NASA SP-7046(10)
January 1984

NASA

Technology for Large Space Systems

A Bibliography
with Indexes

(NASA-SP-7046(10)) TECHNOLOGY FOR LARGE SPACE SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (National Aeronautics and Space Administration) 115 p HC $13.00 CSCL 22A

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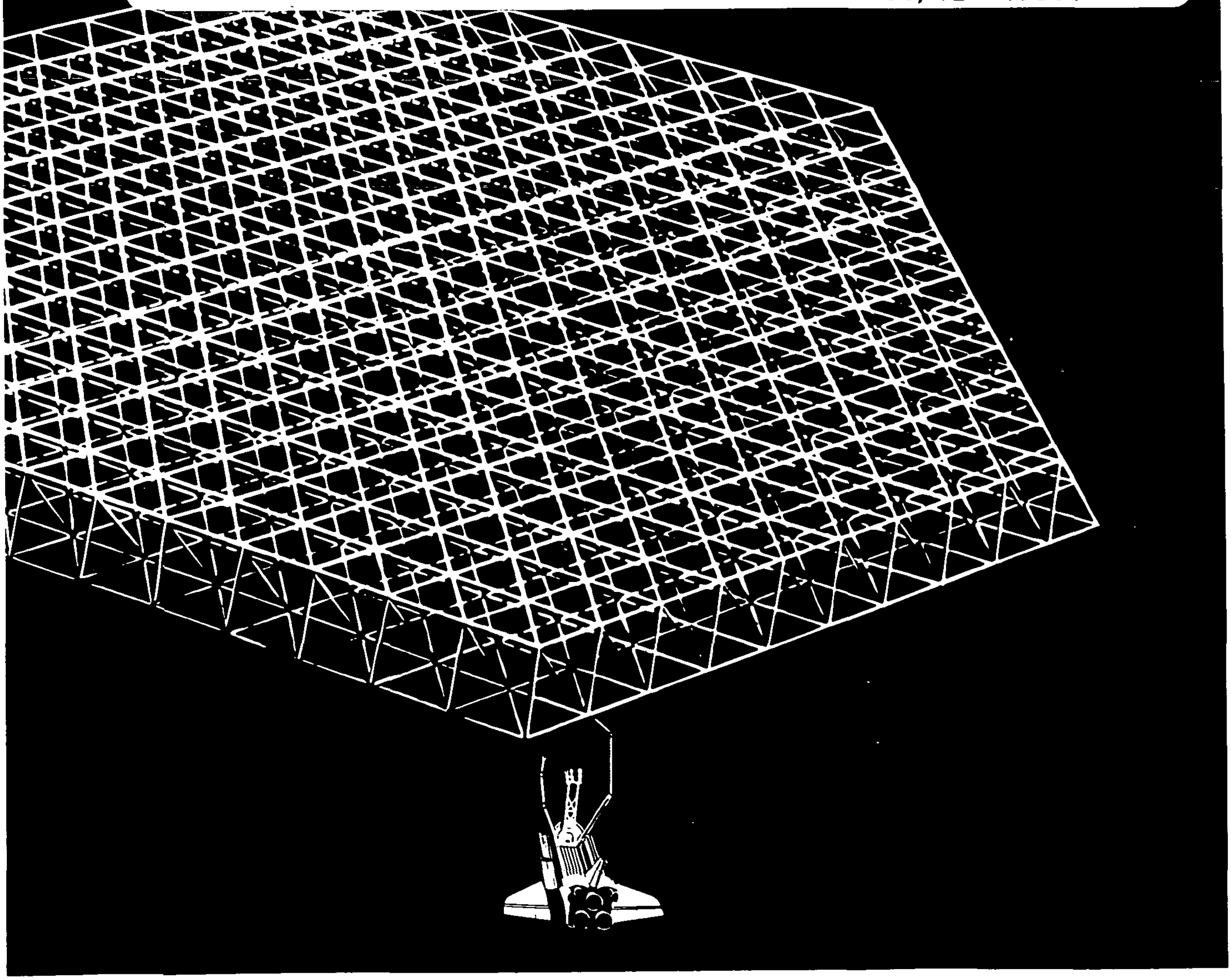

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The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A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

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NASA SP-7046(10)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A SPECIAL BIBLIOGRAPHY WITH INDEXES

Supplement 10

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, 1983 in

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

NASA Scientific and Technical Information Branch 1984
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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 408 reports, articles and other documents announced between July 1, 1983 and December 31, 1983 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 A83-10,000 in ascending accession number order;
2) *STAR* entries identified by accession number series N83-10,000 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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All publications abstracted in this Section are available from the Technical Information Service, American Institute of Aeronautics and Astronautics, Inc. (AIAA), as follows: Paper copies of accessions are available at $8.50 per document. Microfiche[(1)] of documents announced in *IAA* are available at the rate of $4.00 per microfiche on demand. Standing order microfiche are available at the rate of $1.45 per microfiche for *IAA* source documents.

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NASA SPONSORED DOCUMENT — AVAILABLE ON MICROFICHE

NASA ACCESSION NUMBER → **N83-20003*#** Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems. ← CORPORATE SOURCE

TITLE → **GUARANTEED ROBUSTNESS PROPERTIES OF MULTIVARIABLE, NONLINEAR, STOCHASTIC OPTIMAL REGULATORS**

AUTHORS → J. N. TSITSIKLIS and M. ATHANS Feb. 1983 18 p refs ← PUBLICATION DATE

Presented at the 22nd IEEE Conf. on Decision and Control

CONTRACT OR GRANT → (Contract NGL-22-009-124)

REPORT NUMBER → (NASA-CR-170068; NAS 1.26:170068; LIDS-P-1283) Avail: NTIS HC A02/MF A01 CSCL 09C ← AVAILABILITY SOURCE

The robustness of optimal regulators for nonlinear, deterministic and stochastic, multi-input dynamical systems is studied under the assumption that all state variables can be measured. It is shown that, under mild assumptions, such nonlinear regulators have a guaranteed infinite gain margin; moreover, they have a guaranteed 50 percent gain reduction margin and a 60 degree phase margin, in each feedback channel, provided that the system is linear in the control and the penalty to the control is quadratic, thus extending the well-known properties of LQ regulators to nonlinear optimal designs. These results are also valid for infinite horizon, average cost, stochastic optimal control problems. B.W.

TYPICAL CITATION AND ABSTRACT FROM *IAA*

NASA SPONSORED DOCUMENT — AVAILABLE ON MICROFICHE

AIAA ACCESSION NUMBER → **A83-12475*#** TRW, Inc., Redondo Beach, Calif.

OPTIMAL SUN-ALIGNMENT TECHNIQUES OF LARGE SOLAR ARRAYS IN ELECTRIC PROPULSION SPACECRAFT ← TITLE

AUTHORS → H. F. MEISSINGER, C. L. DAILEY (TRW, Inc., Space and Technology Group, Redondo Beach, CA), and M. E. VALGORA (NASA, Lewis Research Center, Cleveland, OH) ← AUTHOR'S AFFILIATION

AIAA, Japan Society for Aeronautical and Space Sciences, and DGLR, International Electric Propulsion Conference, 16th, New Orleans, LA, Nov. 17-19, 1982, AIAA 13 p. refs ← MEETING; MEETING DATE

CONTRACT, GRANT OR SPONSORSHIP → (Contract NAS3-22661)

(AIAA PAPER 82-1898)

Optimum sun-alignment of large solar arrays in electric propulsion spacecraft operating in earth orbit requires periodic roll motions around the thrust axis, synchronized with the apparent conical motion of the sun line. This oscillation is sustained effectively with the aid of gravity gradient torques while only a small share of the total torque is being contributed by the attitude control system. Tuning the system for resonance requires an appropriate choice of moment-of-inertia characteristics. To minimize atmospheric drag at low orbital altitudes the solar array is oriented parallel, or nearly parallel, to the flight direction. This can increase the thrust-to-drag ratio by as much as an order of magnitude. Coupled with optimal roll orientation, this feathering technique will permit use of electric propulsion effectively at low altitudes in support of space shuttle or space station activities and in spiral ascent missions. (Author)

TECHNOLOGY FOR LARGE SPACE SYSTEMS

A Bibliography (Suppl. 10)

JANUARY 1984

01

SYSTEMS

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

A83-30995* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

PLANS FOR A LARGE DEPLOYABLE REFLECTOR FOR SUBMILLIMETER AND INFRARED ASTRONOMY FROM SPACE

P. N. SWANSON, J. B. BRECKINRIDGE, S. GULKIS, T. B. H. KUIPER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA), and M. KIYA (NASA, Ames Research Center, Moffett Field, CA) IN: International Conference on Advanced Technology Optical Telescopes, Tucson, AZ, March 11-13, 1982, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1982, p. 151-155. refs

(Contract NAS7-100)

Continuing plans for a large deployable reflector (LDR), conceived as a 10- to 30-m-diameter clear-aperture telescope, operating at wavelengths from 1000 microns to a diffraction-limited 30 microns, and to be placed in orbit for a life of 10 years by the Space Shuttle, are discussed. The primary reflector will be composed of a number of closely packed hexagonal segments of glass or lightweight composite material and attached to a truss integrating structure through position actuators providing three degrees of freedom for each segment. Technical aspects of optical design, surface measurement systems, deployment, and detectors are discussed, as are practical and fiscal limitations. T.K.

A83-31030

METROLOGY MOUNT DEVELOPMENT AND VERIFICATION FOR A LARGE SPACEBORNE MIRROR

M. H. KRIM (Park-Elmer Corp., Optical Technology, Div., Danbury, CT) IN: International Conference on Advanced Technology Optical Telescopes, Tucson, AZ, March 11-13, 1982, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1982, p. 440-445.

A metrology mount system for large spaceborne optical systems is presented, whose verification testing has demonstrated this ability to simulate a zero-g environment within an uncertainty band of lambda/300 rms for the case of a mirror whose characteristic gravity deformation is 12(lambda). Assessments and/or compensations are obtained, for the effects of stiffness and mass nonuniformity due to faceplate thickness variations and calibration uncertainties in each of the support points of the sandwich structure mirror, by means of a detailed finite element model. Attention is also given to the optimization of forces to yield a minimum rms figure error, and to the method and results of the faceplate thickness mapping which determines spatial weight and stiffness variations. Interferometrically measured figure changes due to discrete changes in the applied force field are compared. O.C.

