedral trusses. (Author)

A82-30083#
PRECISION OF MESH-TYPE REFLECTORS FOR LARGE SPACE-BORNE ANTENNAS
R. X. MEYER (Aerospace Corp., Vehicle Engineering Div., El Segundo, CA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, 1982, p. 60-65.
(Contract F04701-81-C-0082)
(AIAA 82-0652)

Knitted mesh reflectors for deployable, large antennas are shown to conform to minimal surfaces, bounded by the mesh supporting structural members. Closed form expressions and tabulated values are derived for the root-mean-square deviation of the mesh from the ideal, parabolic reflector. It is shown that for cylindrical antennas with quadrilateral bays and for strongly offset axisymmetric antennas, substantial improvements in precision can be obtained by providing curvature to the mesh supports. Expressions are given for the optimal curvatures. (Author)

A82-30149*# California Univ., Los Angeles.
AN APPROXIMATION CONCEPTS METHOD FOR SPACE FRAME SYNTHESIS
W. C. MILLS-CURRAN, R. V. LUST, and L. A. SCHMIT (California, University, Los Angeles, CA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 187-200. refs
(Contract NSG-1490)
(AIAA 82-0682)

A method is presented for the minimum mass design of three dimensional space frames constructed of thin walled rectangular cross-section members. Constraints on nodal displacements and rotations, material stress, local buckling, and cross sectional dimensions are included. A high quality separable approximate problem is formed in terms of the reciprocals of the four section properties of the frame element cross section, replacing all implicit functions with simplified explicit relations. The cross sectional dimensions are efficiently calculated without using multilevel techniques. Several test problems are solved, demonstrating that a series of approximate problem solutions converge rapidly to an optimal design. (Author)

A82-30166*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STRESS CONSTRAINTS IN OPTIMALITY CRITERIA DESIGN
R. LEVY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 368-376. refs
(Contract NAS7-100)
(AIAA 82-0716)

Procedures described emphasize the processing of stress constraints within optimality criteria designs for low structural weight with stress and compliance constraints. Prescreening criteria are used to partition stress constraints into either potentially active primary sets or passive secondary sets that require minimal processing. Side constraint boundaries for passive constraints are derived by projections from design histories to modify conventional stress-ratio boundaries. Other procedures described apply partial structural modification reanalysis to design variable groups to correct stress constraint violations of unfeasible designs. Sample problem results show effective design convergence and, in particular, advantages for reanalysis in obtaining lower feasible design weights. (Author)

A82-31455
AXISYMMETRIC DEFORMATION OF FLEXIBLE INHOMOGENEOUS SHELLS OF REVOLUTION [OSESIMMETRICHNAIA DEFORMATSIIA GIBKIKH NEODNORODNYKH OBOLOCHEK VRASHCHENIIA]
V. I. KLIMANOV and V. V. CHUPIN (Ural'skii Politekhnicheskii Institut, Sverdlovsk, USSR) Prikladnaia Mekhanika, vol. 18, Apr. 1982, p. 36-40. In Russian. refs

A system of first-order differential equations valid for small load increments has been obtained in the deformed surface coordinates for a flexible, elastic, inhomogeneous shell of revolution of the general type. The boundary-value problem is solved numerically using a computer. Results obtained for a flexible spherical panel and an annular plate are discussed. V.L.

A82-31897#

OSMOTIC PUMPED HEAT PIPES FOR LARGE SPACE PLATFORMS

H. J. TANZER, G. L. FLEISCHMAN (Hughes Aircraft Co., Torrance, CA), and D. D. STALMACH (Vought Corp., Dallas, TX) American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 3rd, St. Louis, MO, June 7-11, 1982, AIAA 11 p. refs

(AIAA PAPER 82-0902)

A thermal bus will be required as a thermal control source for future space platforms. The osmotic heat pipe is one candidate device with potential significant payoff toward serving growing thermal management needs. Results of a study evaluating osmotic heat pipes for thermal bus applications are presented. Electrostatic and other techniques are proposed for flow control and solution circulation in zero-gravity. Baseline size and performance design parameters of cellulose acetate membrane/sugar-water solution and other combinations were scaled up to predict osmotic pump performance for heat loads and temperatures of 4 to 120 C. A compact hollow-fiber membrane module measuring 20 inches in diameter by 12 inches long and weighing 190 pounds is projected for 50-kW heat loads. (Author)

A82-31898*# Hughes Aircraft Co., Torrance, Calif.

DESIGN, FABRICATION AND TEST OF LIQUID METAL HEAT-PIPE SANDWICH PANELS

A. BASIULIS (Hughes Aircraft Co., Torrance, CA) and C. J. CAMARDA (NASA, Langley Research Center, Hampton, VA) American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 3rd, St. Louis, MO, June 7-11, 1982, AIAA 8 p. refs

(AIAA PAPER 82-0903)

Integral heat-pipe sandwich panels, which synergistically combine the thermal efficiency of heat pipes and the structural efficiency of honeycomb sandwich panel construction, were fabricated and tested. The designs utilize two different wickable honeycomb cores, facesheets with screen mesh sintered to the internal surfaces, and potassium or sodium as the working fluid. Panels were tested by radiant heating, and the results indicate successful heat pipe operation at temperatures of approximately 922 K (1200 F). These panels, in addition to solving potential thermal stress problems in an Airframe-Integrated Scramjet Engine, have potential applications as cold plates for electronic component cooling, as radiators for space platforms, and as low distortion, large area structures. (Author)

A82-33139*# Astro Research Corp., Carpinteria, Calif.

ACCURACY POTENTIALS FOR LARGE SPACE ANTENNA REFLECTORS WITH PASSIVE STRUCTURE

J. M. HEDGEPETH (Astro Research Corp., Carpinteria, CA) Journal of Spacecraft and Rockets, vol. 19, May-June 1982, p. 211-217. refs

(Contract NAS1-15347)

Analytical results indicate that a careful selection of materials and truss design, combined with accurate manufacturing techniques, can result in very accurate surfaces for large space antennas. The purpose of this paper is to examine these relationships for various types of structural configurations. Comparisons are made of the accuracy achievable by truss- and dome-type structures for a wide range of diameter and focal length of the antenna and wavelength of the radiated signal. (Author)

A82-33141*# Vought Corp., Dallas, Tex.

THERMAL MANAGEMENT FOR LARGE SPACE PLATFORMS

J. A. OREN and R. L. COX (Vought Corp., Dallas, TX) Journal of Spacecraft and Rockets, vol. 19, May-June 1982, p. 278-283. refs

(Contract NAS2-22270)

(AIAA PAPER 81-0451)

This paper provides an evaluation of heat rejection techniques applicable to multihundred-kilowatt space platforms. A number of promising heat rejection concepts were parametrically weight-optimized over a wide range of conditions to provide a 99% reliability of achieving a 10-yr life for the multihundred-kilowatt space platform. Three panel designs were considered: (1) an advanced meteoroid-bumpered hybrid heat pipe concept, (2) a bumpered liquid concept, and (3) a space constructable heat pipe radiator. The following are some of the significant findings from the study: (1) A single subsystem approach can be used with the heat pipe system, whereas several smaller subsystems are required for the pumped fluid systems. (2) The space constructable radiator approach offers a 10% weight reduction and operational advantages over the conventionally deployed panels. (Author)

A82-33722

AN APPROACH TO THE NUMERICAL SOLUTION OF BOUNDARY-VALUE PROBLEMS IN THE STATICS OF FLEXIBLE SHELLS [ODIN PIDKHID DO CHISEL'NOGO ROZV'IAZANNIA GRANICHNIKH ZADACH STATIKI GNUCHKIKH OBOLONOK]

IA. M. GRIGORENKO and M. M. KRIUKOV (Akademiia Nauk Ukrains'koi RSR, Institut Mekhaniki, Kiev, Ukrainian SSR) Akademiia Nauk Ukrains'koi RSR, Dopovidi, Seriia A - Fiziko-Matematichni ta Tekhnichni Nauki, Apr. 1982, p. 21-24. In Ukrainian. refs

A method is proposed for the numerical solution of boundary-value problems concerning geometrically nonlinear deformation of thin-walled shells in the subcritical and supercritical regions. The proposed method involves transformation of the initial boundary-value problem and its solution via quasi-linearization. The method is demonstrated for a problem concerning deformation of an ellipsoid shell. V.L.

A82-34273#

EFFECTIVE LATERAL THERMAL CONDUCTIVITY OF SQUARE-CELL CORES

D. R. FAIRBANKS (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA Journal, vol. 20, July 1982, p. 1009-1014. ARPA-supported research refs

(Contract DAAK40-79-C-0022)

The effective thermal conductivity of square-cell cores has been formulated for heat flow lateral to the principal axes of the cells. The formulation is based on a thermal model involving linearized radiation and solid conduction only, where the application is for cored mirrors in space-based optical systems. The formulation uses an effective view-factor correlation that allows a radiative conductance to be isolated as a component acting in parallel with a solid conductance. By analysis for both normal and diagonal global heat flow, relative to the cell pattern, sensitivity of effective thermal conductivity to lateral heat-flow orientation was found to be quite negligible. (Author)

A82-39886

BUCKLING STRENGTH OF CYLINDRICAL GEODESIC STRUCTURES

T. HAYASHI (Chuo University, Tokyo, Japan) In: Composite materials: Mechanics, mechanical properties and fabrication; Proceedings of the Japan-U.S. Conference, Tokyo, Japan, January 12-14, 1981. Barking, Essex, England, Applied Science Publishers, 1982, p. 428-435.

The global buckling pattern in a geodesic cylinder is investigated by means of the buckling theory of orthotropic cylinders. The governing equations are reviewed, as are those for asymmetric buckling under compression and torsional buckling. Application to a cylindrical geodesic structure is discussed, and some conclusions are drawn about certain consequences for geodesic structures. C.D.

A82-42101
HEAT RECOVERY IN VERTICAL SYSTEMS
H. HETTWER and H.-H. BATH (Deutsche Bauakademie, Berlin, East Germany) In: Advances in heat pipe technology; Proceedings of the Fourth International Heat Pipe Conference, London, England, September 7-10, 1981. Oxford, Pergamon Press, 1981, p. 193-199.

In this paper, the most important results in the framework of developing and testing gravity-type heat pipes in a large-space stable are reported. These results involve the optimum volume of the heat-transfer medium (ammonia), the course of efficiency in dependence on the temperature differential between exhaust air and outside air, and the annual quantity of recovered heat. (Author)

A82-42123* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THERMAL MANAGEMENT OF INSTRUMENTS ON SPACE PLATFORMS USING A HIGH CAPACITY TWO-PHASE HEAT TRANSPORT SYSTEM
S. OLLENDORF (NASA, Goddard Space Flight Center, Greenbelt, MD), A. FOWLE, and D. ALMGREN (Arthur D. Little, Inc., Cambridge, MA) In: Advances in heat pipe technology; Proceedings of the Fourth International Heat Pipe Conference, London, England, September 7-10, 1981. Oxford, Pergamon Press, 1981, p. 525-530.

A system utilizing a pumped, two-phase single component working fluid for heat exchange and transport services necessary to meet the temperature control requirements of typical orbiting instrument payloads on space platforms is described. The design characteristics of the system is presented, together with a presentation of a laboratory apparatus for demonstration of proof of concept. Results indicate that the pumped two-phase design concept can meet a wide range of thermal performance requirements with the only penalty being the requirement for a small liquid pump. (Author)

A82-42125
PROBLEMS ASSOCIATED WITH THERMAL TESTING OF LARGE HEAT PIPE SYSTEMS FOR SPACE APPLICATION
R. SCHLITT, U. LAUX, and R. MEYER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) In: Advances in heat pipe technology; Proceedings of the Fourth International Heat Pipe Conference, London, England, September 7-10, 1981. Oxford, Pergamon Press, 1981, p. 543-560. refs

The influence of a one-g environment on the transport capability and temperature distribution of heat pipes designed for the high dissipating repeater equipment of direct broadcast TV-satellites is investigated using the example of the complex heat pipe system of the TV-SAT/TDF satellites. Results show that the thermal performance of large heat pipe systems during ground testing is limited by the effect of gravitation on the liquid flow mechanism. Higher temperatures are found for the heat pipes and/or heat source during ground testing as a result of the formation of a layer of excess liquid in the condenser zone during adverse tilt operation, partial dry-out of the grooves in the heating zone, and pool boiling with consequent overheating of the evaporator in the reflux mode operation of straight heat pipes. In addition, the sharp decrease in the transport capability in adverse tilt positions can be partially offset by increasing the amount of liquid. N.B.

A82-45265*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THERMAL CONTROL FOR THE 1990'S
S. OLLENDORF (NASA, Goddard Space Flight Center, Greenbelt, MD) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 107-111.
(AIAA 82-1862)

Current thermal distribution systems on large spacecraft, such as the Space Shuttle and Spacelab, use pumped fluid loops that circulate the coolant between a series of user stations and a single rejection point, involving complex plumbing and controls with a significant power penalty and limited reliability. In order to provide heat transport at near-isothermal conditions in future large spacecraft, two-phase flow systems will be implemented by taking advantage of the heat of vaporization and condensation of common working fluids at minimal expenditure of power and temperature variation. Such systems are considered for the cases of the thermal requirements of nearly 100 potential astrophysics and astronomy instruments. Data on temperature requirements, power dissipations, environmental fluxes, heat addition or rejection, and general description, are used to form conceptual designs for the thermal utility. O.C.

A82-47040#
THERMOELASTIC AND THERMAL BUCKLING ANALYSIS OF TWO-DIMENSIONAL LARGE SPACE STRUCTURES
P. SANTINI (Roma, Universita, Rome, Italy) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 26 p.
(IAF PAPER 82-381)

General equations for the heat conduction, thermal stresses, buckling, and thermal buckling analysis for a one-dimensional large space structure are obtained. Simple periodic solutions are found, and the uniform temperatures and stresses are derived. The error with respect to the exact solution is computed for a specific example. These uniform solutions are then applied to the analysis of two-dimensional large space structures, resulting in great simplifications. N.B.

A82-47041#
PREDICTION OF THERMAL EXPANSION COEFFICIENTS OF SANDWICHES USING FINITE ELEMENTS METHODS VALIDATED BY EXPERIMENTAL TEST RESULTS
M. MARCHETTI (Roma, Universita, Rome, Italy) and F. MORGANTI (Selenia S.p.A., Rome, Italy) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 37 p. refs
(IAF PAPER 82-383)

A numerical method for predicting the thermal expansion coefficient of sandwich panels for telecommunication satellite antennas is presented. The method is discussed with particular reference to sandwich panels consisting of carbon-fiber-reinforced plastic skins and an aluminum honeycomb core 6.35 or 12.7 mm thick, but it can be easily generalized to other cases. The inputs of the prediction method are experimental thermomechanical properties of the skins and the adhesive; results are validated experimentally in the temperature range from minus 120 to plus 100 C using a high-precision dilatometer. Detailed numerical results are presented. V.L.

A82-47094
DEFORMATION OF EXTENDED ELASTIC BODIES IN ORBIT [DEFORMATSII PROTIAZHENNYKH UPRUGIKH TEL NA ORBITE]
A. I. LOMACHENKO and V. M. MAMALYGA Akademiia Nauk SSSR, Izvestiia, Mekhanika Tverdogo Tela, July-Aug. 1982, p. 27-35. In Russian. refs

An analysis is presented of the deformations caused by gravitational forces in earth orbit in a large space structure in the form of an elastic beam with loads on its ends. The oscillation frequencies of a beam that is oriented in the orbital plane are determined. An analysis is also presented of the stability of an elastic thin square plate made of homogeneous isotropic material, the center of mass of which moves in a circular earth orbit. B.J.

N82-23129*# Texas A&M Univ., College Station.
CAPILLARY PRIMING CHARACTERISTICS OF A DUAL PASSAGE HEAT PIPE IN ZERO-G Final Report
G. P. PETERSON *In* Houston Univ. The 1981 NASA ASEE Summer Fac. Fellowship Program, Vol. 2 50 p 20 Aug. 1981
Avail: NTIS HC A17/MF A01 CSCL 20D

Technical improvements of a long life heat rejection system, suitable for long duration high power missions, that can be constructed and deployed in orbit is discussed. A mathematical model is formulated and a computer program developed which describes the transient priming characteristics of a dual passage heat pipe. An experimental test package is described for flight in the KC-135 Zero-g Aircraft, to be used to verify the modeling predictions. E.A.K.

N82-23260*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

A USER'S GUIDE TO THE GEOMLLS COMPUTER PROGRAM FOR DETERMINING THE GEOMETRY OF LARGE SEGMENTED SURFACES

A. H. NAYFEH, M. S. ANDERSON, and C. L. HERSTROM Mar. 1981 18 p refs

(NASA-TM-81944; NAS 1.15:81944) Avail: NTIS HC A02/MF A01 CSCL 22B

The GEOMLLS computer program determines dimensions and coordinates of flat segmented triangular surfaces which approximate spherical and paraboloidal surfaces of revolution where the vertices of the triangles lie on the true surface. This program is capable of calculating the complete geometry of the segmented surface and quantities that measure surface accuracy such as maximum deviation and root mean square (rms) deviation from true surface. A 'self-contained' subroutine is included which enables the required design to be displayed graphically. A.R.H.

N82-23358*# Ford Aerospace and Communications Corp., Palo Alto, Calif. Systems Analysis Dept.

DESIGN AND ANALYSIS CONSIDERATIONS FOR DEPLOYMENT MECHANISMS IN A SPACE ENVIRONMENT

P. L. VORLICEK, J. V. GORE, and C. T. PLESCIA *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 211-222 May 1982 Sponsored in part by INTELSAT

Avail: NTIS HC A15/MF A01 CSCL 13I

On the second flight of the INTELSAT V spacecraft the time required for successful deployment of the north solar array was longer than originally predicted. The south solar array deployed as predicted. As a result of the difference in deployment times a series of experiments was conducted to locate the cause of the difference. Deployment rate sensitivity to hinge friction and temperature levels was investigated. A digital computer simulation of the deployment was created to evaluate the effects of parameter changes on deployment. Hinge design was optimized for nominal solar array deployment time for future INTELSAT V satellites. The nominal deployment times of both solar arrays on the third flight of INTELSAT V confirms the validity of the simulation and design optimization. Author

N82-23361*# Lockheed Missiles and Space Co., Sunnyvale, Calif.

DEPLOYMENT/RETRACTION GROUND TESTING OF A LARGE FLEXIBLE SOLAR ARRAY

D. T. CHUNG *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 249-263 May 1982

Avail: NTIS HC A15/MF A01 CSCL 10A

The simulated zero-gravity ground testing of the flexible fold-up solar array consisting of eighty-four full-size panels (.368 m x .4 m each) is addressed. Automatic, hands-off extension, retraction, and lockup operations are included. Three methods of ground testing were investigated: (1) vertical testing; (2) horizontal testing, using an overhead water trough to support the panels; and (3) horizontal testing, using an overhead track in conjunction with a counterweight system to support the panels. Method 3 was selected as baseline. The wing/assembly vertical support structure, the five-tier overhead track, and the mast-element support track comprise the test structure. The flexible solar array wing assembly was successfully extended and retracted numerous times under simulated zero-gravity conditions. Author

N82-23366*# Federal Aircraft Establishment, Emmen (Switzerland). Thermodynamics Sect.

THE MECHANICAL DESIGN OF A VAPOR COMPRESSOR FOR A HEAT PUMP TO BE USED IN SPACE

F. BERNER, H. OESCH, K. GOETZ, and C. J. SAVAGE (ESA) *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 329-340 May 1982 refs

Avail: NTIS HC A15/MF A01 CSCL 20D

A heat pump developed for use in Spacelab as a stand-alone refrigeration unit as well as within a fluid loop system is discussed. It will provide an active thermal control for payloads. Specifications for the heat pump were established: (1) heat removal rates at the source; (2) heat source temperatures from room temperature; (3) heat-sink fluid temperatures at condenser inlet; and (4) minimum power consumption. A reversed Carnot cycle heat pump using Freon 12 as working fluid incorporating a one-cylinder reciprocating compressor was selected. The maximum crankshaft speed was fixed relatively high at 100 rpm. The specified cooling rates then made it necessary to select a cylinder volume of 10 cu cm, which was obtained with a bore of 40 mm and a stroke of 8 mm. N.W.

N82-23474*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

NASTRAN THERMAL ANALYZER IN A UNIFIED FINITE-ELEMENT TREATMENT OF THERMO-STRUCTURAL ANALYSES

H. P. LEE *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 1-22 1982 refs

Avail: NTIS HC A24/MF A01 CSCL 20D

The NASTRAN thermal analyzer (NTA) which performs large-scale unified thermo-structural analyses with the NASTRAN (NASA structural analysis) computer program is described. The mathematical similitude between these two distinct disciplines of thermal and structure is examined. It serves as the theoretical basis upon which the implementation of the thermal capability in NASTRAN was accomplished. The program structure, the functional flow, the solution algorithms, the organization of an input data deck and the solution capabilities of NTA are summarized. Emphasis is placed on the interface of the unified approach in thermo-structural analyses where stresses, deflections, vibrations and bucklings induced by the effect of temperature change are of concern. Attentions are also directed to the preprocessor and post processors. As a specially designed preprocessor, the VIEW program is capable of generating exchange factors which can be output, at user's option, in formats compatible with that required by NTA. Two post processors that serve specific objectives are included. They are the thermal variance analysis and the graphical displaying capability of temperatures in color or black and white. M.G.

N82-23476*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

THE SPAR THERMAL ANALYZER: PRESENT AND FUTURE

M. B. MARLOWE (Engineering Information Systems, Inc., San Jose, Calif.), W. D. WHETSTONE (Engineering Information Systems, Inc., San Jose, Calif.), and J. C. ROBINSON *In its* Computational Aspects of Heat Transfer in Struct. p 35-50 1982 refs

Avail: NTIS HC A24/MF A01 CSCL 20D

The SPAR thermal analyzer, a system of finite-element processors for performing steady-state and transient thermal analyses, is described. The processors communicate with each other through the SPAR random access data base. As each processor is executed, all pertinent source data is extracted from the data base and results are stored in the data base. Steady state temperature distributions are determined by a direct solution method for linear problems and a modified Newton-Raphson method for nonlinear problems. An explicit and several implicit methods are available for the solution of transient heat transfer problems. Finite element plotting capability is available for model checkout and verification. M.G.

N82-23479*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SOME ASPECTS OF ALGORITHM PERFORMANCE AND MODELING IN TRANSIENT THERMAL ANALYSIS OF STRUCTURES
H. M. ADELMAN, R. T. HAFTKA (Virginia Polytechnic Institute and State Univ.), and J. C. ROBINSON *In its* Computational Aspects of Heat Transfer in Struct. p 91-98 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

The status of an effort to increase the efficiency of calculating transient temperature fields in complex aerospace vehicle structures is described. The advantages and disadvantages of explicit and implicit algorithms are discussed. A promising set of implicit algorithms with variable time steps, known as the GEAR package is described. Four test problems, used for evaluating and comparing various algorithms, were selected and finite element models of the configurations are described. These problems include a space shuttle frame component, an insulated cylinder, a metallic panel for a thermal protection system, and a model of the space shuttle orbiter wing. Results generally indicate a preference for implicit oer explicit algorithms for solution of transient structural heat transfer problems when the governing equations are stiff. M.G.

N82-23480*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ALGORITHMIC ASPECTS OF TRANSIENT HEAT TRANSFER PROBLEMS IN STRUCTURES
R. T. HAFTKA and M. H. KADIVAR (Illinois Institute of Technology) *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 99-114 1982 refs
(Contract NSG-1266)
Avail: NTIS HC A24/MF A01 CSCL 20D

It is noted that the application of finite element or finite difference techniques to the solution of transient heat transfer problems in structures often results in a stiff system of ordinary differential equations. Such systems are usually handled most efficiently by implicit integration techniques which require the solution of large and sparse systems of algebraic equations. The assembly and solution of these systems using the incomplete Cholesky conjugate gradient algorithm is examined. Several examples are used to demonstrate the advantage of the algorithm over other techniques. M.G.

N82-23481*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF AN IMPROVED FINITE-ELEMENT THERMAL STRESS CALCULATION TECHNIQUE
C. J. CAMARDA *In its* Computational Aspects of Heat Transfer in Struct. p 115-131 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

A procedure for generating accurate thermal stresses with coarse finite element grids (Ojalvo's method) is described. The procedure is based on the observation that for linear thermoelastic problems, the thermal stresses may be envisioned as being composed of two contributions; the first due to the strains in the structure which depend on the integral of the temperature distribution over the finite element and the second due to the local variation of the temperature in the element. The first contribution can be accurately predicted with a coarse finite-element mesh. The resulting strain distribution can then be combined via the constitutive relations with detailed temperatures from a separate thermal analysis. The result is accurate thermal stresses from coarse finite element structural models even where the temperature distributions have sharp variations. The range of applicability of the method for various classes of thermostructural problems such as in-plane or bending type problems and the effect of the nature of the temperature distribution and edge constraints are addressed. Ojalvo's method is used in conjunction with the SPAR finite element program. Results are obtained for rods, membranes, a box beam and a stiffened panel. M.G.

N82-23482*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEVELOPMENT OF A REDUCED BASIS TECHNIQUE FOR TRANSIENT THERMAL ANALYSIS
C. P. SHORE *In its* Computational Aspects of Heat Transfer in Struct. p 133-146 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

A technique to reduce the degrees of freedom in static and dynamic problems, the reduced basis method, is described. The method combines the classical Rayleigh-Ritz approximation with contemporary finite element methods to retain modeling versatility as the degrees of freedom are reduced. Applications to a nonlinear dynamic response problem are discussed efforts to apply the method to nonlinear transient thermal response problems are summarized. The selection of basis vectors for reducing the system of equations is addressed. M.G.

N82-23483*# Old Dominion Univ., Norfolk, Va.
APPLICATIONS OF PERTURBATION TECHNIQUES
O. A. KANDIL *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 147-160 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

Two perturbation techniques were applied to two singular perturbation problems in heat transfer to obtain uniformly valid solutions which can serve as benchmarks for finite difference and finite element techniques. In the first problem, the method of strained parameters coupled with the application of a solvability condition is used to obtain a uniform solution for the problem of unsteady heat conduction in a long nearly circular cylinder. In the second problem, the method of matched asymptotic expansion coupled with Van Dyke's matching principle is used to obtain a uniform solution for the problem of one dimensional conduction-convection heat transfer of a uniform fluid flow. M.G.

N82-23485*# Old Dominion Univ., Norfolk, Va.
INTEGRATED THERMAL-STRUCTURAL ANALYSIS OF LARGE SPACE STRUCTURES
J. MAHANEY and E. A. THORNTON *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 179-198 1982 refs
(Contract NSG-1321)
Avail: NTIS HC A24/MF A01 CSCL 20D

Optimum performance of large space antennas requires very fine control of the shape of the antenna surface since the shape affects both frequency control and pointing accuracy. A significant factor affecting the antenna shape is the temperature of the structure and the resulting deformation. To accurately predict the temperature of the structure, it is necessary first to accurately predict thermal loads. As the structure orbits the Earth, the thermal loads change constantly so that the thermal-structural response varies continuously throughout the orbit. The results from recent applications of integrated finite element methodology to heat load determination and thermal-structural analysis of large space structures are given. Four areas are concentrated on: (1) the characteristics of the integrated finite element methodology, (2) fundamentals of orbital heat load calculation, (3) description and comparison of some radiation finite elements, and (4) application of the integrated finite-element approach to the thermal-structural analysis of an orbiting truss structure. R.J.F.

N82-23487*# Washington Univ., Seattle.
INTERACTIVE COMPUTATION OF RADIATION VIEW FACTORS
A. F. EMERY, H. R. MORTAZAVI, and C. J. KIPPENHAN *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 221-241 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

The development of a pair of computer programs to calculate the radiation exchange view factors is described. The surface generation program is based upon current graphics capabilities and includes special provisions which are unique to the radiation problem. The calculational program uses a combination of contour and double area integration to permit consideration of radiation with obstruction surfaces. Examples of the surface generation and the calculation are given. Author

N82-23488*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
RECENT DEVELOPMENTS IN THERMAL RADIATION SYSTEM ANALYZER (TRASYS)
R. A. VOGT *In* NASA. Langley Research Center Computational Aspects of Heat Transfer in Struct. p 234-251 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

Changes in the thermal radiation analyzer system (TRASYS) computer program are discussed. New capabilities were added while keeping intact the same data input structure. An overview of the program structure and general capabilities is given. Where appropriate, assessments are made of new features. The application of TRASYS peripheral programs and the importance they have in developing a totally integrated thermal analysis system are discussed. Form factor computations times were reduced approximately 40 percent, and the longer flux runs were reduced 50 percent when shadow tables were used. R.J.F.

N82-23496*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF THE SPAR THERMAL ANALYZER ON THE CYBER-203 COMPUTER
J. C. ROBINSON, K. M. RILEY (Kentron International, Hampton, Va.), and R. T. HAFTKA (Virginia Polytechnic Institute and State Univ.) *In its* Computational Aspects of Heat Transfer in Struct. p 405-424 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

The use of the CYBER 203 vector computer for thermal analysis is investigated. Strengths of the CYBER 203 include the ability to perform, in vector mode using a 64 bit word, 50 million floating point operations per second (MFLOPS) for addition and subtraction, 25 MFLOPS for multiplication and 12.5 MFLOPS for division. The speed of scalar operation is comparable to that of a CDC 7600 and is some 2 to 3 times faster than Langley's CYBER 175s. The CYBER 203 has 1,048,576 64-bit words of real memory with an 80 nanosecond (nsec) access time. Memory is bit addressable and provides single error correction, double error detection (SECDED) capability. The virtual memory capability handles data in either 512 or 65,536 word pages. The machine has 256 registers with a 40 nsec access time. The weaknesses of the CYBER 203 include the amount of vector operation overhead and some data storage limitations. In vector operations there is a considerable amount of time before a single result is produced so that vector calculation speed is slower than scalar operation for short vectors. B.W.

N82-23498*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EVALUATION OF SUPERMINICOMPUTERS FOR THERMAL ANALYSIS
O. O. STORAASLI, J. B. VIDAL (Digital Equipment Corp., Richard, Va.), and G. K. JONES (NASA Goddard Space Flight Center) *In its* Computational Aspects of Heat Transfer in Struct. p 437-451 1982 refs
Avail: NTIS HC A24/MF A01 CSCL 20D

The use of superminicomputers for solving a series of increasingly complex thermal analysis problems is investigated. The approach involved (1) installation and verification of the SPAR thermal analyzer software on superminicomputers at Langley Research Center and Goddard Space Flight Center, (2) solution of six increasingly complex thermal problems on this equipment, and (3) comparison of solution (accuracy, CPU time, turnaround time, and cost) with solutions on large mainframe computers. B.W.

N82-25526# National Centre of Tribology, Risley (England). European Space Tribology Lab.
THERMAL VACUUM QUALIFICATION LEVEL AND ACCELERATED LIFE TESTS OF A DORNIER SYSTEMS QUALIFICATION MODEL ANTENNA POINTING MECHANISM
J. C. ANDERSON Paris ESA Jun. 1981 51 p
(Contract ESA-3426/77/NL-MD)
(ESA-ESTL-048; ESA-CR(P)-1525) Avail: NTIS HC A04/MF A01

A double gimbal carbon fiber reinforced plastic APM with a friction-type stepping motor, driving each axis directly, was tested. Range of rotation, steady state pointing, pointing accuracy, mean motor step size, and zero shift were examined. Pointing accuracy is consistent over a wide thermal range. Accelerated life test performance is good. Displayed resolver backlash errors due to incorrect displaying of the electronics at changes in direction of APM rotation, and a reversible shift in the APM zero position with temperature are recorded. Variations in mean motor step size with temperature and torque are observed, but these do not affect APM performance. Author (ESA)

N82-27352*# National Aeronautics and Space Administration, Washington, D. C.
INVESTIGATION OF COOLING PROPERTIES OF THE GASEOUS MEDIUM OF A SPACE STATION
S. BARANSKI, R. BLOSZNYSKI, M. HERMASZEWSKI, J. KUBICZKOWA, A. PIORKO, R. SAGANIAK, Z. SAROL, F. SKIBNIEWSKI, J. STENDERA, and W. WALICHNOWSKI Mar. 1982 5 p Transl. into ENGLISH from Postepy Astronaut. (Poland), v. 12, no. 4, 1979 p 81-84 Original document announced as A80-30519 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-3541)
(NASA-TM-76794; NAS 1.15:76794) Avail: NTIS HC A02/MF A01 CSCL 22B

An investigation of cooling properties of the gaseous medium was performed in the biosatellite Kosmos-936 as well as in the orbital complexes Soyuz-28/Salyut-6 and Soyuz-30/Salyut-6 with the aid of an especially constructed electric dynamic catathermometer. In this instrument current was measured which was necessary to keep a steady settled temperature of the sensing device. The investigation was performed because of the disturbed heat exhange of the human body caused by lack of natural convection in weightlessness. The instrument also enabled objective estimation of the temperature of the cosmonaut's ody in six optionally selected regions. The results obtained by means of the catathermometer will also enable defining the appropriate hygienic conditions of the gaseous medium of space stations. Author

N82-27376*# Astro Research Corp., Santa Barbara, Calif.
SOME INTERDISCIPLINARY TRADE-OFFS IN THE DESIGN OF LARGE SPACE STRUCTURES
J. M. HEDGEPETH *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 213-219 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

The constraints placed on the design of large space structures by acceleration, attitude control, and stationkeeping forces are discussed. Stiffness requirements for the structures are derived. The use of active versus passive accuracy control methods is also addressed. B.W.

N82-28346*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELIMINARY SIZING OF VIBRATION ABSORBER FOR SPACE MAST STRUCTURES
M. F. CARD, H. G. MCCOMB, JR., and S. W. PEEBLES May 1982 31 p refs
(NASA-TM-84488; NAS 1.15:84488) Avail: NTIS HC A03/MF A01 CSCL 22B

A simple method of sizing a vibration absorber for a large, cantilevered flexible mast is presented. The method is based on Den Hartog's vibration absorber theory for two-degree-of-freedom systems. Generalized design curves are presented as well as specific numerical results for a candidate space experiment in which a long flexible antenna mast is attached to the shuttle orbiter and dynamically excited by orbiter accelerations. Results indicate that for large flexible masts, the mass of the vibration absorber required to meet stringent tip deflection tolerances becomes prohibitively large. Author

N82-29930 Concordia Univ., Montreal (Quebec). Computer Aided Building Design Lab.
THE COMPUTER SIMULATION OF META STRUCTURES
D. W. COLLINS *In* National Research Council of Canada Proc.: Graphics Interface, 1982 p 173-185 1982 refs Sponsored by Natural Science and Engineering Research Council of Canada
Avail: Issuing Activity

A dynamic prediction system for space oriented architecture in meta structures using interactive computer graphics techniques is discussed. Meta structures in architecture are variable, space-enclosing, support systems that allow maximum dimensional changes with minimum effort and/or adjustment. The development of a computing model which allows the user to interactively define a meta structure via linguistic and analog control and to simulate the real time motion of structures that are considered to be part of the indeterminate set is described. The user may deploy a designed structure in real time observing the transformations on the Vector General 3DR graphics display which is controlled by a PDP11/45 using the GRASS language. The specific application of the system is the design of large erectable space structures. M.G.

N82-31646*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STUDIES OF IMPLICIT AND EXPLICIT SOLUTION TECHNIQUES IN TRANSIENT THERMAL ANALYSIS OF STRUCTURES
H. M. ADELMAN, R. T. HAFTKA, and J. C. ROBINSON Aug. 1982 47 p refs
(NASA-TP-2038; L-15245; NAS 1.60:2038) Avail: NTIS HC A03/MF A01 CSCL 20D

Studies aimed at an increase in the efficiency of calculating transient temperature fields in complex aerospace vehicle structures are reported. The advantages and disadvantages of explicit and implicit algorithms are discussed and a promising set of implicit algorithms with variable time steps, known as GEARIB, is described. Test problems, used for evaluating and comparing various algorithms, are discussed and finite element models of the configurations are described. These problems include a coarse model of the Space Shuttle wing, an insulated frame tst article, a metallic panel for a thermal protection system, and detailed models of sections of the Space Shuttle wing. Results generally indicate a preference for implicit over explicit algorithms for transient structural heat transfer problems when the governing equations are stiff (typical of many practical problems such as insulated metal structures). The effects on algorithm performance of different models of an insulated cylinder are demonstrated. The stiffness of the problem is highly sensitive to modeling details and careful modeling can reduce the stiffness of the equations to the extent that explicit methods may become the best choice. Preliminary applications of a mixed implicit-explicit algorithm and operator splitting techniques for speeding up the solution of the algebraic equations are also described. Author

N82-33743*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF THE REDUCED BASIS METHOD TO NONLINEAR TRANSIENT THERMAL ANALYSIS
C. P. SHORE *In its* Res. in Struct. and Solid Mech., 1982 p 49-65 Oct. 1982 refs
Avail: NTIS HC A19/MF A01 CSCL 20K

An effort to apply the reduced basis method to nonlinear transient thermal analysis is described. The method combines the classical Rayleigh-Ritz and modal superposition techniques with contemporary finite element methods to retain modeling versatility as the degrees of freedom in a problem are reduced. The essence of the method is to use a few thermal modes from eigenvalue analyses as basis vectors to represent the temperature response for a given thermal problem similar to the use of vibration modes to represent displacements in a dynamic response problem. Approximate temperature distributions were obtained using the reduced basis method for a small section of the Shuttle Orbiter lower wing undergoing reentry heating. Good agreement was obtained between the reduced basis method solutions and full system solutions with reductions in the degrees of freedom of up to a factor of four. The good agreement indicates the reduced basis method has the potential for significant reduction in computing effort for thermal analysis; however, considerable work remains to determine techniques for selecting the type and number of basis vectors needed for approximate solutions to more complex transient thermal problems. Author

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STRUCTURAL DYNAMICS AND CONTROL

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

A82-28856
LOW ENERGY PARTICLES IN THE MAGNETOSPHERE
C. R. CHAPPELL Advances in Space Research, vol. 2, no. 1, 1982, p. 33-38.

Consideration is given to the low-energy (less than 100 eV) hybrid plasma particle population in the earth's magnetosphere. Satellite observations of a cold plasma in the outer plasmasphere and plasmatrough at temperatures greater than expected for plasma filling by upward flowing ionization are noted, and results of ATS-6 measurements of cold particle angular and density distributions are presented which reveal field-aligned, conical and magnetospheric trapped pitch angle distributions indicative of a number of possible plasma energization processes. Subsequent GEOS and ISEE measurements have confirmed the field-aligned and conical distributions, and revealed the presence of multiply charged ions in the 2 to 100 eV energy range which demonstrates the mixing of plasma of ionospheric and magnetospheric origins. The need for further studies of energization mechanisms and for differential energy spectrum, pitch angle and ion composition measurements such as those to be made by the planned Origin of Plasmas in the Earth's Neighborhood mission is pointed out. A.L.W.

A82-29830
SYNTHESIS OF THE OPTIMAL CONTROL OF A SPACECRAFT WITH ELASTIC ELEMENTS UNDER RANDOM DISTURBANCES [SINTEZ OPTIMAL'NOGO UPRAVLENIIA KOSMICHESKIM APPARATOM S UPRUGIMI ELEMENTAMI PRI SLUCHAINYKH VOZMUSHCHENIIAKH]
G. L. DEGTIAREV and V. G. LIFANOV Aviatsionnaia Tekhnika, no. 4, 1981, p. 23-27. In Russian. refs

The paper considers a spacecraft made up of a rigid central body and two cantilever elastic elements oscillating in counter-phase. External disturbing moments (e.g., gravitational, magnetic, aerodynamic, and light-pressure moments) are assumed to affect the accuracy of the stabilization system. A Kalman filter is developed for the state estimation of the spacecraft, the measured variables being angle and angular velocity or only the angular position of the rigid module. Numerical results on the synthesis of the optimal control for the spacecraft are presented. B.J.

A82-30081#
DEVELOPMENT OF AN ANALYTICAL MODEL FOR LARGE SPACE STRUCTURES
M. ASWANI, N. N. AU, and S. R. LIN (Aerospace Corp., El Segundo, CA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, 1982, p. 41-48. refs
(AIAA 82-0648)

A methodology is presented for modeling large truss-type structures based on the concept of equivalent continuum. The equivalent effective elastic and dynamic properties of the continuum model in terms of the material and geometric properties of the truss are derived in a simple and straightforward manner. The accuracy of the model is demonstrated in a free vibration problem when the results are compared to those obtained from the conventional finite element method. Both simply supported and free-free boundary conditions are considered. In addition, the assumptions made in obtaining the continuum solution are discussed. Numerical results clearly indicate the potential of this approach for modelling large repetitive truss-type structures. (Author)

A82-30127#
STRUCTURAL DYNAMIC DESIGN CONSIDERATIONS OF THE SHUTTLE REMOTE MANIPULATOR SYSTEM
J. A. HUNTER (National Aeronautical Establishment, Ottawa, Canada), T. H. USSHER, and D. M. GOSSAIN (Spar Aerospace, Ltd., Toronto, Canada) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, 1982, p. 499-505. refs
(AIAA 82-0762)

In 1975, an agreement was reached between NASA and the National Research Council of Canada (NRCC) that NRCC would execute a development program to deliver the first flight remote manipulator system for the Space Shuttle Orbiter. The arm of the system was to fit into a 15 foot diameter cylinder 50 feet long. It was to maneuver payloads 60 feet long and 15 feet in diameter weighing up to 65,000 pounds. To aid in the design process, a real time simulation facility (SIMFAC) was constructed and a very detailed nonreal time simulation was developed (ASAD). A general description of the remote manipulator system (RMS) is provided, taking into account the system configuration, aspects of joint construction and operation, the operator interface, the orbiter system interface, and safety precautions. Structural and dynamic design tools are discussed, giving attention to design constraints, the control system, and tests. G.R.

A82-30133*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTIMUM DAMPING LOCATIONS FOR STRUCTURAL VIBRATION CONTROL
G. C. HORNER (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, VA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 29-34. refs
(AIAA 82-0635)

A technique for determining the optimum damper locations and damping rates for a flexible structure has been developed. Using a nonlinear-mathematical-programming algorithm, a diagonal damping matrix is determined such that specified modes have a prescribed modal damping ratio. The design objective is to minimize the total damping effort while constraining the modal damping ratio to be equal or greater than the prescribed amount. Additional constraints require the diagonal elements of the damping matrix to be positive which guarantees that all modes of the damped system will be stable. Results are shown for a uniform free-free beam. (Author)

A82-30136*# Stanford Univ., Calif.
ON PASSIVE DAMPING MECHANISMS IN LARGE SPACE STRUCTURES
H. ASHLEY (Stanford University, Stanford, CA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 56-67. refs
(Contract AF-AFOSR-0062; NAG1-97)
(AIAA 82-0639)

The significance is explained of even tiny amounts of passive energy dissipation to ensure successful stabilization of large, flexible space structures. Study of scale effects on various mechanisms indicates that modal damping ratios are likely to decrease as size increases in a family of similar structures. Paper focuses on thermal dissipation induced by strain gradients during vibration of monolithic configurations. Past work and the expected magnitudes of this damping are reviewed, along with reasons why it is, to some degree, under the designer's control. In the search for the highest practical values, unidirectional metallic composites and other arrangements are examined (Author)

A82-30165#
NONLINEAR ANALYSIS OF OPTIMIZED STRUCTURE WITH CONSTRAINTS ON SYSTEM STABILITY
N. S. KHOT (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 360-367. refs
(AIAA 82-0715)

An optimization algorithm based on an optimality criterion was used to design a minimum weight space truss with different constraint requirements on system stability. The constraints were specified so that the eigenvalues associated with all the critical buckling modes are either equal or separated by a specified factor. For the second case the critical buckling mode was preselected from all the possible critical modes. The designs obtained for the various constraint conditions were analyzed with and without specified geometric imperfections using a nonlinear finite element program which accounts for geometric nonlinearity. The results obtained for various designs were compared for their imperfection sensitivity. (Author)

A82-30175*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COUPLED BENDING-BENDING-TORSION FLUTTER OF A MISTUNED CASCADE WITH NONUNIFORM BLADES
K. R. V. KAZA (NASA, Lewis Research Center, Cleveland; Toledo, University, Toledo, OH) and R. E. KIELB (NASA, Lewis Research Center, Structures Branch, Cleveland, OH) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 446-461. refs
(AIAA 82-0726)

A set of aeroelastic equations describing the motion of an arbitrarily mistuned cascade with flexible, pretwisted, nonuniform blades is developed using an extended Hamilton's principle. The derivation of the equations has its basis in the geometric nonlinear theory of elasticity in which the elongations and shears are negligible compared to unity. A general expression for foreshortening of a blade is derived and is explicitly used in the formulation. The blade aerodynamic loading in the subsonic and supersonic flow regimes is obtained from two-dimensional, unsteady, cascade theories. The aerodynamic, inertial and structural coupling between the bending (in two planes) and torsional motions of the blade is included. The equations are used to investigate the aeroelastic stability and to quantify the effect of frequency mistuning on flutter in turbofans. Results indicate that a moderate amount of intentional mistuning has enough potential to alleviate flutter problems in unshrouded, high-aspect-ratio turbofans. (Author)

A82-30187#
IDENTIFICATION OF THE EIGENSOLUTION OF DISTRIBUTED-PARAMETER SYSTEMS
H. BARUH and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg, VA) In: Structures, Structural Dynamics and Materials Conference, 23rd, New Orleans, LA, May 10-12, 1982, Collection of Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 574-581. refs
(AIAA 82-0771)

A method for the identification of the eigenvalues and eigenfunctions of distributed-parameter systems is presented. The method is an extension to distributed systems of a time-domain approach developed for discrete systems and makes use of the free-vibration response. A limited number of discrete sensors is used to identify the lower eigenvalues as well as the amplitudes of the associated eigenfunctions at the sensors locations. The identified eigenfunctions amplitudes at the chosen discrete points are then interpolated by means of splines to determine the eigenfunctions themselves. (Author)

A82-32201* Iowa State Univ. of Science and Technology, Ames.
DYNAMICS OF BI-PERIODIC STRUCTURES
T. J. MCDANIEL and M. J. CARROLL (Iowa State University of Science and Technology, Ames, IA) Journal of Sound and Vibration, vol. 81, Apr. 8, 1982, p. 311-335. refs
(Contract NSG-1372)

In order to gain insight into the dynamics of biperiodic aerospace structures, a variety of one- and two-dimensional biperiodic structures are considered. It is shown that bands in which natural frequencies lie for periodic structures are further subdivided as a consequence of the biperiodicity. Analytical solutions for the modes and frequencies of finite-length one-dimensional biperiodic structures are obtained for general boundary conditions. A transmission method is developed to simplify the application of boundary conditions. Some modes are found to occur at frequencies outside the frequency bands predicted for biperiodic structures. Two-dimensional biperiodic crossed beam grillage and truss structures are considered in the present study. B.J.

A82-32821#
MODAL-SURVEY TESTING FOR SYSTEM IDENTIFICATION AND DYNAMIC QUALIFICATION OF SPACECRAFT STRUCTURES
N. NIEDBAL and H. HUENERS (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Aeroelastik, Goettingen, West Germany) ESA Journal, vol. 6, no. 1, 1982, p. 21-34. refs

A survey of modern modal-survey testing is presented, covering the phase-resonance method and various phase-separation methods. The use of modal survey results in the dynamic qualification of spacecraft structures is discussed, with emphasis placed on the correlation of analytical and experimental modal data. It is noted that this aspect has attracted growing interest in recent years owing to the need for convenient tools that allow finite-element models to be updated with measured modal data. Further development of the experimental modal-analysis technique may be possible by combining the phase-resonance method with the phase-separation methods. C.R.

A82-32822#
ADAPTIVE CONTROL OF FLEXIBLE SPACE STRUCTURES
B. GOVIN and B. CLAUDINON (Matra, S.A., Velizy-Villacoublay, Yvelines, France) ESA Journal, vol. 6, no. 1, 1982, p. 35-51. European Space Research and Technology Centre refs
(Contract ESTEC-4120/79/NL/AK(SC))

Adaptive control is a promising method for controlling spacecraft in the presence of parameter variation and modeling uncertainties, especially when structural flexibility is already a critical problem. Several control and identification techniques are investigated in this paper. Two techniques with high computational loadings are applied to the modal control of uniform beams (being idealized models of large space structures). Two other techniques that presently seem more realistic are applied to a large three-axis-stabilized satellite. The satellite taken as an example has symmetrical H-type solar arrays and antenna-pointing mechanism. It has been modelled via the Stardyne finite-element program. All of these examples have been tested by simulation and the results and performances are discussed. Finally, the limitations of the various techniques, and guidelines for further work, are outlined. (Author)

A82-35196
TRENDS IN LARGE SPACE STRUCTURE CONTROL THEORY - FONDEST HOPES, WILDEST DREAMS
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IEEE Transactions on Automatic Control, vol. AC-27, June 1982, p. 522-535. refs

The advent of a space transportation system makes it possible to conceive of large space structures (LSS) employed for a variety of purposes, taking into account communications, surveillance, astronomy, space exploration, and electric power generation. Unlike rigid spacecraft design, LSS control is an extremely interdisciplinary subject drawing on structural mechanics and dynamics, mathematical modeling and approximation of distributed parameter systems (DPS), optimization, estimation and control science, numerical analysis, and large-scale computation. A mathematical framework is presented for the discussion of LSS control problems and trends. The fundamental issue in the development of this format is that the LSS is a DPS which is controlled by a few control devices (actuators and sensors) and control logic implemented in an on-board computer of limited size. Attention is given to reduced-order models, reduced-order controllers for LSS, and new directions to LSS control theory. G.R.

A82-35264
EFFECT OF DAMPING ON THE CONTROL DYNAMICS OF THE SPACE SHUTTLE BASED TETHERED SYSTEM
V. J. MODI (British Columbia, University, Vancouver, Canada), A. K. MISRA (McGill University, Montreal, Canada), and C.-F. GENG In: Astrodynamics 1981; Proceedings of the Conference, North Lake Tahoe, NV, August 3-5, 1981. Part 1. San Diego, CA, American Astronautical Society; Univelt, Inc., 1982, p. 487-496. Natural Sciences and Engineering Research Council refs
(Contract NSERC-A-2181; NSERC-A-0967)
(AAS 81-143)

There has been a proposal to use the Space Shuttle (orbiter) as a platform to support a tethered subsatellite system. The vast potential of such a Shuttle-based tethered system has led to many investigations concerning the system dynamics during operational, deployment, and retrieval phases. The present investigation is concerned with a study of the nonlinear dynamics of the system in presence of nutation damping, accounting for the tether mass, the earth's oblateness, and aerodynamic drag in a rotating atmosphere. Based on the results of the conducted analysis, it is concluded that a suitable control strategy in conjunction with an acceptable level of damping will provide a promising approach for resolving the problems associated with the retrieval of a tether supported subsatellite. G.R.

A82-35405#
A THEORETICAL INVESTIGATION OF AN OVERHUNG FLEXIBLE ROTOR MOUNTED ON UNCENTRALIZED SQUEEZE-FILM DAMPER BEARINGS AND FLEXIBLE SUPPORTS
R. A. COOKSON (Cranfield Institute of Technology, Cranfield, Beds., England) and X.-H. FENG (Chinese Aeronautical Establishment, Aero Gas Turbine Research Institute, Beijing, People's Republic of China) American Society of Mechanical Engineers, International Gas Turbine Conference and Exhibit, 27th, London, England, Apr. 18-22, 1982, 10 p. refs
(ASME PAPER 82-GT-218)

Previous investigations have shown that the uncentralized type of squeeze-film damper is an effective means of reducing the transmission of unbalance forces into the supporting structure. In this theoretical study a more complex model, which includes an overhung 'fan' disk and a noncentral 'turbine' disk, has been employed. This model represents the conventional gas turbine somewhat closer than does the previously studied single disk system. This investigation has shown that it is possible to minimize the force transmitted into the surrounding structure by a careful selection of squeeze-film damper characteristics, although it may be found that some larger amplitudes of motion accompany the minimized transmissibility. (Author)

A82-36137* Hulburt (E. O.) Center for Space Research, Washington, D.C.
AN IMAGE DRIFT COMPENSATION SYSTEM FOR A SOLAR POINTED SPACE TELESCOPE
J.-D. F. BARTOE (U.S. Navy, E. O. Hulburt Center for Space Research, Washington, DC) Astrophysics and Space Science, vol. 84, no. 1, May 1982, p. 115-132
(Contract NAVY PROJECT RR-033-02-43; NASA ORDER S-65062-B)
Two sounding rocket test flights have been conducted in the development of an image drift compensation system designed for a solar-pointed space telescope. The system, whose scientific results are presented, employs limb-sensing photodiodes at the telescope focal plane and provides drift compensation to better than + or - 0.1 arcsec. A variation of this device will be employed by the Space Shuttle/Spacelab 2 flight of the High Resolution Telescope and Spectrograph (HRTS) Instrument. The data gathered by the rocket flights of the drift compensation system have revealed high velocity ejecta traveling through the transition zone and corona at velocities up to 400 km/sec. The HRTS configuration and its constitutive instruments' optical parameters are described. O.C.

A82-36277*# Howard Univ., Washington, D. C.
ON THE MODELLING AND SIMULATION OF THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE ORBITING SYSTEMS
P. M. BAINUM, V. K. KUMAR, A. S. S. R. REDDY, and R. KRISHNA (Howard University, Washington, DC) International Association for Mathematics and Computers in Simulation, World Congress on System Simulation and Scientific Computation, 10th, Montreal, Canada, Aug. 8-13, 1982, Paper. 5 p. refs
(Contract NSG-1414)
This paper attempts to review the steps involved in the development of mathematical models that can be used to simulate the in-orbit dynamics of large flexible systems. The use of graph theoretic techniques can often be used to reduce the computational effort involved for calculating the eigenvalues of large ordered systems. Computer generated graphical techniques may provide additional insight into the understanding of elastic modal shape functions of complex systems. Finally the numerical techniques commonly used to develop shape and attitude control laws will be briefly reviewed. (Author)

A82-38417
THE GEOMETRY OF SATELLITE CLUSTERS
J. G. WALKER (Royal Aircraft Establishment, Farnborough, Hants., England) British Interplanetary Society, Journal (Orbital Dynamics), vol. 35, Aug. 1982, p. 345-354. refs
A preliminary examination has been made of some practical considerations affecting the choice of geometry for geosynchronous satellite clusters, including the constraints imposed by orbit dynamics, the effects of orbital perturbations and a possible need for spatial discrimination to allow reuse of inter-satellite link frequencies. Three cluster configurations which appear to deserve consideration involve satellites following, relative to the cluster centre: a common elliptical path in the equatorial plane; a common circular path tilted at 30 deg to the horizontal; and separate elliptical paths in parallel vertical planes inclined to the equatorial plane. (Author)

A82-38438*# Purdue Univ., Lafayette, Ind.
ORDER REDUCTION FOR MODELS OF SPACE STRUCTURES USING MODAL COST ANALYSIS
R. E. SKELTON (Purdue University, West Lafayette, IN), P. C. HUGHES, and H. B. HABLANI Journal of Guidance, Control, and Dynamics, vol. 5, July-Aug. 1982, p. 351-357. refs
(Contract JPL-955369)
Modal cost analysis furnishes a promising methodology for developing dynamical models of space structures for use in control systems analysis. Economy and accuracy can be attained by only retaining vibration modes that contribute significantly to an appropriately defined cost function. Expressions for modal costs (especially simple for 'lightly damped' structures) are derived for attitude control, vibration suppression, and shape control. These techniques are illustrated through application to a high-order finite element model of a large platform-type structure. (Author)

A82-38440*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE TELESCOPE POINTING CONTROL SYSTEM
H. DOUGHERTY (Lockheed Missiles and Space Co., Inc., Space System Div., Sunnyvale, CA), K. TOMPETRINI, J. LEVINTHAL (Bendix Corp., Guidance Systems Div., Teterboro, NJ), and G. NURRE (NASA, Marshall Space Flight Center, System Dynamics Laboratory, Huntsville, AL) Journal of Guidance, Control, and Dynamics, vol. 5, July-Aug. 1982, p. 403-409.
(Contract NAS8-32697)
(AIAA PAPER 80-1784)
The Space Telescope is a free-flying spacecraft designed for Space Shuttle launch. The Space Telescope's pointing control system slews the optical axis from one target star region of the celestial sphere to the next, and maintains precision pointing for the target star for up to 24 hours. The spacecraft digital computer processes the precision attitude and rate sensor data to generate torque commands for the reaction wheels. The pointing control system has four major elements: the command generator, the control system, the attitude reference processing, and momentum management. The emphasis is on relating design requirements to the hardware and software implementation. (Author)

A82-38857#
DECENTRALIZED CONTROL FOR A FLEXIBLE SPACECRAFT
R. A. CALICO, JR. and W. T. MILLER (USAF, Institute of Technology, Wright-Patterson AFB, OH) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 8 p.
(AIAA PAPER 82-1404)
This paper deals with the design of a decentralized controller for a large space structure. The controller consists of two or more separate controllers which control only a subset of the spacecraft modes. The paper uses modal suppression techniques to design the separate controllers such that they do not destabilize one another. The paper includes the conditions for stability which must be met by the several controllers. An example of the technique is provided by considering the control of the CSDL I model. (Author)

A82-38858#
ROBUST SPACECRAFT CONTROL DESIGN IN THE PRESENCE OF SENSOR/ACTUATOR PLACEMENT ERRORS
D. C. HYLAND (MIT, Lexington, MA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 10 p. USAF-sponsored research. refs
(AIAA PAPER 82-1405)
The paper considers various ramifications for spacecraft control design of a priori uncertainties in the locations of sensors and actuators. It is shown how the minimum data/maximum entropy modelling approach developed previously for other types of parameter uncertainty may be applied to the present problem. When conjoined with mean-square optimization, this approach directly and accurately reflects the salient effects of

sensor/actuator placement errors. To illustrate these effects, we specifically consider mean-square optimal, full-state feedback regulator design. The resulting stochastic design formulation is shown to yield an inherently robust control for those modes which are most sensitive to actuator placement errors. (Author)

A82-38859#
IDENTIFICATION OF MASS, DAMPING AND STIFFNESS MATRICES FOR LARGE LINEAR VIBRATORY SYSTEMS
S. L. HENDRICKS, S. RAJARAM, M. P. KAMAT, and J. L. JUNKINS (Virginia Polytechnic Institute and State University, Blacksburg, VA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 6 p. refs
(AIAA PAPER 82-1406)

In order to obtain a finite dimensional model for large space structures, two methods for identifying the mass, damping and stiffness matrices of a linear vibrating system are presented. Both methods require the measurement of acceleration, velocity and displacement at various locations of the system. In the first method, the response of the system subjected to known forces is used, while the second method employs the free vibration data. The unknown parameters are recovered through the standard least squares procedure. Numerical results are presented for several examples. C.D.

A82-38860#
AN INTERACTIVE, INTEGRATED COMPUTER PROGRAM FOR DETERMINING LARGE SPACE SYSTEM ATTITUDE CONTROL SYSTEM REQUIREMENTS
C. E. FARRELL (Martin Marietta Aerospace, Denver, CO) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 10 p. refs
(AIAA PAPER 82-1407)

A computer program is being implemented to integrate geometry, mass, area and mission data to aid in design and analysis of Large Space System (LSS) attitude control systems (ACS). Interactive definition and modification of data permits rapid prediction of ACS requirements in response to LSS design or mission requirement changes. Solar pressure, aerodynamic drag, and gravity gradient forces and torques on the LSS are available interactively in both tabular and plotted form. Results are presented which demonstrate program use for iterative analysis of ACS requirements in response to both configuration changes and mission changes. (Author)

A82-38870#
MODAL SYNTHESIS SIMULATION OF THE SHUTTLE ORBITER TETHERED SATELLITE SYSTEM
J. R. GLAESE (Control Dynamics Co., Huntsville, AL) and H. L. PASTRICK ,American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 9 p. refs
(AIAA PAPER 82-1424)

The modal synthesis technique has been applied to analyze a dynamical system consisting of the Shuttle Orbiter, a subsatellite and the elastic tether connecting them. Rigid body dynamic interaction of the two tether connected masses are modeled in an orbiting reference frame. The approach yields a vector set of ordinary, though nonlinear, differential equations that are amenable to fast, straight forward numerical solutions. Performance analysis of the coupled system is obtained through computer generated experiments that provide output on position stability of the tethered subsatellite extending over the range from fully deployed to a close-in position relative to the Shuttle. (Author)

A82-38874#
ON THE NUMBER AND PLACEMENT OF ACTUATORS FOR INDEPENDENT MODAL SPACE CONTROL
R. E. LINDBERG (U.S. Navy, Naval Research Laboratory, Washington, DC) and R. W. LONGMAN (Columbia University, New York, NY) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 7 p.
(AIAA PAPER 82-1436)

A new formulation of Independent Modal Space Control (IMSC) is developed to handle the attitude and shape control problem for large flexible spacecraft. The fundamental limitation of previous work, the requirement of one actuator for each mode to be controlled, is eliminated. This allows one to obtain an analytical solution, in the infinite time case, for the linear-quadratic optimal control problem for extremely high dimensional systems - limited only by the ability to determine the vibration modes. There is no need for truncation of the system model in the design of the control law, although it is necessary for the observer in practice. This can eliminate control spillover relative to the known system model. It is seen that these properties are obtained at the expense of the ability to adjust directly the penalties on the actuator effort. Actuator placement is seen to be of fundamental importance, and methods are developed which are comparatively very simple to use, and which can determine optimal actuator locations. (Author)

A82-38875#
EXTENSION OF THE PARAMETER SPACE METHOD TO LARGE FLEXIBLE STRUCTURES
S. M. SELTZER, H. E. WORLEY, and R. J. YORK (Control Dynamics Co., Huntsville, AL) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 6 p.
(AIAA PAPER 82-1437)

The application of the parameter space method is extended to a significant class of digital control problems associated with large flexible structures. The control problem considered was to develop a proportional-derivative form of a control law that would keep a sensor inertially fixed that was mounted on a large flexible structure which is represented in modal coordinates by a rigid mode and an arbitrary number of bending modes. An algorithm was developed that would accept as input an arbitrary number of bending modes and would return as output the form of the characteristic equation needed for the parameter space method. Values of the control gains would then be determined from stability considerations and desired damping. (Author)

A82-38876*# Martin Marietta Corp., Denver, Colo.
OPTIMAL CONTROL OF DISTRIBUTED PARAMETER ELASTIC SYSTEMS
J.-N. JUANG (Martin Marietta Aerospace, Denver, CO) and M. HAMIDI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 8 p. NASA-supported research. refs
(AIAA PAPER 82-1439)

This paper presents an analytical solution to the Riccati equation for self-adjoint systems such as beams, plates, strings and membranes moving in space, and shows how the optimal control law can be implemented using the given solution. It is then shown that there always exists a self-adjoint operator describing the distribution of potential energy if the state space is appropriately augmented. A beam-like gravity-stabilized satellite moving in a circular orbit around the earth is used to illustrate the main results in this paper. (Author)

A82-38877*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

CLOSED LOOP CONTROL PERFORMANCE SENSITIVITY TO PARAMETER VARIATIONS

D. B. SCHAECHTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 5 p.

(AIAA PAPER 82-1440)

A very efficient technique for computing the closed loop performance sensitivities to parameter variations of a dynamic system with a reduced order controller has been developed. The eigensystem of the closed loop system is computed once. With this information, the closed loop filter and state rms responses, and the first and second derivatives of these rms values with respect to given parameters are computed. Detailed numerical examples using the JPL flexible beam and a 55 meter offset fed, wrap-rib antenna are included. (Author)

A82-38880*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

ORBIT DETERMINATION OF GEOSYNCHRONOUS SATELLITES BY VLBI AND DIFFERENTIAL VLBI

T. P. YUNCK and S. C. WU (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 6 p. refs

(Contract NAS7-100)

(AIAA PAPER 82-1446)

Four approaches to radio interferometric tracking of geosynchronous satellites are analyzed and compared. Quasar-based differential very-long-baseline interferometry, which requires a very sensitive receiver, can achieve meter-level position accuracy with a two-baseline system. Satellite-based differential VLBI gives somewhat lower accuracy with a compact, inexpensive receiver. Nondifferential VLBI, using less precise media and clock calibrations obtained by observing the GPS satellites, still gives 5-10 m position accuracy with two baselines. For a sufficiently inclined orbit, all interferometric approaches can yield six-component satellite state from a single baseline. (Author)

A82-38883#

ON THE SEMI-AUTONOMOUS STATIONKEEPING OF GEOSYNCHRONOUS SATELLITES

C. C. CHAO (Aerospace Corp., El Segundo, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 7 p. refs

(AIAA PAPER 82-1449)

The feasibility of semi-autonomous stationkeeping of geosynchronous satellites is studied, analyzing a + or - 1.0 deg longitude tolerance mission (FLTSATCOM) and a + or - 0.1 deg latitude and longitude tolerance mission (DSCS III). It is found that when the longitude tolerance is + or - 1.0 deg, semi-autonomous stationkeeping with a 10 percent maneuver uncertainty is feasible for a period of six months. For a DSCS III type requirement, the feasibility of keeping the longitude within + or - 0.1 deg depends largely on the longitude. Within 15 percent of all longitude regions, the number of maneuvers is less than three and autonomous stationkeeping is feasible under the assumption of low eccentricity. In other regions, where the number of required maneuvers is three or greater, the 10 percent maneuver error must be removed by an onboard accelerometer and the longitude error must grow linearly with time. C.D.

A82-38887*# 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, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 10 p.

(Contract NAS7-100)

(AIAA PAPER 82-1458)

A friction estimation technique has been developed for the scan platform control of the Galileo spacecraft. The purpose of the estimation is to reduce the impact of friction in the scan platform actuator on the pointing performance of the scan platform so that tight pointing requirements can be met. The estimator operates by comparing the actual behavior of the platform with the expected behavior and attributing the difference to the presence of friction. The estimator is coupled with a proportional-integral-derivative controller to generate a control torque for the scan platform actuator. Since the algorithm will be implemented on an onboard digital computer, a stability analysis of the estimator-controller in discrete time is presented. The performance of the design is demonstrated by a sample slew test case. (Author)

A82-38903

DYNAMICS OF A SATELLITE WITH MOVABLE BOOMS [DYNAMIK EINES SATELLITEN MIT BEWEGLICHEN AUSLEGERN]

K. EBERT (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) (Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Wuerzburg, West Germany, Apr. 21-24, 1981.) Zeitschrift fuer angewandte Mathematik und Mechanik, vol. 62, Apr. 1982, p. T 34-T 35. In German.

The present investigation is concerned with a satellite which consists of a rigid central body and several booms. The booms of the satellite are attached to the satellite body by means of pivots. The booms themselves consist of rigid components which are connected by means of pivots. All pivots are parallel. The principal configuration considered involves a satellite with two booms. The equations of motion for the considered system are presented, and two different types of constraints are considered. The discussed mathematical approach is applied to a computational example involving a satellite having a boom with three components. G.R.

A82-38952#

DYNAMIC INTERACTION OF THE SHUTTLE ON-ORBIT FLIGHT CONTROL SYSTEM WITH DEPLOYED FLEXIBLE PAYLOADS

L. L. SACKETT and C. B. KIRCHWEY (Charles Stark Draper Laboratory, Inc., Control and Dynamics Div., Cambridge, MA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 232-245.

(AIAA 82-1535)

A general discussion is given of the behavior of the flight control system (FCS) and the kinds of dynamic interaction and load problems that can occur given structural flexibility. Examples are presented illustrating four kinds of dynamic interaction: FCS performance degradation in typical conditions, large flex payload motion or loads due to typical jet firings, resonance of a structural mode due to FCS response to a disturbance acceleration, and structural FCS feedback instability. It is noted that the present on-orbit DCS was designed assuming a rigid structure with small, slowly varying disturbances. It is pointed out that the FCS cannot be expected to dampen structural oscillation and that in general the emphasis should be on avoiding conditions that excite excessive structural vibration or cause adverse dynamic interaction. C.R.

A82-38953#
STRUCTURAL FLEXIBILITY OF THE SHUTTLE REMOTE MANIPULATOR SYSTEM MECHANICAL ARM
P. K. NGUYEN, R. RAVINDRAN, R. CARR, D. M. GOSSAIN (Spar Aerospace, Ltd., Toronto, Canada), and K. H. DOETSCH (National Research Council, Ottawa, Canada) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 246-256. refs
(AIAA 82-1536)
The dynamics of the 15-m long remote manipulator system which is the major element of the payload deployment and retrieval system of the orbiter of the NASA Space Transportation System are, by virtue of the large range of payload masses to be maneuvered throughout the operating envelope, significantly affected by the flexibility of the structural components. The paper addresses the finite-element analyses and computer simulations which were carried out by the Canadian design team to ascertain that both arm and orbiter induced maneuvering loads were maintained below design limits, and that adequate level of stability and controllability were achieved throughout the dynamic operating envelope of the system in the presence of structural flexibility influences. (Author)

A82-38955#
A TIME-INVARIANT ERROR MODEL FOR A SPACE-STABLE INERTIAL NAVIGATION SYSTEM
T. B. CLINE (Analytic Sciences Corp., Reading, MA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 266-276. refs
(Contract N60921-81-C-A122)
(AIAA 82-1545)
A reduced-order, time-invariant, error model is developed for a class of space-stable systems using electrostatic gyroscopes. Its structure displays more clearly the dynamical characteristics of the system's errors than a commonly used equivalent periodic model. The order reduction results from aggregating gyroscopic errors into observable linear combinations that directly affect platform misalignment. Time-invariance of the model permits a modal analysis of navigation errors which shows the strong interplay between Schuler-loop dynamics, gyroscopic error dynamics, and observability and controllability properties of the system. The results clearly demonstrate the importance of choosing the proper coordinate frame for specifying shaping filters to model instrument error sources. (Author)

A82-38965*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADAPTIVE IDENTIFICATION FOR THE DYNAMICS OF LARGE SPACE STRUCTURES
N. SUNDARARAJAN and R. C. MONTGOMERY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 379-387. refs
(AIAA 82-1565)
A new approach for identifying the dynamics of large space structures using noisy measurements is presented. In this approach, a modal system description is avoided and, hence, the a priori specification of model order. Instead, the system's order is recursively determined on-line, along with its parameters, using recursive lattice filters which are widely used in adaptive signal processing. The order determination is carried out based on statistical hypothesis testing theory. The approach is illustrated for the problem of identifying the structural dynamic characteristics of a free-free beam. Results on the effectiveness and accuracy of the identification scheme with respect to noise levels, sampling rates, and data window sizes are presented (Author)

A82-38966#
A LFSS CONTROLLER DESIGN TOOL USING MODE RESIDUALIZATION AND OUTPUT FEEDBACK
J. A. BOSSI (Washington, University, Seattle, WA) and G. A. PRICE (Boeing Aerospace Co., Seattle, WA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 388-393. refs
(AIAA 82-1566)
Proposed Large Flexible Space System (LFSS) will involve multiple actuators and sensors, providing the prospect of integrated control algorithms for attitude control and structural mode damping. One tool for control system design is the ORACLS package which implements the linear quadratic Gaussian (LQG) theory for multivariable control. A study of mode residualization is conducted with the objective to reduce the order of compensators obtained by ORACLS, and attention is given to the extension of an output feedback technique which has been developed to alter the compensator in order to overcome instability induced by the residualization. The ORACLS-based computer tools considered are applied to a tetrahedron structural model. G.R.