A83-35952#

LARGE SIZE MULTI-USE PLATFORM

PH. CROCIONI (SocieteNationale Industrielle Aerospatiale, Cannes; Lyon, Ecole Centrale, Ecully, Rhone, France), CH. SIRMAIN (SocieteNationale Industrielle Aerospatiale, Cannes; Ecole Nationale Superieure de Micromecanique, France), and A. THUBERT (SocieteNationale Industrielle Aerospatiale, Cannes, France) IN: Space 2000; International Astronautical Congress, 33rd, Paris, France, September 27-October 2, 1982, Selection of Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 679-687.

The essential characteristics of the large size multimission platforms dedicated mainly to telecommunications which are to be placed into geostationary orbit by the Ariane in the years 1995-2000 are discussed. The basic platform concept is summarized, and the scenario for its launching and use is described. The characteristics and dimensions of the various types of equipment which will be used on the platform, including the transfer module, the servicing module, the power generation system, the attitude and orbit control system, the payloads, and the platform robot system, are briefly presented. The platform geometry, deployment, and orbital configuration are summarized, the articulations and deployment sequence are depicted, and the lattice structure characteristics are presented. C.D.

A83-38053* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

INTERACTIVE ANALYSIS OF A LARGE APERTURE EARTH OBSERVATIONS SATELLITE

R. L. WRIGHT, D. D. DERYDER, M. J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA), and J. C. SMITH (Virginia, University, Charlottesville, VA) Society of Allied Weight Engineers, Annual Conference, 42nd, Anaheim, CA, May 23-25, 1983. 21 p. refs

(SAWE PAPER 1556)

A system level design and analysis has been conducted on an Earth Observation Satellite (EOS) system using the Interactive Design and Evaluation of Advanced Spacecraft (IDEAS) computer-aided design and analysis program. The IDEAS program consists of about 40 user-friendly technical modules and an interactive graphics display. The reflector support system and feed mast of the EOS spacecraft are constructed with a box-truss structural concept, a lattice configuration which can be packaged for delivery in a single Shuttle flight and deployed in orbit. The deployed spacecraft consists of a 120-m by 60-m parabolic reflector, a 120-m-long support structure, and a 30-m feed arc beam on the focal axis. The spacecraft was modeled for structural, thermal, and control systems analysis and structural elements were designed. On-orbit dynamic and thermal loading analyses were conducted and spacecraft weights were determined. Author

A83-40466* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A LARGE DEPLOYABLE REFLECTOR FOR INFRARED AND SUBMILLIMETER ASTRONOMY FROM SPACE
M. W. WERNER (NASA, Ames Research Center, Moffett Field, CA) and T. B. H. KUIPER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: ESO Infrared Workshop, 2nd, Garching, West Germany, April 20-23, 1982, Proceedings . Garching, European Southern Observatory, 1982, p. 421-423. refs

A83-41696#
THE MILITARY SPACE SYSTEM TECHNOLOGY MODEL - A GUIDANCE, NAVIGATION AND CONTROL PERSPECTIVE
K. DANNENBERG, K. DALY, E. DORROH, D. FOSTH, R. IWENS, G. PELKA, and R. WILLIAMSON IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 368-377. refs
(AIAA PAPER 83-2212)
The reply by the AIAA Guidance, Navigation, and Control panel to a request for evaluation of a Military Space Systems Technology Model (MSSTM) based on perceived military mission requirements in the next 20 yrs is reported. The MSSTM was developed to systematically identify future necessities and aid in planning USAF space technology programs. Consideration was given to attitude determination and navigation, acquisition, pointing and tracking, large space structure control, space operations, and systems factors. The large space structures that are expected to be developed were identified, together with ground testing trials that can be performed. It was concluded that demonstrations are needed to perform quick target acquisition and tracking and accurate pointing of large space structures. M.S.K.

A83-43737* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WEIGHT AND STRUCTURAL ANALYSIS OF FOUR STRUCTURAL CONCEPTS FOR A LAND MOBILE SATELLITE SYSTEM
M. J. FEREBEE, R. L. WRIGHT (NASA, Langley Research Center, Hampton, VA), and J. T. FARMER (Georgia Institute of Technology, Atlanta, GA) Society of Allied Weight Engineers, Annual Conference, 41st, San Jose, CA, May 17-19, 1982. 22 p. refs
(SAWE PAPER 1456)
The present study is concerned with a Land Mobile Satellite System (LMSS) which can provide mobile communications for commercial and government applications in nonmetropolitan areas of the continental U.S. and Canada as an augmentation to existing and planned terrestrial systems. The satellite system would provide 'narrow band' telecommunications services, thin-route fixed telephone and data services in the 806-890 MHz band, and continuous emergency beacon monitoring in the 406-406.1 MHz band. It is pointed out that a satellite system operating in concert with terrestrial cellular systems could provide truly ubiquitous mobile communications services in the U.S. and Canada. A single shuttle shuttle launch could place the LMSS spacecraft in geosynchronous orbit over the continental U.S. in 1995 with a 10-year lifetime. Attention is given to the structural concepts, a weight analysis, and a structural analysis. G.R.

A83-44161
THE MILITARY SPACE SYSTEM TECHNOLOGY MODEL - A GUIDANCE, NAVIGATION AND CONTROL PERSPECTIVE
K. DANNENBERG (Lockheed Missiles and Space Co., Inc., Austin, TX), K. C. DALY (Charles Stark Draper Laboratory, Inc., Cambridge, MA), W. E. DORROH (Martin Marietta Aerospace, Denver, CO), D. FOSTH (Boeing Aerospace Co., Seattle, WA), R. IWENS (TRW, Inc., Redondo Beach, CA), G. PELKA (Lockheed Missiles and Space CO., Inc., Sunnyvale, CA), and R. K. WILLIAMSON (Aerospace Corp., Los Angeles, CA) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 3-20. refs
(AAS PAPER 83-001)
The Military Space Systems Technology Model (MSSTM) represents a systematic approach to identify future technology needs based on perceived mission requirements. In provides help in the planning of technology programs which support the mission of the Space Division, Air Force Systems Command. The MSSTM represents a broad range of information concerning the projected military space missions systems, and technology requirements for the next 20 years. In an attempt to obtain an industry view of the MSSTM, the AIAA was asked by Space Division to review this model. The activity was divided into 15 different functional areas. The present investigation is concerned with the Guidance Navigation and Control (GNC) results. Attention is given to attitude determination and navigation, acquisition, pointing, tracking, large space structure control, GNC space operations, and questions of systems design. It is concluded that new GNC technology is needed to enable 17 of the considered missions to be performed. G.R.

A83-44531
FUTURE CONFIGURATIONS OF COMMUNICATION AND BROADCAST SATELLITES
E. W. ASHFORD (ESA, Communication Satellite Systems Div., Noordwijk, Netherlands) Space Communication and Broadcasting (ISSN 0167-9368), vol. 1, April 1983, p. 17-31. refs
Configurations of communication satellites have changed widely during the twenty years since they were first initiated, and can be expected to continue to change in the future. This paper makes some predictions as to the directions this evolution could take, by looking first at certain historical trends, and then examining the factors which could influence how these trends should be extrapolated into the future. Several types of advanced space segment configurations are introduced, each of which can be expected to play a significant role in meeting the challenges in the space communications field in the next two decades. Author

A83-45721
LAUNCHING LARGE ANTENNAS
H. W. BRANDLI Satellite Communications (ISSN 0147-7439), vol. 7, Sept. 1983, p. 40, 42.
Large antennas will provide communication to rural and remote areas in times of need. This is seen as facilitating the work of law enforcement agencies. All mobile radio communications will enjoy advantages in distances covered and information relayed owing to the large number of beams possible from super radio transmitters in space. If the antennas are placed in low-earth orbit, advantages will be realized in the remote sensing of the earth's resources. It is pointed out that with umbrella or bicyclelike antennas turned outward toward space, the universe could be scouted for signals from intelligent life. Various concepts that have been put forward by U.S. companies are described. These include the radial rib, wrap rib, and parabolic erectable truss designs. Others are the mesh hoop column collapsable umbrella made of gold and molybdenum and the maypole design. C.R.

A83-45858
LARGE SPACE STRUCTURES
D. L. BROWNING (General Dynamics Corp., Convair Div., San Diego, CA) IN: Space industrialization. Volume 2 . Boca Raton, FL, CRC Press, Inc., 1982, p. 55-123. refs

Techniques, materials, structural concepts, tools, and human activities that are under development, design, or are prepared for the construction of large space structures (LSS) are surveyed. It is expected that the spaceborne structures will first be constructed on the ground, then packed for launch, then assembled once in space. The earliest projects will comprise platforms, antennas, and other products such as solar sails and orbit transfer vehicles. In microgravity, operating loads will be significantly reduced, thereby allowing more material to be carried by the Shuttle. A critical design area will be to avoid volume-limited projects, so that the object delivered can be assembled to the final configuration within the mission. The structures will experience environmental extremes, as well as earth erection, packing, and launch forces, including orbit transfer forces. The versatility and lightness of composites properties commends their use as structural materials. Structural concepts like multibeam and multicell arrays, and subassemblies comprising columns, beams, piece parts, and joints are described, together with Shuttle-based construction and tending tools and techniques. M.S.K.

A83-47359#
A LARGE DEPLOYABLE ANTENNA STRUCTURE FOR THE ERS-1 SATELLITE
R. WAGNER, M. WESTPHAL (Dornier System GmbH, Friedrichshafen, West Germany), and R. A. KARSTEN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne, West Germany) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 10 p. refs
(IAF PAPER 83-361)

The design and development testing of the slotted waveguide array antenna for the C-band synthetic aperture radar to be flown on the first ESA Remote Sensing Satellite ERS-1 are examined. The electrical performance requirements and geometric constraints are shown to impose stringent conditions on the structural configurations and the mechanical tolerances of this antenna. The antenna has overall dimensions of 10 m x 1 m, and is mechanically divided into 5 panels which are reinforced by a very light weight deployable truss structure. The structural and waveguide components of the antenna are fabricated from a carbon fiber reinforced plastic material. Test results for mechanical and thermal testing, and deployment testing with gravity compensation are presented. N.B.