A82-38967*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICS AND CONTROL OF A LARGE SPACE ANTENNA
S. J. WANG and J. M. CAMERON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 394-402. refs
(Contract NAS7-100)
(AIAA 82-1568)
It is pointed out that large space antennae and other large space structures will play an important role in the coming decades as commercial applications of space become feasible. A investigation is conducted of the structural dynamics and the control properties for a 64-meter diameter center fed antenna. Attention is given to antenna configuration and structural dynamic porperties, the attitude and structural control system, disturbance assessment, hardware sizing, the construction of weighting matrices, and numerical results. It is found that structural uncertainties and model error can cause serious performance deterioration and can even destabilize the controllers. Flight test and in-orbit system identification of critical structural modes will insure performance and reduce risk for large space antenna missions. G.R.

A82-38968*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SIMULATION AND TESTING OF DIGITAL CONTROL ON A FLEXIBLE BEAM
J. P. WILLIAMS and R. C. MONTGOMERY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 403-409. refs
(AIAA 82-1569)
Large space structures are expected to have control problems due to low stiffness and damping, and control laws for these structures must deal with shape and configuration control as well as attitude and orbit maintenance. In general, these control tasks must be accomplished without adversely interacting with the lightly damped and low frequency vibration modes of the structure. Modal control schemes have been proposed to deal with these problems. A discrete time parameter adaptive control scheme which uses modal control has been proposed by Montgomery and Johnson (1978). In the present investigation the method considered by Montgomery and Johnson is applied to a homogeneous free-free beam in both numerical simulation and laboratory experimentation. Mathematical modeling of the beam is treated in a manner expedient for digital simulation and control implementation. G.R.

A82-38974#
DESIGN ASPECTS OF THE SHUTTLE REMOTE MANIPULATOR CONTROL
R. RAVINDRAN (Spar Aerospace, Ltd., Toronto, Canada) and K. H. DOETSCH (National Research Council, Ottawa, Canada) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 456-465.
(AIAA 82-1581)

The Shuttle Remote Manipulator System (SRMS) is a critical element of the orbiter of the Space Transportation System (STS) and is used principally for the deployment and retrieval of payloads from or to the orbiter cargo bay. The design, development, qualification, and manufacture of the SRMS was performed by a team of Canadian companies. The SRMS is a multi-degree-of-freedom man-machine system governed by a complex set of nonlinear equations. The SRMS control system is designed to enable the smooth movement of the SRMS in all of its operational modes. The design of the control system is discussed, giving particular attention to the rationale used in arriving at the SRMS control configuration. Details regarding the SRMS design are considered along with the SRMS control system, the SRMS control modes, the SRMS performance requirements, aspects of control system philosophy, display and control algorithms, SRMS servo requirements, and potential SRMS modifications. G.R.

A82-38976#
INTEGRATED ACTUATOR/SENSOR POSITIONING AND FEEDBACK DESIGN FOR LARGE FLEXIBLE STRUCTURES
G. SCHULZ and G. HEIMBOLD (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 476-483. refs
(AIAA 82-1590)

A method which allows an integrated determination of actuator/sensor positions and feedback gains of flexible structures is presented. It is based on the maximization of dissipation energy due to control action. The optimality criterion is determined via an efficient solution of a Liapunov equation, and it is maximized with a recursive quadratic programming algorithm that allows implementation of linear and nonlinear constraints. The application of this method to a simple flexible structure yields several generally dislocated actuator and sensor locations which are locally optimal. The number of local solutions depends on the number of zero crossings of the modeled mode shapes. An extension of the method to treat spillover effects is implemented as an additional constraint to the optimization criterion. C.D.

A82-38977#
ROBUST CONTROL OF SELF-ADJOINT DISTRIBUTED-PARAMETER STRUCTURES
A. L. HALE and G. A. RAHN (Illinois, University, Urbana, IL) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 484-494. refs
(AIAA 82-1592)

This paper examines the active vibration control of distributed-parameter structures in which a self-adjoint differential operator expresses the stiffness distribution. Structural modeling and computational requirements necessitate the use of a reduced-order controller. However, although only discrete sensors and discrete actuators are usually available, spatially distributed control forces and spatially distributed observations are desirable for implementing a reduced-order controller. Therefore, a distinction arises between (1) designing distributed control forces for a reduced-order model, (2) implementing the control forces with a number of actuators, and (3) estimating the distributed state from a number of sensors. Herein, the distinction is realized by introducing three appropriate projection operators. The effects of the three projection operators on the actual closed loop eigenvalues are investiaged in detail. A criterion for the controller to be robust in the stability sense is discussed and illustrative examples are presented. (Author)

A82-38978#
CRITICAL PARAMETER SELECTION IN THE VIBRATION SUPPRESSION PROBLEM OF LARGE FLEXIBLE SPACE STRUCTURES
R. K. YEDAVALLI (Stevens Institute of Technology, Hoboken, NJ) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 495-499. refs
(AIAA 82-1593)

The paper addresses the application of parameter sensitivity analysis to large flexible space structure models with uncertain parameters such as modal dampings, modal frequencies, mode shape slopes at actuator (sensor) locations. A criterion that allows the specific control objective to influence the parameter selection process is given to delineate the critical parameters in linear regulator problems. The quantitative measure is labelled 'parameter error index (PEI)'. Explicit and simple formulas are obtained in terms of modal data for PEI for the vibration suppression problem of an LSS. The proposed procedure is applied to the 'Purdue model', a generic two dimensional LSS model. Results are presented which indicate that, for this problem modal frequencies are more critical parameters than mode shapes. This type of information is useful in parameter estimation, robust control design, structure redesign, etc. (Author)

A82-38979#
A MICROTHRUSTER SYSTEM FOR THE CONTROL OF A LARGE SPACE SYSTEM
H. F. ZIMBELMAN, P. ASCHWANDEN, and G. OGG (Martin Marietta Aerospace, Denver, CO) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 500-508.
(AIAA 82-1594)

The control of a Large Space System (LSS) requires a complex control system. An Electrostatically Charged Membrane Mirror (ECMM) radiometer in a circular orbit about the earth is considered. In an approach used to initially determine the type and size of the control system actuators, the ECMM as LSS is considered as a rigid body. The requirements of a ten year mission without resupply, compensation of noncycle angular momentum over an orbit, redundancy, and packaging of the control actuators resulted in the selection of an active control system consisting of microthrusters. Flight qualified mercury ion or pulsed plasma electric microthrusters are integrated with the ECMM to function as the active control system to successfully perform stationkeeping and maintain attitude control. G.R.

A82-38991*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SYNTHESIS OF A MODERN/CLASSICAL CONTROLLER FOR LARGE SPACE STRUCTURES
H. B. HABLANI (NASA, Johnson Space Center, Houston, TX) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 597-610. Research supported by the U.S. National Research Council. refs

The paper is concerned with wide-sense stationary random vibrations of a representative large space structure subject to nonwhite excitations, and with synthesis of its controller amid modeling uncertainties due to truncated modes. Dynamics is analyzed by residue calculus in frequency domain. Steady state variance of a modal coordinate is shown to depend on, among other things, power spectral density of excitation at the modal frequency. Modal cost analysis is performed for an order reduction with a performance objective of attitude, attitude rate and energy control. Optimal and suboptimal output feedback controllers are compared. By treating deleted modes as an additive and a multiplicative perturbation in an idealized transfer function, the low frequency modes omitted according to modal cost analysis are found to cause instability. Finally, the size of the idealized model is shown to be governed by light damping and stringency in performance and stability specifications. (Author)

A82-38993#
DSCS III ATTITUDE CONTROL SYSTEM AND MISSION PERFORMANCE ANALYSIS TECHNIQUES
S. BASUTHAKUR (General Electric Co., Space Systems Div., Valley Forge, PA) In: Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 619-628.
(AIAA 82-1616)
The Defense Satellite Communications System (DSCS) III is designed for effective implementation of a world-wide military communications mission. The DSCS III is a geosynchronous spacecraft which provides protected communication services. Users of the system range from airborne terminals with 33-inch diameter antennas to fixed installations with 60-foot diameter antennas. Mobile terminals supporting ground and naval operations communicate with each other and the command chain through the spacecraft. A communications overview is provided, and attention is given to control system implementation concepts, and system pointing error analysis procedures. G.R.

A82-40002#
SATELLITE ATTITUDE DYNAMICS AND CONTROL IN PRESENCE OF ENVIRONMENTAL TORQUES - A BRIEF SURVEY
S. K. SHRIVASTAVA (Indian Institute of Science, Bangalore, India) and V. J. MODI (British Columbia, University, Vancouver, Canada) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 14 p. refs
(AIAA PAPER 82-1414)
The attitude dynamics of satellites in the presence of environmental torques deriving from the gravity gradient, atmosphere, solar radiation pressure, and earth's magnetic field is reviewed. Passive and semipassive stabilization and control procedures using these torques are also discussed. It is pointed out that despite the voluminous literature, major gaps exist in the present understanding, especially with reference to flexible satellites subjected to environmental forces. It is thought that this review may serve as a quick source of relevant information to designers. C.R.

A82-40003#
COMBINED SATELLITE ATTITUDE AND ORBIT DETERMINATION WITH DYNAMIC COUPLING
P. W. CHODAS American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 8 p. Department of Communications refs
(Contract DCC-36001-0-3033; DCC-36001-1-0261)
(AIAA PAPER 82-1419)
A combined attitude and orbit determination problem which includes the coupling between attitude and orbit dynamics is formulated. The study focuses on large spacecraft missions in low earth orbit in which the measurements employed include observations of stars and known landmarks and ground tracking. Both the attitude and orbit states are propagated using the dynamic equations of motion. The attitude and orbit dynamics are coupled through perturbing forces and torques which include gravity gradient and aerodynamic torques and atmospheric drag. The influence of the dynamic coupling on the attitude and orbit determination accuracies is discussed. (Author)

A82-40008#
THE FUNDAMENTAL STRUCTURE OF DEGREE OF CONTROLLABILITY AND DEGREE OF OBSERVABILITY
R. W. LONGMAN, S. W. SIRLIN (Columbia University, New York, NY), T. LI, and G. SEVASTON American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 12 p. refs
(AIAA PAPER 82-1434)
There are four fundamental steps which should underlie the development of any degree of controllability definition for a regulator problem. In such a problem, the objective of control is to return the system to the origin after a disturbance. Similar steps as in the case of controllability apply for the degree of observability definitions. The considered primitive steps are developed into a fundamental unifying framework from which the full range of possible degree of controllability and degree of observability concepts can be understood. Various new definitions are generated pertinent to specific objectives in controller design, and by duality of controllability and observability still other concepts are generated. Attention is given to energy optimal control problems, fixed end-point and free end-point quadratic control problems, applications to model reduction, application to decoupling, and applications to actuator placement. G.R.

A82-40009#
OPTIMIZATION OF ACTUATOR PLACEMENT VIA DEGREE OF CONTROLLABILITY CRITERIA INCLUDING SPILLOVER CONSIDERATIONS
R. E. LINDBERG, JR. (U.S. Navy, Naval Research Laboratory, Washington, DC) and R. W. LONGMAN (Columbia University, New York, NY) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 29 p. refs
(AIAA PAPER 82-1435)
The concept of the degree of controllability is employed here in connection with the problem of optimizing actuator locations for the vibrational control of flexible structures. Three forms of the degree of controllability, reflecting time optimal, energy optimal, and fuel optimal control policies, are compared using a simply supported beam as the structural model. Both predictable and unanticipated optimal solutions are encountered. The concept of a degree of control spillover is then developed, motivated by the acknowledged limitation in fidelity of structural models used for control system design. The degree of control spillover is combined with the degree of controllability to form a composite criterion which is again applied to the simply supported beam problem. (Author)

A82-40012*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
GALILEO SPACECRAFT POINTING ACCURACY ANALYSIS
S. A. HAYATI and M. H. JAHANSHAHI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 12 p. NASA-supported research. refs
(AIAA PAPER 82-1459)
This paper describes the analysis required to evaluate the pointing performance of the Galileo spacecraft science instruments and antenna. The main contribution lies in the development of the models needed for pointing analysis. Pointing control mechanisms of the science instruments, as well as the spacecraft autonomous attitude determination process and the pointing control mechanisms for the high gain antenna, are provided in order to identify the various error sources involved. A covariance analysis method is then used to obtain the pointing capabilities of the instruments and the antenna. The results are depicted in tabular form to compare the capabilities against the levied requirements. (Author)

A82-40015#
COMPONENT COST ANALYSIS FOR MANEUVERING SATELLITES
R. E. SKELTON (Purdue University, West Lafayette, IN), K. T. ALFRIEND, R. E. LINDBERG, and S. FISHER (U.S. Navy, Naval Research Laboratory, Washington, DC) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 21 p. refs
(AIAA PAPER 82-1464)

This paper describes difficulties encountered in the synthesis of an on-line feedback control policy for the slew maneuver of a flexible spacecraft. Specifically, it is shown that the optimal linear controller for the slew maneuver tends to be unstable, and that this slew maneuver is much more sensitive to the effects of modeling errors than are attitude control problems. (Author)

A82-40016*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A DEFINITION OF THE DEGREE OF DISTURBANCE REJECTION
R. A. LASKIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA; Columbia University, New York, NY), R. W. LONGMAN, and P. W. LIKINS (Columbia University, New York, NY) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 12 p. refs
(Contract NSF CEE-80-19275)
(AIAA PAPER 82-1466)

The problem of rejecting disturbances that are known a priori to reside in a particular function class is treated. Two scalar measures, the degree of disturbance rejection (DODR) and the degree of disturbability (DOD) are defined and shown to be useful in rating a candidate controller's ability to counter the expected disturbances. The measures can thus be used as criteria for controller design and actuator placement. It is shown that the DODR can guarantee that constraints on the control action will not be violated. The DOD assumes a closed-loop controller realization, and this gives a simplified formulation in terms of one state space region instead of two. With the DOD, a variety of performance indices can be considered, together with a spectrum of possible controller implementations. C.R.

A82-42427
DYNAMIC DAMPING OF TORSIONAL VIBRATION [DINAMICHESKOE GASHENIE KRUTIL'NYKH KOLEBANII]
P. A. LONTSIKH (Irkutskii Politekhnicheskii Institut, Irkutsk, USSR) Zagadnienia Drgan Nieliniowych, no. 20, 1981, p. 47-52. In Russian.

The paper is concerned with the damping of constant-frequency torsional vibration in a system where the vibration source is coupled to the excited object through an elastic shaft. The problem is solved by introducing an additional bolt-and-nut-type inertial element into the initial system. The dynamic characteristics of the system under steady state conditions are estimated from the amplitude-frequency characteristic. The possibility of damping torsional vibration of variable frequency by using an active damping system is discussed. V.L.

A82-43401
ON A VARIATIONAL THEOREM IN ACOUSTO-ELASTODYNAMICS
B. S. THOMPSON (Wayne State University, Detroit, MI) Journal of Sound and Vibration, vol. 83, Aug. 22, 1982, p. 461-477. refs
(Contract NSF CME-79-21242)

A variational theorem is presented which may be used as a basis for developing the equations of motion and the boundary conditions appropriate for studying the vibrational behavior of flexible bodied systems and the surrounding acoustic medium. The theorem is a generalization of two theorems which are both based on the principle of virtual work: the first governs the elastodynamics of the mechanical system and the second governs the behavior of the fluid medium. Lagrange multipliers are used in the development of the two basic theorems and they are also employed to incorporate the constraints at the solid-fluid interface within the functional for the acousto-elastodynamic theorem. As an illustrative example, the derivation of the problem statement for a flexible slider crank mechanism operating in a perfect gas is presented in which it is assumed that the flexural motion of the links is governed by the Timoshenko beam theory. (Author)

A82-43912
LOAD ON THE FLEXIBLE ELEMENT OF A SEALED TWO-WAVE TRANSMISSION DUE TO THE WAVE GENERATOR [O NAGRUZKE NA GIBKII ELEMENT DVUKHVOLNOVOI GERMETICHNOI PEREDACHI SO STORONY GENERATORA VOLN]
K. KH. KOZHAKHMETOV and A. M. KLIMOV In: Development of scientific instruments for space use Moscow, Izdatel'stvo Nauka, 1981, p. 67-72. In Russian.

An analytical expression is obtained for determining the load on the flexible element of a sealed two-wave transmission caused by the wave generator. The expression does not account for the response of the rigid gear. The load and its equivalent are calculated numerically using a computer. V.L.

A82-44477#
VALIDATION OF REDUCED-ORDER MODELS FOR CONTROL SYSTEMS DESIGN
M. E. SEZER (University of Petroleum and Minerals, Dhahran, Saudi Arabia) and D. D. SILJAK (Santa Clara, University, Santa Clara, CA) (Institute of Electrical and Electronics Engineers, Conference on Decision and Control, San Diego, CA, Dec. 16-18, 1981.) Journal of Guidance, Control, and Dynamics, vol. 5, Sept.-Oct. 1982, p. 430-437. refs
(Contract F30602-80-C-0177)

The concept of suboptimality is applied to testing validity of reduced-order models in design of feedback schemes for large-scale systems. Aggregation and singular value decomposition, as model reduction techniques, are interpreted in the expansion-contraction framework, which is suitable for evaluation of suboptimality of closed-loop systems resulting from reduced-order designs. The proposed validation procedure is applied to a control design of a large space structure. (Author)

A82-44485*# Rensselaer Polytechnic Inst., Troy, N. Y.
DISCRETE-TIME STABILITY OF CONTINUOUS-TIME CONTROLLER DESIGNS FOR LARGE SPACE STRUCTURES
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) Journal of Guidance, Control, and Dynamics, vol. 5, Sept.-Oct. 1982, p. 541-543. Research supported by the Charles Stark Draper Laboratory, Inc. refs
(Contract NAG1-171)

In most of the stable control designs for flexible structures, continuous time is assumed. However, in view of the implementation of the controllers by on-line digital computers, the discrete-time stability of such controllers is an important consideration. In the case of direct-velocity feedback (DVFB), involving negative feedback from collocated force actuators and velocity sensors, it is not immediately apparent how much delay due to digital implementation of DVFB can be tolerated without loss of stability. The present investigation is concerned with such questions. A study is conducted of the discrete-time stability of DVFB, taking into account an employment of Euler's method of approximation of the time derivative. The obtained result gives an indication of the acceptable time-step size for stable digital implementation of DVFB. A result derived in connection with the consideration of the discrete-time stability of stable continuous-time systems provides a general condition under which digital implementation of such a system will remain stable. G.R.

A82-44724*#
CONTROL SYSTEMS SYNTHESIS FOR A LARGE FLEXIBLE SPACE ANTENNA
S. M. JOSHI (Old Dominion University, Hampton, VA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 14 p. refs
(Contract NAG1-102)
(IAF PAPER 82-320)

The problem of control systems synthesis is considered for controlling the rigid-body attitude and elastic motion of a large deployable space-based antenna. Two methods for control systems synthesis are considered. The first method utilizes the stability and robustness properties of the controller consisting of torque actuators and collocated attitude and rate sensors. The second method is based on the linear-quadratic-Gaussian (LQG) control theory. A combination of the two methods, which results in a two-level hierarchical control system, is also briefly discussed. The performance of the controllers is analyzed by computing the variances of pointing errors, feed misalignment errors and surface contour errors in the presence of sensor and actuator noise.
(Author)

A82-44725*# Wisconsin Univ., Madison.
FOKKER-PLANCK RESPONSE OF STOCHASTIC SATELLITES
T. C. HUANG (Wisconsin, University, Madison, WI) and A. DAS (General Electric Co., Space Div., Valley Forge, PA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p. refs
(Contract NAS5-21798)
(IAF PAPER 82-321)

The present investigation is concerned with the effects of stochastic geometry and random environmental torques on the pointing accuracy of spinning and three-axis stabilized satellites. The study of pointing accuracies requires a knowledge of the rates of error growth over and above any criteria for the asymptotic stability of the satellites. For this reason the investigation is oriented toward the determination of the statistical properties of the responses of the satellites. The geometries of the satellites are considered stochastic so as to have a phenomenological model of the motions of the flexible structural elements of the satellites. A widely used method of solving stochastic equations is the Fokker-Planck approach where the equations are assumed to define a Markoff process and the transition probability densities of the responses are computed directly as a function of time. The Fokker-Planck formulation is used to analyze the response vector of a rigid satellite.
G.R.

A82-44728#
SPOT - THE VERY FIRST SATELLITE TO USE MAGNETIC BEARINGS WHEELS
P. ANSTETT, M. SOULIAC (Matra, S.A., Velizy-Villacoublay, Yvelines, France), C. ROUYER, and M. GAUTHIER (Societe Nationale Industrielle Aerospatiale, Les Mureaux, Yvelines, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p. refs
(IAF PAPER 82-331)

The SPOT platform is the prototype of a multimission satellite platform for earth observation currently being developed by MATRA. The platform's attitude control and reaction wheels, which are described, utilize magnetic bearings; the main advantages of the magnetic bearings include: no wear due to the absence of mechanical contract between the rotor and the stator, no lubrication, very low stiction and drag torques. A comparison of ball bearings and magnetic bearings reveals the tradeoffs involved with the use of each. For momentum wheels, the high kinetic momentum possible with magnetic bearings (150 Nms and up) favored their choice, while low friction and stiction torques favored their choice for reaction wheels. The four-channel wheel drive unit to be employed is also described, with particular attention paid to torque quantization, time response, and torque noise.
A.B.

A82-44740*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL MEASUREMENT OF PASSIVE MATERIAL AND STRUCTURAL DAMPING FOR FLEXIBLE SPACE STRUCTURES
E. F. CRAWLEY, G. L. SARVER, and D. G. MOHR (MIT, Cambridge, MA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p. Research supported by the Aerospace Corp. refs
(Contract NAGW-21)
(IAF PAPER 82-380)

Among the design objectives for large space structures are the maintenance of tight dimensional tolerance and the reduction of settling time after disturbance input. Two options are under consideration for the design of flexible structures to meet these objectives, including an active control option and a passive control option. In connection with both options, it is necessary to include material and structural damping in the design. A description is presented of the results of an experimental investigation of the damping of metallic and fibrous composite materials, taking into account also the analytical modeling and experimental verification of frictional damping schemes. To demonstrate how material and frictional damping can be combined, a simple structural optimization is performed, indicating the potential for significant savings in mass by the addition of frictional dampers.
G.R.

A82-44926#
GRAVITATIONAL ORBIT-ATTITUDE COUPLING FOR VERY LARGE SPACECRAFT
G. B. SINCARSIN and P. C. HUGHES (Toronto, University, Toronto, Canada) American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, San Diego, CA, Aug. 9-11, 1982, AIAA 11 p. Natural Sciences and Engineering Research Council refs
(Contract NSERC-A-4183)
(AIAA PAPER 82-1402)

Motion equations for the gravitationally coupled orbit-attitude motion of a spacecraft are presented. The gravitational force and torque are expanded in a Taylor series in the small ratio (spacecraft size/orbital radius). A recursive definition for higher moments of inertia is introduced which permits terms up to fourth order to be retained. The expressions are fully nonlinear in the attitude variables. A quasi-sun-pointing (QSP) passive attitude-control mode is used to assess the effects of higher moments of inertia and gravitational coupling. The attitude motion is detectably coupled to the orbital motion. However, the higher moments of inertia influence only the attitude motion.
(Author)

A82-45257*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE TELESCOPE - MEETING THE POINTING CONTROL CHALLENGE WITH TODAY'S TECHNOLOGY
H. DOUGHERTY, C. RODONI, J. RODDEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), and K. TOMPETRINI (Bendix Corp., System Div., Teterboro, NJ) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 42-50. refs
(Contract NAS8-32697)
(AIAA 82-1842)

The pointing control system of the Space Telescope, which provides target-to-target maneuvering capability and precision pointing on the target star (with 0.007-arcsec stability and 0.01-arcsec accuracy), is described. Spacecraft attitude control is undertaken by onboard computer processing of attitude and rate sensor data that generates reaction wheel torque commands. The Space Telescope Operations Control Center communicates with the Space Telescope via the synchronous altitude tracking and data relay satellite system, and determines vehicle attitude more precisely by means of sun sensors, magnetometers and fixed-head star trackers. Such disturbance torques as those of gravity gradients and aerodynamics act on the Space Telescope, causing the speeds of the four reaction wheels to increase. In order to prevent the wheels from reaching a speed-saturated condition, a momentum control system is provided for the management of reaction wheel speed buildup. Attention is given to development testing and control hardware investigations and improvements. O.C.

A82-45600* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EFFECTS OF FLEXIBILITY ON AGS PERFORMANCE
H. L. SHELTON (NASA, Marshall Space Flight Center, Huntsville, AL), D. C. CUNNINGHAM (Sperry Corp., Sperry Flight Systems, Phoenix, AZ), H. E. WORLEY (Control Dynamics Co., Huntsville, AL), and S. M. SELTZER In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 3-17.
(AAS 82-002)
The Marshall Space Flight Center has had under development the Annular Suspension Pointing System Gimbal System (AGS) since early 1979. The AGS is an Orbiter cargo bay mounted subarcsecond 3 axis inertial pointer that can accommodate a wide range of payloads which require more stringent pointing than the Orbiter can provide. This paper will describe the AGS, state performance requirements and the control law configuration. Then an approach to investigating the flexible body effects on control system design will be discussed. (Author)

A82-45602
MOMENTUM MANAGEMENT FOR THE SPACE PLATFORM
D. BARROWS (McDonnell Douglas Astronautics Co., Huntington Beach, CA), H. BEDELL, E. HAHN, R. KACZYNSKI, and J. LEVINTHAL (Bendix Corp., Guidance System Div., Teterboro, NJ) In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 39-49.
(AAS 82-004)
A momentum management concept of control moment gyros (CMG) for cyclic momentum storage, with magnetic torquer bars and vehicle tilt for bias torque counteraction, is discussed. The concept is sized for a variety of configurations, attitudes, solar flux, altitudes, and beta angles. The parameters that determine the number of CMGs required for momentum storage and the number of magnetic torquer bars required for bias torque removal are shown. C.D.

A82-45615* Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE TELESCOPE POINTING CONTROL SYSTEM SOFTWARE
H. DOUGHERTY, C. RODONI, R. ROSSINI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), K. TOMPETRINI, A. NAKASHIMA, and A. BRADLEY (Bendix Corp., Guidance Systems Div., Teterboro, NJ) In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 285-319. refs
(Contract NAS8-32697)
(AAS 82-027)
The Space Telescope Pointing Control System software is in the advanced development stage, having been tested on both the airbearing and the static simulator. The overall structure of the software is discussed, along with timing and sizing evaluations. The interaction between the controls analysts and software designer is described. (Author)

A82-45616
BINOCULAR EARTH SENSOR
L. M. SMITHLINE (Ithaco, Inc., Ithaca, NY) In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 323-338. Research sponsored by the International Telecommunications Satellite Organization.
(AAS 82-030)
An earth horizon sensor with a novel biconical scan geometry is described. Designed for use in geosynchronous orbit, it provides high accuracy attitude measurements over a range of + or - 12 deg. The geometrical performance of the sensor is analyzed, and its robustness with regard to noise immunity, sun/moon rejection and wide operating range is demonstrated. (Author)

A82-45618* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SHAPES - A SPATIAL HIGH-ACCURACY, POSITION-ENCODING SENSOR FOR SPACE-SYSTEMS CONTROL APPLICATIONS
J. M. MCLAUCHLAN, W. C. GOSS, and E. F. TUBBS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 371-382. refs
(Contract NAS7-100)
(AAS 82-032)
(Previously announced in STAR as N82-18295)

A82-45620* Sperry Flight Systems, Phoenix, Ariz.
MAGNETIC SUSPENSION - THE NEXT GENERATION IN PRECISION POINTING
B. J. HAMILTON (Sperry Corp., Sperry Flight Systems, Phoenix, AZ) In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 397-409. refs
(Contract NAS1-15008)
(AAS 82-034)
Today's large optical experiments, both free-flying and Shuttle-borne, are finding an increasing need for a stable pointing platform in a vibration environment. As the resolution of optical systems has improved, conventional techniques for isolation and pointing have become less attractive. This paper describes the present state of the art in magnetic suspension pointing systems. This technology combines the functions of translational isolation and precision pointing to achieve performance in the 0.01 arcsec range, in the presence of disturbances such as random noise or reaction jet firings. Ongoing technology refinements and their importance to the experiment community are also discussed. The key to these refinements is a high-resolution, vibrating quartz force sensor that will improve pointing stability. (Author)

A82-45621* Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE TELESCOPE - THE NEXT GENERATION
H. DOUGHERTY, C. RODONI, J. RODDEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), K. TOMPETRINI, J. DAWSON, and J. HENRY (Bendix Corp., Guidance Systems Div., Teterboro, NJ) In: Guidance and control 1982; Proceedings of the Annual Rocky Mountain Guidance and Control Conference, Keystone, CO, January 30-February 3, 1982. San Diego, CA, Univelt, Inc., 1982, p. 411-425.
(Contract NAS8-32697)
(AAS 82-035)
The command handling approach as applied to fine guidance sensor guide star acquisition is described in order to illustrate the flexibility it provides to users of the Space Telescope. User control of pointing operations is detailed, and the pointing control system/fine guidance system interface is depicted along with the guide star acquisition sequence. Reaction wheel interaction with

vehicle structural modes and the rate gyro assembly noise level are discussed and some test data are shown. C.D.

A82-46094* Texas Univ., Austin.

LONG-TERM MOTION OF RESONANT SATELLITES WITH ARBITRARY ECCENTRICITY AND INCLINATION

P. E. NACOZY (Texas, University, Austin, TX) and R. E. DIEHL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Celestial Mechanics, vol. 27, Aug. 1982, p. 375-397. refs

A first-order, semi-analytical method for the long-term motion of resonant satellites is introduced. The method provides long-term solutions, valid for nearly all eccentricities and inclinations, and for all commensurability ratios. The method allows the inclusion of all zonal and tesseral harmonics of a nonspherical planet. We present here an application of the method to a synchronous satellite including J2 and J22 harmonics. Global, long-term solutions for this problem are given for arbitrary values of eccentricity, argument of perigee and inclination. (Author)

A82-46903#

ACTIVE VIBRATION CONTROL OF A FLEXIBLE BEAM-CABLE STRUCTURE

G. R. SKIDMORE and M. A. MASSE (Virginia Polytechnic Institute and State University, Blacksburg, VA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p. refs

(IAF PAPER 82-ST-02)

The experimental study presented represents a preliminary step in the study of active control of vibrations of large flexible spacecraft and/or space structures. It is an attempt to demonstrate the effectiveness and feasibility of direct velocity feedback control before applying a more sophisticated control system to a more complex structure. A flexible beam-cable structure with several low-frequency modes was controlled with a single electro-magnetic actuator, an analog control circuit utilizing integrated circuit operational amplifiers, and a single piezoelectric accelerometer as the control sensor. Frequency response testing and free decay measurements were conducted to measure natural modes of the structure and performance of the control system. Direct velocity feedback control was demonstrated to be effective and stable, and useful information pertinent to further experiments was gained. (Author)

A82-46917#

THE CAPTURE-CELL EXPERIMENT FOR THE FIRST LDEF MISSION

E. IGENBERGS (Muenchen, Technische Universitaet, Munich, West Germany) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 6 p.

(IAF PAPER 82-24)

A description is presented of experiments to be performed by the long duration exposure facility (LDEF), which will be placed in LEO in 1984 by the Shuttle and retrieved a year later. The LDEF will gather data on the chemical and isotopic compositions of interplanetary dust, serve as a data base for the follow-up spacecraft in the series, and aid in distinguishing cosmic dust particles from particles generated by spacecraft. The 30-ft long, 14-ft diameter LDEF will feature experimental trays, a viscous magnetic motion dampler, and grappler and ground handler fittings. Targets in the experiment trays will be covered with a thin foil vellum, which dust particles will breach to become imbedded in the Ge target. Spectroscopy will allow chemical analysis of the collected particles. A hypervelocity accelerator will be employed to model the impacts of reference particles for comparison purposes. M.S.K.

A82-46925#

THE DYNAMICS OF THE SPACE SHUTTLE ORBITER WITH A FLEXIBLE PAYLOAD

M. PALUSZEK (Charles Stark Draper Laboratory, Inc., Cambridge, MA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p. refs

(IAF PAPER 82-41)

The Space Shuttle Orbiter will be used as an orbital base for near-term space operations. Its payloads will range from compact satellites to large, flexible antennas. This paper addresses the problem of the dynamics and control of the Orbiter with a flexible payload. Two different cases are presented as examples. The first is a long, slender beam which might be used as an element in a larger orbiting structure. The second is a compact satellite mounted on a spin table in the Orbiter payload bay. The closed loop limit cycles are determined for the first payload and the open loop eigenvalues are calculated for the second. Models of both payloads are mechanized in a simulation with the Shuttle on-orbit autopilot. The vehicle is put through a series of representative maneuvers and its behavior analyzed. The degree of interaction for each payload is determined and strategies are discussed for its reduction. (Author)

A82-46930#

THE ORBIT DYNAMICS OF SATELLITE CLUSTERS

J. MURDOCH and J. J. POCHA (British Aerospace Public, Ltd., Co., Space and Communications Div., Stevenage, Herts., England) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 11 p. European Space Agency

(Contract ESA-4818/81/NL/MD)

(IAF PAPER 82-54)

The demand for space communications capacity is predicted to increase during the next decade. New space segment concepts are required to meet these demands. One design is the satellite cluster in which a number of satellites are co-located in near-geostationary orbit. The individual satellites cannot be resolved by a communications ground station. The available cluster geometries are reviewed and their properties examined. Orbit evolution of the cluster is discussed together with the implications for absolute and relative station keeping and tracking. An assessment is made of the feasibility of cluster operations and the maintenance of inter-satellite links. Areas requiring further attention are outlined. (Author)

A82-47016#

DYNAMICS AND CONTROL OF TETHER CONNECTED TWO-BODY SYSTEMS - A BRIEF REVIEW

A. K. MISRA (McGill University, Montreal, Canada) and V. J. MODI (British Columbia, University, Vancouver, Canada) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 25 p. refs

(IAF PAPER 82-315)

Cable connected systems have been used extensively in water and air environments, and tether systems have been proposed for applications in the space environment. The potential of tether connected two-body orbiting systems has led to many investigations of their dynamics and control during deployment, stationkeeping, and retrieval stages. The present study has the objective to discuss such analyses. Related earlier investigations are considered along with rotating space station-cable-counterweight systems, and concepts for possible future applications. The modelling of Shuttle supported tethered systems is investigated, taking into account important parameters, environmental effects, gravitational forces, solar radiation pressure, and aerodynamic forces. The dynamics and control of Shuttle supported tethered systems are also explored, giving attention to fixed length tether, variable length tether, deployment, and retrieval. G.R.

A82-47017#
ON THE DYNAMICS OF TETHER-CONNECTED TWO-BODY SYSTEMS
V. A. SARYCHEV (Akademiia Nauk SSSR, Institut Prikladnoi Matematiki, Moscow, USSR) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 6 p. refs
(IAF PAPER 82-316)

Research that has been carried out in this area is surveyed. Attention is called to a cycle of works relating to the Shuttle program; here the possibility of tethered system dynamics control through a change in the tether length is considered. It is noted that this approach makes it possible to efficiently introduce damping in the tether length, thereby providing good dynamical characteristics to the system motion in the orbital plane. It is also pointed out that whereas a large number of works are concerned with tethered systems under the gravity stabilization control mode, the aerodynamic torque control is poorly studied despite its usefulness for experiments with scientific purposes. Other studies described deal with the spatial oscillations of the tethered system (two material points connected by a flexible tether) in both librational and rotational modes providing non-zero tension of the tether. C.R.

A82-47024#
A CONFIGURATION FOR A GEOSTATIONARY TELECOMMUNICATION SATELLITE WHOSE PLATFORM /SERVICE MODULE/ IS POINTED AT THE SOLAR MEAN [PRESENTATION D'UNE CONFIGURATION DE SATELLITE DE TELECOMMUNICATION GEOSTATIONNAIRE DONT LA PLATE-FORME /MODULE DE SERVICE/ EST POINTEE SUR LE SOLEIL 'MOYEN']
P. DUCHON and A. ROLFO (Centre National d'Etudes Spatiales, Toulouse, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 15 p. In French.
(IAF PAPER 82-338)

Positive and negative features of a solar pointing stabilizer system for a geostationary orbit telecommunication satellite are discussed. The study results originated from the CNES STAR project. A review of nominal attitude and thermal control systems for present GEO satellites is presented, and a solar-pointing spacecraft is noted to have two parts in rotation around a north-south axis, which is oriented toward the star Polaris. Antennas and solar cell panels extend from the main body of the satellite, which contains mechanisms for power generation, attitude and orbit control, a counterrotative structure for transferring power to the payload equipment, and control systems. The changing configuration of the spacecraft when moving through the transfer orbit are described, as is fuel distribution to maintain proper center-of-mass. Maintenance of orientation in orbit is detailed, with attention paid to allowances for seasonal changes requiring a 25 deg latitude for the solar pointer. The control logic and placement of thrusters are delineated, along with cost comparisons for components in three-axis stabilizer systems. M.S.K.

A82-47970
A GENERAL PROCEDURE FOR IMPROVING SUBSTRUCTURES REPRESENTATION IN DYNAMIC SYNTHESIS
A. L. HALE and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg, VA) Journal of Sound and Vibration, vol. 84, Sept. 22, 1982, p. 269-287. refs
(Contract DAAG29-78-0038)

The procedure described here is an iterative one leading to an improved eigensolution for the intermediate structure (that is, a fictitious structure defined by the approximate compatibility conditions); here, the improved eigensolution is obtained while always using the same number of degrees of freedom to represent a given substructure. In any iteration, the computations associated with each substructure are independent of those for all other substructures, and they can be carried out in parallel. With an increase in the number of iterations, the eigensolution for the intermediate structure is approached. It is noted that the procedure is applicable to assembled structures that are either positive definite or positive semidefinite. What is more, the procedure represents an extension of the concept of subspace iteration to structures composed of substructures. C.R.

A82-48246*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL RESEARCH ON STRUCTURAL DYNAMICS AND CONTROL
R. C. MONTGOMERY, G. C. HORNER, and S. R. COLE (NASA, Langley Research Center, Hampton, VA) Virginia Polytechnic Institute and State University and American Institute of Aeronautics and Astronautics, Symposium on Dynamics and Control of Large Flexible Spacecraft, 3rd, Blacksburg, VA, June 15-17, 1981, Paper. 14 p. refs

This report describes an apparatus at the NASA Langley Research Center for conducting research on dynamics and control of structural dynamics systems. The apparatus consists of a 3.66 m (12 ft.) long flexible beam to which are attached four electromagnetic actuators, nine noncontacting sensors to measure deflection of beam at various locations, and four strain gage type load cells one at each actuator attachment point. The important feature of the apparatus is that the actuators can be controlled and deflection and load sensor data can be processed in real time using the research centers CDC Cyber 175 computer system - thereby allowing research to be conducted on structural dynamics systems using advanced control laws. The facility is described in the report along with a detailed discussion of the actuators used. (Author)

A82-48247*# Howard Univ., Washington, D. C.
GRAPH THEORY APPROACH TO THE EIGENVALUE PROBLEM OF LARGE SPACE STRUCTURES
A. S. S. R. REDDY and P. M. BAINUM (Howard University, Washington, DC) Virginia Polytechnic Institute and State University and American Institute of Aeronautics and Astronautics, Symposium on Dynamics and Control of Large Flexible Spacecraft, 3rd, Blacksburg, VA, June 15-17, 1981, Paper. 9 p. refs
(Contract NSG-1414)

Graph theory is used to obtain numerical solutions to eigenvalue problems of large space structures (LSS) characterized by a state vector of large dimensions. The LSS are considered as large, flexible systems requiring both orientation and surface shape control. Graphic interpretation of the determinant of a matrix is employed to reduce a higher dimensional matrix into combinations of smaller dimensional sub-matrices. The reduction is implemented by means of a Boolean equivalent of the original matrices formulated to obtain smaller dimensional equivalents of the original numerical matrix. Computation time becomes less and more accurate solutions are possible. An example is provided in the form of a free-free square plate. Linearized system equations and numerical values of a stiffness matrix are presented, featuring a state vector with 16 components. M.S.K.

N82-22303*# Bendix Corp., Teterboro, N. J. Guidance Systems Div.
MODULAR DESIGN ATTITUDE CONTROL SYSTEM Final Report
F. D. CHICHESTER 8 Mar. 1982 137 p refs
(Contract NAS8-33979)
(NASA-CR-161998; NAS 1.26:161998) Avail: NTIS HC A07/MF A01 CSCL 22B

A hybrid multilevel linear quadratic regulator (ML-LQR) approach was developed and applied to the attitude control of models of the rotational dynamics of a prototype flexible spacecraft and of a typical space platform. Three axis rigid body flexible suspension models were developed for both the spacecraft and the space platform utilizing augmented body methods. Models of the spacecraft with hybrid ML-LQR attitude control and with LQR attitude control were simulated and their response with the two different types of control were compared. S.L.

N82-22697*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPS STRUCTURES AND CONTROL: A PERSPECTIVE
R. C. RIED *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 164-167 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The characteristics and design requirements for the structure and control systems for a solar power satellite were evaluated. A simplistic, indicative analysis on a representative configuration was developed. Representative configuration masses and dimensions are given in convenient approximate magnitudes. The significance of structure control interaction and the significance of stiffness to the minimization of dynamic energy was demonstrated. It was found that the thermal environment for the SPS was dominated by solar radiation and waste heat rejection by the antenna. A more in-depth assessment of the control system design and associated system performance is still needed, specifically the inter-relatonships between control sensors, actuators, and structural response. M.D.K.

N82-22698*# Rockwell International Corp., Downey, Calif.
SPS ATTITUDE CONTROL AND STATIONKEEPING: REQUIREMENTS AND TRADEOFFS
R. E. OGLEVIE *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 168-171 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The dominant control requirements of solar power satellites change appreciably relative to small contemporary spacecraft. Trade studies and analyses illustrated preferred control approaches. It was found that the geosynchronous equatorial orbit is preferred over the alternative orbits considered, that the solar pressure orbit perturbation dominates stationkeeping propulsion requirements and that a combined AC and SK system using ion electric propulsion can satisfy the attitude control requirements. It was also found that control system/structural dynamic interaction stability can be obtained through frequency separation with reasonable structural dynamic requirements and simplify spacecraft design. M.D.K.

N82-22700*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMICS AND CONTROL OF THE SATELLITE POWER SYSTEM
S. J. WANG, J. N. JUANG, and G. RODRIQUEZ *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 176-179 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

An investigation of the dynamics and control problems specifically related to the Satellite Power System (SPS), to assess performance of selected control concepts, and to identify and initiate development of advanced control technology that would enhance feasibility and performance of the SPS system was made. The initial stages of the study are reported. M.D.K.

N82-22701*# Grumman Aerospace Corp., Bethpage, N.Y.
A MODERN CONTROL APPROACH TO THE DESIGN OF THE SPS CONTROL SYSTEM
R. GRAN *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 180-183 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The structural dynamics of the solar power satellite were considered. The requirements on the vibration of the microwave antenna and the possibility of thermal induced vibration and severe structural-thermal interactions were considered. The possibility of using an active control system and modern control methods to mitigate structural problems is discussed. M.D.K.

N82-22703*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPS STRUCTURAL DYNAMICS AND CONTROL WORKSHOP: FINDINGS AND RECOMMENDATIONS
R. C. RIED and D. L. MINGORI (California Univ., L.A.) *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 169-192 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The structural dynamics and control of the Solar Power Satellite (SPS), a concept which holds promise for meeting a portion of the energy needs of the United States beyond the year 2000 are examined. The assumptions, methodologies and conclusions of existing SPS studies in the areas of structural dynamics and control (with structural design and materials also being considered) are assessed. N.W.

N82-22722*# Mathematical Sciences Northwest, Inc., Bellevue, Wash.
SOLAR DRIVEN LASERS FOR POWER SATELLITE APPLICATIONS
R. TAUSSIO, P. CASSADY, and E. KLOSTERMAN *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 267-270 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The technological feasibility of using multimagawatt lasers for space power transmission is discussed. Candidate lasers include electric discharge lasers, direct optically pumped lasers, and free electron lasers. J.D.

N82-23352*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DUAL DRIVE ACTUATORS
D. T. PACKARD *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 123-141 May 1982
Avail: NTIS HC A15/MF A01 CSCL 13I

A new class of electromechanical actuators is described. These dual drive actuators were developed for the NASA-JPL Galileo Spacecraft. The dual drive actuators are fully redundant and therefore have high inherent reliability. They can be used for a variety of tasks, and they can be fabricated quickly and economically. Author

N82-23354*# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
DEVELOPMENT OF A HIGH STABILITY POINTING MECHANISM FOR WIDE APPLICATION
A. J. D. BRUNNEN and R. H. BENTALL (European Space Agency) *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 159-173 May 1982 refs
Avail: NTIS HC A15/MF A01 CSCL 13I

A recurrent requirement of spaceborne instruments and communications equipment is that of accurate pointing. This need is recognizable in such diverse applications as Star Sensor trimming, Momentum Wheel gimballing, in-orbit adjustment or alignment of equipment, inter-satellite communication and Antenna Pointing. A pointing mechanism of novel design having several advantages over the more conventional gimbal, centre-pivoted, or cross axis pointing concepts is described. Author

N82-24221# Centre National d'Etudes Spatiales, Toulouse (France).
SATELLITE STABILIZATION [STABILISATION DES SATELLITES]
P. DUCHON and J. M. GUILBERT *In its* The Technol. of Spaceborne Sci. Expts. p 161-213 1981 In FRENCH
Avail: NTIS HC A99/MF A01

General categories of satellite missions are reviewed, after which the suitability of different attitude and orbit stabilization techniques is explained. Satellite applications include telecommunication, meteorology, and Earth observation. Satellites also serve as experiment platforms and space probes. Satellite perturbation is discussed and both passive and active remedies are evoked. The phases and functional modes of satellite orbital life are then considered. The satellite SPOT is taken as an example of an observation satellite in low altitude orbit along with the OTS satellites as examples of telecommunication satellites. Attitude control is defined theoretically. Only spin stabilization and three axis stabilization are treated. The Euler equations and kinetic equations describing the evolution in attitude of a rigid body in space are derived. The attitude measurement and command system of METEOSAT is evaluated. Author (ESA)

N82-24280*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
CONTROL OF LARGE SPACE STRUCTURES AND ASSOCIATED PRECISION-POINTED PAYLOADS Annual Progress Report, 15 Feb. 1981 - 14 Feb. 1982
S. M. JOSHI and G. L. GOGLIA May 1982 25 p refs
(Contract NAG1-102)
(NASA-CR-168920; NAS 1.26:168920) Avail: NTIS HC A02/MF A01 CSCL 22B

Stability and robustness of a two-level control system for large space structures were investigated. In particular, the effects of actuator/sensor nonlinearities and dynamics on the closed-loop stability were studied and the problem of control-systems design for fine-pointing of several individually pointed payloads mounted on a large space platform was examined. A composite controller is proposed and is stable and robust. T.M.

N82-24282*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MOTION OF THE ANGULAR MOMENTUM VECTOR IN BODY COORDINATES FOR TORQUE-FREE DUAL-SPIN SPACECRAFT
J. V. FEDOR Dec. 1981 26 p refs
(NASA-TM-83879; NAS 1.15:83879) Avail: NTIS HC A03/MF A01 CSCL 22B

The motion of the angular momentum vector in body coordinates for torque free, asymmetric dual spin spacecraft without and, for a special case, with energy dissipation on the main spacecraft is investigated. Without energy dissipation, two integrals can be obtained from the Euler equations of motion. Using the classical method of elimination of variable, the motion about the equilibrium points (six for the general case) are derived with these integrals. For small nutation angle, theta, the trajectories about the theta = 0 deg and theta = 180 deg points readily show the requirements for stable motion about these points. Also the conditions needed to eliminate stable motion about the theta = 180 deg point as well as the other undesireable equilibrium points follow directly from these equations. For the special case where the angular momentum vector moves about the principal axis which contains the momentum wheel, the notion of 'free variable' azimuth angle is used. Physically this angle must vary from 0 to 2 pi in a circular periodic fashion. Expressions are thus obtained for the nutation angle in terms of the free variable and other spacecraft parameters. Results show that in general there are two separate trajectory expressions that govern the motion of the angular momentum vector in body coordinates. S.L.

N82-24283# Engins Matra, Velizy (France).
STUDY OF DIGITAL ADAPTIVE ATTITUDE CONTROL TECHNIQUES FOR FLEXIBLE SPACECRAFT Final Report
B. CLAUDINON and B. GOVIN Paris ESA Jun. 1981 250 p refs
(Contract ESTEC-4120/79/NL-AK(SC))
(ESA-CR(P)-1519) Avail: NTIS HC A11/MF A01

Adaptive control techniques for application to flexible large space structures were investigated. Both idealized and realistic spacecraft, having complex configurations with poorly known or defined attitude dynamics characteristics, were modeled, using finite element methods (NASTRAN, STARDYNE). Digital adaptive active structural modal control of spacecraft, implemented with onboard processors, was studied. Digital aspects were considered for simulation, algorithm implementation, sampling rate selection, and transfer function discretization. Model reduction schemes were reviewed and one (modal gain truncation criterion) was retained. A typical satellite configuration was chosen and analyzed through the STARDYNE finite element analysis program. Modal data were then analyzed with the multivariable flexible systems analysis program, MFSAP, in order to obtain a reduced model and optimal gains for a linear quadratic regulator. Author (ESA)

N82-25277*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
NUMBER AND PLACEMENT OF CONTROL SYSTEM COMPONENTS CONSIDERING POSSIBLE FAILURES
C. R. CARIGNAN and W. E. VANDERVELDE Mar. 1982 25 p refs
(Contract NAG1-126)
(NASA-CR-168988; NAS 1.26:168988) Avail: NTIS HC A02/MF A01 CSCL 22B

A decision making methodology is presented which is intended to be useful in the early stages of system design, before a control system is designed in detail. The methodology accounts for the likelihood of failure among the sensors and actuators in a control system. A method to compute the degree of controllability and degree of observability of a system for a given set of actuators and sensors is also presented. T.M.

N82-25314# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
DECENTRALIZED CONTROL OF LARGE SPACE STRUCTURES M.S. Thesis
W. T. MILLER Dec. 1981 85 p refs
(AD-A111171; AFIT/GAE/AA/81D-20) Avail: NTIS HC A05/MF A01 CSCL 22A

A development and analysis of a single controller, before and after the elimination of 'spillover' terms, is implemented to attempt to achieve desired response characteristics of the structure under evaluation. Using this derived data as a basis for comparison, a pair of decentralized controllers are implemented on the structure. Problems encountered with the implementation of more than two decentralized controllers are investigated. The structure used for the investigation is a lumped mass tetrahedron. Author (GRA)

N82-25315# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
DESIGN OF A DIGITAL CONTROLLER FOR A LARGE FLEXIBLE SPACE STRUCTURE M.S. Thesis
D. B. LEGGETT Dec. 1981 119 p refs
(AD-A111170; AFIT/GAE/AA/81D-18) Avail: NTIS HC A06/MF A01 CSCL 22B

Modern optimal control techniques are used to design a digital controller for a large flexible space structure. The structure is modeled as a tetrahedron formed by four lumped masses connected by massless truss members. A NASTRAN analysis is used to generate the twelve mode shapes and frequencies of oscillation. The controller is designed in discrete-time using linear optimal regulator theory. An observer is used to estimate the states. Active control is achieved using six collocated sensor actuator pairs. The effectiveness of the controller is determined using pointing accuracy as a figure of merit. Three controller designs are compared. The first demonstrates the effects of 'control' and 'observation spillover.' The second uses a singular value decomposition to eliminate the spillover terms. The third design uses a more accurate optimal performance index than the first two. The first design proved inadequate to achieve the desired performance. The second and third designs were able to achieve the desired performance for small sampling times. For small sampling times the simplified performance index used in Design II proved to provide a very accurate approximation to the optimal. Author (GRA)

N82-25317# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.
DYNAMIC STRUCTURAL ANALYSES OF A SPACECRAFT USING EXPERIMENTAL MODAL DATA Final Report
A. BERTRAM and P. CONRAD Paris ESA 12 May 1981 96 p refs
(Contract ESTEC-3347/77/NL-PP(SC))
(DFVLR-IB-232-81-C-06; ESA-CR(P)-1510) Avail: NTIS HC A05/MF A01

Application of software for modal coupling (MODAC) and configuration change calculation (DIMOC) to a complicated modular spacecraft structure with typical interface connections and appendages using data from structures already tested experimentally is summarized. Criteria for selecting the most suitable mode sets for modal synthesis are established. The characteristics of the complete spacecraft are determined for the structural dynamic synthesis by using an analytical model constructed by coupling the normal modes of the individual structure modules. The modal parameters required for the coupling are reduced from modal survey test data. The modal data of a modified spacecraft configuration for small configuration modifications are derived from the modal parameters of the unmodified spacecraft. The DIMOC program gives exact results for structures described by a complete set of modes, and also MODAC performs well. Author (ESA)

N82-25931# Paris XI Univ., Orsay (France). Inst. de Physique Nucleaire.
RELATIVISTIC AND SEPARABLE CLASSICAL HAMILTONIAN PARTICLE DYNAMICS
H. SAZDJIAN Jan. 1981 100 p refs
(DE81-700141; IPNO-TH-81-4) Avail: NTIS (US Sales Only) HC A05/MF A01; DOE Depository Libraries

Within the Hamiltonian formalism the existence of classical relativistic mechanics of N scalar particles are shown interacting at a distance which satisfies the requirements of Poincare invariance, separability, world line invariance and Einstein causality. The line of approach which is adopted uses the methods of the systems with constraints applied to manifestly covariant systems of particles. The study is limited to the case of scalar interactions remaining weak in the whole phase space and vanishing at large space like separation distances of he particles. Poincare invariance requires the inclusion of many body, up to N body, potentials. Separability requires the use of individual or two body variables and the construction of the total interaction from basic two body interactions. Position variables of the particles are constructed in terms of the canonical variables of the theory according to the world line invariance condition and the subsidiary conditions of the nonrelativistic limit and separability. Positivity constraints on the interaction masses squared of the particles ensure that the velocities of the latter remain always smaller than the velocity of light. DOE

N82-26361# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
ACTIVE CONTROL OF LINEAR PERIODIC SYSTEMS M.S. Thesis
G. S. YEAKEL Dec. 1981 111 p refs
(AD-A111067; AFIT/GA/AA/81D-12) Avail: NTIS HC A06/MF A01 CSCL 22C

The linearized equations describing the attitude motion of two generic satellite cases are developed. In both cases, the symmetric satellite in an elliptical orbit and an unsymmetric satellite in a circular orbit, the linearized equations are periodic. Using Floquet theory, the stability of the attitude motion for several satellite designs is checked. For satellites with unacceptable attitude stability, an active control scheme utilizing modal control design techniques is developed. With this control scheme, various satellite test cases are stabilized and the results are verified via a digital simulation of the satellite attitude motion. GRA

N82-26396* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ELECTRICALLY CONDUCTIVE PALLADIUM CONTAINING POLYIMIDE FILMS Patent
L. T. TAYLOR (Virginia Polytechnic Inst. and State Univ.), A. K. ST.CLAIR, V. C. CARVER (Virginia Polytechnic Inst. and State Univ.), and T. A. FURTSCH, inventors (to NASA) (Virginia Polytechnic Inst. and State Univ.) 19 Jan. 1982 5 p Filed 28 Mar. 1980 Supersedes N80-24549 (18 - 15, p 1974)
(NASA-CASE-LAR-12705-1; US-PATENT-4,311,615; US-PATENT-APPL-SN-135058; US-PATENT-CLASS-252-514)
Avail: US Patent and Trademark Office CSCL 07D

Lightweight, high temperature resistant, electrically conductive, palladium containing polyimide films and methods for their preparation are described. A palladium (II) ion-containing polyamic acid solution is prepared by reacting an aromatic dianhydride with an equimolar quantity of a palladium II ion-containing salt or complex and the reactant product is cast as a thin film onto a surface and cured at approximately 300 C to produce a flexible electrically conductive cyclic palladium containing polyimide. The source of palladium ions is selected from the group of palladium II compounds consisting of LiPdCl4, PdS(CH3)2Cl2Na2PdCl4, and PdCl2. The films have application to aerodynamic and space structures and in particular to the relieving of space charging effects.
Official Gazette of the U.S. Patent and Trademark Office

N82-27353# Royal Aircraft Establishment, Farnborough (England). Space Dept.
STUDY OF STRAPDOWN INERTIAL OPTICAL SYSTEMS (SIOS) FOR FUTURE ESA SPACECRAFT, VOLUME 1 Final Report
Paris ESA Mar. 1981 202 p refs Prepared in cooperation with British Aerospace Dynamics Group, Bristol, England 2 Vol.
(Contract ESA-3804/78/NL-JS(SC))
(ESA-CR(P)-1549-VOL-1) Avail: NTIS HC A10/MF A01

A baseline (Kalman filter) SIOS, consisting of a set of high performance gyros, two or more star mappers and an onboard processor, is described. Centralized and modular data processing are considered. Control systems are specified and the performance of the attitude measurement and control system, using a Kalman filter, is simulated for low orbit Earth pointing cases and for a celestial target mission. Geostationary mission studies assumed the use of a simple constant gain filter and RF sensor, although results with the baseline system are included. The former approach is adequate, but the autonomy of optical systems is attractive. Kalman filter system performance is impressive for an Earth pointing satellite, and the whole system is immune to high noise levels, but geometrical misalignments limit absolute pointing accuracy. Analysis reveals doubt as to whether the Kalman filter is necessary, although its inclusion is not difficult. Author (ESA)

N82-27354# Royal Aircraft Establishment, Farnborough (England). Space Dept.
STUDY OF STRAPDOWN INERTIAL OPTICAL SYSTEMS (SIOS) FOR FUTURE ESA SPACECRAFT, VOLUME 2 Final Report
Paris ESA Mar. 1981 189 p refs Prepared in cooperation with British Aerospace Dynamics Group, Bristol, England 2 Vol.
(Contract ESA-3804/78/NL-JS(SC))
(ESA-CR(P)-1549-VOL-2) Avail: NTIS HC A09/MF A01

A baseline (Kalman filter) SIOS, consisting of a set of high performance gyros, two or more star mappers and an onboard processor, is described. Centralized and modular data processing are considered. Control systems are specified and the performance of the attitude measurement and control system, using a Kalman filter, is simulated for low orbit Earth pointing cases and for a celestial target mission. Geostationary missions studies assumed the use of a simple constant gain filter and RF sensor, although results with the baseline system are included. The former approach is adequate, but the autonomy of optical systems is attractive. Kalman filter system performance is impressive for an Earth pointing satellite, and the whole system is immune to high noise levels, but geometrical misalignments limit absolute pointing accuracy.

Analysis reveals doubt as to whether the Kalman filter is necessary, although its inclusion is not difficult. Author (ESA)

N82-27377*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACTIVE LARGE STRUCTURES
K. SOOSAAR *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 221-237 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

Some performance requirements and development needs for the design of large space structures are described. Areas of study include: (1) dynamic response of large space structures; (2) structural control and systems integration; (3) attitude control; and (4) large optics and flexibility. Reference is made to a large space telescope. B.W.

N82-28345*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
CONTROLLABILITY OF INHERENTLY DAMPED LARGE FLEXIBLE SPACE STRUCTURES
A. S. S. R. REDDY and P. M. BAINUM 1982 10 p refs
Proposed for presentation at 33rd Congr. of the Intern. Astron. Federation, Paris, 26 Sep. - 2 Oct. 1982
(Contract NSG-1414)
(NASA-CR-169127; NAS 1.26:169127; IAF-82-319) Avail: NTIS HC A02/MF A01 CSCL 22B

Graph theoretic techniques are used to study controllability of linear systems which represent large flexible orbiting space systems with inherent damping. The controllability of the pair of matrices representing the system state and control influence matrices is assured when all states in the model are reachable in a digraph sense from at least one input and also when the term rank of a Boolean matrix whose non trivial components are based on the state and control influence matrices has a term rank of the order of the state vector. The damping matrix does not influence the required number of actuators but gives flexibility to the possibility locations of the actuators for which the system is controllable. S.L.

N82-29339*# RCA Labs., Princeton, N. J. Microwave Technology Center.
ADVANCED MULTIPURPOSE RENDEZVOUS TRACKING SYSTEM STUDY Final Report, 11 Nov. 1980 - 1 Dec. 1981
R. J. LAURIE and F. STERZER 1 Jun. 1982 161 p refs
(Contract NAS9-16252)
(NASA-CR-167708; NAS 1.26:167708; RCA-PRRL-82-CR-1)
Avail: NTIS HC A08/MF A01 CSCL 22A

Rendezvous and docking (R&D) sensors needed to support Earth orbital operations of vehicles were investigated to determine the form they should take. An R&D sensor must enable an interceptor vehicle to determine both the relative position and the relative attitude of a target vehicle. Relative position determination is fairly straightforward and places few constraints on the sensor. Relative attitude determination, however, is more difficult. The attitude is calculated based on relative position measurements of several reflectors placed in a known arrangement on the target vehicle. The constraints imposed on the sensor by the attitude determination method are severe. Narrow beamwidth, wide field of view (fov), high range accuracy, and fast random scan capability are all required to determine attitude by this method. A consideration of these constraints as well as others imposed by expected operating conditions and the available technology led to the conclusion that the sensor should be a cw optical radar employing a semiconductor laser transmitter and an image dissector receiver. S.L.

N82-29344*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
FILTER FAILURE DETECTION FOR SYSTEMS WITH LARGE SPACE STRUCTURE DYNAMICS M.S. Thesis
C. R. CARIGNAN Jun. 1982 107 p refs
(Contract NAG1-126)
(NASA-CR-169146; NAS 1.26:169146; SSL-1-82) Avail: NTIS HC A06/MF A01 CSCL 22B

A failure detection filter is applied to the detection of actuator and sensor failures on a free-free beam. Computer simulation tests are used to verify the filter design and study the effect of unmodeled modes on filter performance. In actuator tests, the failure signal to spillover noise ratio was found to be greatest when the filter bandwidth was 5 rad/sec beyond the input frequency. Observation spillover, however, was found to vary widely in tests run under similar conditions (same input frequency and filter poles) but with different detector gains. In sensor tests, the maximum signal-to-noise ratio for varying filter bandwidth depended upon the initial conditions placed on the unmodeled modes; the performance was good even for initial amplitudes on the first unmodeled mode 7.5% of that on the last modeled mode. Author

N82-30263# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NATURAL MODES OF AN IMMERSED STRUCTURE
J. BOUJOT and J. J. ANGELINI *In its* La Rech. Aerospatiale, Bi-monthly Bull. No. 1982-1, Jan.-Feb. 1982 (ESA-TT-755) p 23-29 May 1982 refs Transl. into ENGLISH from La Rech. Aerospatiale, Bull. Bimestriel (Paris), No. 1982-1, Jan.-Feb. 1982
Avail: NTIS HC A04/MF A01; original report in FRENCH available at ONERA, Paris FF 55

A mathematical model for studying the coupling of a flexible shell with an exterior compressible fluid is proposed. It is shown that for an infinite medium without gravity, if the ratio of frequency to sound velocity is small, a coherent definition of vibration Eigen mode shapes can be obtained. These equivalent mode shapes follow an approximation of the initial vibration problem. Helmholtz's equation in an exterior domain is used to define pressure due to the fluid. A fluid structure direct coupling method is used to demonstrate that the problem is equivalent to solving a coupled system of integral equations and partial differential equations. The approximation hypothesis of the initial problem is used to obtain a model self-adjoint spectral problem, on the basis of which vibration modes can be defined. Discretization methods can be exploited. Author (ESA)

N82-30331# RESULT, Munich (West Germany).
DYNAMICS OF TWISTED BOOMS AND OF BOOMS WITH OFFSET
P. H. KULLA Paris ESA Mar. 1982 132 p refs
(Contract ESTEC-4376/80/NL-PP(SC))
(ESA-CR(P)-1571) Avail: NTIS HC A07/MF A01

The effects on spacecraft axial boom dynamic behavior of (a) translational and/or rotational offset of the boom root, and (b) a natural twist in the boom, are discussed. For condition (a) the nonlinear differential equations describing the equilibrium state are set up and solved. For certain parameter combinations not encountered with standard systems, multiple solutions do exist. The linear differential equations, describing small oscillations around the equilibrium states, are derived and solved for natural frequencies and related eigenfunctions. For standard axial booms, an offset error slightly increases the lowest natural frequency. For (b), coinciding in the undistrubed state with the spin axis, the eigenvalues and eigenfunctions are determined. For a boom with different bending stiffness in the two axes of the cross section, a pretwist slightly increases the lowest natural frequency, augmenting stability. Author (ESA)

N82-30870*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
EVALUATION OF SMART SENSOR DISPLAYS FOR MULTIDIMENSIONAL PRECISION CONTROL OF SPACE SHUTTLE REMOTE MANIPULATOR
A. K. BEJCZY, J. W. BROWN (JPL, Calif. Inst. of Tech., Pasadena), and J. L. LEWIS *In* MIT Proc. of 16th Ann. Conf. on Manual Control p 607-627 1980 refs
(Contract NAS7-100)
Avail: NTIS HC A99/MF A01 CSCL 05H

An enhanced proximity sensor and display system was developed and tested on the full scale Space Shuttle remote manipulator. The sensor system, integrated with a four claw end effector, measures range error up to 6 inches, and pitch and yaw alignment errors within + or - 15 deg., and displays error data on both graphic and numeric displays. The errors are referenced to the end effector control axes through appropriate data processing by a microcomputer acting on the sensor data in real time. Methods to minimize terminal range and alignment errors by utilizing range, pitch and yaw error information from the sensor displays were investigated. The test runs aided by sensor displays are contrasted with test runs without sensor display aids. The enhanced sensor and display system, the test runs and results are described. It is indicated that the use of graphic/numeric displays of proximity sensor information improves precision control of grasp/capture range by more than a factor of two for both static and dynamic grapple conditions. E.A.K.

N82-30951*# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.
COMPONENT COST ANALYSIS OF LARGE SCALE SYSTEMS Final Report
R. E. SKELTON and A. YOUSUFF 10 Jan. 1982 57 p refs
(Contract JPL-955369)
(NASA-CR-169210; NAS 1.26:169210; JPL-9950-693) Avail: NTIS HC A04/MF A01 CSCL 09B

The ideas of cost decomposition is summarized to aid in the determination of the relative cost (or 'price') of each component of a linear dynamic system using quadratic performance criteria. In addition to the insights into system behavior that are afforded by such a component cost analysis CCA, these CCA ideas naturally lead to a theory for cost-equivalent realizations. S.L.

N82-31397# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
HYBRID EQUATIONS FOR TRANSLATIONAL AND ROTATIONAL MOTION OF FLEXIBLE SPACECRAFT
P. T. L. M. VANWOERKOM 29 Sep. 1981 77 p refs
(Contract NIVR-1910)
(NLR-TR-81116-U) Avail: NTIS HC A05/MF A01

Equations of motion of a generic spacecraft with a rigid main body, and with flexible appendages, rotors, and jets on or in the main body were obtained by hybrid coordinate modeling. The equations were linearized to obtain the motion equations of three-axis stabilized spacecraft. The reduction of the exact motion equations to those describing the motion of a multibody spacecraft, composed of rigid main body with finite moments of inertia and of point masses with zero moments of inertia, is outlined. Author (ESA)

N82-31405# Lockheed Missiles and Space Co., Palo Alto, Calif. Research Lab.
ACOSS FIVE (ACTIVE CONTROL OF SPACE STRUCTURES), PHASE 1A Final Technical Report, 13 Mar. 1980 - 3 Sep. 1981
J. N. AUBURN, J. A. BREAKWELL, N. K. GUPTA, M. G. LYONS, and G. MARGULIES Mar. 1982 120 p refs
(Contract F30602-80-C-0102; ARPA ORDER 3654)
(AD-A116655; LMSC-D811889) Avail: NTIS HC A06/MF A01 CSCL 22B

The theory of steady-state disturbance rejection for large space structures is developed and tested analytically on a complex optical strawman configuration (CSDL Model 2). 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. Author (GRA)

N82-32009*# Houston Univ., Tex. Dept. of Electrical Engineering.
RESEARCH ON NUMERICAL ALGORITHMS FOR LARGE SPACE STRUCTURES Final Report, 15 Mar. 1981 - 31 Oct. 1982
E. D. DENMAN 31 Oct. 1982 145 p refs
(Contract NSG-1603)
(NASA-CR-169279; NAS 1.26:169279) Avail: NTIS HC A07/MF A01 CSCL 12A

Numerical algorithms for large space structures were investigated with particular emphasis on decoupling method for analysis and design. Numerous aspects of the analysis of large systems ranging from the algebraic theory to lambda matrices to identification algorithms were considered. A general treatment of the algebraic theory of lambda matrices is presented and the theory is applied to second order lambda matrices. Author

N82-32410# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
PRELIMINARY STUDY OF THE DYNAMIC CONTROL OF LARGE SPACECRAFT. VOLUME 1: SUMMARY Final Report
M. BURTON and C. ROGERS Paris ESA Nov. 1981 32 p 4 Vol.
(Contract ESTEC-4008/79)
(BAE-TP-7937-VOL-1; ESA-CR(P)-1608-VOL-1) Avail: NTIS HC A03/MF A01

Following a discussion of the nature of the LSS control problem a review is given of techniques for attitude and vibration control. The large number of flexible modes and their low damping complicates system modelling and identification and the selection of a low order design model may be difficult. The application of standard design techniques to a reduced order model is discussed. Modes excluded from the design model can easly become unstable and a number of techniques for avoiding this problem have been proposed. Other techniques provide theoretically robust controllers at the cost of a more limited design. A selection of techniques are applied to the generic model of a large spacecraft and their performance is discussed on the basis of eigenvalue analysis. Related problems, including shape control and actuator and sensors for application of large structures, are discussed and a literature survey presented. Author ESA

N82-32411# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
PRELIMINARY STUDY OF THE DYNAMIC CONTROL OF LARGE SPACECRAFT, VOLUME 2 Final Report
Paris ESA 1981 147 p 4 Vol.
(Contract ESTEC-4008/79)
(BAE-TP-7937-VOL-2; ESA-CR(P)-1608-VOL-2) Avail: NTIS HC A07/MF A01

Dynamic interaction of flexible appendages with the controller is investigated. A classical control law, with actuators and sensors located on the rigid body is used. For truly large spacecraft (e.g. a communications platform or the solar power satellite) flexibility is distributed actuators and sensors. The status of these techniques is appraised. ESA

N82-32412# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
PRELIMINARY STUDY OF THE DYNAMIC CONTROL OF LARGE SPACECRAFT. VOLUME 3: CASE STUDIES Final Report
Paris ESA 1981 134 p 4 Vol.
(Contract ESTEC-4008/79)
(BAE-TP-7937-VOL-3; ESA-CR(P)-1608-VOL-3) Avail: NTIS HC A07/MF A01

A generic model of a large flexible spacecraft represents a platform 62.5 Sq Km with a rigid body at the center. This has similarities asuch as solar power stations, but is intended to have some of the dynamic properties of a large category of spacecraft, in particular its low inerent damping of the many flexible modes as well as the closeness of the natural frequencies. The structure would be built usting a truss structure but for modelling purposes it is represented as an elastic cntinuum, prior to application of finite element analysis techniques. The spacecraft can be regarded as a typical large space structure. Using this 100 degree of freedom model as a starting point a number of lower order models were preposed for investigation of specific control problems. S.L.