N83-23345# Los Alamos Scientific Lab., N. Mex.
THE ROLE OF NUCLEAR REACTORS IN FUTURE MILITARY SATELLITES
D. BUDEN and J. A. ANGELO, JR. 1982 19 p Presented at the 8th DARPA Strategic Space Symp., Monterey, Calif., 22-25 Jun. 1982
(Contract W-7405-ENG-36)
(DE82-018381; LA-UR-82-1649; CONF-820665-1) Avail: NTIS HC A02/MF A01

Future military capabilities should certainly be profoundly influenced by emerging shuttle era space technology. Regardless of the specific direction or content of tomorrow's military space program, it is clear that advanced space transportation systems, orbital support facilities, and large-capacity power subsystems are needed to create the generally larger, more sophisticated military space systems of the future. The critical role that space nuclear reactors should play in America's future space program are explored and the current state of nuclear reactor power plant technology is reviewed. Space nuclear reactor technologies have the potential of satisfying power requirements ranging from 10 kW/sub (e)/ to 100 MW/sub (e)/. DOE

N83-23497*# TRW, Inc., Redondo Beach, Calif.
REQUIREMENTS FOR A MOBILE COMMUNICATIONS SATELLITE SYSTEM. VOLUME 1: EXECUTIVE SUMMARY Final Report, 15 Dec. 1981 - 31 Mar. 1983
11 Apr. 1983 50 p refs 2 Vol.
(Contract NAS3-23257)
(NASA-CR-168128; NAS 1.26:168128) Avail: NTIS HC A03/MF A01 CSCL 17B

Three types of satellite-aided mobile communications are considered for users in areas not served by (terrestrial) cellular radio systems. In System 1, mobile units are provided a direct satellite link to a gateway station, which serves as the interface to the terrestrial toll network. In System 2, a terrestrial radio link similar to those in cellular systems connects the mobile unit to a translator station; each translator relays the traffic from mobile units in its vicinity, via satellite, to the regional gateway. It is not feasible for System 2 to provide ubiquitous coverage. Therefore, System 3 is introduced, in which the small percentage of users not within range of a translator are provided a direct satellite link as in System 1. While System 2 can operate with leased satellite capacity, Systems 1 and 3 require a dedicated satellite. A major portion of this study is concerned with the design of a satellite for System 1. A weight limit of 10,000 lbs, corresponding to the projected 1990 STS capability, is imposed on the design. Frequency re-use of the allocated spectrum, through multiple satellite beams, is employed to generate the specified system capacity. Both offset-fed and center-fed reflectors are considered. For an assumed 10-MHz allocation and a population of 350,000 subscribers, a two-satellite system is required. The reflector diameters corresponding to offset-fed and center-fed geometries are 46 m and 62 m, respectively. Thus, large-space-structure technology is inherent to the implementation of System 1. In addition to establishing the technical requirements for the three types of satellite systems, the monthly service charge needed to provide a specified return on invested capital is computed. A net present value analysis is used for this purpose. Author

N83-23498*# TRW, Inc., Redondo Beach, Calif.
REQUIREMENTS FOR A MOBILE COMMUNICATIONS SATELLITE SYSTEM. VOLUME 2: TECHNICAL REPORT Final Report, 15 Dec. 1981 - 31 Mar. 1983
M. HORSTEIN 11 Apr. 1983 382 p refs 2 Vol.
(Contract NAS3-23257)
(NASA-CR-168129; NAS 1.26:168129) Avail: NTIS HC A17/MF A01 CSCL 17B

Three types of satellite aided mobile communications are considered for users in areas not served by (terrestrial) cellular radio systems. In system 1, mobile units are provided a direct satellite link to a gateway station, which serves as the interface to the terrestrial toll network. In system 2, a terrestrial radio link similar to those in cellular systems connects the mobile unit to a translator station; each translator relays the traffic from mobile units in its vicinity, via satellite, to the regional gateway. It is not feasible for system 2 to provide obiquitous coverage. Therefore, system 3 is introduced, in which the small percentage of users not within range of a translator are provided a direct satellite link as in system 1. Author

N83-24526*# General Dynamics/Convair, San Diego, Calif. Advanced Space Programs.
SPACE CONSTRUCTION EXPERIMENT DEFINITION STUDY (SCEDS), PART 3. VOLUME 1: EXECUTIVE SUMMARY Final Report
Mar. 1983 28 p 2 Vol.
(Contract NAS9-16303)
(NASA-CR-171661; NAS 1.26:171661; GDC-ASP-83-007) Avail: NTIS HC A03/MF A01 CSCL 22A

Study tasks were directed toward definition of an early shuttle controls and dynamics flight experiment, as well as evolutionary or supplemental experiments, that address the needs of the dynamics and controls community and demonstrates the shuttle system capability to perform construction operations. A requirement that the first bending mode of the SCE be above 0.15 Hertz to avoid coupling with the DAP was adopted. S.L.

N83-24527*# General Dynamics/Convair, San Diego, Calif. Advanced Space Programs.
SPACE CONSTRUCTION EXPERIMENT DEFINITION STUDY (SCEDS), PART 3. VOLUME 2: STUDY RESULTS Final Report
Mar. 1983 98 p 2 Vol.
(Contract NAS9-16303)
(NASA-CR-171660; NAS 1.26:171660; GDC-ASP-83-006) Avail: NTIS HC A05/MF A01 CSCL 22A

The essential controls and dynamics community needs for a large space structures is addressed by the basic Space Construction Experiments (SCE)/MAST configuration and enhanced configurations for follow-on flights. The SCE/MAST can be integrated on a single structures technology experiments platform (STEP). The experiment objectives can be accomplished without the need for EVA and it is anticipated that further design refinements will eliminate the requirement to use the remote manipulator system. Author

N83-25745*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
EVOLUTIONARY SPACE PLATFORM CONCEPT STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report
May 1982 73 p 3 Vol.
(Contract NAS8-33592)
(NASA-CR-170827; NAS 1.26:170827; MDC-H0072; DPD-610; DR-4) Avail: NTIS HC A04/MF A01 CSCL 22B

The Evolutionary Space Platform Concept Study encompassed a 10 month effort to define, evaluate and compare approaches and concepts for evolving unmanned and manned capability platforms beyond the current Space Platform concepts to an evolutionary goal of establishing a permanent manned presence in space. Areas addressed included: special emphasis trade studies on the current unmanned concept, assessment of manned platform concepts, and utility analysis of a manned platform for defense related missions. Author

N83-25768*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
EVOLUTIONARY SPACE PLATFORM CONCEPT STUDY. VOLUME 2, PART A: SASP SPECIAL EMPHASIS TRADE STUDIES
May 1982 100 p refs 3 Vol.
(Contract NAS8-33592)
(NASA-CR-170828; NAS 1.26:170828; MDC-H0072; DPD-610; DR-4) Avail: NTIS HC A05/MF A01 CSCL 22B

Efforts are in progress to define an approach to provide a simple and cost effective solution to the problem of long duration space flight. This approach involves a Space Platform in low Earth orbit, which can be tended by the Space Shuttle and which will provide, for extended periods of time, stability, utilities and access for a variety of replaceable payloads. The feasibility of an evolutionary space system which would cost effectively support unmanned payloads in groups, using a Space Platform which provides centralized basic subsystems is addressed. S.L.

N83-26854*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE SPACEBORNE ANTENNA TECHNOLOGY: A SYSTEM PERSPECTIVE
F. NADERI *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 1-16 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

Land Mobile Satellite System (LMSS) is a communication system which provides radio communication to a large group of users within a vast geographical area (e.g. communications to and from mobile vehicles anywhere within the U.S.). Such radio communication may be in the form of radio telephone, paging, dispatch, or data transmission. The intended applications of LMSS range from emergency medical to disaster relief, from law enforcement to truck dispatch. By providing service to vast rural areas, LMSS compliments the current terrestrial service in the metropolitan areas and hence provides for a nationally ubiquitous coverage. Author

N83-26855*# General Electric Co., Philadelphia, Pa. Space System Div.
LAND MOBILE SATELLITE SYSTEM REQUIREMENTS
J. D. KIESLING *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 17-28 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

A Land Mobile Satellite System (LMSS) provides voice, data and related communications services to moving vehicles and persons. Communications between the mobiles and satellite are in the 806-890 MHz band. The satellite translates these signals to a "fixed services band" such as 14/12 GHz band (Ku-band), and communicates in this band with fixed terminals called gateways. The gateways are located at convenient places such as telephone switches (which provide entry into the national telephone system), dispatcher headquarters, computer centers, etc. Communications are therefore principally mobile to fixed. A third communications link, also at Ku-band, is needed between the satellite and a single fixed ground station. This link provides satellite command, telemetry and ranging and also provides a network control function. The latter, through a common signalling system, receives requests and assigns channel slots, and otherwise controls, monitors and polices the network and collects billing information. Author

N83-26856*# TRW Space Technology Labs., Redondo Beach, Calif.
SATELLITE SYSTEMS REQUIREMENTS FOR LAND MOBILE COMMUNICATIONS
M. HORSTEIN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 29-46 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

The system design objective is to provide a satellite link through a gateway station, connecting mobile users in areas not served by a terrestrial cellular system to the switched telephone network (STN). The proposed frequency allocation comprises a pair of 10-MHz bands in the 806-890 MHz range specified by the 1979 World Administrative Radio Conference (WARC) for land-mobile satellite service (LMSS). The satellite design is constrained by projected STS capability with an upper stage of the wide-body Centaur or Integral Propulsion System (IPS) type. For the latter (a TRW design), the payload is limited to approximately 10,400 lb. The design is to be based on 1990's technology, with initial operating capability scheduled for 1995. The satellite should be designed for a 7-year life. Mobile-unit compatibility with cellular system specifications is desirable, if consistent with other system requirements. Author

N83-26857*# National Aeronautics and Space Administration, Washington, D. C.
AUDIO DIRECT BROADCAST SATELLITES
J. E. MILLER *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 47-52 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Satellite sound broadcasting is, as the name implies, the use of satellite techniques and technology to broadcast directly from space to low-cost, consumer-quality receivers the types of sound programs commonly received in the AM and FM broadcast bands. It would be a ubiquitous service available to the general public in the home, in the car, and out in the open. Author

N83-26858*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE DEPLOYABLE REFLECTOR: AN INFRARED AND SUBMILLIMETER ORBITING OBSERVATORY
P. N. SWANSON (JPL) and M. K. KIYA *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 53-60 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The Large Deployable Reflector (LDR) is to be a dedicated astronomical observatory in space. It will operate in the 1 mm to 30 micron wavelength region where the Earth's atmospheric opacity makes ground-based observations nearly impossible. The primary mirror will be 20 m in diameter, made up of 37 individual segments. The reflector will be actively controlled to provide an overall surface accuracy of less than or approximately 2 microns. The LDR will be placed in orbit by the Space Shuttle and revisited at approximately 2 year intervals during its 10 year lifetime. Author

N83-26859*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ANTENNA TECHNOLOGY FOR ORBITAL VERY LONG BASELINE INTERFEROMETRY (VLBI)
E. C. HAMILTON *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 61-80 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Since it is not economically feasible to construct steerable antennas much larger than 100 meters on Earth (400 meters for fixed telescopes), radio interferometry became a very useful technique for high resolution astronomy observations of quasars, galactic nuclei, and interstellar hydroxyl (OH) and water vapor (H2O) masers. The subsystems necessary to do the space VLBI experiment appear are available but require space qualifications. There are several 50-meter antenna concepts that could be used. Certainly there are problems to be solved. Feed positioning with respect to reflector, pointing such a large structure to accuracy indicated, and integration into the Shuttle control system are all significant engineering challenges. However, there are no problems that are insurmountable in the latter part of this decade. Author