N82-32413# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
PRELIMINARY STUDY OF THE DYNAMIC CONTROL OF LARGE SPACECRAFT. VOLUME 4: LITERATURE SURVEY Final Report
Paris ESA 1981 72 p refs 4 Vol.
(Contract ESTEC-4008/79)
(BAE-TP-7937-VOL-4; ESA-CR(P)-1608-VOL-4) Avail: NTIS HC A04/MF A01

A bibliography containing 399 citations on dynamic modeling, attitude and vibration control, shape control, and control technology of large space structures is presented. The subjects covered include: systems engineering, interactive analysis and design, structural concept, control systems, electronics implementation, advanced materials. actuators/propulsion, and sensors. S.L.

N82-33422*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
ATTITUDE AND VIBRATION CONTROL OF A LARGE FLEXIBLE SPACE-BASED ANTENNA Progress Report, period ending 14 Aug. 1982
S. M. JOSHI and G. L. GOGLIA Sep. 1982 33 p refs
(Contract NAG1-102)
(NASA-CR-169419; NAS 1.26:169419) Avail: NTIS HC A03/MF A01 CSCL 22B

The problem of control systems synthesis is considered for controlling the rigid body attitude and elastic motion of a large deployable space based antenna. Two methods for control systems synthesis are considered. The first method utilizes the stability and robustness properties of the controller consisting of torque actuators and collocated attitude and rate sensors. The second method is based on the linear quadratic Gaussian (LQG) control theory. A combination of the two methods, which results in a two level hierarchical control system, is also briefly discussed. The performance of the controllers is analyzed by computing the variances of pointing errors, feed misalignment errors and surface contour errors in the presence of sensor and actuator noise. Author

N82-33423*# Howard Univ., Washington, D. C. Dept. Of Mechanical Engineering.
THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES-V Final Report
P. M. BAINUM, A. S. S. R. REDDY, C. M. DIARRA, and V. K. KUMAR Aug. 1982 83 p refs
(Contract NSG-1414)
(NASA-CR-169360; NAS 1.26:169360) Avail: NTIS HC A05/MF A01 CSCL 22B

A general survey of the progress made in the areas of mathematical modelling of the system dynamics, structural analysis, development of control algorithms, and simulation of environmental disturbances is presented. The use of graph theory techniques is employed to examine the effects of inherent damping associated with LSST systems on the number and locations of the required control actuators. A mathematical model of the forces and moments induced on a flexible orbiting beam due to solar radiation pressure is developed and typical steady state open loop responses obtained for the case when rotations and vibrations are limited to occur within the orbit plane. A preliminary controls analysis based on a truncated (13 mode) finite element model of the 122m. Hoop/Column antenna indicates that a minimum of six appropriately placed actuators is required for controllability. An algorithm to evaluate the coefficients which describe coupling between the rigid rotational and flexible modes and also intramodal coupling was developed and numerical evaluation based on the finite element model of Hoop/Column system is currently in progress. Author

N82-33741*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
MINIMIZATION VERSUS HOMOTOPY ALGORITHMS
M. P. KAMAT, L. T. WATSON, and V. B. VENKAYYA (AFFDL) *In* NASA. Langley Research Center Res. in Struct. and Solid Mech., 1982 p 11-24 Oct. 1982 refs
(Contract NAG1-139)
Avail: NTIS HC A19/MF A01 CSCL 20K

The relative merits and demerits of the minimization techniques are assessed using globally convergent quasi-Newton algorithms on the one hand and the homotopy algorithms on the other hand for the solution of problems of nonlinear structural analysis. Like the homotopy algorithms, the globally convergent quasi-Newton algorithms are equally suited for the solution of the nonlinear equations of structural analysis directly without having to pose the problem as an equivalent minimization problem. In the close neighborhood of the limit and bifurcation points quasi-Newton algorithms experience difficulties. Homotopy algorithms are robust for practically all types of nonlinear problems but are computationally not as cost effective since they provide an extremely accurate prediction of the response by calculating it as a large number of points. Globally convergent algorithms can perform well with very approximate Hessians, while homotopy algorithms require extremely accurate Hessians. While quasi-Newton algorithms can be very easily structured to exploit sparsity and symmetry, homotopy algorithms are not presently so structured and would require special modifications for exploitation of such features without sacrificing robustness and global convergence. Author

N82-33762*# Cincinnati Univ., Ohio.
CONSTRAINED MULTIBODY SYSTEM DYNAMICS: AN AUTOMATED APPROACH
J. W. KAMMAN and R. L. HUSTON *In* NASA. Langley Research Center Res. in Struct. and Solid Mech., 1982 p 363-373 Oct. 1982 refs
(Contract N00014-76-C-0139)
Avail: NTIS HC A19/MF A01 CSCL 20K

The governing equations for constrained multibody systems are formulated in a manner suitable for their automated, numerical development and solution. The closed loop problem of multibody chain systems is addressed. The governing equations are developed by modifying dynamical equations obtained from Lagrange's form of d'Alembert's principle. The modifications is based upon a solution of the constraint equations obtained through a zero eigenvalues theorem, is a contraction of the dynamical equations. For a system with n-generalized coordinates and m-constraint equations, the coefficients in the constraint equations may be viewed as constraint vectors in n-dimensional space. In this setting the system itself is free to move in the n-m directions which are orthogonal to the constraint vectors. E.A.K.

N82-33763*# North Carolina State Univ., Raleigh.
SYSTEM IDENTIFICATION: A QUESTION OF UNIQUENESS, REVISITED
J. E. HARDEE and V. C. MATZEN *In* NASA. Langley Research Center Res. in Struct. and Solid Mech., 1982 p 375-389 Oct. 1982 refs
(Contract NSF PFR-80-07389)
Avail: NTIS HC A19/MF A01 CSCL 20K

Questions of uniqueness of parameters which were obtained from a system identification algorithm were investigated. The local properties of the surface defined by the error function were used. Static and dynamic numerical experiments on determinate and indeterminate trusses and on shear buildings illustrate the procedure. Examples are given of loading and sensor configurations which produce unique parameters E.A.K.

06

ELECTRONICS

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

A82-31571

POSSIBLE APPLICATIONS OF LARGE SOLAR ARRAYS IN ASTRONOMY AND ASTROPHYSICS

S. DANAHER, D. J. FEGAN, N. A. PORTER (University College, Dublin, Ireland), T. C. WEEKES (Mount Hopkins Observatory, Amado, AZ), and T. COLE (Ford Motor Co., Dearborn, MI) Solar Energy, vol. 28, no. 4, 1982, p. 335-343. Research supported by the National Board of Science and Technology of Ireland. refs

It is pointed out that the large collection area of solar test facilities may be useful in certain astronomical experiments. Since only nighttime hours would be involved, there would be no conflict with daytime solar research. Although solar concentrators are optically crude by conventional astronomical telescope standards, there are certain applications where angular resolutions of 0.25 deg can be tolerated. These applications are discussed, along with results from the nighttime use of large concentrators. A table comparing the parameters of a typical astronomical telescope with those of a typical solar concentrator is included. Four areas of astronomical research where solar concentrators might be useful are discussed. They are the detection of Cerenkov light from extensive air showers, optical bursts, optical detection of meteors, and stellar photometry. C.R.

A82-34271#

HOLOGRAPHIC INTERFEROMETRY NEAR GAS/LIQUID CRITICAL POINTS

H. KLEIN and K. WANDERS (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) AIAA Journal, vol. 20, July 1982, p. 946-949. refs

Facilities for the examination of critical phenomena are substantially extended by access to the reduced-gravity environment in space. First, however, it seems desirable to demonstrate the advantages of experimentation in space by, for example, measuring the extremely sensitive density profiles of critical fluid samples under the influence of reduced gravity onboard Spacelab. The objective of this work is to illustrate that such measurements may be conveniently performed by holographic interferometry. The fluid under investigation (CClF3 with a critical overall density) is cooled from temperatures above the critical temperature. Changes in the density profile induced by gravity and temperature gradients are visualized by holographic interferometry. The interferometric patterns are analyzed in terms of the theory of critical phenomena. Two different means by which temperature gradients may arise in critical samples have been revealed in our experiments: convection and adiabatic changes in the density distribution. (Author)

A82-34604

REGENERATIVE SELF-STEERING ARRAY COMBINERS

Y.-S. YEH, R. E. LANGSETH, and W. L. ARANGUREN (Bell Telephone Laboratories, Inc., Holmdel, NJ) IEEE Transactions on Communications, vol. COM-30, May 1982, pt. 2, p. 1218-1223. refs

Several designs for self-steering array combiners together with a simple frequency-offset tagging method which permits locking of a combiner to one of several cochannel but spatially separate signals are discussed. The combiners use the output signal as a reference for extraction of phase information from each individual element-signal, thereby utilizing the full transmitted signal (rather than a separate pilot) for element phase measurement. Designed for receiving PSK signals, the combiner inherently provides, as part of its design, the CW signal required for coherent demodulation of the combined array output. Laboratory measurements made with a four-branch combiner for two-phase PSK signals demonstrate the salient features of the combiner. (Author)

A82-36285*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

DESIGN PRACTICES FOR CONTROLLING SPACECRAFT CHARGING INTERACTIONS

N. J. STEVENS (NASA, Lewis Research Center, Cleveland, OH) American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 19 p. refs

(AIAA PAPER 82-0115)

(Previously announced in STAR as N82-18311)

A82-36864

CZOCHRALSKI SILICON SOLAR CELL MODULES - PRESENT COST AND FUTURE PROSPECTS

R. M. MOORE (Solar Energy Research Institute, Golden, CO; Chevron Research Corp., Solar Div., Richmond, CA) Solar Cells, vol. 5, Apr. 1982, p. 313-329. refs

A multipath learning curve model of the development of the Czochralski process silicon solar cell industry is first tested through application of historical data for the 1974-1979 period, and upon confirmation of its ability to predict price dynamics is used to forecast production costs in 1980-1985. The 1985 forecasts, in 1979 U.S. dollars, are $2.2/peak W at 10% estimated confidence level, $3.1-3.2/peak W at 50% estimated confidence level and $4.8/peak W at 90% estimated confidence level. It is concluded in light of these estimates that the 1985 state of development of the Czochralski silicon solar cell industry does not represent an attractive investment for major companies presently involved in related work, while a very attractive market is presented for small companies which are already participating in production. The resource base of small companies, however, is insufficient to support the investment levels required in 1980-1985. A primary consequence of this research is that the choice of the wafer or ribbon form of silicon crystal material chosen for intensive development is less important than the research and development emphasis which must be placed on the reduction of high purity polycrystalline silicon feedstock costs. O.C.

A82-37463*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PLASMA FLOW MEASUREMENTS IN A SIMULATED LOW EARTH ORBIT PLASMA

S. B. GABRIEL (California Institute of Technology, Jet Propulsion Laboratory, Electrical Power and Propulsion Section, Pasadena, CA), J. E. MCCOY (NASA, Johnson Space Center, Houston, TX), and M. R. CARRUTH, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 3rd, St. Louis, MO, June 7-11, 1982, AIAA 8 p. NASA-supported research. refs

(AIAA PAPER 82-0925)

The employment of large, higher power solar arrays for space operation has been considered, taking into account a utilization of high operating voltages. In connection with the consideration of such arrays, attention must be given to the fact that the ambient environment of space contains a tenuous low energy plasma which can interact with the high voltage array causing power 'leakage' and arcing. An investigation has been conducted with the aim to simulate the behavior of such an array in low-earth-orbit (LEO). During the experiments, local concentrations of the 'leakage' current were observed when the panel was at a high voltage. These concentrations could overload or damage a small area of cells in a large string. It was hypothesized that this effect was produced by electrostatic focusing of the particles by the sheath fields. To verify this experimentally, an end-effect Langmuir probe was employed. The obtained results are discussed. G.R.

A82-37809#
MICROWAVE SENSING FROM SPACE
H. SCHUESSLER (Dornier System GmbH, Friedrichshafen, West Germany) American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium on Spacelab, Space Platforms and the Future, 20th, Greenbelt, MD, Mar. 17-19, 1982, AAS 15 p. Research supported by the Bundesministerium fuer Forschung und Technologie.
(AAS PAPER 82-127)

The design, functions, and performance of satellite microwave sensor systems for earth imaging are described. It is noted that microwave operations can be carried out in all weather and in day or night conditions, and that current satellite systems operate in the interval of 1-20 GHz. Applications for soil characterization, moisture, and wind vector measurements over the sea are described in terms of frequency selection, power, and antenna requirements. Sunsynchronous orbits offer the advantage of low power storage capabilities due to avoidance of eclipse conditions. Areas of development necessary to implement an SAR for GEO positioning are reviewed, and features of a microwave remote sensing experiment involving SAR operating at 9.6 GHz during the first Spacelab flight on the Shuttle are presented. Finally, details of the ERS-1 satellite, which will carry a radar altimeter, wind scatterometer, and SAR are outlined. M.S.K.

A82-37811#
MODULAR OPTOELECTRONIC MULTISPECTRAL SCANNER /MOMS/ DEVELOPMENT
D. MEISSNER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium on Spacelab, Space Platforms and the Future, 20th, Greenbelt, MD, Mar. 17-19, 1982, AAS 11 p. Research supported by the Bundesministerium fuer Forschung und Technologie and Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt.
(AAS PAPER 82-131)

The Modular Optoelectronic Multispectral Scanner (MOMS) is a new opto-electronic scanning system for remote sensing from aircraft and space platforms. The imaging principle is based on the use of high resolution linear CCD detector arrays. The basic instrument performance would allow up to 10,000 pixels per scan line, corresponding to about 20 m ground element size at 200 km swath width from observation satellite altitudes with narrower spectral bands than used on the current systems. High spectral resolution (up to 20 nm) is feasible at medium spatial resolution (about 60m) and at 7 to 8 bit radiometric resolution. Several experimental airborne scanners have been successfully flown since 1978. The first spaceborne two-channel scanner is scheduled for Space Shuttle Flight No. 7 in March, 1983. (Author)

A82-39162
ENVIRONMENTAL PROBLEMS WITH MICROWAVE POWER TRANSFER FROM SATELLITE TO GROUND
Advances in Space Research, vol. 2, no. 3, 1982, p. 94-103.

The environmental effects of the microwave radiation beamed to earth by a proposed solar power satellite are considered. The effects on the public and terrestrial workers, on workers in space and on terrestrial and aquatic ecosystems are discussed in general. Specific attention is given to the tropospheric effects of the microwaves and the intense electromagnetic fields surrounding the receiving rectantenna. These fields would probably be no greater than that produced by a suburban area. The effects on communications systems are now being investigated, including various propagation modes and system degradation models. Preliminary estimates show that functional degradation ranges from a few percent to about a 50 percent increase of threshold values in an average overall operating mode and geographic range. C.D.

A82-40156
ELECTRICAL PUMPING OF COLOR CENTER LASERS
R. W. BOYD, M. S. MALCUIT, and K. J. TEEGARDEN (Rochester, University, Rochester, NY) IEEE Journal of Quantum Electronics, vol. QE-18, Aug. 1982, p. 1202-1208. Army-supported research. refs

This paper presents an assessment of the feasibility of using electrical pumping to achieve laser action in color centers in the alkali halides. The discussion is mainly of the self-trapped exciton in the alkali halides, which is a prime candidate for such a pumping scheme because it is known to produce strong electroluminescence. The theory of electrical contacts to insulating crystals is reviewed, as is the theory of space-charge-limited currents in insulators. It is shown that sufficient energy can be delivered to an alkali halide crystal by a space-charge-limited current to reach the threshold for laser action. Experimental evidence is presented which demonstrates that when ohmic contact is made to a KI single crystal, large space-charge-limited currents can flow. Finally, from the measured value of the electroluminescent intensity, the value of the population inversion achieved through electrical pumping of KI with blocking contacts is inferred. (Author)

A82-43483
THE DIRECTIVITY PROPERTIES OF UNFOLDING REFLECTOR ANTENNAS [O NAPRAVLENNYKH SVOISTVAKH RASKRYVAIUSHCHIKHSIA ZERKAL'NYKH ANTENN]
A. V. AZIUKIN and V. I. KLASSEN Radiotekhnika i Elektronika, vol. 27, no. 8, Aug. 1982, p. 1519-1526. In Russian. refs

Numerical results are presented on the radiation pattern and directive gain of unfolding parabolic antennas of umbrella type with different geometries. The optimal location of the feed in such antennas is determined for axial radiation as well as for deflected rays. Numerical and experimental results are compared, and recommendations on the choice of geometry for such antennas are presented. B.J.

A82-44750*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPONENT TECHNOLOGY FOR SPACE POWER SYSTEMS
R. C. FINKE (NASA, Lewis Research Center, Cleveland, OH) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p. refs
(IAF PAPER 82-408)

Progress made by NASA toward implementation of equipment for the conversion, management, and distribution of voltage power in space applications are reviewed. Work has been carried forward on components such as bipolar transistors, deep impurity semiconductors, conductors, dielectrics, magnetic devices, and rotary power transfer. Specific programs for the high voltage systems have included research on lightweight, low-cost conductors featuring graphite fibers containing electron donor materials for wires and cables with reduced mass and the conductivity of copper. Attention has also been given p-n junction technology for high-speed, high-current, high-voltage materials and diamond-like dielectric films which are hard, have high dielectric strength, and can operate up to 300 C. A transistor has been fabricated with a voltage of 1200 V at 100 A, with a gain of 10 and a 0.5 microsec rise/fall time. A 25 kW transformer has also been built which performs at 20 kHz with an efficiency of 99.2%. M.S.K.

A82-44929*# National Aeronautics and Space Administration, Washington, D. C.
PHOTOVOLTAIC OUTLOOK FROM THE NASA VIEWPOINT
L. P. RANDOLPH (NASA, Washington, DC) In: Photovoltaic Specialists Conference, 15th, Kissimmee, FL, May 12-15, 1981, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1981, p. 10-13. refs

The NASA photovoltaic outlook for space applications focuses on the needs for increasing the specific power (W/kg), establishing radiation damage control, and reducing the specific cost ($/W). In each of these areas the technology requirements and potential impediments are presented. Technology trends and forecasts are also discussed. (Author)

A82-45007* Pennsylvania Univ., Philadelphia.
METALLIZATION FOR LARGE-AREA SOLAR CELLS
M. WOLF (Pennsylvania, University, Philadelphia, PA) In: Photovoltaic Specialists Conference, 15th, Kissimmee, FL, May 12-15, 1981, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1981, p. 506-511. Research supported by the U.S. Department of Energy
(Contract JPL-954976)

In large area, low cost solar cells of any type, the contact and grid structure metallization is an important factor which has an effect on the efficiency of the solar cell and its reliability. The present investigation is concerned with aspects of solar cell efficiency. An optimized metallization design leads to minimum total power loss, which is related to a simultaneous minimization of ohmic voltage drops and of shading of the front surface of the cell by the overlaid metal. The requirements regarding the design for a low-loss metallization pattern for the front surface of large area solar cells are represented by a set of design rules listed in a table. The total shading and voltage drop on such cells can be held to about 5%. However, not every metallization process is suited for meeting the requirements of the low-cost design. The low losses can be achieved only by use of several bus lines containing a bulk conductor, such as a wire. G.R.

A82-45013
DESIGN APPROACH TOWARD 100KW FLEXIBLE SOLAR ARRAYS
B. GOERGENS, H. BEBERMEIER, and G. BEHRENS (Telefunken AG, Hamburg, West Germany) In: Photovoltaic Specialists Conference, 15th, Kissimmee, FL, May 12-15, 1981, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1981, p. 544-549. refs

New requirements for large flexible Shuttle launched solar arrays are: protection against shadowing, retractability, high power/mass ratio, easy maintenance. In the scope of ESA studies the design for solar arrays in the 100 KW range has been investigated leading to the use of glass fibre reinforced kapton substrate and 5cmx5cm, 150 microns, BSF-BSR solar cells in connection with 2cmx2cm flat shunting diodes on the array for protection against shadow impacts. A rear side wiring system of 10 micron Ag bars completely covering the array rear side was selected to be the optimum choice from overall system aspects. High voltage application is limited to approximately 500V maximum in order to avoid discharge events and damage of the solar array. For achieving full retractability a new on array padding technique has been developed. Small crosslike pads of RTV silicone material between the solar cells are preventing the cells from damage during launch and retrieval in orbit. (Author)

A82-45014
SHUNT AND BLOCKING DIODES FOR PROTECTION OF SPACE SOLAR ARRAYS
K.-D. RASCH and K. ROY (Telefunken AG, Heilbronn, West Germany) In: Photovoltaic Specialists Conference, 15th, Kissimmee, FL, May 12-15, 1981, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1981, p. 550-553. European Space Research and Technology Centre
(Contract ESTEC-3662/78/NL/HP)

A thin large area protection diode for blanket integration on space solar arrays is presented. The diode (2 cm x 2 cm x 0.02 cm) can be used as a shunt or a blocking diode in the extensive temperature range from - 150 C to + 150 C. The characteristics for forward and reverse bias conditions are given. The switching behavior for critical modes in the high temperature range is tested. Maximum ratings are discussed. The diode shows no remarkable electrical degradation in an electron radiation environment. Advantages of the diode are high thermal radiation, high reflectance and low heat generation. (Author)

A82-46934#
COMMUNICATION SATELLITE PAYLOAD TECHNOLOGIES - STATE OF THE ART AND TRENDS IN EUROPE
G. MICA and R. COIRAULT (ESA, Technical Directorate, Noordwijk, Netherlands) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p. refs
(IAF PAPER 82-63)

Communication satellite payload technologies are examined, in terms of past, present, and future ESA guidelines. Various existing payload systems are presented, such as Marecs, ECS, and L-Sat (which will carry four payloads). Future services within the market include 2 Mb/sec high speed data, 2-8 Mb/sec video conference, and 64 Mb/sec television distribution, and growth in these areas is dependent on traffic requirements. Pre-operational satellites are outlined, for example Telecom 1 has an estimated system capacity of 150 Mb/sec, Italsat has an expected 1180 Mb/sec, and DFS demonstrates a possible 1540 Mb/sec capacity. It is found that the 20/30 GHz band should be applied for use in wideband and high capacity trunks among heavy traffic centers. To accommodate for the noise in this waveband, the parametric amplifier developed for L-Sat must be used. Finally, development objectives for future programs include improving spectrum and geostationary orbit utilization, cost-efficiency, and standardization of systems. R.K.R.

A82-47253
FUTURE MILITARY SPACECRAFT POWER SYSTEMS
R. R. BARTHELEMY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) In: Making space work for mankind; Proceedings of the Nineteenth Space Congress, Cocoa Beach, FL, April 28-30, 1982. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982, p. 1-7 to 1-12. refs

Evolutionary and revolutionary needs for future military spacecraft power systems are discussed. Missions in the communications, navigation, and meteorological areas will require 5-15 kW by the 1990s, and these can be met by evolutionary adaptions. Missions in the surveillance, defense, special communication, and propulsion fields will require prime power of as much as 400 kWe, but most uses will require only up to 100 kW. Life goals for synchronous orbit will be 10-15 yrs, while no significant trend towards longer low earth orbit life cycles is foreseen. Nuclear reactor power subsystems will be needed to meet high power density requirements, but only limited development programs are now ongoing. Hardness to nuclear weapons has been successfully demonstrated for solar power systems, and laser threat hardening is being addressed. For cost reasons, solar power systems have up to now been chosen over nuclear power systems. An outline for an integrated development approach is presented. C.D.

N82-22683*# Rockwell International Corp., Downey, Calif.
EMERGING SPS CONCEPTS
G. HANLEY and G. R. WOODCOCK (Boeing Co., Seattle) *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 95-98 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

Four technologies were evaluated to determine their effect on Satellite Power System concepts. Two of these technologies, solid-state power amplifiers and magnetrons, are replacements for the Klystrons used for dc to RF conversion on the satellite. A third technology, laser power transmission, transmits the energy at laser frequencies rather than microwave frequencies. The fourth technology, multibandgap solar cells, has the promise of significantly increased solar to dc conversion efficienty as compared to the reference-concept silicon and gallium arsenide solar cells. The design characteristics of concepts resulting from application of these technologies are summarized. M.G.

N82-22718*# Rockwell International Corp., Downey, Calif.
GALLIUM ARSENIDE (GAAS) POWER CONVERSION CONCEPT
A. A. NUSSBERGER *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 246-249 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

A summary design analysis of a GaAs power conversion system for the solar power satellite (SPS) is presented. Eight different satellite configuration options for the solar arrays are compared. Solar cell annealing effects after proton irradiation are considered. Mass estimates for the SPS and the effect of solar cell parameters on SPS array design are discussed. J.D.

N82-22719*# Boeing Aerospace Co., Seattle, Wash.
SPS SILICON REFERENCE SYSTEM
G. R. WOODCOCK *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 250-253 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The design analysis of a silicon power conversion system for the solar power satellite (SPS) is summarized. The solar array, consisting of glass encapsulated 50 micrometer silicon solar cells, is described. The general scheme for power distribution to the array/antenna interface is described. Degradation by proton irradiation is considered. The interface between the solar array and the klystron equipped power transmitter is described. J.D.

N82-22721*# Little (Arthur D.), Inc., Cambridge, Mass.
EVALUATION OF SOLAR CELL MATERIALS FOR A SOLAR POWER SATELLITE
P. E. GLASER, D. W. ALMGREN, and K. I. CSIGI *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 263-266 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

Alternative solar cell materials being considered for the solar power satellite are described and price, production, and availability projections through the year 2000 are presented. The chief materials considered are silicon and gallium arsenide. J.D.

N82-22724*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MICROWAVE SYSTEM PERFORMANCE SUMMARY
G. D. ARNDT and E. J. NALOS (Boeing Co., Seattle) *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 277-280 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The design of the microwave system for the solar power satellite is described. Design modifications recommended include changes in phase control to the power module level, a reduction in allowable amplitude jitter, the use of metal matrix waveguides, and sequences for startup/shutdown procedures. Investigations into reshaping the beam pattern to improve overall rectenna collection efficiency and improve sidelobe control are surveyed.

N82-22725*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SATELLITE POWER SYSTEM CONCEPT DEVELOPMENT AND EVALUATION PROGRAM, CRITICAL SUPPORTING INVESTIGATIONS. SUMMARY
J. W. SEYL *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 281-284 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

Investigations in critical technology of the solar power satellite (SPS) concept development program are summarized. Studies of the potential application of fiber optics transmission links across the SPS one kilometer antenna and evaluation of gallium arsenide field effect transistors and their associated power amplifier circuitry are discussed in more detail. J.D.

N82-22726*# LinCom Corp., Pasadena, Calif.
PHASE CONTROL SYSTEM CONCEPTS AND SIMULATIONS
V. C. LINDSAY *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 285-288 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

A phase control system concept for a solar power satellite is proposed which partitions the system into three major levels. The first level of phase control consists of a reference phase distribution system implemented in the form of phase distribution tree structure. The major purpose of the tree structure is to electronically compensate for the phase shift due to the transition path lengths from the center of the spacetenna to each phase control center located in each subarray. In the reference system, this is accomplished using the master slave returnable timing system technique. The second level of phase control consists of the beam steering and microwave power generating system which houses the power transponders. This transponder consists of a set of phase conjugation multipliers driven by the reference phase distribution system output and the output of a pilot spread spectrum receiver which accepts the received pilot via a diplexer connected to a separate receive horn or the subarray itself. The output of the phase conjugation circuits serve as inputs to the third level of the phase control system. The third level of phase control is associated with maintaining an equal and constant phase shift through the microwave power amplifier devices while minimizing the associated phase noise effects on the generated power beam. This is accomplished by providing a phase locked loop around each high power amplifier. M.G.

N82-22727*# Novar Electronics Corp., Barberton, Ohio.
AN INTERFEROMETER BASED PHASE CONTROL SYSTEM
J. H. OTT and J. S. RICE *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 289-292 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

An interferometer based phase control system for focusing and pointing the solar power satellite (SPS) power beam is discussed. The system is ground based and closed loop. One receiving antenna is required on Earth. A conventional uplink data channel transmits an 8 bit phase error correction back to the SPS for sequential calibration of each power module. Beam pointing resolution is better than 140 meters at the rectenna. Author

N82-22736*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RECTENNA SYSTEM DESIGN
W. C. BROWN (Raytheon Co., Waltham, Mass.), R. M. DICKINSON, E. J. NALOS (Boeing Aerospace Co.), and J. H. OTT (Nova Electronics Corp.) *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 328-331 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The function of the rectenna in the solar power satellite system is described and the basic design choices based on the desired microwave field concentration and ground clearance requirements are given. One important area of concern, from the EMI point of view, harmonic reradiation and scattering from the rectenna is also designed. An optimization of a rectenna system design to minimize costs was performed. The rectenna cost breakdown for a 56 w installation is given as an example. M.D.K.

N82-22737*# Novar Electronics Corp., Barberton, Ohio.
A THEORETICAL STUDY OF MICROWAVE BEAM ABSORPTION BY A RECTENNA
J. H. OTT, J. S. RICE, and D. C. THORN *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 332-335 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The rectenna's microwave power beam absorption limit was theoretically confirmed by two mathematical models descriptive of the microwave absorption process; first one model was based on the current sheet equivalency of a large planar array above a reflector and the second model, which was based on the properties of a waveguide with special imaging characteristics, quantified the electromagnetic modes (field configurations) in the immediate vicinity of a Rectenna element spacing which permit total power beam absorption by preventing unwanted modes from propagating (scattering) were derived using these models. Several factors causing unwanted scattering are discussed. M.D.K.

N82-22738*# Raytheon Co., Waltham, Mass.
POWER AMPLIFIERS (TUBE)
W. C. BROWN *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 336-339 Jul. 1980
Avail: NTIS HC A99/MFA01 CSCL 10A

An experimental model of the SPS transmitting antenna architecture was developed by combining a microwave oven magnetron with a ferrite circulator, a section of slotted waveguide radiator, and a control system to force the amplitude and the phase of the radiated output to follow phase and amplitude references. The amplitude control arrangement is depicted and evaluated. M.D.K.

N82-22742*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
HIGH-POWER MICROWAVE OPTICS FOR FLEXIBLE POWER TRANSMISSION SYSTEMS
K. E. DREXLER and B. R. SPERBER (Boeing Aerospace Co.) *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 352-355 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

A large concave microwave mirror near the transmitter can magnify the apparent size of the Earth as seen from a phased array, and vice versa, permitting a small phased array to be coupled to a small rectenna while preserving the transmission efficiency (the reflection loss is slight) and peak power densities characteristic of the reference system. This augmentation of the phased array aperture with a large mirror gives the system greater resolution (in the optical sense), and opens new degrees of freedom in SPS design. The consequences of such an approach for a prototype satellite were explored. Its consequences for a mature SPS are discussed. N.W.

N82-22743*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ELECTRIC POWER PROCESSING, DISTRIBUTION, MANAGEMENT AND ENERGY STORAGE
R. J. GIUDICI *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 359-363 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

Power distribution subsystems are required for three elements of the SPS program: (1) orbiting satellite, (2) ground rectenna, and (3) Electric Orbiting Transfer Vehicle (EOTV). Power distribution subsystems receive electrical power from the energy conversion subsystem and provide the power busses rotary power transfer devices, switchgear, power processing, energy storage, and power management required to deliver control, high voltage plasma interactions, electric thruster interactions, and spacecraft charging of the SPS and the EOTV are also included as part of the power distribution subsystem design. N.W.

N82-22746*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
HIGH VOLTAGE SPACE PLASMA INTERACTIONS
J. E. MCCOY *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 372-375 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

Two primary problems resulted from plasma interactions; one of concern to operations in geosynchronous orbit (GEO), the other in low orbits (LEO). The two problems are not the same. Spacecraft charging has become widely recognized as a problem, particularly for communications satellites operating in GEO. The very thin thermal plasmas at GEO are insufficient to bleed off voltage buildups due to higher energy charged particle radiation collected on outer surfaces. Resulting differential charging/discharging causes electrical transients, spurious command signals and possible direct overload damage. An extensive NASA/Air Force program has been underway for several years to address this problem. At lower altitudes, the denser plasmas of the plasmasphere/ionosphere provide sufficient thermal current to limit such charging to a few volts or less. Unfortunately, these thermal plasma currents which solve the GEO spacecraft charging problem can become large enough to cause just the opposite problem in LEO.

N82-22750*# Electromagnetic Compatibility Analysis Center, Annapolis, Md.
THE EMC OF SATELLITE POWER SYSTEMS AND DOD C-E SYSTEMS
J. H. ATKINSON and M. D. AASEN (ITT Research Inst., Annapolis, Md.) *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 424-427 Jul. 1980 refs
Avail: NTIS HC A99/MF A01 CSCL 10A

The solar power satellite (SPS) technical parameters that are needed to accurately assess the electromagnetic compatibility (EMC) between SPS systems and DoD communications-electronics (C-E) systems are identified and assessed. The type of electromagnetic interactions that could degrade the performance of C-E systems are described and the major military installations in the southwestern portions of CONUS where specially sensitive C-E systems are being used for combat training and evaluation are identified. Classes of C-E systems that are generally in the vicinity of these military installations are considered. The Technical parameters that govern the degree of compatibility of the SPS with these C-E systems, and some technical requirements that are necessary to ensure short-term and long-term EMC are identified. J.D.

N82-23117*# Houston Univ., Tex.
INVESTIGATION OF A SOLID STATE POWER COMBINING ANTENNA PROPOSED FOR USE IN THE SOLAR POWER SATELLITE
L. A. FARMER (Kansas Technical Inst.) *In its* The 1981 NASA ASEE Summer Fac. Fellowship Program, Vol. 1 28 p 20 Aug. 1981 refs
Avail: NTIS HC A14/MF A01 CSCL 10A

Performance tests performed on a four-feed microstrip antenna and feed network are analyzed. Frequency response with and without amplifiers, an investigation of noise threshold, phase tracking, and jitter are included. Recommendations for further development of SPS power conversion modules are also included. Author

N82-23261*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ENVIRONMENTALLY INDUCED DISCHARGES ON SATELLITES
N. J. STEVENS 1982 14 p refs Presented at the 2nd EMC Seminar, Noordwijk, Netherlands, 11-13 May 1982; sponsored by ESTEC
(NASA-TM-82849; E-1219; NAS 1.15:82849) Avail: NTIS HC A02/MF A01 CSCL 22B

The problem of assessing hazards to geosynchronous satellite systems from geomagnetic substorm encounters is investigated. The available space flight data, coupled with analytical modeling studies, show that only relatively low differential charging is possible from environmental encounters. Using an analytical study of a discharge event on SCATHA, a discharge process is postulated where a small amount of charge is lost to space. These characteristics could then be used as inputs to a coupling model to determine the hazard to a spacecraft. The procedure is applied to a three axis stabilized satellite design. B.W.

N82-23359*# British Aerospace Dynamics Group, Bristol (England).

A DEPLOYMENT MECHANISM FOR THE DOUBLE ROLL-OUT FLEXIBLE SOLAR ARRAY ON THE SPACE TELESCOPE

T. R. CAWSEY *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 223-233 May 1982 refs

Avail: NTIS HC A15/MF A01 CSCL 13I

A roll-out flexible array which provides more than 4 kW of power for the space telescope was developed. The Array is configured as two wings. The deployment mechanism for each wing is based on flight-proven FRUSA design. Modifications have been incorporated to accommodate an increase in size and mission requirements. The assembly and operation of the deployment mechanism are described together with environmental and functional tests results. Author

N82-23367*# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.

DESIGN OF A 7KW POWER TRANSFER SOLAR ARRAY DRIVE MECHANISM

J. G. SHEPPARD *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 341-350 May 1982 refs

Avail: NTIS HC A15/MF A01 CSCL 13I

With the availability of the Shuttle and the European launcher, Ariane, there will be a continuing trend towards large payload satellite missions requiring high-power, high-inertia, flexible solar arrays. The need arises for a solar array drive with a large power transfer capability which can rotate these solar arrays without disturbing the satellite body pointing. The modular design of such a Solar Array Drive Mechanism (SADM) which is capable of transferring 7kW of power or more is described. Total design flexibility has been achieved, enabling different spacecraft power requirements to be accommodated within the SADM design. Author

N82-24256# Joint Publications Research Service, Arlington, Va.

HOLOGRAPHIC EXPERIMENTS IN SPACE

S. GOREVICH *In its* USSR Rept.: Space, No. 15 (JPRS-80424) p 17-19 29 Mar. 1982 Transl. into ENGLISH from Aviats. Kosmonavt. (USSR), no. 11, Nov. 1981 p 42-43

Avail: NTIS HC A07/MF A01

Experiments conducted on board the Salyut-6 station to demonstrate the suitability and efficiency of the holographic method and television equipment are discussed. The holographic method is of great value to aerospace sciences. It can gather a large amount of information within a short time onboard an orbital station. The information content per exposure is increased and a three dimensional or phased information is obtained. The performance of a series of experiments by the station crew requires continuous participation and monitoring by specialists in a narrow scientific discipline and by technicians on Earth. The activities can be enhanced when television transmitted images are three dimensional. E.A.K.

N82-25642*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

SATELLITE POWER SYSTEM. CONCEPT DEVELOPMENT AND EVALUATION PROGRAM. VOLUME 4: ENERGY CONVERSION AND POWER MANAGEMENT

Nov. 1981 366 p refs

(NASA-TM-58237; NAS 1.15:58237) Avail: NTIS HC A16/MF A01 CSCL 10A

Analyses performed for the satellite power system (SPS) reference system concept are presented. The reference concept together with descriptions of energy conversion, power distribution, and power management for solar photovoltaics, solar thermal, and concept comparisons are reviewed. Studies on energy conversion and power management (environmental impacts, annealing, nuclear SPS concept, and thermionic) are also reported. E.A.K.

N82-26343*# TRW, Inc., Redondo Beach, Calif.

ELECTRIC POWER NEEDS IN SPACE

D. M. WALTZ *In* NASA. Marshall Space Flight Center Float Zone Workshop p 89-98 Sep. 1981

Avail: NTIS HC A10/MF A01 CSCL 22A

The power requirements for specific float zone experiments in space are presented. Power figures for the Space Shuttle and projected available power for advanced vehicles are given. The following power related trends are derived: (1) float zone processing of up to 5 cm diameter silicon and 16.0 cm diameter cadmium telluride can be conducted on a Shuttle pallet mission; (2) float zone processing of up to 8.5 cm diameter silicon for 70% total heating efficiency can be conducted on the initial MEC/space platform; (3) projected available host vehicle power for float zone sample heating; (4) induction heating is found to be the most promising heating method; (5) process control and ease of equipment integration into the host vehicle influence heating method selection. E.A.K.

N82-27378*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

POWER SYSTEMS INTEGRATION

L. W. BRANTLEY *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 239-255 Jun. 1982

Avail: NTIS HC A12/MF A01 CSCL 22B

Power systems integration in large flexible space structures is discussed with emphasis upon body control. A solar array is discussed as a typical example of spacecraft configuration problems. Information on how electric batteries dominate life-cycle costs is presented in chart form. Information is given on liquid metal droplet generators and collectors, hot spot analysis, power dissipation in solar arrays, solar array protection optimization, and electromagnetic compatibility for a power system platform. R.J.F.

N82-27671# Virginia Univ., Charlottesville. Dept. of Materials Science.

DESIGN AND TESTING OF HIGH PERFORMANCE BRUSHES Final Report, 1 Jul. 1976 - 31 Jan. 1982

D. KUHLMANN-WILSDORF Mar. 1982 51 p

(Contract N00014-76-C-1009)

(AD-A113735; UVA/525324/MS82/104) Avail: NTIS HC A04/MF A01 CSCL 20C

A new breed of electrical brush, i.e., unlubricated flexible metal brushes, has been developed. Of these, two specific types, namely metal fiber brushes and metal foil brushes, have been constructed and tested, and theory has been developed which accounts for their behavior, based on Holm's theory of electrical contacts. It has been shown that electrical tunneling makes a significant contribution to current conduction in fiber brushes, outside of the areas needed for bearing the brush force. Correspondingly brush resistance is reduced, the more so the finer the fibers are, and brush performance was found to be very superior. Some of these developments plus a number of other novel designs of unlubricated flexible metal brushes have given rise to two extensive patent applications. The most promising of those latter designs have not yet been reduced to practice but they should go far to eliminate most, and perhaps all, of remaining shortcomings of electrical brushes. In addition, some theoretical research in other areas of ancillary interest to brush behavior has been conducted, most of it in metal fatigue. GRA

N82-28330*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

LAND MOBILE SATELLITE SERVICE (LMSS): A CONCEPTUAL SYSTEM DESIGN AND IDENTIFICATION OF THE CRITICAL TECHNOLOGIES: PART 2: TECHNICAL REPORT

F. NADERI, ed. 15 Feb. 1982 405 p refs 2 Vol.

(Contract NAS7-100)

(NASA-CR-169136; JPL-PUB-82-19-PT-2; NAS 1.26:169136)

Avail: NTIS HC A18/MF A01 CSCL 17B

A conceptual system design for a satellite-aided land mobile service is described. A geostationary satellite which employs a large (55-m) UHF reflector to communicate with small inexpensive user antennas on mobile vehicles is discussed. It is shown that such a satellite system through multiple beam antennas and frequency reuse can provide thousands of radiotelephone and dispatch channels serving hundreds of thousands of users throughout the U.S.

N82-28336*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CASSEGRAIN DUAL REFLECTOR ANTENNA DESIGN
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 8 p 15 Feb. 1982 refs
Avail: NTIS HC A18/MF A01 CSCL 17B

A folded optics reflector system could mitigate problems associated with the pointability and controllability of the large UHF antenna for MSAT. Such a system is comprised of a parabolic main reflector and a hyperboloidal subreflector (Cassegrain arrangement) or an ellipsoidal subreflector (Gregorian arrangement), either of which brings the feed closer to the main reflector. By shaping the subreflector and the main reflector, an improved scan capability might be achieved and the size of the required feed aperture-per-beam could be reduced. In such a shaped dual reflector system, the need for overlapping cluster feed arrangement and its concomitant beam forming network could be removed. In this system, a relatively low gain feed element together with the shaped subreflector would be sufficient to produce the required high illumination taper that at the main reflector. A.R.H.

N82-28337*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DUAL-SHAPED REFLECTOR DESIGN
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 8 p 15 Feb. 1982
Avail: NTIS HC A18/MF A01 CSCL 17B

Software for dual shaped reflector synthesis was upgraded to more rapidly and automatically generate an entire 3-dimensional, 2-reflector system as opposed to arbitrarily chosen profiles. A physical optics/physical optics analysis program was developed which used raw data without interpolation and converts these data into triangular facets that are appropriately ordered and thinned. A series of profiles was developed. These profiles are not rotationally symmetric nor a portion of a parent circularly symmetric geometry. They should provide -30 dB sidelobes for the feed located at the focus. The eometry permits one beam for feed in a multiple beam configuration. The geometric theory of diffraction was used to test the geometry. A.R.H.

N82-28339*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERMODULATION ANALYSIS
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 11 p 15 Feb. 1982 refs
Avail: NTIS HC A18/MF A01 CSCL 17B

In single channel-per-carrier (SCPC) telecommunication system, hundreds of carriers are routed through common nonlinear satellite amplifiers causing intermodulation distortion. While development of nearly linear and efficient high-power amplifiers is essential to LMSS to reduce this distortion, some degree of intermodulation is unavoidable. An evaluation of the carrier-to-intermodulation ratio for each channel is an essential element in the design of such systems for optimum utilization of satellite power and bandwidth. The determination of channel distribution within the power amplifier bandwidth is considered. A.R.H.

N82-28340*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIPLE BEAM OFFSET ANTENNA DESIGN PROCESSES
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 15 p 15 Feb. 1982 refs
Avail: NTIS HC A18/MF A01 CSCL 17B

Both RF design steps and performance evaluation processes of multiple beam offset parabolic reflectors are described. Attempts are made to present the general methodology with a demonstration of the final results. A.R.H.

N82-30474*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPONENT TECHNOLOGY FOR SPACE POWER SYSTEMS
R. FINKE 1982 13 p refs Presented at the 33rd Intern. Astronautical Federation Congr., Paris, 26 Sep. - 2 Oct. 1982
(NASA-TM-82928; E-1322; NAS 1.15:82928) Avail: NTIS HC A02/MF A01 CSCL 09C

The Lewis/OAST program for the development of Component Technology for Space Power Systems is described. The program is divided into five generic areas: semiconductor devices (transistors, thyristors, and diodes); conductors (materials and transmission lines); dielectrics; magnetic devices; and thermal control devices. Examples of progress in each of the five areas is discussed. Bipolar power transistors up to 1000 V at 100 A with a gain of 10 and a 0.5 mu sec rise and fall time are presented. A new class of semiconductor devices with a possibility of switching 1000 000 V is described. Several 100 kW rotary power transformer designs and a 25 kW, 20 kHz transformer weighting 3.2 kg have been developed. Progress on the creation of diamond-like films for thermal devices and intercalated carbon fibers with the strength of steel and the conductivity of copper at one third the mass of copper is presented. Author

N82-30706*# Spire Corp., Bedford, Mass.
DEVELOPMENT OF A LARGE AREA SPACE SOLAR CELL ASSEMBLY Final Report, Jul. 1981 - Mar. 1982
M. B. SPITZER May 1982 65 p refs
(Contract NAS3-22236)
(NASA-CR-167929; NAS 1.26:167929; FR-10081) Avail: NTIS HC A04/MF A01 CSCL 10A

The development of a large area high efficiency solar cell assembly is described. The assembly consists of an ion implanted silicon solar cell and glass cover. The important attributes of fabrication are the use of a back surface field which is compatible with a back surface reflector, and integration of coverglass application and cell fabrications. Cell development experiments concerned optimization of ion implantation processing of 2 ohm-cm boron-doped silicon. Process parameters were selected based on these experiments and cells with area of 34.3 sq cm wre fabricated. The average AMO efficiency of the twenty-five best cells was 13.9% and the best bell had an efficiency of 14.4%. An important innovation in cell encapsulation was also developed. In this technique, the coverglass is applied before the cell is sawed to final size. The coverglass and cell are then sawed as a unit. In this way, the cost of the coverglass is reduced, since the tolerance on glass size is relaxed, and costly coverglass/cell alignment procedures are eliminated. Adhesive investigated were EVA, FEP-Teflon sheet and DC 93-500. Details of processing and results are reported. B.W.

N82-31348*# Lockheed Missiles and Space Co., Sunnyvale, Calif. 22b
MULTI-100 KW: PLANAR LOW COST SOLAR ARRAY DEVELOPMENT Final Review Report
Jun. 1982 45 p
(Contract NAS8-32981)
(NASA-CR-162067; NAS 1.26:162067) Avail: NTIS HC A03/MF A01

The development of a 100 kW planar low cost solar array is presented. Tasks are defined, objectives are stated, and test results are given. A study of alternate contact configuration concluded that gridded back contact cells sharply reduced solar absorptance, that copper contacts will require a developmental program before interface can be achieved, and that gridded back contact cells using Ti-Pd-Ag as the contact materials appear to be the most cost-effective design. R.J.F.

N82-31349*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
MULTI-100 KW: PLANAR LOW COST SOLAR ARRAY DEVELOPMENT Final Report, 1 Sep. 1981 - 31 Jul. 1982
Jun. 1982 76 p Original contains color illustrations
(Contract NAS8-32981)
(NASA-CR-162068; LMSC-D843500; NAS 1.26:162068) Avail: NTIS HC A05/MF A01 CSCL 22B

The applicability of selected low cost options to solar array blanket design was studied by fabricating representative modules and submitting them to thermal cycle environment. Large area (5.9 x 5.9 cm) solar cells of 3 varieties were purchased: (1) Standard wraparound, (2) Copper contacts substituted for the conventional Titanium-Palladium-Silver, and (3) Standard wraparound except with gridded back contact instead of continuous metallization. The baseline cell was purchased to compare fabrication cost and to serve as a control cell during test evaluation of the other two cells. All cells were assembled into either substrate modules where the cell is individually filtered and welded to an integrated Kapton-copper circuit or into a superstrate configuration with 4 cells jointly adhered to a single sheet of microsheet and then welded to the integrated Kapton-copper circuit. Cell quality, particularly in the metallization of contacts, was less than desired. Problems were encountered with copper metallization in laying down a barrier metal which would ohmically bond to the silicon. The cells received were shunted (sintered) or with low contact pull strength (non-sintered), thus leading to the decision to solder rather than weld the copper cells to the Kapton substrate. R.J.F.

N82-32287# Joint Publications Research Service, Arlington, Va.
PROSPECTS FOR POWER ENGINEERING IN SPACE
V. S. AVDUYEVSKIY, S. D. GRISHIN, L. V. LESKOV, V. K. ABLEKOV, and A. F. YEVICH *In its* USSR Rept.: Space, No. 17 (JPRS-81552) p 62-70 17 Aug. 1982 Transl. into ENGLISH from Zemlya Vselennaya (USSR), no. 6, Nov. - Dec. 1981 p 2-6
Avail: Issuing Activity

Methods for producing electric power in space, including satellite solar power stations, nuclear breeder reactors, and thermonuclear reactors are examined in terms of estimated costs and power production capabilities. Mass reduction of power stations, the transport of components into space, and the delivery of assemblies into a geosynchronous orbit are discussed. The advantages of using electric rocket engines for interorbital delivery 'tugs' are outlined and the feasibility of using laser engine launch vehicles with Earth based laser energy sources is explored. M.G.

N82-32855*# PRC Systems Sciences Co., Tucson, Ariz.
GALLIUM ARSENIDE SOLAR ARRAY SUBSYSTEM STUDY Final Report, Jan. 1981 - Feb. 1982
F. Q. MILLER Feb. 1982 221 p refs
(Contract NAS3-22667)
(NASA-CR-167869; NAS 1.26:167869) Avail: NTIS HC A10/MF A01 CSCL 10A

The effects on life cycle costs of a number of technology areas are examined for a gallium arsenide space solar array. Four specific configurations were addressed: (1) a 250 KWe LEO mission - planer array; (2) a 250 KWe LEO mission - with concentration; (3) a 50 KWe GEO mission planer array; (4) a 50 KWe GEO mission - with concentration. For each configuration, a baseline system conceptual design was developed and the life cycle costs estimated in detail. The baseline system requirements and design technologies were then varied and their relationships to life cycle costs quantified. For example, the thermal characteristics of the baseline design are determined by the array materials and masses. The thermal characteristics in turn determine configuration, performance, and hence life cycle costs. Author

N82-33593*# National Aeronautics and Space Administration. Pasadena Office, Calif.
METHOD AND APPARATUS FOR SELF-CALIBRATION AND PHASING OF ARRAY ANTENNA Patent Application
C. WU, inventor (to NASA) (JPL, California Inst. of Tech., Pasadena) 30 Jul. 1982 22 p
(Contract NAS7-100)
(NASA-CASE-NPO-15920-1; US-PATENT-APPL-SN-403848)
Avail: NTIS HC A02/MF A01 CSCL 09C

A central feed broadcasts a continuous and coherent wave from a transmitter to array elements through radiation electronics. Return electromagnetic wave energy is received from each element by a synchronous receiver through a circulator, either by leakage of energy from a power amplifier through a circulator to a receiver amplifier coupled to a reciprocal phase shifter by a directional coupler in one mode, or from a short circuit switch in another mode. The phase shifters are assumed to be set for a precomputed array pattern for a predetermined array structure. A phase controller advances the phase angles for the phase shifters at different rates in order to introduce a distinct frequency modulation of the returned energy for each array element. The composite return energy is coherently demodulated by a Fourier transform processing system, the output of which corresponds to the response of the array elements. The phase compensation required for each antenna element to achieve the precomputed array pattern is then derived from its response by the phase controller. NASA

07

ADVANCED MATERIALS

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

A82-31878#
ULTRAVIOLET AND ELECTRON IRRADIATION OF DC-704 SILOXANE OIL IN ZINC ORTHOTITANATE PAINT
D. L. MOSSMAN, M. K. BARSH, and S. A. GREENBERG (Aerojet ElectroSystems Co., Azusa, CA) American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 3rd, St. Louis, MO, June 7-11, 1982, AIAA 6 p. refs
(AIAA PAPER 82-0865)

Discrepancies exist between accelerated laboratory simulation and geosynchronous orbit flight data for zinc orthotitanate (ZOT) paint degradation. The effects of ultraviolet and electron irradiation on ZOT contaminated with DC-704 silicone oil are reported. In-situ solar absorptance and emittance changes for contaminated and clean specimens are discussed with reference to post-test surface morphology, determined by scanning electron microscope analysis. Features of the contaminated ZOT degradation kinetics correlate with orbital performance (Author)

A82-32350#
THE APPLICATION OF WEIGHTLESSNESS
M. EYB Dornier-Post (English Edition), no. 1, 1982, p. 39-44.

A Shuttle-retrievable payload carrier is currently under study by ESA as a facility for conducting materials research and life sciences experiments in space requiring high energy, long durations, low disturbing accelerations and reduced safety precautions. Payloads defined for the carrier provide for experiments on materials production involving the use of a mirror heating facility, mirror furnaces, a gradient furnace with quenching device and an arc welding facility. Life sciences experiments would make use of biochambers similar to the Biorack developed for Spacelab but with handling operations performed automatically and separate chambers for the cultivation of plants, protozoa, cells and tissues, and insects. A.L.W.

A82-36275* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

SHORT-TERM STABILITY OF HIGH-SILICA GLASSES

D. B. LEISER (NASA, Ames Research Center, Moffett Field, CA) Ceramic Engineering and Science Proceedings, vol. 2, July-Aug. 1981. 9 p. refs

The devitrification characteristics of high-silica (70-90%) glasses for use in potential higher temperature coatings on advanced insulation systems for space vehicles were determined at 1260 C after 24 h. These data indicate that additives can be used to maintain the stability of these coatings relative to cristobalite formation. (Author)

A82-37801#

THE GERMAN MATERIAL PROCESSING IN SPACE ACTIVITIES

G. GREGER (Bundesministerium fuer Forschung und Technologie, Bonn, West Germany) American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium on Spacelab, Space Platforms and the Future, 20th, Greenbelt, MD, Mar. 17-19, 1982, AAS 20 p.
(AAS PAPER 82-105)

The paper provides a survey about the present material processing activities in the FRG: the first chapter deals with the scientific tasks and objectives, the second part describes the flight test programs and equipment, like the TEXUS sounding rocket program, MAUS packages for Shuttle flights, the SPAS-01 carrier, the Material Science Lab for FSLP and the German Spacelab Mission D1. The third part covers programmatic aspects and future planning with emphasis on the continued use of manned facilities and the new means of retrievable platforms for extended mission periods. (Author)

A82-37805#

ESA MICROGRAVITY PLATFORM PLANS AND EXPERIMENTS

G. SEIBERT (ESA, Paris, France) American Astronautical Society and Deutsche Gesellschaft fuer Luft- und Raumfahrt, Goddard Memorial Symposium on Spacelab, Space Platforms and the Future, 20th, Greenbelt, MD, Mar. 17-19, 1982, AAS 17 p.
(AAS PAPER 82-110)

The primary payload of the Space Shuttle Retrievable Carrier's (RC) first flight, in late 1986, will be a microgravity experiment package. After separation from the Space Shuttle and boosting to a higher orbit, the RC will operate for several months at a continuous microgravity level of 0.0005 g in a 450-km orbit. The microgravity experiments currently being formulated are of two main types, materials processing and life sciences. The former will emphasize crystal growth investigations, incorporating an ellipsoidal mirror furnace facility for zone melting, and facilities for crystal growth from solution and from vapor, as well as for protein crystal growth. Life sciences investigations will be served by a Biochamber carrying plants, insects, mammalian cells and tissues, and micro-organisms. Experiments will include the formation and stability of organic molecules in cosmic matter, and the assessment of the biological importance of certain components of cosmic radiation. O.C.

A82-39888

NEW CFRP STRUCTURAL ELEMENTS

T. HOSOMURA, T. KAWASHIMA (Nissan Motor Co., Ltd., Aeronautical and Space Div., Tokyo, Japan), and D. MORI (Tokyo, University, Tokyo, Japan) In: Composite materials: Mechanics, mechanical properties and fabrication; Proceedings of the Japan-U.S. Conference, Tokyo, Japan, January 12-14, 1981. Barking, Essex, England, Applied Science Publishers, 1982, p. 447-452.

Two types of carbon fiber reinforced plastic (CFRP) were successfully fabricated and tested as structural elements. One is a cylindrical grid structure so fabricated that the continuous yarns are wound over each other in one dimension, while the other consists of pipes of cast thread with the longitudinal fibers fastened by circumferential ones. The fabrication and test methods are described in detail, and the calculated and measured stresses at specific points of the diagonal and circumferential bar in the bending and compressive tests are shown for the grid structural type. For the pipe type, the materials, dimensions, and required and measured strength of the stay and slant bars are exhibited. C.D.

A82-40960#

A NEW TESTING METHOD OF IMPULSIVE BEHAVIOUR FOR AEROSPACE MATERIALS

K. KAWATA, S. HASHIMOTO, and N. TAKEDA (Tokyo, University, Tokyo, Japan) In: International Council of the Aeronautical Sciences, Congress, 13th and AIAA Aircraft Systems and Technology Conference, Seattle, WA, August 22-27, 1982, Proceedings. Volume 2. New York, American Institute of Aeronautics and Astronautics, 1982, p. 826-836. refs

Constitutive equations for BCC and FCC crystal lattice metals are presented which model mild steel and high-strength aluminum alloys, respectively, on the basis of dislocation micromechanics. The equations are then used to analyze elastoplastic wave propagation in BCC and FCC metals by means of finite element methods, demonstrating a clear difference between the two metals with respect to the presence of a sharp stress peak at the wavefront. A novel one-bar high velocity tension testing method of the block-to-bar type is devised on the basis of comparisons among previous results, and formulae are derived for dynamic stress and strain on the basis of one-dimensional stress wave propagation theory. Comparisons are made among the high velocity tension behaviors of carbon fiber and glass fiber reinforced plastics, in addition to the two metals cited. O.C.

A82-41429

DETERMINATION OF THE FRACTURE TOUGHNESS CHARACTERISTICS OF HIGH-STRENGTH ALUMINUM ALLOYS AT LOW TEMPERATURE [OPREDELENIE KHARAKTERISTIK TRESHCHINOSTOIKOSTI VYSOKOPROCHNYKH ALIUMINIEVYKH SPLAVOV PRI NIZKIKH TEMPERATURAKH]

S. Z. STASIUK Kosmicheskie Issledovaniia na Ukraine, no. 15, 1981, p. 23-28. In Russian. refs

A method involving off-center tensile testing of notched specimens has been used to determine the specific energy of crack propagation in aluminum-magnesium alloys AMg 6 and 5083 (including welded joints) at 293 and 77 K. A correlation is established between fracture toughness parameters and specific energy of crack propagation. It is shown that the rupture strength and the resistance to brittle fracture increase with alloy purity both at 293 and 77 K. V.L.

A82-41441#

CERTAIN PROBLEMS IN SPACE MANUFACTURING [NEKOTORYE VOPROSY KOSMICHESKOI TEKHNOLOGII]

S. S. KIPARISOV Srpska Akademija Nauka i Umetnosti, Posebna Izdanja, no. 529, Odeljenje Tekhnichkikh Nauka, no. 20, 1980. 22 p. In Russian. refs

Various aspects of space manufacturing are discussed, including the use of the Bridgman furnace, powder-metallurgical processes, crystal growth and volume crystallization in a universal furnace during the Morava experiment, and the Sirena experiment on Salyut-6-Soyuz. The conducting of biomedical experiments in space is discussed, and the repair and maintenance of space stations is considered. B.J.

A82-42675

AEROSPACE APPLICATIONS OF COMPOSITES

G. LUBIN and S. J. DASTIN (Grumman Aerospace Corp., Bethpage, NY) In: Handbook of composites. New York, Van Nostrand Reinhold Co., 1982, p. 722-743. refs

It is estimated that within 10 years composites will comprise up to 40 percent of all aircraft structures. This is due to the fact that high performance composites are the only existing materials meeting the requirements for light weight, high strength, high stiffness and good fatigue resistance characteristic of aerospace applications. For example, a graphite composite has a tensile strength of 3.6 x 10 to the sixth in. compared with 0.8 x 10 to the sixth for aluminum, and a fatigue endurance of 80 percent of its static strength, compared with 35 percent for aluminum. Additional advantages over commonly used metals include: superior surface finish, dimensional stability, material uniformity and freedom of aerodynamic design and contouring. Current applications to spacecraft include: rocket nozzles, filament wound tanks and grid-stiffened composite panels. Applications for aircraft currently include wing skins and stabilizers, with static engine components envisioned. A.B.

A82-43149
NONDESTRUCTIVE TESTING TO STUDY STRESS-RELAXATION IN ADVANCED COMPOSITES FOR TELECOMMUNICATIONS SATELLITES
T. J. DELACY (Ford Aerospace and Communications Corp., Palo Alto, CA) SAMPE Journal, vol. 18, Sept.-Oct. 1982, p. 8-15. refs

Manufacture and post-processing parameters aimed at optimizing the residual properties of advanced graphite composites for telecommunications satellites are considered. Ultrasonic system calibration has been developed in order to identify stress relaxation sites in the composite. Acoustic emission testing was performed to analyze the influence manufacturing parameters have on the residual stress state of the composite. A 0-500 KHz wideband transducer selects the optimum test frequency, and testing is conducted over a temperature excursion from approximately -40 C to 80 C. It is shown that viscoelastic behavior is confirmed by stress relaxation (an unexpected result for such low temperature testing). Autoclave cure and postcure conditioning parameter analysis indicates that the nature of postcure processing influences the stress distribution state of a composite. These conclusions advance the application of nondestructive testing to control the stress distribution potential. R.K.R.

A82-44679#
THE EXISTENCE AND POSITION OF NODAL CIRCLES ON A LIQUID SPHERICAL SEGMENT OSCILLATING AT ITS FUNDAMENTAL RESONANT FREQUENCY IN WEIGHTLESSNESS [EXISTENCE ET POSITION DE CERCLES NODAUX SUR UNE CALOTTE SPHERIQUE LIQUIDE OSCILLANT EN MICROGRAVITE A SA FREQUENCE PRINCIPALE DE RESONANCE F/R/. S,C. BISCH (CNRS, LABORATOIRE D'AEROTHERMIQUE, MEUDON, HAUTS-DE-SEINE, FRANCE]
International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 5 p. In French.
(IAF PAPER 82-135)

Droplets of a benzene-carbon tetrachloride suspended in distilled water were examined experimentally to detect the presence of circular nodes during maximum deformation in oscillation. Photographs were made of each deformation of the semispheres, which rested on a base, as the oscillation was induced. It was found that the deformations progressed toward the equator of the droplet as the deformation increased, and maximum deformation was limited to forming a free sphere with an equatorial angle of 90 deg. The oscillation tended to eliminate any movement of the sphere itself, a feature which is suggested to be useful to materials processing studies on board the Spacelab. M.S.K.

A82-44744#
OPTICAL FIBER DEVICES IN SPACE ENVIRONMENTAL CONDITIONS
K. SHIMODAIRA (National Space Development Agency of Japan, Tokyo, Japan), T. MATSUOKA, Y. MIYAJI (National Space Development Agency of Japan, Sakura, Ibaraki, Japan), K. MURATA, Y. KOYAMA, and M. SHIMIZU (Nippon Electric Co. Ltd., Yokohama, Japan) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 10 p.
(IAF PAPER 82-391)

The performance of various optical fiber devices, such as optical fiber cords and light emitting diode (LED) receptacles, is presented in terms of mechanical, thermal, out-gassing, and irradiation characteristics. First, the optical fiber cord strength proved sufficient, and out-gassing and thermal (-55 C to 150 C) characteristics were improved in trial manufacturing. Second, tests show an output variation for LED receptacles of less than 0.06 dB at 0.87 x 10 to the 6th rad (Si) of gamma radiation, and + or - 0.5 dB for -55 C to 150 C when temperature variation is considered. A future spaceborne fiber optic data system offers a 56% weight reduction, and tests show the good potential of such a system. R.K.R.

A82-45269#
SPACE TELESCOPE OPTICAL TELESCOPE ASSEMBLY STRUCTURAL MATERIALS CHARACTERIZATION
L. L. MCMAHAN (Boeing Aerospace Co., Seattle, WA) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 127-137.
(AIAA 82-1858)

The Optical Telescope Assembly of the Space Telescope incorporates a metering truss structure (MTS) which uses high strength/high modulus Thornel fibers, and a flight focal plane structure (FFPS) employing three different fibers, as well as an optical bench structure and a fine guidance system optical bench with similar fiber reinforcements. Attention is given the MTS and FFPS, both of whose fibers are prepregged by a 934 epoxy resin that must be subsequently cured. Techniques and verification data for zero coefficient of thermal expansion layups are presented for the 275 F cure selected. Typical strengths of selected lamina are found to range from 100 to 240 kilopounds/sq in, while the Young's modulus ranged from 20 to 46 million pounds/sq in, depending on the reinforcing fiber used. O.C.

A82-46972#
BRIEF DESCRIPTION OF TYPICAL ELEMENTS OF A MULTI-FURNACE ASSEMBLY CONCEPT /M.F.A./ ACCOMMODATED ON EURECA
F. J. CHANGEART, G. CAMBON, R. BARILLOT (Centre National d'Etudes Spatiales, Groupe d'Etude et Recherche sur les Materiaux dans l'Espace, Toulouse, France), and J. C. LAUNAY (Bordeaux I, Universite, Talence, Gironde, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 7 p. European Space Agency refs
(Contract ESA-4953/81/F)
(IAF PAPER 82-166)

Characteristics of the multi-furnace assembly (MFA) for the EUropean REtrievable CArrier (EURECA) spacecraft are described, along with two candidate furnaces. The MFA concept allows multiuser experiments in zero-g conditions, with a sufficient power supply and autonomous operation for relatively long time periods. Experiments are possible in the fields of directional solidification of metal, alloys, and composites, crystal growth from either vapor phase or solution, glass, ceramics, etc. Features of the proposed apparatus are described, including sensors, power supply, the mechanical and support structure, a thermal sink, and a levitator. A ground-based MFA simulator would be employed for qualification tests. Attention is given to a multi-purpose isothermal gradient furnace, which would furnish a 100 mm isothermal zone with gradients up to 400 C/cm. Specifications of a heat pipe furnace for vapor phase crystal growth are provided. M.S.K.

N82-22315*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEVELOPMENT AND DEMONSTRATION OF MANUFACTURING PROCESSES FOR FABRICATING GRAPHITE/LARC 160 POLYIMIDE STRUCTURAL ELEMENTS Final Report
R. K. FROST, J. S. JONES, P. J. DYNES, and D. H. WYKES Dec. 1981 499 p refs
(Contract NAS1-15371)
(NASA-CR-165809; NAS 1.26:165809) Avail: NTIS HC A21/MF A01 CSCL 11D

The development and demonstration of manufacturing technologies for the structural application of Celion graphite/LARC-160 polyimide composite material is discussed. Process development and fabrication of demonstration components are discussed. Process development included establishing quality assurance of the basic composite material and processing, nondestructive inspection of fabricated components, developing processes for specific structural forms, and qualification of processes through mechanical testing. Demonstration components were fabricated. The demonstration components consisted of flat laminates, skin/stringer panels, honeycomb panels, chopped fiber compression moldings, and a technology demonstrator segment (TDS) representative of the space shuttle aft body flap. R.J.F.

N82-22720*# Boeing Aerospace Co., Seattle, Wash.
PROTON DAMAGE ANNEALING KINETICS IN SILICON SOLAR CELLS
W. E. HORNE, I. ARIMURA, and A. C. DAY *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 254-257 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

Proton damage annealing as a method for prolonging the life of solar power systems in space is discussed. Variables are minimized and fundamental characteristics of proton damage annealing are considered. The usefulness of annealing for prolonging space missions is evaluated. A preliminary determination of optimum annealing conditions is made, and base data provided for more detailed research programs. J.D.

N82-23410# Comelin, Limours (France).
INTERCONNECTIONS: STUDY OF RESISTANCE IN INSULATION OF FLEXIBLE AND SEMIRIGID CIRCUITS [ETUDE DES RESISTANCES D'ISOLEMENT SUR CIRCUITS SOUPLES ET FLEX-RIGIDES]
G. GUILLERM 5 Nov. 1981 87 p refs In FRENCH
Avail: NTIS HC A05/MF A01

The influence of different parameters that define the electrical resistance of insulating materials between conductors was studied in order to deduce laws which can be used in designing interconnecting systems, e.g. MAGIC or STACP. Test specimens of insulation were obtained from several manufacturers and electrical measurements conditions were parameterized. Problems relative to measuring high resistance were identified. A three-step procedural scheme for quality control of insulation is presented, i.e. (1) prediction of insulation resistance before fabrication, (2) verification during fabrication, and (3) inspection after fabrication. Author (ESA)

N82-24274# Aerospace Corp., El Segundo, Calif. Space Sciences Lab.
LABORATORY AND SPACE RESULTS FROM THE SSPM EXPERIMENT
P. F. MIZERA, M. S. LEUNG, and H. K. A. KAN 15 Jul. 1981 47 p refs
(Contract F04701-80-C-0081)
(TOR-0081(6505-02)-3) Avail: NTIS HC A03/MF A01

Material charging results from the satellite surface potential monitor experiment were used as a framework for the modeling of spacecraft charging. Data from two magnetically disturbed times were chosen; one when the P78-2 satellite was in eclipse and the other which occurred prior to eclipse. On both days, the spacecraft charged negatively in the Earth's shadow to greater than 5 kV. Charging profiles of typical spacecraft materials received from the satellite surface potential monitor experiment aboard the P78-2 SCATHA Satellite show a number of interesting as well as unexpected features. During the natural charging event on April 24, 1979, the Kapton sample was charged to a voltage significantly lower than that of the Teflon sample whereas earlier test results showed they should be comparable. At the same time, also contrary to previous ground measurements, the quartz fabric sample acquired a surface potential up to several kilovolts instead of a few hundred volts normally observed in the laboratory. In order to resolve the difference observed between flight and ground measurements, a laboratory study was carried out. B.W.