N83-26860*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PUSHBROOM RADIOMETRY AND ITS POTENTIAL USING LARGE SPACE ANTENNAS
R. F. HARRINGTON and L. S. KEAFER, JR. *In its* Large Space Antenna Systems Technol., Pt. 1 p 81-104 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Electromagnetic radiation is emitted by matter which was heated to a temperature above absolute zero. The amount of blackbody radiation in the microwave frequency region of interest (10 to the 8th power f 10 to the 10th power Hz) emitted by matter can be determined from the Rayleigh-Jeans approximation to Planck's Radiation Law. The amount of electromagnetic radiation from matter which is not a blackbody is a function of the emissivity of the material. The emissivity is a factor less than unity and is a function of several parameters including chemical composition, temperature, frequency, surface characteristics, and viewing angle. A radiometer is an instrument which detects and provides a measure of the electromagnetic radiation being emitted by a material or surface area within the radiometer's antenna beamwidth. Microwave radiometers provide the capability for remote measurements from Earth orbits of geophysical parameters. These measurements will require the use of a microwave imaging radiometer using a large aperture deployable antenna with multiple beams in a pushbroom mode to achieve high spatial resolution and large swath width. Author

N83-26861*# Martin Marietta Aerospace, Denver, Colo.
EARTH OBSERVATION SYSTEM: SPACECRAFT DESIGN
J. J. HERBERT and W. A. SCHARTEL *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 105-130 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The Earth Observation Satellite (EOS) was a study funded by NASA Langley Research Center. The study was a system investigation of the total spacecraft integration with its major subsystems and sensors. Mission optimization and ranking using various sensors was also an objective of the contract. Integrating the spacecraft and major subsystems with the large microwave radiometer was done, essentially making the radiometer a free-flyer without an external spacecraft. Another program objective was to provide design and analysis data on microwave radiometer satellites augmented with additional Earth, ocean, and atmospheric sensors. A top-down systems approach resulted in a detailed design integrating subsystems and sensors into the microwave support structure. An important objective of the program was to identify technology needs for Earth observation satellites. The definition and understanding of these design drivers are critical in order to set priorities for future EOS work. Author

N83-26862*# Martin Marietta Aerospace, Denver, Colo.
A 15-METER DEPLOYABLE APERTURE MICROWAVE RADIOMETER
J. V. COYNER, JR. *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 131-156 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The Large Antenna Multifrequency Microwave Radiometer (LAMMR) was a 4-meter-diameter mechanically scanned (at 1 rps) antenna operating at frequencies from 4.3 to 36 GHz. This LAMMR system was scheduled to fly on the National Oceanic Satellite System (NOSS) in 1986 to measure sea surface temperature and wind speed along with several other atmospheric and sea ice parameters. The LAMMR was limited to a 4-meter solid reflector to stay within the Shuttle/NOSS launch volume and to operate with radiometric precision up to 36.5 GHz. Under the 4-meter aperture constraint, LAMMR could not meet the user resolution requirement for sea surface temperature (25 km minimum, 50 km goal) in an RFI free band, i.e., 4.3 GHz. This study explores the feasibility of meeting this requirement goal with a 15-meter mechanically scanned deployable reflector. Two other research objectives can also be studied by adding one active (approximately 5 GHz) and two additional passive (1.4 and 6.4 GHz) channels to investigate soil moisture and precipitation profiles over land. These two objectives are closely related because the precipitation is the source of the soil moisture in unirrigated regions, and the soil moisture changes between samples (2/day) could indicate that precipitation may have occurred while the sensor was not in view. B.W.

N83-26863*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYSTEMS DESIGN AND COMPARATIVE ANALYSIS OF LARGE ANTENNA CONCEPTS
L. B. GARRETT and M. J. FEREBEE, JR. *In its* Large Space Antenna Systems Technol., Pt. 1 p 157-174 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Conceptual designs are evaluated and comparative analyses conducted for several large antenna spacecraft for Land Mobile Satellite System (LMSS) communications missions. Structural configurations include trusses, hoop and column and radial rib. The study was conducted using the Interactive Design and Evaluation of Advanced Spacecraft (IDEAS) system. The current capabilities, development status, and near-term plans for the IDEAS system are reviewed. Overall capabilities are highlighted. IDEAS is an integrated system of computer-aided design and analysis software used to rapidly evaluate system concepts and technology needs for future advanced spacecraft such as large antennas, platforms, and space stations. The system was developed at Langley to meet a need for rapid, cost-effective, labor-saving approaches to the design and analysis of numerous missions and total spacecraft system options under consideration. IDEAS consists of about 40 technical modules efficient executive, data-base and file management software, and interactive graphics display capabilities. B.W.

N83-26865*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SUMMARY OF MISSION AND SYSTEM PERFORMANCE REQUIREMENTS FOR LARGE SPACE ANTENNAS
L. S. KEAFER, JR. and W. R. HOOK *In its* Large Space Antenna Systems Technol., Pt. 1 p 201-212 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Mission definition studies and system analyses have been described for a number of potential civilian missions and a few military missions. In this paper, an attempt is made to summarize the most formidable mission and system performance requirements for large space antennas. The emphasis will be on the civilian systems; only those aspects of military mission and system requirements that are unclassified are included. Author

N83-26872*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SURVEY OF DEPLOYABLE ANTENNA CONCEPTS
R. E. FREELAND *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 381-422 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

Deployable space antenna concepts are surveyed. Precision reflector antennas, stiffened membrane antennas, truss antennas, infrared antennas, and electrostatically figured membrane reflectors are described. R.J.F.

N83-26873*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
WRAP-RIB ANTENNA CONCEPT DEVELOPMENT OVERVIEW
A. A. WOODS, JR. and N. F. GARCIA *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 423-468 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The wrap rib antenna design of a parabolic reflector large space antenna is discussed. Cost estimates, design/mission compatibility, deployment sequence, ground based tests, and fabrication are discussed. R.J.F.

N83-26874*# Harris Corp., Melbourne, Fla.
HOOP/COLUMN ANTENNA DEVELOPMENT PROGRAM
M. R. SULLIVAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 469-512 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The development of the hoop/column spacetenna reflector is discussed. Schedules, mission configurations, systems compatibility, deployment sequence, cable development, and ground model fabrication and assembly are discussed. R.J.F.

N83-26878*# Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics.
ELECTROSTATICALLY FIGURED MEMBRANE REFLECTORS: AN OVERVIEW
J. H. LANG *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 575-582 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Electrostatically figured membrane reflectors (EFMR) are described. Static and dynamic models were developed and verified. The models were used to develop control systems capable of stabilizing EFMR instabilities and providing EFMR disturbance rejection. Expected reflector figure diameter to surface tolerance ratios are given. R.J.F.

N83-26888*# Hughes Aircraft Co., El Segundo, Calif. Space and Communications Group.
INTELSAT 6 ANTENNA SYSTEM DESIGN AND DEVELOPMENT
M. F. CAULFIELD, F. A. TAORMINA, B. M. FLYNN, S. O. LANE, T. M. PAIGE, and V. E. CASCIA *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 743-765 May 1983 refs
Avail: NTIS HC A20/MF A01

An overview of INTELSAT VI is presented. Author

N83-26898*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE NEED FOR SPACE FLIGHT EXPERIMENTS AND TESTING IN THE DEVELOPMENT OF LARGE SPACE ANTENNA SYSTEMS TECHNOLOGY
E. K. HUCKINGS, III *In its* Large Space Antenna Systems Technol., Pt. 2 p 923-940 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

Flight experiments for large space antennas are discussed. A history of flight experimentation in the manned spacecraft program, space shuttle development, and planetary spacecraft is presented. Large space antenna systems are defined, and the needs for flight experiments justified. S.L.

N83-26901*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE TECHNOLOGY EXPERIMENT PLATFORM (STEP): A SHUTTLE-BORNE SUPPORT FACILITY FOR STRUCTURES, STRUCTURAL DYNAMICS, AND CONTROL TECHNOLOGY FLIGHT EXPERIMENTS
J. E. HARRIS and L. D. PINSON *In its* Large Space Antenna Systems Technol., Pt. 2 p 969-980 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The Space Transportation System (STS) is used for technology experiments in space. The Space Technology Experiment Platform (STEP) is a Shuttle-borne experiment support facility for use by structures, structural dynamics, and controls technology flight experiments. STEP represents a key element in the commitment to STS utilization. The STEP concept and definition process is discussed, and the results obtained to date on the configuration and function capability are summarized, and preliminary schedule information is presented. S.L.

N83-26903*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SAFE II: LARGE SYSTEMS SPACE PLASMA EVALUATION EXPERIMENT
M. R. CARRUTH, JR., L. E. YOUNG, C. K. PURVIS, and N. J. STEVENS *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 991-1006 May 1983 refs
Prepared in cooperation with NASA. Lewis Research Center
Avail: NTIS HC A20/MF A01 CSCL 20I

A shuttle flight experiment, the purpose of which is to obtain space data on the interaction of a high voltage solar array with the ambient space plasma is addressed. This flight experiment is a reflight of the solar array flight experiment, SAFE, except that three active solar array panels, electron release devices and plasma diagnostics are added. This experiment, SAFE 2, evaluates power loss due to parasitic current collected by the solar array, arcing on the solar array and perturbations to the plasma which may increase power loss and disturb plasma and charged particle science acquisition. S.L.

N83-26904*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MAST SPACE RESEARCH FLIGHT EXPERIMENT
J. L. ALLEN and B. HANKS *In its* Large Space Antenna Systems Technol., Pt. 2 p 1007-1019 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The MAST flight experiments comprise a research program focusing on major LSS issues for which it is deemed necessary to test, measure, and validate techniques and concepts in the space environment. The MAST Shuttle attached test articles are transported to space by the STEP experiment carrier and are copatible with STEP interfaces in all configurations. As the experiments require no particular orbit and the operational timeliness needed for mission performance are not extensive, it is forseen that the STEP/MAST combination could provide an attractive repetitive element within the Shuttle mixed cargo manifesting process. Using the STEP experiment carrier and a retractable reusable test article allows repetitive flight research to the extent that the STEP is able to be manifested on a regular basis. Since this research program examines generic phenomena, maximum emphasis is placed upon information quality and the fidelity with which the phenomena model emulates the LSS issue. S.L.