N82-24306# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
EFFECT OF ENVIRONMENTAL INFLUENCES ON THE MECHANICAL PROPERTIES OF CFRP [AUSWIRKUNG VON UMWELTEINFLUESSEN AUF DIE MECHANISCHEN EIGENSCHAFTEN VON CFK]
M. GAEDKE *In its* Damage Mech. for Fiber Reinforced Composite Struct. p 85-119 Jun. 1981 refs In GERMAN; ENGLISH summary
Avail: NTIS HC A11/MF A01; DFVLR, Cologne DM 71,10

Hygrothermal, thermal and radiation degradation of carbon fiber reinforced plastics were studied. Specific aerospace environmental conditions affect mechanical properties, such as strength and moduli. Variations in these properties, either decreasing or increasing, were determined. The test program and procedures are described. Test results demonstrate that environmental moisture and temperature parameters cause a decrease in mechanical strength and elasticity. Thermal cycling (+95 to -155 C) is particularly detrimental, while outgassing is also related to temperature. Results of electron irradiation show degradation similar to thermal damage. Author (ESA)

N82-24309# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
MECHANISMS AND KNOWN VALUES FOR THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON CFRP [MECHANISEM UND KENNWERTE DES EINFLUSSES VON E UNWELTBEDINGUNGEN AUF DAS VERHALTEN VON CFK]
P. NITSCH *In its* Damage Mechanics for Fiber Reinforced Composite Struct. p 197-226 Jun. 1981 refs In GERMAN; ENGLISH summary
Avail: NTIS HC A11/MF A01; DFVLR, Cologne DM 71,10

Degradation mechanisms and characteristic values for environmental effects on graphite-epoxy composite materials are discussed with reference to aeronautics. The generally attractive strength properties of CFRP tend to diminish under the influence of irradiation, thermal cycling, and moisture. Quantitative results are shown for UV radiation damage, temperature dependence (including outgassing), and for effects of moisture content. Author (ESA)

N82-24337# National Bureau of Standards, Washington, D.C.
US DEPARTMENT OF COMMERCE PUBLIC WORKSHOP ON CRITICAL MATERIALS NEEDS IN THE AEROSPACE INDUSTRY
J. B. WACHTMAN, JR., ed. Jul. 1981 700 p refs Workshop held 9-10 Feb. 1981
(PB82-137266; NBSIR-81-2305) Avail: NTIS HC A99/MF A01 CSCL 11F

The materials issues of primary concern to the American aerospace industry and its suppliers; recommendations of the *American aerospace industry and its suppliers for Federal action* to address these issues. Specific materials the Department of Commerce should review in detail over the next few months in order to recommend the most urgently needed programs for Federal action were considered. These topics were addressed within three distinct areas: critical raw materials, critical engineering materials, and substitution, conservation, specialized recycling, and higher performance. The formal views presented to the plenary workshop sessions, the reports of the workshop task forces in each of the three areas, and the written submissions invited in

the Federal Register notice of the workshop are presented.
GRA

N82-24363# European Space Research and Technology Center, Noordwijk (Netherlands).
THE SPACE TECHNOLOGY DEMAND ON MATERIALS AND PROCESSES
J. DAUPHIN *In* ESA 2nd ESA Prod. Assurance Symp. p 3-11 Jan. 1982 refs
Avail: NTIS HC A22/MF A01; ESA, Paris FF 140 Member States, AU, CN and NO (+20% others)

Space technologies which entail materials or process problems, such as clean satellites, thermal control materials with electrical conductivity, space stations and reusable hardware are reviewed. The statistical approaches to selection used are jeopardized by small production volumes, while the analogy methods are limited by experience. Commercially available materials are extensively used in order to cut development costs, e.g., solar panel adhesives are obtained by cleaning commercial silicones by molecular distillation. The long-life and reusable spacecraft requirements, e.g., for very thin laminates, which cannot be met by commercial products are discussed. Space agencies either meet needs themselves (NASA makes white conductive paint) or they develop solutions in partnership with manufacturers. Author (ESA)

N82-24431*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIRST RESULTS OF MATERIAL CHARGING IN THE SPACE ENVIRONMENT Interim Report
N. J. STEVENS, F. BERKOPEC, J. STASKUS, P. F. MIZERA, H. C. KOONS, E. R. SCHNAUSS, D. R. CROLEY, JR., H. K. KAN (Aerospace Corp.), M. S. LEUNG (Aerospace Corp.), W. L. LEHN (AFML) et al. 15 Mar. 1981 20 p refs Prepared in cooperation with SRI International, Menlo Park, Calif.
(Contract F04701-80-C-0081)
(NASA-TM-84743; NAS 1.15:84743; TOR-0081(6506-1)-1) Avail: NTIS HC A02/MF A01 CSCL 09C

A satellite experiment, designed to measure potential charging of typical thermal control materials at near geosynchronous altitude, was flown as part of the SCATHA program. Direct observations of charging of typical satellite materials in a natural charging event (5 keV) are presented. The results show some features which differ significantly from previous laboratory simulations of the environment. S.L.

N82-24445# Aeritalia S.p.A., Torino (Italy). Gruppo Equipaggiamenti.
CHARACTERIZATION OF ELECTROSTATIC DISCHARGE TRANSIENTS Final Report
G. GERBI, M. MENSA, and D. GOLZIO Paris ESA 30 Oct. 1980 144 p refs
(Contract ESTEC-4165/79/NL-JS)
(RCE-2163; ESA-CR(P)-1523) Avail: NTIS HC A07/MF A01

Electrostatic discharges which occur on spacecraft were simulated on Teflon, Mylar and Kapton samples. Electric field emission, magnetic field emission, structure discharge current, and voltage and current coupling on interface circuits were examined. Results show that discharge amplitude is a function of sample size, but the relation is not directly proportional. Teflon has the highest discharge amplitude. Mylar and Kapton have almost the same discharge amplitudes, but Mylar is damaged after 30 min testing. Perforated Kapton does not discharge. Author (ESA)

N82-25303*# Dayton Univ., Ohio. Research Inst.
OUTGASSING: ITS EFFECTS ON SPACECRAFT. VIBRATION DAMPING MATERIALS
M. L. DRAKE, M. F. KLUESENER, and W. R. GODDARD *In* NASA. Goddard Space Flight Center 12th Space Simulation Conf. 25 p 1982 refs Sponsored in part by International Telecommunication Satellite Organization
Avail: NTIS HC A15/MF A01 CSCL 22B

The correlation of outgassing to the stability of the damping properties of polymer materials to be used in spacecraft structures is discussed. A test series was devised to obtain basic information from off-the-shelf damping materials. The test results could be considered as a guideline toward the application of these materials. Eight materials were selected to form a representative cross section of those polymers having both ready availability as commercial damping materials and desirable properties. A table indicates the temperatures at which peak damping occurs at 1 Hz and the type of beam specimen used in the vacuum exposure tests. These materials as a group cover the temperature range of -85 C to 38 C. R.J.F.

N82-25310*# Martin Marietta Aerospace, Denver, Colo.
CONTAMINANT CHARACTERIZATION OF FIVE SATELLITE MATERIALS
J. A. MUSCARI *In* NASA. Goddard Space Flight Center 12th Space Simulation Conf. 16 p 1982 refs
(Contract F33615-78-C-5168)
Avail: NTIS HC A15/MF A01 CSCL 22B

An extensive laboratory test program was performed to characterize outgassing of five satellite materials. The materials were Chemglaze Z-306 over 9922 primer, M-773 adhesive, multilayer insulation, polyurethane foam, and silverized Teflon. The souces were prepared to the specifications of a typical satellite program. Dynamic thermogravimetric mass loss characteristics of these five materials were obtained in vacuum with a beam microbalance. The temperature of the material was linearly raised from 25 C to over 650 C while monitoring the mass loss, rate of mass loss, temperature, and the composition of the outgassed material by residual gas analysis. Isothermal source emission/capture coefficients/reemission parameters were obtained with an array of quartz crystal microbalances (QCM). A detailed test matrix in which the temperatures of the QCMs (-160 C, - 100 C, -40 C, and +10 C) and the source material (125 C, and 90 C, and 50 C) were varied was performed. The array of QCMs was also used to measure the spatial distribution of the source emission. The effects of vacuum ultraviolet radiation on the deposition and reemission parameters was determined.
Author

N82-25311*# Boeing Aerospace Co., Seattle, Wash.
IUS MATERIALS OUTGASSING CONDENSATION EFFECTS ON SENSITIVE SPACECRAFT SURFACES
C. R. MULLEN, C. G. SHAW, and E. R. CRUTCHER *In* NASA. Goddard Space Flight Center 12th Space Simulation Conf. 22 p 1982
(Contract F04701-78-C-0053)
Avail: NTIS HC A15/MF A01 CSCL 22B

Four materials used on the inertial upper state (IUS) were subjected to vacuum conditions and heated to near-operational temperatures (93 to 316 C), releasing volatile materials. A fraction of the volatile materials were collected on 25 C solar cells, optical solar reflectors (OSR's) or aluminized Mylar. The contaminated surfaces were exposed to 26 equivalent sun hours of simulated solar ultraviolet (UV) radiation. Measurements of contamination deposit mass, structure, reflectance and effects on solar cell power output were made before and after UV irradiation. Standard total mass loss - volatile condensible materials (TML - VCM) tests were also performed. A 2500 A thick contaminant layer produced by EPDM rubber motor-case insulation outgassing increased the solar absorptance of the OSR's from 0.07 to 0.14, and to 0.18 after UV exposure. An 83,000 A layer caused an increase from 0.07 to 0.21, and then the 0.46 after UV exposure. The Kevlar-epoxy motor-case material outgassing condensation raised the absorptance from 0.07 to 0.13, but UV had no effect. Outgassing from multilayer insulation and carbon-carbon nozzle materials did not affect the solar absorptance of the OSR's. Author

N82-25312*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

OXYGEN ATOM REACTION WITH SHUTTLE MATERIALS AT ORBITAL ALTITUDES

L. J. LEGER May 1982 26 p refs
(NASA-TM-58246; S-516; NAS 1.15:58246) Avail: NTIS HC A03/MF A01 CSCL 22B

Surfaces of materials used in the space shuttle orbiter payload bay and exposed during STS-1 through STS-3 were examined after flight. Paints and polymers, in particular Kapton used on the television camera thermal blanket, showed significant change. Generally, the change was a loss of surface gloss on the polymer with apparent aging on the paint surfaces. The Kapton surfaces showed the greatest change, and postflight analyses showed mass loss of 4.8 percent on STS-2 and 35 percent on STS-3 for most heavily affected surfaces. Strong shadow patterns were evident. The greatest mass loss was measured on surfaces which were exposed to solar radiation in conjunction with exposure in the vehicle velocity vector. A mechanism which involves the interaction of atomic oxygen with organic polymer surfaces is proposed. Atomic oxygen is the major ambient species at low orbital altitudes and presents a flux of 8 x 10 to the 14th power atoms/cu cm sec for reaction. Correlation of the expected mass loss based on ground-based oxygen atom/polymer reaction rates shows lower mass loss of the Kapton than measured. Consideration of solar heating effects on reaction rates as well as the high oxygen atom energy due to the orbiter's orbital velocity brings the predicted and measured mass loss in surprisingly good agreement. Flight sample surface morphology comparison with ground based Kapton/oxygen atom exposures provides additional support for the oxygen interaction mechanism. M.G.

N82-25385*# IIT Research Inst., Chicago, Ill.

INVESTIGATION OF DEGRADATION MECHANISMS IN COMPOSITE MATRICES Final Report, 25 Jul. 1978 - 25 Mar. 1980

C. GIORI and T. YAMAUCHI Washington NASA Jun. 1982 111 p
(Contract NAS1-15469)
(NASA-CR-3559; NAS 1.26:3559; C06428-17) Avail: NTIS HC A06/MF A01 CSCL 11D

Degradation mechanisms were investigated for graphite/polysulfone and graphite/epoxy laminates exposed to ultraviolet and high-energy electron radiations in vacuum up to 960 equivalent sun hours and 10 to the ninth power rads respectively. Based on GC and combined GC/MS analysis of volatile by-products evolved during irradiation, several free radical mechanisms of composite degradation were identified. The radiation resistance of different matrices was compared in terms of G values and quantum yields for gas formation. All the composite materials evaluated show high electron radiation stability and relatively low ultraviolet stability as indicated by low G values and high quantum for gas formation. Mechanical property measurements of irradiated samples did not reveal significant changes, with the possible exception of UV exposed polysulfone laminates. Hydrogen and methane were identified as the main by-products of irradiation, along with unexpectedly high levels of CO and CO2. Author

N82-27486*# North Carolina State Univ., Raleigh.

EFFECT OF 1.33 MEV GAMMA RADIATION AND 0.5 MEV ELECTRONS ON THE MECHANICAL PROPERTIES OF GRAPHITE FIBER COMPOSITES

R. E. FORNES, J. D. MEMORY, and N. NARANONG 1982 17 p refs
(Contract NSG-1562-S2)
(NASA-CR-169117; NAS 1.26:169117) Avail: NTIS HC A02/MF A01 CSCL 11G

Epoxy/graphite fiber, polyimide/graphite fiber, and polysulfone/graphite fiber composites were exposed to 1.33 Mev gamma irradiation and 0.5 Mev electron bombardment for varying periods of time. The effects of the irradiation treatments on the breaking stress and Young's modulus were studied by a three point bending test. Effects were small; both electron radiation up to 5000 Mrad and gamma radiation up to 350 Mrad resulted in slight increases in both stress and modulus. M.G.

N82-29424*# Advanced Research and Applications Corp., Sunnyvale, Calif.

THE RELATIVE STRESS-CORROSION-CRACKING SUSCEPTIBILITY OF CANDIDATE ALUMINUM-LITHIUM ALLOYS FOR AEROSPACE APPLICATIONS Final Report

P. P. PIZZO Washington NASA Jun. 1982 128 p refs
(Contract NAS2-10365)
(NASA-CR-3578; NAS 1.26:3578; TR-45-2) Avail: NTIS HC A07/MF A01 CSCL 11F

Stress corrosion tests of Al-Li-Cu powder metallurgy alloys are described. Alloys investigated were Al-2.6% Li-1.4% and Al-2.6% Li-1.4% Cu-1.6% Mg. The base properties of the alloys were characterized. Process, heat treatment, and size/orientational effects on the tensile and fracture behavior were investigated. Metallurgical and electrochemical conditions are identified which provide reproducible and controlled parameters for stress corrosion evaluation. Preliminary stress corrosion test results are reported. Both Al-Li-Cu alloys appear more susceptible to stress corrosion crack initiation than 7075-T6 aluminum, with the magnesium bearing alloy being the most susceptible. Tests to determine the threshold stress intensity for the base and magnesium bearing alloys are underway. Twelve each, bolt loaded DCB type specimens are under test (120 days) and limited crack growth in these precracked specimens has been observed. General corrosion in the aqueous sodium chloride environment is thought to be obscuring results through crack tip blunting. J.D.

N82-31407# Fulmer Research Inst. Ltd., Stoke Poges (England).

GUIDELINES FOR SELECTION OF FIBRE REINFORCED COMPOSITE MATERIALS FOR SPACECRAFT APPLICATIONS

A. K. GREEN Paris ESA Jan. 1982 56 p 4 Vol.
(Contract ESA-4389/80/NL-AK(SC))
(R878/1A; ESA-CR(P)-1586-VOL-1) Avail: NTIS HC A04/MF A01

The properties of fiber reinforcement and matrix systems available for the fabrication of advanced composite structures are reviewed, and guidelines on the procurement of these materials are presented. Kevlar, S and S2 glass, FP alumina, boron, silicon carbide, and carbon fibers are discussed. Composite matrices covered are: epoxy, polyester and high temperature thermosetting resins; and thermoplastic and metal structures. Author (ESA)

N82-31408# Fulmer Research Inst. Ltd., Stoke Poges (England).

GUIDELINES FOR THE USE OF KEVLAR ARAMID REINFORCING FIBRES IN SPACECRAFT CONSTRUCTION

A. K. GREEN Paris ESA Jan. 1982 113 p refs 4 Vol.
(Contract ESA-4389/80/NL-AK(SC))
(R878/2A; ESA-CR(P)-1586-VOL-2) Avail: NTIS HC A06/MF A01

The properties and application areas for Kevlar aramid fibers are described. The manufacture and machining of Kevlar laminates are discussed, taking Kevlar 49 laminates as an example. Uses of Kevlar in spacecraft include: filament wound motor cases and pressure vessels; textile reinforced deployable structures; thermally stable composite structures; impact protection; and as a weight saving replacement of glass fiber composite parts. Industrial uses of Kevlar include the reinforcement of rubber, and in high performance cables and textiles. Author (ESA)

N82-31409# Fulmer Research Inst. Ltd., Stoke Poges (England).
GUIDELINES FOR THE USE OF SUPERPLASTIC FORMING OF METALS IN SPACECRAFT CONSTRUCTION
A. K. GREEN Paris ESA Jan. 1982 85 p refs 4 Vol.
(Contract ESA-4389/80/NL-AK(SC))
(R878/3A; ESA-CR(P)-1586-VOL-3) Avail: NTIS HC A05/MF A01

Aerospace uses of superplastically formed parts are reviewed, and commercial sources of superplastic materials and technology in Europe are listed. The opportunities for, and constraints on, component and structural design presented by the use of superplastic forming are outlined. The metallurgical features of superplasticity are described. Superplastic forming processes, i.e., hydraulic bulging, sheet thermoforming, blow molding, forging, deep drawing, dieless drawing, and powder metallurgy processes are discussed. Concurrent superplastic forming and diffusion bonding of titanium alloys is introduced. Zinc-aluminum, aluminum base, and titanium alloys are treated, as are stainless steels and nickel base superalloys. Author (ESA)

N82-31410# Fulmer Research Inst. Ltd., Stoke Poges (England).
GUIDELINES FOR THE USE OF BERYLLIUM IN SPACECRAFT APPLICATIONS
D. P. BASHFORD Paris ESA Jan. 1982 156 p refs 4 Vol.
(Contract ESA-4389/80/NL-AK(SC))
(R878/4A; ESA-CR(P)-1586-VOL-4) Avail: NTIS HC A08/MF A01

The status of beryllium technology is reviewed, highlighting advances in beryllium powder comminution and consolidation techniques. Methods of fabricating spacecraft components for a variety of structural, optical, thermal, and instrument applications are presented, citing examples of the use of beryllium in European spacecraft. Difficulties and constraints in the designing of beryllium components are emphasized. Listings of beryllium producers and machining facilities are included. Author (ESA)

N82-34335*# Christopher Newport Coll., Newport News, Va. Dept. of Chemistry.
THEORETICAL STUDIES OF RADIATION EFFECTS IN COMPOSITE MATERIALS FOR SPACE USE Final Report
C. K. CHANG and E. KAMARATOS Washington NASA Sep. 1982 40 p refs
(Contract NSG-1614)
(NASA-CR-3618; NAS 1.26:3618) Avail: NTIS HC A03/MF A01 CSCL 11D

Tetraglycidyl 4,4'-diamino diphenyl methane epoxy cured with diamino diphenyl sulfone was used as a model compound. Computer programs were developed to calculate (1) energy deposition coefficients of protons and electrons of various energies at different depths of the material; (2) ranges of protons and electrons of various energies in the material; and (3) cumulative doses received by the composite in different geometric shapes placed in orbits of various altitudes and inclination. A preliminary study on accelerated testing was conducted and it was found that an elliptical equitorial orbit of 300 km perigee by 2750 km apogee can accumulate, in 2 years or less, enough radiation dose comparable to geosynchronous environment for 30 years. The local plasma model calculated the mean excitation energies for covalent and ionic compounds. Longitudinal and lateral distributions of excited species by electron and proton impact as well as the probability of overlapping of two tracks due to two charged particles within various time intervals were studied. A.R.H.

08

ASSEMBLY CONCEPTS

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

A82-33909#
WORKING IN SPACE
G. V. BUTLER and H. L. WOLBERS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA Student Journal, vol. 19, Fall 1981, p. 2-9, 47.

Aspects of the history, current status and future plans for humans working in space are discussed. Following a brief outline of the development of manned space flight, the facilities on board the Skylab orbital station are described, and experience gained in spacecraft maintenance and repair as well as the testing of a manned maneuvering unit and the operation of scientific experiments on Skylab is related. The potentials of the reusable Space Transportation System are then discussed in relation to the benefits that the transport of persons with a variety of talents may have for various world problems. Changes in the nature of the tasks to be performed as space missions evolve from short sorties to permanent installations supporting a large work force, as exemplified by the proposed Space Operations Center are then considered, with particular attention given to crew work schedules and space construction activities. It is concluded that almost any task that man can perform on the ground can also be performed in space, provided adequate tools and positioning restraints are used. A.L.W.

A82-35613*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
AN HIERARCHICAL SYSTEM ARCHITECTURE FOR AUTOMATED DESIGN, FABRICATION, AND REPAIR
R. A. CLIFF (NASA, Goddard Space Flight Center, Greenbelt, MD) In: Space manufacturing 4; Proceedings of the Fifth Conference, Princeton, NJ, May 18-21, 1981. New York, American Institute of Aeronautics and Astronautics, 1981, p. 121-126. refs

The architecture of an automated system which has the following properties is described: (1) if it is presented with a final product specification (within its capabilities) it will do the detailed design (all the way down to the raw materials if need be) and then produce that product; (2) if a faulty final product is presented to the system, it will repair it. Interesting extensions of this architecture would be the ability to add fabricator nodes when required and the ability to add entire ranks when required. This sort of system would be a useful component of a self-replicating system (used in space exploration). B.J.

A82-45259#
WORKING IN A SHUTTLE EMU
H. R. GRISWOLD and J. D. NASH (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 58-66.
(AIAA 82-1847)

When conducting extravehicular activities (EVA), Space Shuttle astronauts will use the Shuttle Extravehicular Mobility Unit (EMU), which is the most advanced space-suit system developed by NASA to date. The EMU incorporates new gloves and joints which provide the astronaut with the pressure-suit mobility and dexterity required for the performance of a wide range of complex manual tasks. Astronaut and satellite safety are noted as key factors in the design of an orbital service satellite, which must withstand induced mechanical loads without damage and present no sharp edges and corners that might damage the EMU. The variety and extent of EMU movements available for EVA are illustrated, and an inventory is given of the suit components and of the hand tools that have been employed in simulations. A number of EVA tasks already simulated in the laboratory are presented photographically. O.C.

A82-45260*# Grumman Aerospace Corp., Bethpage, N.Y.
OPEN CHERRY PICKER SIMULATION RESULTS
C. A. NATHAN (Grumman Aerospace Corp., Bethpage, NY) In: Technology for Space Astrophysics Conference: The Next 30 Years, Danbury, CT, October 4-6, 1982, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, 1982, p. 67-77.
(Contract NAS9-15507; NAS9-15881)
(AIAA 82-1848)

The Open Cherry Picker (OCP) is a manned platform, mounted at the end of the Remote Manipulator System (RMS), which is used to enhance extravehicular activities. The objective of the simulation program described was to reduce the existing complexity of those OCP design features that are mandatory for initial Space Shuttle applications. The OCP development test article consists of a torque box, a rotating foot restraint, a rotating stanchion that houses handholds, and a tool storage section with an interface with payload modules. If the size or complexity of the payload increases, payload handling devices may be added at a later data. The simulations have shown that the crew can control the RMS from the Aft Flight Deck of the Shuttle, using voice commands from the EVA crewman. No need for a stabilizer was evident, and RMS dynamics due to crew-induced workloads were found to be minor. O.C.

A82-46490*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
TELEOPERATOR MANEUVERING SYSTEM
J. R. TURNER (NASA, Marshall Space Flight Center, Huntsville, AL), R. J. FRENCH, and W. E. AGAN (Vought Corp., Dallas, TX) AIAA, DGLR, AAS, and BIS, Space Systems Conference: The Space Transportation System: A Review of Its Present Capability and Probable Evolution, Washington, DC, Oct. 18-20, 1982, AIAA 9 p.
(AIAA PAPER 82-1817)

The Teleoperator Maneuvering System (TMS) is a Shuttle launched, free-flying, remotely controlled reusable propulsive stage capable of performing spacecraft and payload placement services, retrieval functions, assembly/servicing support for large space systems, dexterous manipulator operations for planned or contingency satellite servicing, satellite viewing, and subsatellite science support. The basic TMS segments, subsystems and performance are described, beginning with the criteria and requirements derived from mission models. Examples of TMS benefits to the STS and user communities are demonstrated. TMS applications such as support and servicing of Space Station, materials processing and subsatellite missions are presented. (Author)

A82-46922#
CONSIDERATIONS ON THE DEVELOPMENT APPROACH OF AN ORBITAL INFRASTRUCTURE FOR THE NINETIES
H. SAX and W. LEY (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p. refs
(IAF PAPER 82-35)

European user requirements with respect to a future orbital infrastructure are examined. Both low-earth-orbit (LEO) and geostationary-earth-orbit (GEO) missions are considered. It is shown that space processing platforms in LEO and communication and navigation systems in GEO will require the development, within the next 20 years, of the following functional capabilities of such space systems: (1) in-orbit servicing, repair, and maintenance; (2) in-orbit assembly and construction; and (3) retrieval and return to earth. A robotic service vehicle to be operated in either LEO or GEO is found to be the central new element of an advanced orbital infrastructure. F.G.M.

A82-46929#
RENDEZ-VOUS AND DOCKING IN GEOSTATIONARY ORBIT AND OTHER APPLICATIONS
C. COUGNET, J. M. AUBERTIN, B. GOVIN (Matra, S.A., Paris, France), and P. NATENBRUK (ERNO Raumfahrttechnik GmbH, Ottobrunn, West Germany) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 13 p.
(IAF PAPER 82-53)

A survey of all orbital phases of the rendezvous and docking (RVD) techniques for GEO is presented, with attention given to hardware interfaces. Results of a simulation of the final approach phase involving six degrees of freedom are discussed. The focus of the paper is the presence of an ESA modular communications spacecraft in GEO as the target, and the delivery and latching of a modular component. The definition and use of RVD systems are noted to be influenced by the location of sensors, the docking ports, and the time of docking. Consideration is given to H- and rosette configurations for the modular platforms, which are passive to the approach of a payload module. Communications between the spacecraft occur within 800 km, with ranging data gathered by the target, sent to the ground for processing, then followed by commands to the payload module. RVD concepts are also useful for LEO and elliptical orbit modular construction. M.S.K.

A82-47027#
TOWARDS INTELLIGENT SPACE SYSTEMS
G. BERGER, R. HAVAS (MATRA, S.A., Velizy-Villacoublay, Yvelines, France), and R. PRAJOUX (CNRS, Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 8 p. European Space Research and Technology Centre refs
(Contract ESTEC-4504/80/NL/PP)
(IAF PAPER 82-344)

The role that robotics and artificial intelligence will play in the space systems of the future is considered by surveying the relevant techniques and methods and setting increased autonomy standards for space missions. The technology of robotics and artificial intelligence is thought to provide new mission opportunities and contribute to an increase in conventional mission efficiency. At the same time, it reduces the cost by eliminating certain ground-based operations. The tools developed in the fields of robotics and artificial intelligence are seen as holding promise for application to space systems provided that the prerequisites for their successful implementation are satisfied. Three factors in space missions argue for more autonomous operations. The first is a limitation in remote control capabilities arising from restricted visibility, limited data rate, or time delay in communication. The second is the growing complexity of ground-based operations, and the third is the need for mission cost effectiveness. C.R.

A82-47028#
SPACE AUTOMATION AT THE CNES - MIDTERM PROBLEMS AND PROGRAMS [LA ROBOTIQUE SPATIALE AU CNES - PROBLEMES POSES ET PROGRAMME DE TRAVAIL A MOYEN TERME]
J. M. GUILBERT and M. MAURETTE (Centre National d'Etudes Spatiales, Toulouse, France) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 6 p. In French.
(IAF PAPER 82-345)

The potential needs of a space automation program in Europe and research in the field being performed at CNES are presented. The two primary areas of research are a self-repaired, self-maintained intervention device, and an unfinished device demonstrating assemblage and construction. The basis of these studies is the capture, automatically, of a target satellite by a hunter satellite. Considerations particular to this mission include the minimizing of mass and a distancing of the operator for a nonrepetitive task. The work program includes the construction of a functioning arm, and a laboratory representation of the manipulator. Structural and motor specifications for the manipulator include a possible 10 W of power at speeds less than 0.1 m/sec, and command is achieved on a 16 bit processor. The laboratory simulation should be completed by the end of 1982, and the program is expected to continue for five years. R.K.R.

A82-47045#
EVA CAPABILITIES FOR THE ASSEMBLY OF LARGE SPACE STRUCTURES
D. L. AKIN and M. L. BOWDEN (MIT, Cambridge, MA) International Astronautical Federation, International Astronautical Congress, 33rd, Paris, France, Sept. 27-Oct. 2, 1982, 9 p. refs
(IAF PAPER 82-393)

Results of the MIT Space Systems Lab neutral buoyancy tests are summarized in this paper. The tests have studied EVA operations as applied to manual and machine-augmented assembly of large space structures. Learning has been found to be extremely fast (70% average learning rate). Human productivity is consistently high (over 1000 kg/hr), and not very significantly affected by fatigue over extended periods. Assembly aids, such as a manned maneuvering unit and the remote manipulator system, were evaluated. Time and motion data and data on structural loads incurred during assembly are also presented in this report. (Author)

N82-22735*# Bechtel International Corp., San Francisco, Calif.
AUTOMATED CONSTRUCTION OF LIGHTWEIGHT, SIMPLE, FIELD-ERECTED STRUCTURES
R. S. LEONARD *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 324-327 Jul. 1980
Avail: NTIS HC A99/MF A01 CSCL 10A

The feasibility of automation of construction processes which could result in mobile construction robots is examined. The construction of a large photovoltaic power plant with a peak power output of 100 MW is demonstrated. The reasons to automate the construction process, a conventional construction scenario as the reference for evaluation, and a list of potential cost benefits using robots are presented. The technical feasibility of using robots to construct SPS ground stations is addressed. E.A.K.

N82-23347*# Spar Aerospace Products Ltd., Toronto (Ontario).
THE DESIGN AND DEVELOPMENT OF AN END EFFECTOR FOR THE SHUTTLE REMOTE MANIPULATOR SYSTEM
R. G. DANIELL and S. S. SACHDEV *In* NASA. Kennedy Space Center The 16th Aerospace Mech. Symp. p 45-62 May 1982
Avail: NTIS HC A15/MF A01 CSCL 22B

The design requirements, the design, and qualification and development test problems encountered on the Remote Manipulator End Effector are described. The constraints and interfaces with the arm, the Orbiter, and the payload are identified. The design solution to meet the requirements is a unique device that provides a soft-docking feature termed capture and a hard-docking feature termed rigidization. Author

N82-27375*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
CAPABILITIES IN LARGE SPACE SYSTEMS CONSTRUCTION
E. M. CRUM *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 199-211 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

Orbital construction, demonstration, space construction system analysis, solar power satellite, and space operations are reviewed. Satellite services, holding and positioning aids, and space construction experiments are discussed. N.W.

N82-34127*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
SPACE APPLICATIONS OF AUTOMATION, ROBOTICS AND MACHINE INTELLIGENCE SYSTEMS (ARAMIS). VOLUME 1: EXECUTIVE SUMMARY Final Report
R. H. MILLER, M. L. MINSKY, and D. B. S. SMITH Aug. 1982 46 p refs 4 Vol.
(Contract NAS8-34381)
(NASA-CR-162079; NAS 1.26:162079; SSL-21-82-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 09B

Potential applications of automation, robotics, and machine intelligence systems (ARAMIS) to space activities, and to their related ground support functions are explored. The specific tasks which will be required by future space projects are identified. ARAMIS options which are candidates for those space project tasks and the relative merits of these options are defined and evaluated. Promising applications of ARAMIS and specific areas for further research are identified. The ARAMIS options defined and researched by the study group span the range from fully human to fully machine, including a number of intermediate options (e.g., humans assisted by computers, and various levels of teleoperation). By including this spectrum, the study searches for the optimum mix of humans and machines for space project tasks. Author

N82-34128*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
SPACE APPLICATIONS OF AUTOMATION, ROBOTICS AND MACHINE INTELLIGENCE SYSTEMS (ARAMIS). VOLUME 3: ARAMIS OVERVIEW Final Report
R. H. MILLER, M. L. MINSKY, and D. B. S. SMITH Aug. 1982 177 p refs 4 Vol.
(Contract NAS8-34381)
(NASA-CR-162081; NAS 1.26:162081; SSL-23-82-VOL-3) Avail: NTIS HC A09/MF A01 CSCL 09B

An overview of automation, robotics, and machine intelligence systems (ARAMIS) is provided. Man machine interfaces, classification, and capabilities are considered. N.W.

09

PROPULSION

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

A82-35054#
THE FUTURE - LIQUID BIPROPELLANT ROCKET ENGINES/SYSTEMS FOR SATELLITES AND SPACECRAFT
R. C. STECHMAN, J. CAMPBELL, and T. E. HUDSON (Marquardt Co., Van Nuys, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA 7 p. refs
(AIAA PAPER 82-1194)

The design characteristics and performance levels of state-of-the-art bipropellant rocket engines which may be used by such large, Space Shuttle- and Ariane-launched satellites as Insat, SAL, Arabsat and L-SAT are considered. The engine thrust range in question is from 5 lbf for attitude and orbit control to 100 lbf for apogee acquisition. Attention is given to existing and improved N2O4/MMH rockets applicable to satellites with 10-year operational lives, ClF5/N2H4 fluorinated propellant rockets, and gaseous O2/H2 rockets in which the propellants are generated by solar cell-powered, onboard electrolysis of water. The primary disadvantage of a water electrolysis-based propulsion system is the limitation of short-period impulse by the small amount of gaseous O2 and H2 stored in reasonably proportioned tanks. O.C.

A82-35056*# Aerojet Liquid Rocket Co., Sacramento, Calif.
PROPULSION SYSTEM OPTIONS FOR LOW-ACCELERATION ORBIT TRANSFER
L. SCHOENMAN (Aerojet Liquid Rocket Co., Sacramento, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA 7 p. refs
(Contract NAS3-21940; NAS3-22665)
(AIAA PAPER 82-1196)

The present inventory of developed bipropellant engines suitable for the orbit transfer of large space structures is based on the use of storable propellants (nitrogen tetroxide/monomethyl hydrazine). A range of engine sizes from 22N (5 lbF) to over 26,690N (6000 lbF) is available. These engines are capable of delivering specific impulse values from 2795 to 3089 N-s/kg (285 to 315 lbF-sec/lbm). A comparison is made between the attainable specific impulse of these demonstrated engines and future low-thrust engine designs which can utilize LOX/RP-1, LOX-methane, and LOX/hydrogen propellants. The requirements for cooling these small engines for multi-hour burns as well as the merits of operating at nonoptimum performance mixture ratios to improve cooling margins and reduce tank volumes are addressed in this paper. (Author)

A82-35057#
THRUSTER LOCATION AND ORIENTATION OPTIMIZATION BASED ON ROCKET PLUME EFFECTS
T.-P. YEH and M. S. DIETZ (Ford Aerospace and Communications Corp., Palo Alto, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA 6 p. refs
(AIAA PAPER 82-1197)

A computerized optimization technique has been developed to aid in the determination of an optimum thruster placement and orientation. The technique employs constraints imposed by spacecraft mission control, thermal control and other factors governing spacecraft stability and control loop design. The computer generates a set of isolevel contours plotted as a function of thruster clock and tilt orientation for each constraint parameter. The limiting value of each constraint bounds a zone which satisfies that particular constraint. Superposition of all the constraint contours provides the locus of clock and tilt angles which satisfy all constraints. Typical results of the technique are presented. (Author)

A82-36128
A REVIEW OF FUTURE ORBIT TRANSFER TECHNOLOGY
D. G. FEARN (Royal Aircraft Establishment, Farnborough, Hants., England) (Symposium on Space Transportation Systems for the 1990's - Requirements and Solutions, London, England, Apr. 15, 1981.) British Interplanetary Society, Journal (Space Technology), vol. 35, July 1982, p. 304-325. refs

An assessment of future orbit transfer missions and technology indicates that electric, rather than conventional chemical propulsion will play the dominant role in the transfer of spacecraft from low earth orbit to the geostationary orbit, especially in the case of such massive payloads as solar power satellite construction materials. An electric thruster's exhaust acceleration by means of electrostatic or electromagnetic fields is shown to yield specific impulse values one to two orders of magnitude greater than those attainable by chemical means, allowing a reduction of propellant mass from 2 kg per kg of payload to less than 0.1 kg/kg payload. After considering Kaufman ion, magnetoplasmadynamic (MPD) arc, RF ion, magnetoelectrostatic containment (MESC), colloid, field emission, and contact ionization devices, the Kaufman ion thruster is identified as best suited for the task. The transport of personnel, which requires short transfer times, will continue to be effected by means of chemical propulsion vehicles. O.C.