N83-26905*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
A LARGE ANTENNA SYSTEM FLIGHT EXPERIMENT
K. SOOSAAR *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 1021-1027 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The design and development of large antenna systems are discussed. The validation objectives and techniques of the structural behavior of the system are outlined along with studies of the dynamics, deployment, and unpacking. The validation of flexible control and system performance are also considered. S.L.

N83-26906*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SADE: A SPACE EXPERIMENT TO DEMONSTRATE STRUCTURAL ASSEMBLY
J. K. HARRISON and D. C. CRAMBLIT *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 1027-1036 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The Structural Assembly and Demonstration Experiment (SADE) demonstrates that the Shuttle is a suitable base for space construction; this includes a test of the Shuttle's control system to determine its performance when a long attached truss or beam is extended from the bay. Examples of Shuttle-related systems that will receive special attention are the RMS, the lighting system, and the crew assembly capabilities. A second purpose is to determine the extent to which the assembly results from the Neutral Buoyancy Simulator can be used to forecast the results of space assembly is determined. Finally, the SADE truss design will be validated by measuring the performance of the deployment, the special connectors, and the assembly methods. S.L.

N83-26919*# Rockwell International Corp., Downey, Calif. Space Operations/Integration and Satellite Systems Div.
DEVELOPMENT OF DEPLOYABLE STRUCTURES FOR LARGE SPACE PLATFORM SYSTEMS, VOLUME 1 Interim Report
Aug. 1982 185 p refs
(Contract NAS8-34677)
(NASA-CR-170689; NAS 1.26:170689; SSD-82-0121-1) Avail: NTIS HC A09/MF A01 CSCL 22B

Generic deployable spacecraft configurations and deployable platform systems concepts were identified. Sizing, building block concepts, orbiter packaging, thermal analysis, cost analysis, and mass properties analysis as related to platform systems integration are considered. Technology needs are examined and the major criteria used in concept selection are delineated. Requirements for deployable habitat modules, tunnels, and OTV hangars are considered. A.R.H.

N83-27939*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LARGE DEPLOYABLE REFLECTOR SCIENCE AND TECHNOLOGY WORKSHOP. VOLUME 2: SCIENTIFIC RATIONALE AND TECHNOLOGY REQUIREMENTS
D. HOLLENBACH, ed. Jun. 1983 70 p refs Workshop held at Pacific Grove, Calif., 21-25 Jun. 1982
(NASA-CP-2275; T-5349; NAS 1.55:2275) Avail: NTIS HC A04/MF A01 CSCL 03A

The scientific rationale for the large deployable reflector (LDR) and the overall technological requirements are discussed. The main scientific objectives include studies of the origins of planets, stars and galaxies, and of the ultimate fate of the universe. The envisioned studies require a telescope with a diameter of at least 20 m, diffraction-limited to wavelengths as short as 30-50 micron. In addition, light-bucket operation with 1 arcsec spatial resolution in the 2-4 microns wavelength region would be useful in studies of high-redshifted galaxies. Such a telescope would provide a large increase in spectroscopic sensitivity and spatial resolving power compared with existing or planned infrared telescopes. Author

N83-28410*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RADIOMETER REQUIREMENTS FOR EARTH-OBSERVATION SYSTEMS USING LARGE SPACE ANTENNAS
L. S. KEAFER, JR. and R. F. HARRINGTON Jun. 1983 44 p refs
(NASA-RP-1101; L-15429; NAS 1.61:1101) Avail: NTIS HC A03/MF A01 CSCL 14B

Requirements are defined for Earth observation microwave radiometry for the decade of the 1990's by using large space antenna (LSA) systems with apertures in the range from 50 to 200 m. General Earth observation needs, specific measurement requirements, orbit mission guidelines and constraints, and general radiometer requirements are defined. General Earth observation needs are derived from NASA's basic space science program. Specific measurands include soil moisture, sea surface temperature, salinity, water roughness, ice boundaries, and water pollutants. Measurements are required with spatial resolution from 10 to 1 km and with temporal resolution from 3 days to 1 day. The primary orbit altitude and inclination ranges are 450 to 2200 km and 60 to 98 deg, respectively. Contiguous large scale coverage of several land and ocean areas over the globe dictates large (several hundred kilometers) swaths. Radiometer measurements are made in the bandwidth range from 1 to 37 GHz, preferably with dual polarization radiometers with a minimum of 90 percent beam efficiency. Reflector surface, root mean square deviation tolerances are in the wavelength range from 1/30 to 1/100. Author

N83-29304*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERACTIVE ANALYSIS OF A LARGE APERTURE EARTH OBSERVATIONS SATELLITE
R. L. WRIGHT, D. D. DERYDER, M. J. FEREBEE, JR., and J. C. SMITH May 1983 22 p refs
(NASA-TM-85638; NAS 1.15:85638) Avail: NTIS HC A02/MF A01 CSCL 22B

A system level design and analysis has been conducted on an Earth Observation Satellite (EOS) system using the Interactive Design and Evaluation of Advanced Spacecraft (IDEAS) computer-aided design and analysis program. The IDEAS program consists of about 40 user-friendly technical modules and an interactive graphics display. The reflector support system and feed mast of the EOS spacecraft are constructed with box-truss structural concept, a lattice configuration which can be packaged for delivery in a single Shuttle flight and deployed in orbit. The deployed spacecraft consists of a 120-m by 60-m parabolic focal axis. The spacecraft was modeled for structural, thermal, and control systems analysis and structural elements were designed. On-orbit dynamic and thermal loading analyses were conducted; spacecraft weights and developmental and first unit costs were determined. Author

N83-29305*# Vought Corp., Dallas, Tex.
DEVELOPMENT OF DEPLOYABLE STRUCTURES FOR LARGE SPACE PLATFORM SYSTEMS, VOLUME 2 Final Technical Report
R. L. COX and R. A. NELSON 9 May 1983 115 p refs
(Contract NAS8-34678)
(NASA-CR-170800; NAS 1.26:170800;
REPT-2-32300/3R-53434-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 22B

Ground test article design, deployable volumes concept development, habitat and hangar conceptual designs, and deployable volumes analyses are addressed. Author

N83-29306*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
EVOLUTIONARY SPACE PLATFORM CONCEPT STUDY. VOLUME 2, PART B: MANNED SPACE PLATFORM CONCEPTS Final Technical Report
May 1982 500 p refs
(Contract NAS8-33592)
(NASA-CR-170829; NAS 1.26:170829; MDC-H0072-VOL-2-PT-B) Avail: NTIS HC A21/MF A01 CSCL 22B

Logical, cost-effective steps in the evolution of manned space platforms are investigated and assessed. Tasks included the analysis of requirements for a manned space platform, identifying alternative concepts, performing system analysis and definition of the concepts, comparing the concepts and performing programmatic analysis for a reference concept. Author

N83-31549*# Perkin-Elmer Corp., Danbury, Conn. Electro-Optical Div.
LDR SEGMENTED MIRROR TECHNOLOGY ASSESSMENT STUDY Final Report
M. KRIM and J. RUSSO 3 Mar. 1983 334 p
(Contract NAS2-11104)
(NASA-CR-166493; NAS 1.26:166493) Avail: NTIS HC A15/MF A01 CSCL 03A

In the mid-1990s, NASA plans to orbit a giant telescope, whose aperture may be as great as 30 meters, for infrared and sub-millimeter astronomy. Its primary mirror will be deployed or assembled in orbit from a mosaic of possibly hundreds of mirror segments. Each segment must be shaped to precise curvature tolerances so that diffraction-limited performance will be achieved at 30 micron (nominal operating wavelength). All panels must lie within 1 micron on a theoretical surface described by the optical precipitation of the telescope's primary mirror. To attain diffraction-limited performance, the issues of alignment and/or position sensing, position control of micron tolerances, and structural, thermal, and mechanical considerations for stowing, deploying, and erecting the reflector must be resolved. Radius of curvature precision influences panel size, shape, material, and type of construction. Two superior material choices emerged: fused quartz (sufficiently homogeneous with respect to thermal expansivity to permit a thin shell substrate to be drape molded between graphite dies to a precise enough off-axis asphere for optical finishing on the as-received a segment) and a Pyrex or Duran (less expensive than quartz and formable at lower temperatures). The optimal reflector panel size is between 1-1/2 and 2 meters. Making one, two-meter mirror every two weeks requires new approaches to manufacturing off-axis parabolic or aspheric segments (drape molding on precision dies and subsequent finishing on a nonrotationally symmetric dependent machine). Proof-of-concept developmental programs were identified to prove the feasibility of the materials and manufacturing ideas. Author

N83-31618# Joint Publications Research Service, Arlington, Va.
ZAYTSEV COMMENTS ON MODULAR ORBITAL STATIONS
Y. ZAYTSEV *In its* USSR Rept.: Space, No. 23 (JPRS-83994) p 1 28 Jul. 1983 Transl. into ENGLISH from Sov. Estoniya (Tallinn), 12 Apr. 1983 p 4
Avail: NTIS HC A06

The use of large space stations verses small modular laboratories is discussed. The advantages and disadvantage of the modular laboratories are examined. B.G.

N83-31632*# Vought Corp., Dallas, Tex.
DEVELOPMENT OF DEPLOYABLE STRUCTURES FOR LARGE SPACE PLATFORM SYSTEMS. VOLUME 1: EXECUTIVE SUMMARY
R. L. COX and R. A. NELSON 9 May 1983 24 p
(Contract NAS8-34678)
(NASA-CR-170838; NAS 1.26:170838;
REPT-2-32300/3R-53434-VOL-1) Avail: NTIS HC A02/MF A01 CSCL 22A

Candidate deployable linear platform system concepts suitable for development to technology readiness by 1986 are reviewed. The systems concepts were based on trades of alternate deployable/retractable structure concepts, integration of utilities, and interface approaches for docking and assembly of payloads and subsystems. The deployable volume studies involved generation of concepts for deployable volumes which could be used as unpressurized or pressurized hangars, habitats and interconnecting tunnels. Concept generation emphasized using flexible materials and deployable truss structure technology. Author

N83-32832# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. des Systemes Balistiques et Spatiaux.
MULTIPURPOSE COMMUNICATION SATELLITES
F. CANEPARO 1982 26 p Presented at ENKOR '82, Seoul, Nov. 1982
(SNIAS-831-422-102) Avail: NTIS HC A03/MF A01

A medium size satellite based on the ARABSAT design, and a large satellite based on TDF and TV-SAT are presented. The standard subsystems are sketched and typical missions are suggested. Author (ESA)

N83-34121*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
PRELIMINARY DESIGN OF A 15 M DIAMETER MECHANICALLY SCANNED DEPLOYABLE OFFSET ANTENNA Final Report
1983 69 p
(Contract NAS5-26495)
(NASA-CR-170573; NAS 1.26:170573; LMSC-D714659) Avail: NTIS HC A04/MF A01 CSCL 20N

The preliminary design of a 15 meter diameter mechanically scanned, offset rotating, fed parabolic reflector antenna system is reported and the results of preliminary performance, structural and thermal analyses are presented. Author

N83-34123*# Martin Marietta Corp., Denver, Colo.
THE 15-METER DIAMETER MECHANICALLY SCANNED DEPLOYABLE ANTENNA Final Report
J. V. COYNER, J. J. HERBERT, and E. E. BACHTELL Apr. 1982 220 p refs
(Contract NAS5-26496)
(NASA-CR-170576; NAS 1.26:170576; MCR-82-1307) Avail: NTIS HC A10/MF A01 CSCL 09C

A preliminary design with structural model data and thermal-performance estimates of a 15-meter mechanically scanned deployable antenna (MSDA) that could be launched onboard a Shuttle Orbiter to provide radiometric brightness temperature maps of the Earth and oceans in selected bands over a frequency range from 1.4 to 11 GHz is provided. The study objectives were met through the design of a unique, integrated, offset feed mast and reflector design that uses the deployable box-truss structure as a building block. The performance of this system is summarized. The all graphite-epoxy, 4.57-meter prototype cube that was completed in 1981 and is proposed for this reflector and feed mast design is presented. Author

N83-34193*# Harris Corp., Melbourne, Fla. Government Electronic Systems Div.
MECHANICALLY SCANNED DEPLOYABLE ANTENNA STUDY Final Report
9 Mar. 1983 145 p
(Contract NAS5-26494)
(NASA-CR-170579; NAS 1.26:170579) Avail: NTIS HC A07/MF A01 CSCL 09C

The conceptual design of a Mechanically Scanned Deployable Antenna which is launched by the STS (Space Shuttle) to provide radiometric brightness temperature maps of the Earth and oceans at selected frequency bands in the frequency range of 1.4 GHz to 11 GHz is presented. Unlike previous scanning radiometric systems, multiple radiometers for each frequency are required in order to fill in the resolution cells across the swath created by the 15 meter diameter spin stabilized system. This multiple beam radiometric system is sometimes designated as a "whiskbroom" system in that it combines the techniques of the scanning and "pushbroom" type systems. The definition of the feed system including possible feed elements and location, determination of the fundamental reflector feed offset geometry including offset angles and f/D ratio, preliminary estimates of the beam efficiency of the feed reflector system, a summary of reflector mesh losses at the proposed radiometric frequency bands, an overall conceptual configuration design and preliminary structural and thermal analyses are included. Author

N83-34350*# College of William and Mary, Newport News, Va.
THE EFFECT OF ATMOSPHERIC DRAG ON THE DESIGN OF SOLAR-CELL POWER SYSTEMS FOR LOW EARTH ORBIT
A. C. KYSER Jun. 1983 77 p refs
(Contract NAS1-16042)
(NASA-CR-166020; NAS 1.26:166020) Avail: NTIS HC A05/MF A01 CSCL 20K

The feasibility of reducing the atmospheric drag of low orbit solar powered satellites by operating the solar-cell array in a minimum-drag attitude, rather than in the conventional Sun pointing attitude was determined. The weights of the solar array, the energy storage batteries, and the fuel required to overcome the drag of the solar array for a range of design life times in orbit were considered. The drag of the array was estimated by free molecule flow theory, and the system weights were calculated from unit weight estimates for 1990 technology. The trailing, minimum drag system was found to require 80% more solar array area, and 30% more battery capacity, the system weights for reasonable life times were dominated by the thruster fuel requirements. E.A.K.

N83-35444# Joint Publications Research Service, Arlington, Va.
PROSPECTS FOR SOLAR ELECTRIC POWER STATIONS IN ORBIT
V. VANKE *In its* USSR Rept.: Earth Sci., No. 28 (JPRS-84367) p 66-68 20 Sep. 1983 Transl. into ENGLISH from Izvestiya (USSR), 25 Feb. 1983 p 3
Avail: NTIS HC A05

The feasibility of solar powered electric power stations in orbit is discussed. The application of modern science and technology to the use of solar energy generated from space is examined, and the utilization of direct solar energy for terrestrial conditions is outlined. E.A.K.

N83-35958*# Lockheed Missiles and Space Co., Palo Alto, Calif.
LARGE DEPLOYABLE REFLECTOR (LDR) FEASIBILITY STUDY UPDATE Final Report
W. H. ALFF and L. W. BANDERMAN Moffett Field, Calif. NASA. Ames Research Center Aug. 1983 187 p
(Contract NAS2-11358)
(NASA-CR-166518; NAS 1.26:166518; LMSC-D939654) Avail: NTIS HC A09/MF A01 CSCL 03A

In 1982 a workshop was held to refine the science rationale for large deployable reflectors (LDR) and develop technology requirements that support the science rationale. At the end of the workshop, a set of LDR consensus systems requirements was established. The subject study was undertaken to update the initial LDR study using the new systems requirements. The study included mirror materials selection and configuration, thermal analysis, structural concept definition and analysis, dynamic control analysis and recommendations for further study. The primary emphasis was on the dynamic controls requirements and the sophistication of the controls system needed to meet LDR performance goals. Author

02

ANALYSIS AND DESIGN TECHNIQUES

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

A83-32719*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMAL MODELING AND ANALYSIS OF STRUCTURALLY COMPLEX SPACECRAFT USING THE IDEAS SYSTEM
L. B. GARRETT (NASA, Langley Research Center, Space Systems Div., Hampton, VA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 11 p. refs
(AIAA PAPER 83-1459)

Large antenna satellites of unprecedented sizes are needed for a number of applications. Antenna diameters on the order of 50 meters and upward are required. Such antennas involve the use of large expanses of lattice structures with hundreds or thousands of individual connecting members. In connection with the design of such structures, the consideration of thermal effects represents a crucial factor. Software capabilities have emerged which are coded to include major first order thermal effects and to purposely ignore, in the interest of computational efficiency, the secondary effects. The Interactive Design and Evaluation of Advanced Spacecraft (IDEAS) is one such system. It has been developed for an employment in connection with thermal-structural interaction analyses related to the design of large structurally complex classes of future spacecraft. An IDEAS overview is presented. Attention is given to a typical antenna analysis using IDEAS, the thermal and loading analyses of a tetrahedral truss spacecraft, and ecliptic and polar orbit analyses. G.R.

A83-32720#
THE SPECIALIZED THERMAL MODELING OF SPARSE STRUCTURES IN SPACE
J. E. BAUMANN and C. L. JENSEN (Martin Marietta Aerospace, Engineering Mechanics Dept., Denver, CO) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 7 p.
(AIAA PAPER 83-1461)

An integrated approach to the thermal modeling of large box-truss and lattice-type space structures is outlined. The technique employs an envelope approach to modeling that maintains sufficient resolution to accurately characterize the thermal gradients throughout the structure under both steady-state and transient simulations. The envelope approach begins with an accurate calculation of the temperature of each structural member within a number of repeating macroelements (individual boxes for a box-truss structure) positioned at the periphery and at the shadowed midsection of the structure. A spatial interpolation procedure is employed to extend these data into a file that contains a mean temperature, plus minimum and maximum circumferential temperatures, for each element throughout the structure. The procedure presented here is based on a very accurate prediction of the structure's thermal radiation environment and on specialized temperature calculations that account for wall conduction and internal radiation across hollow elements. C.R.

A83-48141#

PRODUCT DECOMPOSITIONS FOR CERTAIN TYPES OF COORDINATE TRANSFORMATION

T. W. BARBEE (Space Applications Corp., Santa Ana, CA) Journal of Spacecraft and Rockets (ISSN 0022-4560), vol. 20, Sept.-Oct. 1983, p. 510-512.

An algorithm is derived for the decomposition of composite coordinate-transformation matrices (relating the reference frames of large-space-system components) into their component rotations. The order of the factors is preserved, and the iterative procedure produces a unique decomposition. The method can be applied to verify the matrix product of known rotation factors or to find the rotation factors of a given transformation. This method, like the one described by Pio (1964), offers an alternative to the cumbersome multiplication of rotation matrices. T.K.

N83-24544*# Martin Marietta Corp., Denver, Colo.

ADVANCED EARTH OBSERVATION SPACECRAFT COMPUTER-AIDED DESIGN SOFTWARE: TECHNICAL, USER AND PROGRAMMER GUIDE Contractor Report, Sep. 1981 - Dec. 1982

C. E. FARRELL and L. D. KRAUZE Apr. 1983 144 p refs (Contract NAS1-16756)

(NASA-CR-166063; NAS 1.26:166063; MCR-82-1337) Avail: NTIS HC A07/MF A01 CSCL 22B

The IDEAS computer of NASA is a tool for interactive preliminary design and analysis of LSS (Large Space System). Nine analysis modules were either modified or created. These modules include the capabilities of automatic model generation, model mass properties calculation, model area calculation, nonkinematic deployment modeling, rigid-body controls analysis, RF performance prediction, subsystem properties definition, and EOS science sensor selection. For each module, a section is provided that contains technical information, user instructions, and programmer documentation. Author

N83-26735# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

MODELS OF AN INTEGRATED DESIGN DATA BASE IN SUPPORT OF A DESIGN AUTOMATION SYSTEM M.S. Thesis

M. A. TEBO Dec. 1982 181 p refs

(AD-A124726; AFIT/GOS/EE/82D-35) Avail: NTIS HC A09/MF A01 CSCL 09B

This report presents a model for an integrated design data base that will be used within an integrated design system for microelectronics. This report also describes a model of an integrated design system, whose functions include a single, flexible interface between the designer and the design system. These two models provide a conceptual-level design of a Design Automation System; however, the emphasis in this report is on the data base model. The results described in this report are two of the models necessary for the design of a Design Automation (DA) System. The first model is a high-level design which shows the components and the interactions of these components within the DA System. The second model constitutes the design at the conceptual-level of the data base required by the DA System. This data base, called an Integrated Design Data Base, is an integral part of the DA System. The model of the data base defines the data requirements of the design tasks within the microelectronic design cycle. Author (GRA)