A82-37700#
COMMUNICATION SATELLITE PROPULSION - EVOLUTION AND OPTIONS
R. SCHREIB (International Telecommunications Satellite Organization, Washington, DC) AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA 11 p. refs
(AIAA PAPER 82-1193)

An overview of communication satellite development is provided, with examples cited of the changes that have occurred in their propulsion systems since about 1965. The peroxide used as the monopropellant for on-orbit propulsive functions in the early satellites underwent slow decomposition, even under the best of storage conditions. The peroxide then gave way to hydrazine, which offered better performance and storability. It is noted that even though current bipropellant feed system technology is fully adequate to justify its use on various types of spacecraft, there are only a limited number of levels available that have a significant development base. The qualification and flight use of augmented electrothermal thrusters in Intelsat V did much to stimulate interest in electrothermal hydrazine. C.R.

A82-37713*# Xerox Electro-Optical Systems, Pasadena, Calif.
DEVELOPING A SCALABLE INERT GAS ION THRUSTER
E. JAMES, W. RAMSEY, and G. STEINER (Xerox Electro-Optical Systems, Pasadena, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 18th, Cleveland, OH, June 21-23, 1982, AIAA 9 p. refs
(Contract NAS3-22444; NAS3-22876)
(AIAA PAPER 82-1275)

Analytical studies to identify and then design a high performance scalable ion thruster operating with either argon or xenon for use in large space systems are presented. The magnetoelectrostatic containment concept is selected for its efficient ion generation capabilities. The iterative nature of the bounding magnetic fields allows the designer to scale both the diameter and length, so that the thruster can be adapted to spacecraft growth over time. Three different thruster assemblies (conical, hexagonal and hemispherical) are evaluated for a 12 cm diameter thruster and performance mapping of the various thruster configurations shows that conical discharge chambers produce the most efficient discharge operation, achieving argon efficiencies of 50-80% mass utilization at 240-310 eV/ion and xenon efficiencies of 60-97% at 240-280 eV/ion. Preliminary testing of the large 30 cm thruster, using argon propellant, indicates a 35% improvement over the 12 cm thruster in mass utilization efficiency. Since initial performance is found to be better than projected, a larger 50 cm thruster is already in the development stage. N.B.

A82-42795*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
NASA'S LASER-PROPULSION PROJECT
L. W. JONES (NASA, Marshall Space Flight Center, Huntsville, AL) and D. R. KEEFER (Tennessee, University, Space Institute, Tullahoma, TN) Astronautics and Aeronautics, vol. 20, Sept. 1982, p. 66-73. refs

Design concepts, study results, and research directions toward development of CW laser heating of remotely flying spacecraft fuels to provide high impulse thrust are presented. The incident laser radiation would be absorbed by hydrogen through a medium of a laser-supported plasma. The laser energy could be furnished from an orbiting solar-powered laser platform and used to drive the engines of an orbital transfer vehicle (OTV) at costs less than with a chemical propulsion system. The OTV propulsion chamber would be reduced in size comparable to the volume addition of the incident laser energy absorber. The temperatures in the hydrogen-fueled system could reach 5000-15,000 K, and studies have been done to examine the feasibility of ion-electron recombination. Kinetic performance, temperature field, and power necessary to sustain a laser thrust augmented system modeling results are discussed, along with near-term 30 kW CO_2 laser system tests. M.S.K.

N82-22292# Royal Aircraft Establishment, Farnborough (England).
A REVIEW OF FUTURE ORBIT TRANSFER TECHNOLOGY
D. G. FEARN 30 Jun. 1981 65 p refs Presented at Symp. on Space Transportation Systems for the 1990's: Requirements and Solutions, London, 15 Apr. 1981
(RAE-TR-81080; RAE-SPACE-599; BR81558) Avail: NTIS HC A04/MF A01

Cargo and crew transfer to outer orbits for space industrialization projects is discussed. Chemical, electric, resistojet, nuclear, and high thrust ion propulsion systems are reviewed. Chemical propulsion systems are needed for personnel transfer, but the high specific impulse offered by electric propulsion provides an enormous economic advantage for the movement of nonpriority cargo. Propellant mass required to transport a payload to geostationary Earth orbit can be reduced to 0.1 kg/kg. Kaufman ion thrusters are best suited. Author (ESA)

N82-22709*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE APPLICABILITY OF MFD THRUSTERS TO SATELLITE POWER SYSTEMS
R. M. JONES and L. K. RUDOLPH *In* NASA, Washington The Final Proc. of the Solar Power Satellite Program Rev. p 210-213 Jul. 1980
(Contract NAS7-100)
Avail: NTIS HC A99/MF A01 CSCL 10A

The high power self field MPD thruster uses electromagnetic forces rather than electrostatic to accelerate a neutral plasma. The most attractive application of MPD thrusters to satellite power systems is in the area of electric propulsion for a cargo orbit transfer vehicle (COTV). Calculations were performed in order to compare the performance of a COTV using an ion or MPD propulsion system. Results show that the MPD propulsion system gives a shorter trip time with the same power and payload when compared to the ion thruster propulsion system at either value of specific impulse. More important than the trip time benefit may be the advantage a MPD propulsion system provides in system simplicity. Another interesting COTV concept using MPD thrusters is the use of a remote power supply located on the Earth, at GEO, or somewhere in between to transmit power to the COTV in a microwave transmission. The specific impulse at thrust levels of tens of newtons makes a MPD propulsion system a candidate for stationkeeping and attitude control of large space structures such as a SPS. A.R.H.

N82-24286*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN INSIGHT INTO AUXILIARY PROPULSION REQUIREMENTS OF LARGE SPACE SYSTEMS
J. E. MALOY and W. W. SMITH (Boeing Aerospace Co., Seattle) 1982 21 p refs To be presented at the 18th Joint Propulsion Conf., Cleveland, 21-23 Jun. 1981
(NASA-TM-82827; E-1185; NAS 1.15:82827) Avail: NTIS HC A02/MF A01 CSCL 21H

Electric and chemical propulsion systems' requirements for Large Space Systems (LSS) launchable by a single Shuttle are considered. Sets of generic LSS classes (ranging in size from 30 m to 250 m) are described and the disturbance force and torque requirements for low Earth orbit (LEO), geosynchronous Earth orbit (GEO), and LEO-GEO transfer, are given. Auxiliary propulsion requirements were determined as a function of: specific impulse (250 and 500 sec. for chemical and 1000, 3000, and 10000 sec. for electric); orbit; and angle of orientation. The results were used to size the Auxiliary Propulsion System (thruster size, fuel requirements, power processor, etc). T.M.

N82-27366*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
ELECTRIC PROPULSION: SYNERGY OF ORBIT TRANSFER AND MAINTENANCE
S. ZAFRAN *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 61-69 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 21C

Electric propulsion systems for transferring large payload masses to geosynchronous Earth orbits and providing accurate on-orbit stationkeeping are evaluated. Orbit boosting, inclination change, attitude control, stationkeeping, relocation, disposal, and power sharing on orbits using electric propulsion are compared with the use of chemical propulsion. J.D.

N82-27368*# Martin Marietta Aerospace, Denver, Colo.
STRUCTURES-PROPULSION INTERACTIONS AND REQUIREMENTS
J. V. COYNER *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 81-86 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 21H

The effects of low-thrust primary propulsion system characteristics on the mass, area, and orbit transfer characteristics of large space systems (LSS) were determined. Three general structural classes of LSS were considered, each with a broad range of diameters and nonstructural surface densities. While transferring the deployed structure from LEO and to GEO, an acceleration range of 0.02 to 0.1 g's was found to maximize deliverable payload based on structural mass impact. After propulsion system parametric analyses considering four propellant combinations produced values for available payload mass, length and volume, a thrust level range which maximizes deliverable LSS diameter was determined corresponding to a structure and propulsion vehicle. The engine start and/or shutdown thrust transients on the last orbit transfer (apogee) burn can impose transient loads which would be greater than the steady-state loads at the burnout acceleration. The effect of the engine thrust transients on the LSS was determined from the dynamic models upon which various engine ramps were imposed. M.G.

N82-27369*# Boeing Aerospace Co., Seattle, Wash.
CENTRALIZED VERSUS DISTRIBUTED PROPULSION
J. P. CLARK *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 87-100 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 21H

The functions and requirements of auxiliary propulsion systems are reviewed. None of the three major tasks (attitude control, stationkeeping, and shape control) can be performed by a collection of thrusters at a single central location. If a centralized system is defined as a collection of separated clusters, made up of the minimum number of propulsion units, then such a system can provide attitude control and stationkeeping for most vehicles. A distributed propulsion system is characterized by more numerous propulsion units in a regularly distributed arrangement. Various proposed large space systems are reviewed and it is concluded that centralized auxiliary propulsion is best suited to vehicles with a relatively rigid core. These vehicles may carry a number of flexible or movable appendages. A second group, consisting of one or more large flexible flat plates, may need distributed propulsion for shape control. There is a third group, consisting of vehicles built up from multiple shuttle launches, which may be forced into a distributed system because of the need to add additional propulsion units as the vehicles grow. The effects of distributed propulsion on a beam-like structure were examined. The deflection of the structure under both translational and rotational thrusts is shown as a function of the number of equally spaced thrusters. When two thrusters only are used it is shown that location is an important parameter. The possibility of using distributed propulsion to achieve minimum overall system weight is also examined. Finally, an examination of the active damping by distributed propulsion is described. M.G.

N82-27370*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SYSTEM REQUIREMENTS
R. E. AUSTIN *In* NASA. Lewis Research Center Large Space System/Propulsion Interactions p 101-121 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22B

Requirements of future space systems, including large space systems, that operate beyond the space shuttle are discussed. Typical functions required of propulsion systems in this operational regime include payload placement, retrieval, observation, servicing, space debris control and support to large space systems. These functional requirements are discussed in conjunction with two classes of propulsion systems: (1) primary or orbit transfer vehicle (OTV) and (2) secondary or systems that generally operate within or relatively near an operational base orbit. Three propulsion system types are described in relation to these requirements: cryogenic OTV, teleoperator maneuvering system and a solar electric OTV. M.G.

N82-27379*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEM DESIGN AND INTEGRATION PANEL WORKSHOP SUMMARY
C. CARL *In* NASA. Lewis Research Center Large Space Systems/Propulsion Interactions p 257-260 Jun. 1982
Avail: NTIS HC A12/MF A01 CSCL 22A

Priorties are identifiied for spacecraft propulsion system development and for the integration of the propulsion system with various subsystems. Near-term and long-term propulsion technology needs are identified. R.J.F.

N82-28341*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ELECTRIC PROPULSION
In its Land Mobile Satellite Serv. (LMSS): A Conceptual System Design and Identification of the Critical Technol. 7 p 15 Feb. 1982
Avail: NTIS HC A18/MF A01 CSCL 21C

An alternative propulsion subsystem for MSAT is presented which has a potential of reducing the satellite weight by more than 15%. The characteristics of pulsed plasma and ion engines are described and used to estimate of the mass of the propellant and thrusters for attitude control and stationkeeping functions for MSAT. Preliminary estimates indicate that the electric propulsion systems could also replace the large momentum wheels necessary to counteract the solar pressure; however, the fine pointing wheels would be retained. Estimates also show that either electric propulsion system can save approximately 18% to 20% of the initial 4,000 kg mass. The issues that require further experimentation are mentioned. A.R.H.

N82-30323# Royal Aircraft Establishment, Farnborough (England). Space Dept.
THE APPLICATION OF ION PROPULSION TO THE TRANSPORTATION AND CONTROL OF SOLAR POWER SATELLITES
D. G. FEARN Apr. 1981 33 p refs
(RAE-TR-81043; BR80079; SPACE-595) Avail: NTIS HC A03/MF A01

The methods of transporting such masses as are characteristic of solar power satellites to geostationary orbit are reviewed. It is concluded that electric propulsion techniques offer very considerable technical and financial advantages, and that ion thrusters currently represent the most suitable technology to employ. It is also shown that the use of ion propulsion for attitude and orbit control would be of great benefit. An advanced form of ion thruster, which offers a very high beam velocity and current density, is proposed for these applications. M.G.

N82-33714# Albany International Corp., Dedham, Mass.
SEAMLESS COLLAPSIBLE FUEL TANKS, PHASE 1 Final Report, Apr. 1980 - Mar. 1982
N. J. ABBOTT and R. E. ERLANDSON Mar. 1982 18 p
(Contract DAAK70-80-C-0045)
(AD-A116765) Avail: NTIS HC A02/MF A01 CSCL 13D

A tubular fabric has been woven to make two 23 x 17 foot pillow tanks. A nitrile coating which could be applied as an aqueous latex was developed. The fabric will be coated and the tanks fabricated in Phase II of this report. Author (GRA)

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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.

A82-30076
STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 23RD, NEW ORLEANS, LA, MAY 10-12, 1982, COLLECTION OF TECHNICAL PAPERS. PART 1 - STRUCTURES AND MATERIALS. PART 2 - STRUCTURAL DYNAMICS AND DESIGN ENGINEERING
Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1982. Pt. 1, 532 p.; pt. 2, 645 p.

An integration scheme to determine the dynamic response of a launch vehicle with several payloads is considered along with aeroelastic characteristics of the Space Shuttle external tank cable trays, the structural design of integral tankage for advanced space transportation systems, and optimum damping locations for structural vibration control. Attention is given to a damage induced aeroelastic failure mode involving combination and parametric resonant instabilities of lifting surfaces, passive damping mechanisms in large space structures, an automated technique for improving modal test/analysis correlation, pressure measurements on twin vertical tails in buffeting flow, and a wind-tunnel study of the aerodynamic characteristics of a slotted versus smooth-skin supercritical wing. Other topics explored are related to the active control of aeroelastic divergence, stress constraints in optimality criteria design, and damage tolerant design using collapse techniques. G.R.

A82-32023
MP/C - A MULTIPROCESSOR/COMPUTER ARCHITECTURE
B. W. ARDEN (Princeton University, Princeton, NJ) and R. GINOSAR IEEE Transactions on Computers, vol. C-31, May 1982, p. 455-473. refs

A computer architecture for concurrent computing is proposed which has the shared memory aspect of tightly coupled multiprocessor systems and also the connection simplicity associated with message-connected, loosely-coupled multicomputer systems. A large address space is dynamically partitioned into contiguous segments that can be accessed by a single processor. The partitioning is accomplished by switching the system buses. The completion of a concurrent process is signaled by a processor's return to an idle state and the reattachment of its memory segment to the neighboring active processor. In effect, the assignment of an address sequence and the activation of a processor is a process-fork operation, and the processor deactivation and memory segment reattachment is a process-join. Following a description of the MP/C structure and operation, programming conventions are explained and demonstrated. Applications include tree-structured multiprocessing, recursive and nondeterministic procedures, very high precision numerical calculations, process-structured operating systems, and others. The linear MP/C structure is extensible to higher dimensions. A two-dimensional system is described and its application is discussed. Finally, performance issues are presented, and the MP/C architecture is compared with related designs. (Author)

A82-35262

ASTRODYNAMICS 1981; PROCEEDINGS OF THE CONFERENCE, NORTH LAKE TAHOE, NV, AUGUST 3-5, 1981. PARTS 1 & 2

A. L. FRIEDLANDER, (ED.) (Science Applications, Inc., Schaumburg, IL), P. J. CEFOLA (Charles Stark Draper Laboratory, Inc., Cambridge, MA), B. KAUFMAN (U.S. Navy, Naval Research Laboratory Washington, DC), W. WILLIAMSON (Sandia National Laboratory, Albuquerque, NM), and G. T. TSENG (Aerospace Corp., Los Angeles, CA) Conference sponsored by the American Astronautical Society and American Institute of Aeronautics and Astronautics. San Diego, CA, American Astronautical Society ; Univelt, Inc., 1982. Pt. 1, 548 p.; pt. 2, 571 p.

Papers presented in the two parts of this volume cover a wide range of subjects including attitude dynamics, celestial mechanics, mission analysis for solar exploration and earth orbiting applications, flexible spacecraft dynamics, and trajectory design and optimization. Other topics discussed are attitude determination and control, orbit determination, flexible spacecraft control, future missions to explore the solar system, and autonomous orbital systems. Papers presented at a special geodesy session and a special lecture on the Voyager and the world of Saturn are also included. V.L.

A82-35575#

PROJECTED SPACE TECHNOLOGIES, MISSIONS AND CAPABILITIES IN THE 2000-2020 TIME PERIOD

New York, American Institute of Aeronautics and Astronautics, 1981. 203 p. refs

Space technologies, mission activities and capabilities are projected into the 2000-2020 time period, identifying pertinent technologies that may be expected to undergo development during the next 20 years if mission-oriented civil and military space programs are established within the next few years. The projected materials technologies include high temperature alloys, tailored composites and advanced ceramics. The propulsion systems envisaged extend to chemical rockets with greater operational flexibility than current designs, multi-cycle air breathing engines capable of efficient subsonic, supersonic and hypersonic flight, and long-lived electric rockets. Attention is given to nuclear and photovoltaic space power systems, large space structures, heat shields and methods for aerodynamic maneuvering and braking during spacecraft reentry. Prospective missions are expected to demonstrate space industrialization, solar and galactic exploration and a variety of military activities. O.C.

A82-35601

SPACE MANUFACTURING 4; PROCEEDINGS OF THE FIFTH CONFERENCE, PRINCETON UNIVERSITY, PRINCETON, NJ, MAY 18-21, 1981

J. GREY, (ED.) (American Institute of Aeronautics and Astronautics, New York, NY) and L. A. HAMDAN Conference sponsored by Princeton University and American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, 1981. 464 p.

Space manufacturing is discussed in regard to international and legal considerations, social sciences, novel concepts, materials resources and processing, and space stations and habitats. Particular topics discussed include the military implications of a satellite power system; a self-replicating, growing lunar factory; the supply of lunar oxygen to low earth orbit; a small-scale lunar launcher for early lunar material utilization; a decision-analytic evaluation of the SPS program; powder metallurgy in space manufacturing; and United States and Soviet life sciences factors in long-duration space flight. B.J.

A82-38926

GUIDANCE AND CONTROL CONFERENCE, SAN DIEGO, CA, AUGUST 9-11, 1982, COLLECTION OF TECHNICAL PAPERS

Conference sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, 1982. 851 p.

Aspects of Space Shuttle ascent guidance and control are considered along with missile guidance design trade-offs for high altitude air defense, adaptive noise estimation and guidance for homing missiles, process-noise-adaptive Kalman filters for tracking, optimal pulse motor control, a classical look at modern control for missile autopilot design, and a commercial flight management computer system. Attention is given to air-to-air missile avoidance, the effects of time delays on systems subject to manual control, Lorentz force perturbations of a charged ballistic missile, analysis and design of a digital controller for a seismically stable platform, the Shuttle inertial system, dynamics and control of a large space antenna, and a Shuttle payload deployment and retrieval system. Other topics explored are related to atmospheric guidance techniques and performance, an investigation of low order lateral directional transfer function models for augmented aircraft, avoiding the pitfalls in automatic landing control system design, and the Space Shuttle as a dynamic test tool for high accuracy missile guidance systems. G.R.

A82-41819

INTERNATIONAL INSTRUMENTATION SYMPOSIUM, 28TH, LAS VEGAS, NV, MAY 3-6, 1982, PROCEEDINGS. PARTS 1 & 2

Symposium sponsored by the Instrument Society of America. Research Triangle Park, NC, Instrument Society of America (Instrumentation in the Aerospace Industry. Volume 28; Advances in Test Measurement. Volume 19), 1982, Pt. 1, 524 p.; pt. 2, 528 p.

Topics investigated are related to shock and vibration, microcomputer applications in instrumentation and control, energy source instrumentation instrumentation in the transportation industry, pressure and flow, acoustic emission, machinery instrumentation, wind tunnel instrumentation and control, nondestructive testing and strain, force, and torque. Other subjects explored are in the areas of electrooptical instrumentation, space transportation systems experiment instruction, data acquisition and analysis, flight test instrumentation, two-phase flow measurements, advanced system concepts, and reentry vehicle testing. Attention is given to a new temperature threshold detector and its application to missile monitoring, full scale torch tests on a spent fuel cask shipping system, pyrotechnic plate analysis and test results, the selection of a dynamic pressure sensor for use inside a steam turbine, microprocessor-based control of large constant-speed centrifugal compressors, and a modular data system for Spacelab experiments. G.R.

A82-44928

PHOTOVOLTAIC SPECIALISTS CONFERENCE, 15TH, KISSIMMEE, FL, MAY 12-15, 1981, CONFERENCE RECORD

Conference sponsored by the Institute of Electrical and Electronics Engineers. New York, Institute of Electrical and Electronics Engineers, Inc., 1981. 1523 p.

GaAs cells for space applications are considered, taking into account AlGaAs/GaAs high efficiency cascade solar cells, and a thermochemical model of radiation damage and continuous annealing applied to GaAs solar cells. Other topics discussed are related to silicon solar cells for space applications, photovoltaic concentrator receivers and application experiments, photovoltaic concentrator cells, economics and feasibility analysis, space solar cell calibration, low cost technology for space applications, thin film solar cells, low cost processes, and low cost cell and array processes. A description is also presented of subjects in the areas of low cost Si and sheet technology, amorphous silicon solar cells, flat-plate array subsystem and system technology, cadmium sulfide and copper sulfide solar cells, flat-plate array subsystem design and test methods, module failure/degradation mechanism and reliability, measurement techniques for photovoltaic cells and materials, and flat-plate residential and intermediate system applications. G.R.

A82-45386

LEADERSHIP IN SPACE FOR BENEFITS ON EARTH; PROCEEDINGS OF THE TWENTY-EIGHTH ANNUAL CONFERENCE, SAN DIEGO, CA, OCTOBER 26-29, 1981

W. F. RECTOR, III, (ED.) (General Dynamics Corp., St. Louis, MO) *Conference sponsored by the American Astronautical Society* and American Institute of Aeronautics and Astronautics San Diego, CA, Univelt, Inc. , 1982. 308 p

Among the topics discussed in the present conference on the transfer of space technology to civilian markets are the management of military space communications, the uses of the Navstar global positioning system, the defense of spacecraft from attack, new approaches in narrow-beam communications for the improvement of orbit spectrum utilization, the use of the Space Shuttle as a launch vehicle for future communications satellites, planetary exploration through the year 2000, and cost reductions effected by means of technology development. Also considered are cost-effective data systems for spacecraft, navigation and position location from space in order to increase air and sea lane safety, and Navstar user equipment and applications. O.C.

A82-45599

GUIDANCE AND CONTROL 1982; PROCEEDINGS OF THE ANNUAL ROCKY MOUNTAIN GUIDANCE AND CONTROL CONFERENCE, KEYSTONE, CO, JANUARY 30-FEBRUARY 3, 1982

R. D. CULP, (ED.) (Colorado, University, Boulder, CO), E. J. BAUMAN (Colorado University, Colorado Springs, CO), and W. E. DORROH, JR. (Martin Marietta Aerospace, Denver, CO) Conference sponsored by the American Astronautical Society. San Diego, CA, Univelt, Inc. , 1982. 558 p

Advances in guidance and control are discussed. General topics include earth orbiting control systems, historical guidance and control hardware, new uses of software, prospective advances in guidance and control, and lessons learned from flight experience. More specific topics include: angular momentum and nutation damping; momentum management for the space platform; a double-gimballed momentum wheel for three-axis attitude control; history of the Viking project; the Shuttle automatic lander system; high-order languages for flight control applications; programming real-time executives in higher-order language; and automation of Shuttle avionics system software verification. Also covered are: the use of quaternions with an all-attitude IMU; Space Telescope pointing control system software; binocular earth sensor; *autonomous attitude control; and attitude control of the SME* satellite. C.D.

A82-47251

MAKING SPACE WORK FOR MANKIND; PROCEEDINGS OF THE NINETEENTH SPACE CONGRESS, COCOA BEACH, FL, APRIL 28-30, 1982

Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1982. 360 p.

Topics in the practical applications of space are discussed. General subjects considered include: space power systems; future Shuttle cargo programs; international Shuttle users; expendable vehicle payloads; space manufacturing operations; commercial space applications; energy choices of the future; special interest topics; space communications. Specific topics addressed include; the EUropean REtrievable CArrier; future military spacecraft power systems; Space Platform solar array; European use of the Space Shuttle; Japanese satellites; the expendable launch vehicle and satellite development; space manufacturing; space manufacturing and the Space Operations Center; the Long Duration Exposure Facility; commerce and remote sensing; robots, progress in renewables; *artificial intelligence in space missions; life support* system considerations for space station. C.D.

N82-22676*# National Aeronautics and Space Administration, Washington, D. C.

THE FINAL PROCEEDINGS OF THE SOLAR POWER SATELLITE PROGRAM REVIEW

Jul. 1980 701 p refs Rev. held in Lincoln, Nebr., 22-25 Apr. 1980

(Contract DE-FG05-79ER-10116)

(NASA-TM-84183; NAS 1.15:84183; CONF-800491) Avail: NTIS HC A99/MF A01 CSCL 10A

The solar power satellite (SPS) concept defined as 'placing gigantic satellites in geosynchronous orbit to capture sunlight, changing the energy into an appropriate form for transmission to Earth, and introducing the energy into the electric power grid' is evaluated in terms of costs and benefits. The concept development and evaluation program is reviewed in four general areas: systems definition; environmental; societal; and comparative assessments. Specific factors addressed include: transportation, construction in space, methods of conversion of sunlight into energy, transmission to Earth, maintenance in orbit and decommissioning of satellites; environmental, political, and economic effects; and comparison of SPS to other forms of power generation, both terrestrial and in space.

N82-23108*# Houston Univ., Tex.

THE 1981 NASA ASEE SUMMER FACULTY FELLOWSHIP PROGRAM, VOLUME 1 Technical Final Report

N. G. ROBERTSON and C. J. HUANG 20 Aug. 1981 324 p refs 2 Vol.

(Contract NGT-44-005-115)

(NASA-CR-168775; NAS 1.26:168775) Avail: NTIS HC A14/MF A01 CSCL 05I

A review of NASA research programs related to developing and improving space flight technology is presented. Technical report topics summarized include: space flight feeding; aerospace medicine; reusable spacecraft; satellite soil, vegetation, and climate *studies; microwave landing systems; anthropometric studies;* satellite antennas; and space shuttle fuel cells.

N82-23137# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Zentralbereich Entwicklung.

RESEARCH AND DEVELOPMENT AT MBB. TECHNICAL AND SCIENTIFIC PUBLICATIONS, 1981 [FORSCHUNG UND ETWICKLUNG. TECHNISCH-WISSENSCHAFTLICHE VEROEFFENTLICHUNGEN 1981]

1981 193 p refs Partly in ENGLISH and GERMAN

Avail: NTIS HC A09/MF A01

Research and development work carried out during 1981 at Messetschmitt-Bolkow-Blohm GmbH, Ottobrunn, FRG is presented. Aerodynamics, materials science, infrared imagery, aircraft and spacecraft design, and production engineering are discussed. *Calculation methods, mathematical and scale models,* and computer aided design are treated. Solar energy and high speed trains were investigated.

N82-23344*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.

THE 16TH AEROSPACE MECHANISMS SYMPOSIUM

May 1982 343 p refs Proceedings of conf. held at Kennedy Space Center, Fla., 13-14 May 1982; sponsored in part by Calif. Inst. of Technology and Lockheed Missiles and Space Co., Inc., Sunnyvale

(NASA-CP-2221; NAS 1.55:2221) Avail: NTIS HC A15/MF A01 CSCL 12T

A technology survey of devices designed for use in space operations is presented. Technological areas covered include *design of unique ground support equipment, orbiter specialized* hardware, payload deployment, and positioning.

N82-23473*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL ASPECTS OF HEAT TRANSFER IN STRUCTURES
H. M. ADELMAN, Comp. 1982 554 p refs Symp. held at Hampton, Va., 3-5 Nov. 1981; sponsored by NASA, George Washington Univ., and Old Dominion Univ.
(NASA-CP-2216; L-15108; NAS 1.55:2216) Avail: NTIS HC A24/MF A01 CSCL 20D

Techniques for the computation of heat transfer and associated phenomena in complex structures are examined with an emphasis on reentry flight vehicle structures. Analysis methods, computer programs, thermal analysis of large space structures and high speed vehicles, and the impact of computer systems are addressed.

N82-24781*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
METEOROLOGICAL SATELLITES: PAST, PRESENT, AND FUTURE
May 1982 61 p refs Proc. of the Session on Meteorol. Satellites at the AIAA 20th Aerospace Sci. Meeting, Orlando, Fla., 11-14 Jan. 1982
(NASA-CP-2227; NAS 1.55:2227) Avail: NTIS HC A04/MF A01 CSCL 04B

Past developments, accomplishments and future potential of meteorological satellites are discussed. Meteorological satellite design is described in detail. Space platforms and their meteorological applications are discussed. User needs are also discussed.

N82-25291*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
TWELFTH SPACE SIMULATION CONFERENCE: SHUTTLE PLUS ONE. A NEW VIEW OF SPACE
R. T. HOLLINGSWORTH, ed. 1982 339 p refs Conf. held in Pasadena, Calif., 17-19 May 1982; sponsored by JPL, IES, AIAA and the Am. Soc. for Testing and Mater.
(NASA-CP-2229; NAS 1.55:2229; REPT-82B0455) Avail: NTIS HC A15/MF A01 CSCL 22B

The proceedings address the state-of-the-art in space simulation test technology, thermal simulation and protection, contamination, remote sensing, and dynamics testing and assessment.

N82-26026# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
MINUTES OF THE FIRST SEMINAR ON USE OF THE NATIONAL SYSTEM FOR COLLECTION OF SATELLITE DATA [1ST SEMINARIO DE USUARIOS DO SISTEMA NACIONAL DE COLETA DE DODOS POR SATELITES]
Jul. 1981 253 p refs In PORTUGESE Seminar held at Sao Jose Dos Campos, Brazil, 28-30 May 1980
(INPE-2168-RPE/384) Avail: NTIS HC A12/MF A01

The activities and plans of the Brazilian system for collection of hydrological and meteorological data are described.

N82-27358*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LARGE SPACE SYSTEMS/PROPULSION INTERACTIONS
Jun. 1982 253 p refs Workshop held at Cleveland, 22-23 Oct. 1981
(NASA-TM-82904; E-1288; NAS 1.15:82904) Avail: NTIS HC A12/MF A01 CSCL 22A

Material illustrating the presentations on and the conclusions of workshop panels considering the missions, systems requirements and operations, and systems design and integration is presented.

N82-32860# Department of Energy, Oak Ridge, Tenn. Technical Information Center.
DIRECT ENERGY CONVERSION, A CURRENT AWARENESS BULLETIN
30 Aug. 1982 20 p
(PB82-946616; DOEDEC-82/16) Avail: NTIS HC A02/MF A01 CSCL 10A

This bulletin contains 94 abstracts and bibliographic citations of scientific and technical reports, journal articles, conference proceedings, patents, books, and other published literature on all aspects of direct energy conversion. A subject index and a report number index are provided. This information is selected from the DOE/TIC Energy Data Base. J.M.S.

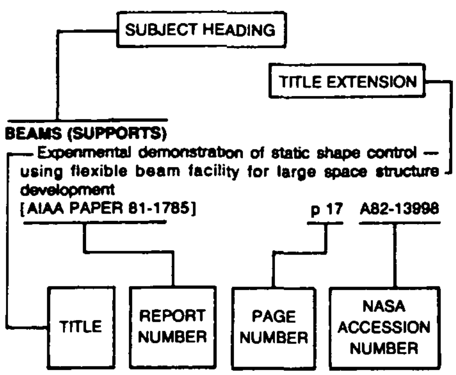
N82-33739*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESEARCH IN STRUCTURAL AND SOLID MECHANICS, 1982 Research-In-Progress Reports
J. M. HOUSNER, comp. and A. K. NOOR, comp. (George Washington Univ., Washington, D.C.) Oct. 1982 427 p refs Proc. of Symp. on Advan. and Trends in Struct. and Solid Mech., Washington, D.C., 4-7 Oct. 1982; sponsored in cooperation with NSF, AFOSR, ONR, American Society of Civil Engineers and American Society of Mechanical Engineers
(NASA-CP-2245; L-15506; NAS 1.55:2245) Avail: NTIS HC A19/MF A01 CSCL 20K

Advances in structural and solid mechanics, including solution procedures and the physical investigation of structural responses are discussed.

SUBJECT INDEX

SUBJECT

Typical Subject Index Listing



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PERSONAL AUTHOR INDEX

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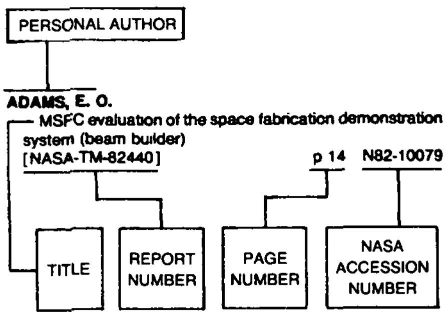

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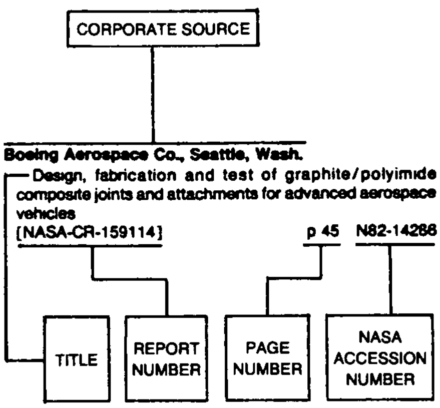

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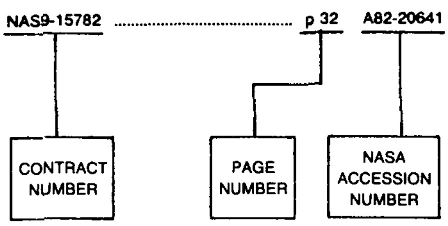

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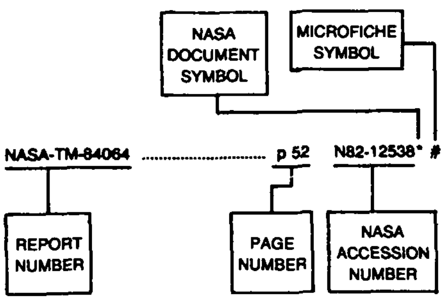
CONTRACT

REPORT NUMBER INDEX

Typical Report Number Index Listing



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REPORT

ACCESSION NUMBER INDEX

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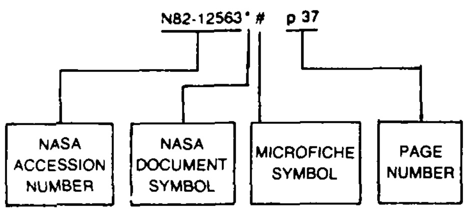

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1. Report No. NASA SP-7046(08)	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle TECHNOLOGY FOR LARGE SPACE SYSTEMS A Bibliography with Indexes		5. Report Date February 1983
		6. Performing Organization Code
7. Author(s)		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		11. Contract or Grant No.
		13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address		14. Sponsoring Agency Code

15. Supplementary Notes

Report prepared, in part, by personnel in the Space Technology Flight Experiments Office and the Technical Library Branch, Hampton, Virginia.

16. Abstract

This bibliography lists 414 reports, articles and other documents introduced into the NASA scientific and technical information system between July 1, 1982 and December 31, 1982. Its purpose is 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.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Large Space Systems Large Space Structures Large Space Antenna	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
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