N83-33933*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

ORBITAL THERMAL ANALYSIS OF LATTICE STRUCTURED SPACECRAFT USING COLOR VIDEO DISPLAY TECHNIQUES

R. L. WRIGHT, D. D. DERYDER, and M. T. PALMER Jun. 1983 20 p refs Original contains color illustrations

(NASA-TM-85640; NAS 1.15:85640) Avail: NTIS HC A02/MF A01 CSCL 22B

A color video display technique is demonstrated as a tool for rapid determination of thermal problems during the preliminary design of complex space systems. A thermal analysis is presented for the lattice-structured Earth Observation Satellite (EOS) spacecraft at 32 points in a baseline non Sun-synchronous (60 deg inclination) orbit. Large temperature variations (on the order of 150 K) were observed on the majority of the members. A gradual decrease in temperature was observed as the spacecraft traversed the Earth's shadow, followed by a sudden rise in temperature (100 K) as the spacecraft exited the shadow. Heating rate and temperature histories of selected members and color graphic displays of temperatures on the spacecraft are presented. Author

03

STRUCTURAL CONCEPTS

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

A83-36351#

SOLAR SAIL AS OTV (SOLAR SAIL CONCEPT STUDY - PHASE II REPORT)

T. SVITEK AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 9 p. refs

(AIAA PAPER 83-1347)

Design and control concepts for a solar sail system, developed analytically by students, are presented. The sunlight exerts pressure on the sail in a normal direction relative to the solar position. A solar-sail powered vehicle would gradually leave orbit by acquiring thrust on half the orbit, then reducing the exposed sail surface area on the return half of the orbit. The sails can be constructed in either a hard or soft configuration. Composite beams or gas-filled tubes can be used for a rigid or semi-rigid sail. A spinner is a design for a soft sail, wherein the shape of the sail is maintained by centrifugal force. The spinner method offers greater navigational problems than do rigid or semi-rigid sails. Thrust control would also be difficult with a parachute sail. However, due to a lower thrust/weight ratio than other designs, the spinner concept is concluded to be currently the most efficient method for travel beyond GEO. M.S.K.

A83-37970

COMPOSITE MATERIALS AND DEPLOYABLE BOOM TECHNOLOGY

K. KNAPP (Astro Research Corp., Carpinteria, CA) Society of Automotive Engineers, Aerospace Congress and Exposition, Anaheim, CA, Oct. 25-28, 1982. 8 p.

(SAE PAPER 821395)

Space missions planned for Shuttle launches in the next decade require deployable booms that are stronger, stiffer, and longer than those that have been flown in the past. Recent developments in deployable lattice boom technology include improved designs of the Astromast using S-glass/epoxy rods as linear elements and a new folding boom called STACBEAM (Stacking Triangular Articulated Compact Beam) which employs graphite/epoxy rods or tubes. The design features of this new sequentially deployable truss result in improved performance and reliability compared with earlier booms. Author

N83-24891*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SECURING MECHANISM FOR THE DEPLOYABLE COLUMN OF THE HOOP/COLUMN ANTENNA
E. L. AHL, JR. *In* JPL The 17th Aerospace Mech. Symp. p 157-170 May 1983
Avail: NTIS HC A17/MF A01 CSCL 13I

The Column Longeron Latch (CLL) was designed and developed as the securing mechanism for the deployable, telescoping column of the Hoop/Column antenna. The column is an open lattice structure with three longerons as the principal load-bearing members. It is divided into telescoping sections that are deployed after the antenna is place in Earth orbit. The CLL provides a means to automatically lock the longeron sections into position during deployment as well as a means of unlocking the sections when the antenna is to be restowed. The CLL is a four bar linkage mechanism using the over center principle for locking. It utilizes the relative movement of the longeron sections to activate the mechanism during antenna deployment and restowing. The CLL design is one of the first mechanisms developed to meet the restowing requirements of spacecraft which will utilize the STS retrieval capability. S.L.

N83-24892*# Fairchild Space and Electronics Co., Germantown, Md.
A HIGH STRENGTH, TORSIONALLY RIGID, DEPLOYABLE AND RETRACTABLE MAST FOR SPACE APPLICATIONS
L. DIBIASI and R. KRAMER *In* JPL The 17th Aerospace Mech. Symp. p 171-180 May 1983
Avail: NTIS HC A17/MF A01 CSCL 22B

A structural mast was developed which during and after full deployment produces a supporting structure with the characteristics of a high bending moment capability, high stiffness and, particularly important for instrument deployment, a high degree of position repeatability and torsional rigidity. These features were accomplished while providing and easily retractable mast with a high life cycle capability. Since these properties are consistent throughout the full range of deployed lengths, partial deployments or retractions can be utilized for checkout, balance, fine tuning or whatever other reason may be deemed necessary for operation modes or spacecraft stability. S.L.

N83-24898*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
LATCH FITTINGS FOR THE SCIENTIFIC INSTRUMENTS ON THE SPACE TELESCOPE
J. D. DOZIER and E. KAELBER (Perkin-Elmer) *In* JPL The 17th Aerospace Mech. Symp. p 253-265 May 1983
Avail: NTIS HC A17/MF A01 CSCL 13I

Latch fittings which kinematically mount the replaceable scientific instruments onto the Space Telescope must maintain precise alignment and thermal stability for on-orbit observations. Design features which are needed to meet stringent criteria include the use of ceramic isolators for thermal and electrical insulation, materials with different coefficients of thermal expansion for athermalization, precision manufacturing procedures, and extremely tight tolerances. A specific latch fitting to be discussed is a ball-and-socket design. In addition, testing, crew aids, and problems will be covered. Author

N83-26868*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCES IN STRUCTURAL CONCEPTS
M. M. MIKULAS, JR. and H. G. BUSH *In its* Large Space Antenna Systems Technol., Pt. 1 p 257-284 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

A number of different structural concepts are currently under development as a means of placing large structures in orbit. Three commonly considered concepts are described. The radial rib structure and the hoop-column structure have undergone considerable early development because of their seeming potential for providing a reliably deployable reflector surface. In the present paper, attention is focused on truss structures which historically have been widely used in ground based structures because of their inherent simplicity, versatility, and high stiffness. B.W.

N83-26871*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURES FOR LARGE PRECISION REFLECTORS
J. M. HEDGEPETH (Astro Research Corp., Carpinteria, Calif.) and W. H. GREENE *In its* Large Space Antenna Systems Technol., Pt. 1 p 361-380 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

The design and fabrication of a highly accurate large aperture infrared reflecting telescope is discussed. The structural concept is an off axis Cassegrainian design with a focal length equal to the aperture diameter. Thermal shielding, peak heat fluxes, cooling rates, active control tasks, and deployment sequence are discussed. R.J.F.

N83-28066*# Astro Research Corp., Carpinteria, Calif.
LARGE DIAMETER ASTROMAST DEVELOPMENT, PHASE 1 Final Report
P. R. PREISWERK, L. A. FINLEY, and K. KNAPP 30 Apr. 1983 67 p refs
(Contract NAS8-34547)
(NASA-CR-170781; NAS 1.26:170781; ARC-TN-11119) Avail: NTIS HC A04/MF A01 CSCL 22B

Coilable-longeron lattice columns called Astromasts (trademark) were manufactured for a variety of spacecraft missions. These flight structures varied in diameter from 0.2 to 0.5 meter (9 to 19 in.), and the longest Astromast of this type deploys to a length of 30 meters (100 feet). A double-laced diagonal Astromast design referred to as the Supermast (trademark) which, because it has shorter baylengths than an Astromast, is approximately four times as strong. The longeron cross section and composite material selection for these structures are limited by the maximum strain associated with stowage and deployment. As a result, future requirements for deployable columns with high stiffness and strength require the development of both structures in larger. diameters. The design, development, and manufacture of a 6:1-m-long (20-ft), 0.75-m-diameter (30-in.), double-laced diagonal version of the Astromast is described. Author

N83-35178*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SEQUENTIALLY DEPLOYABLE MANEUVERABLE TETRAHEDRAL BEAM Patent Application
M. M. MIKULAS, JR. and R. F. CRAWFORD, inventors (to NASA) (General Research Corp., Santa Barbara, Calif.) 8 Sep. 1983 16 p
(NASA-CASE-LAR-13098-1; US-PATENT-APPL-SN-530339)
Avail: NTIS HC A02/MF A01 CSCL 13B

A tetrahedral beam that can be compactly stowed, sequentially deployed, and widely manipulated to provide a structurally sound yet highly maneuverable truss structure is comprised of a number of repeating units of tandem tetralhedral sharing common sides. Fixed length battens are joined into equilateral triangles called batten frames. Apexes of adjacent triangles are interconnected by longerons having mid-point folding hinges. Joints, comprised of gussets pivotably connected by links, permit two independent degrees of rotational freedom between joined adjacent batten frames, and provide a stable structure from packaged configuration to complete deployment. The longerons and joints can be actuated in any sequence, independently of one another. The beam is suited to remote actuation. Longerons may be provided with powered mid-point hinges enabling beam erection and packaging under remote control. Providing one or more longerons with powered telescoping segments permits the shape of the beam central axis to be remotely manipulated so that the beam may function as a remote manipulator arm. NASA

04

STRUCTURAL AND THERMAL ANALYSIS

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

A83-32705#
HIGH-CAPACITY HONEYCOMB PANEL HEAT PIPES FOR SPACE RADIATORS
H. J. TANZER (Hughes Aircraft Co., Torrance, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 12 p. refs
(AIAA PAPER 83-1430)

The integral heat-pipe honeycomb panel structure is evaluated for application to future space platforms as lightweight, reliable, and highly efficient radiators. Performance predictions and structural development of a representative 120 by 24 by 0.25-in. depth segment of a full-sized modular radiator fin is presented. The panel design utilizes an all-welded stainless steel wickable honeycomb core and facesheet construction, and methanol working fluid for the operating temperature range of -20 to 65 C. Critical parameters affecting heat-pipe thermal transport capacity are isolated, and current fabrication constraints are identified. In addition, several new concepts for an alternative high peformance mode of radiator operation using heat-pipe panel structures are described. Based on work presented in previous development, and the performance predictions and hardware design described herein, the internally wickable core panel appears to be a viable concept for highly efficient space radiators; however, additional in-depth hardware development and testing will determine the optimum combination of materials, core configuration, and manufacturing technique. Author

A83-32706#
MONOGROOVE HEAT PIPE DEVELOPMENT FOR THE SPACE CONSTRUCTIBLE RADIATOR SYSTEM
J. ALARIO, R. BROWN, and R. KOSSON (Grumman Aerospace Corp., Bethpage, NY) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 9 p.
(AIAA PAPER 83-1431)

A high-capacity, high-reliability space radiator is needed in order to satisfy the future heat rejection requirements of large space platforms or space stations. The Space Constructible Radiator (SCR) system is being developed to fill this need. The most important component of the SCR system is the high-capacity monogroove heat pipe which theoretically has a heat transport capacity of 12,700 W-m to 25,400 W-m. This performance represents a better than two order of magnitude increase in transport capacity over currently existing heat pipes. The present investigation is concerned with testing developments which occurred in connection with the monogroove heat pipe during the last two years. A short description of the SCR system is presented, and results are provided for two series of tests which were run on a 15.7-m long heat pipe. The first test series included both performance and diagnostic tests, which pointed to some design modifications which were necessary. The second test series, run on the modified heat pipe, showed improved performance. G.R.

A83-32721*# Washington Univ., Seattle.
RADIATION EXCHANGE IN LARGE SPACE STRUCTURES AND FRAMES
A. F. EMERY, H. R. MORTAZAVI, and M. N. NGUYEN (Washington, University, Seattle, WA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 9 p. refs
(Contract NAG1-41)
(AIAA PAPER 83-1462)

The analysis of radiation heat transfer is determined by the need to determine the geometrical quantity, F(ij), which is commonly called the view factor, and which represents the fraction of energy leaving surface i which strikes surface j. The present investigation shows that the use of a rotating plane to model a one-dimensional radiation element is both computationally efficient and accurate. Because of the reduced computational cost of this element, radiation view factors for complex structures can be calculated directly. Under some conditions, the characteristics of the one-dimensional element may lead to a loss in accuracy when it is used to model obstructing cylinders. In cases in which the element is too close to the radiating surfaces, curved surfaces must be represented by a collection of flat planes. However, it appears that as long as the one-dimensional element is more than 5 diameters from the other surfaces, its use is valid. G.R.

A83-32722#
THERMAL MODELING AND DESIGN CONSIDERATIONS FOR LARGE COMMUNICATIONS SPACECRAFT
W. H. KELLY and J. H. REISENWEBER (COMSAT Laboratories, Clarksburg, MD) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 6 p. Research sponsored by the Communications Satellite Corp.
(AIAA PAPER 83-1463)

This paper discusses the evolution of communications spacecraft with emphasis on potential problems which may be encountered by thermal engineers with respect to spacecraft thermal design and modeling. The anticipated increase in spacecraft size will require advanced techniques of thermal control with new approaches to the concept of thermal modeling and design verification. Design considerations for thermal control subsystems are presented. Modifications of traditional thermal modeling concepts and the influence of appropriately sized test facilities on thermal design and analysis are discussed. Author

A83-34561
FIELD REDISTRIBUTION IN FINITE ELEMENTS - A MATHEMATICAL ALTERNATIVE TO REDUCED INTEGRATION
J. F. OLESEN (Danmarks Tekniske Hojskole, Lyngby, Denmark) Computers and Structures (ISSN 0045-7949), vol. 17, no. 2, 1983, p. 157-159. refs

The method of reduced integration has been proposed as a possible way of overcoming the problem of shear locking in finite element procedures, and good results have been achieved with this technique. However, a drawback of this method is its heuristic nature. Here, an approach based on the method developed by Olesen and Byskov (1982) is proposed whereby high-order finite element fields are redistributed into lower-order fields. The method is demonstrated by applying it to a simple shear flexible beam element, and it is shown that the derived stiffness matrix is identical to the one obtained by applying reduced integration. Since the method presented here is consistent with a variational principle, it might be able to solve problems where the reduced integration technique has failed. V.L.

A83-35926
THE NONAXISYMMETRIC DEFORMATION OF FLEXIBLE CONICAL SHELLS OF VARIABLE THICKNESS [NEOSESIMMETRICHNAIA DEFORMATSIIA GIBKIKH KOMICHESKIKH OBOLOCHEK PEREMENNOI TOLSHCHINY]
IA. M. GRIGORENKO, N. N. KRIUKOV, and X. SAPAROV (Akademiia Nauk Ukrainskoi SSR, Institut Mekhaniki, Kiev, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 19, May 1983, p. 29-35. In Russian. refs

A numerical approach is used to analyze the nonaxisymmetric deformation of flexible isotropic conical shells of variable thickness in the meridional and circumferential directions under nonuniform loading. The appraoch proposed here is based on the method of straight lines combined with the linearization and discrete orthogonalization methods. Calculations are carried out for the frustums of conical shells for various edge conditions and loads. V.L.

A83-38505
THE STABILITY OF FLEXIBLE SHALLOW SHELLS IN A TEMPERATURE FIELD [USTOICHIVOST' GIBKIKH POLOGIKH OBOLOCHEK V TEMPERATURNOM POLE]
L. F. VAKHLAEVA and V. A. KRYSKO (Saratovskii Politekhnicheskii Institut, Saratov, USSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 19, Jan. 1983, p. 16-23. In Russian. refs

The stability of flexible shallow shells of rectangular planform loaded by a transverse force in a temperature field is analyzed using the finite-difference method to solve the governing thermoelasticity equations. The solution is based on a high-order approximation; the convergence of the approximation is demonstrated. To determine the temperature field, matching conditions are obtained for various boundary conditions on the shell surfaces. The efects of the various boundary conditions, transverse forces, and heat sources on the shell stability are discussed. V.L.

A83-40123
DYNAMIC CONTACT PROBLEM OF FLEXIBLE ORTHOTROPIC PLATES AND SHELLS WITH ALLOWANCE FOR TRANSVERSE SHEAR [DINAMICHESKAIA KONTAKTNAIA ZADACHA GIBKIKH ORTOTROPNYKH PLASTIN I OBOLOCHEK S UCHETOM POPERECHNOGO SDVIGA]
A. V. TISHCHENKO (Dnepropetrovskii Institut Inzhenerov Zheleznodorozhnogo Transporta, Dnepropetrovsk, Ukrainian SSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 19, June 1983, p. 101-104. In Russian. refs

The paper presents an analysis of the nonlinear steady forced vibrations of flexible orthotropic plates and shells in contact with an elastic base of Winkler type. The fact that there is a unilateral connection between the base and the shell is taken into account; and the shell material is assumed to be linear elastic. Equations for the vibrations of flexible orthotropic shells with allowance for transverse shear are derived by assuming a thicknesswise distribution of transverse shear stresses and in accordance with the Reissner principle. A numerical solution to the nonlinear dynamic problem is obtained, and a numerical example is presented. B.J.

A83-41154
ON THE INTERACTION BETWEEN LOCAL AND OVERALL BUCKLING OF AN ASYMMETRIC PORTAL FRAME
M. PIGNATARO and N. RIZZI (Roma, Universita, Rome, Italy) Meccanica (ISSN 0025-6455), vol. 18, June 1983, p. 92-96. refs

The post-buckling behavior of an asymmetric portal frame with fixed edges is analyzed. The results reveal that both the local and overall buckling modes have unstable post-buckling behavior; the slope of the post-buckling equilibrium path depends linearly on h/l, h being the height and l the span of the frame. If the ratio of EI(1) to EI(2), the bending stiffnesses of the columns, is equal to 7.263, the two buckling modes occur simultaneously and the slope of the three bifurcated paths is still a linear function in h/l. Along the path of steepest descent, the imperfection sensitivity of the frame is found to be considerably higher than the one caused by the single buckling modes. C.R.

A83-47425
A REVIEW OF POLYMERIC SATELLITE THERMAL CONTROL MATERIAL CONSIDERATIONS
M. F. HITCHCOCK (USAF, Materials Laboratory, Wright-Patterson AFB, OH) SAMPE Journal (ISSN 0091-1062), vol. 19, Sept.-Oct. 1983, p. 15-19, 88. refs

Thermal control is a critical consideration in satellite design. As power requirements, service life and in the case of military satellites, laser hardening requirements increase, passive thermal control will take on even more importance. A great deal of emphasis has been placed on actively dissipating heat from components; however, the final step in disposing of this heat involves radiator surface materials. The various passive techniques currently used, as well as the environmental impact on these concepts, are discussed in this paper. Author

N83-22541*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN, FABRICATION AND TEST OF LIQUID METAL HEAT-PIPE SANDWICH PANELS
A. BASIULIS (Hughes Aircraft Co., Torrance, Calif.) and C. J. CAMARDA Apr. 1983 9 p refs Presented at AIAA/ASME 3rd Joint Thermophys., Fluids, Plasma and Heat Transfer Conf., St. Louis, 7-11 Jun. 1982 Prevously announced in IAA as A82-31898
(NASA-TM-84631; NAS 1.15:84631) Avail: NTIS HC A02/MF A01 CSCL 20D

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 922K (1200F). 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

N83-24819*# Los Alamos Scientific Lab., N. Mex.
LONG TITANIUM HEAT PIPES FOR HIGH-TEMPERATURE SPACE RADIATORS
S. P. GIRRENS and D. M. ERNST (Thermacore, Inc., Lancaster, Pa.) 1982 6 p refs Presented at the 17th Intersoc. Energy Conversion Eng. Conf., Los Angeles, 8-13 Aug. 1982
(Contract W-7405-ENG-36)
(DE82-014069; LA-UR-81-1054; CONF-820814-2) Avail: NTIS HC A02/MF A01

Titanium heat pipes are being developed to provide light weight, reliable heat rejection devices as an alternate radiator design for the Space Reactor Power System (SP-100). The radiator design includes 360 heat pipes, each of which is 5.2 m long and dissipates 3 kW of power at 775 K. The radiator heat pipes use potassium as the working fluid, have two screen arteries for fluid return, a roughened surface distributive wicking system, and a D shaped cross section container configuration. A prototype titanium heat pipe, 5.5 m long, was fabricated and tested in space simulating conditions. Results from startup and isothermal operation tests are presented. These results are also compared to theoretical performance predictions that were used to design the heat pipe initially. DOE

N83-28886# Naval Postgraduate School, Monterey, Calif.
AN INVESTIGATION OF THE FEASIBILITY OF IMPLEMENTING SUBSTANTIAL FINITE ELEMENT CODES ON POPULAR MICROCOMPUTERS M.S. Thesis
D. J. MULHOLLAND Oct. 1982 288 p refs
(AD-A125629) Avail: NTIS HC A13/MF A01 CSCL 09B

The size and cost of microcomputers continue to decrease while their memory capacity and execution speed increase. These advances should result in small, inexpensive machines attaining the same computing power as current mainframe models. The interim need is to adapt general finite element codes to present day, less capable microcomputers. This thesis explores the program structure, memory management, input/output procedures and equation solving methods necessary to accomplish that task. The equation solving capacity and speed of the Apple-II Plus Personal Computer System and the Hewlett-Packard System 45(A) Desktop Computer are compared. A finite element program for the static analysis of space trusses is presented, as adapted to and tested on the Apple-II Plus. The program output may be printed in either English or French. Author (GRA)

N83-30480# Aeritalia S.p.A., Torino (Italy). Space Sector.
FRACTURE MECHANICS AND FATIGUE CRITERIA IN MATERIAL SELECTION FOR SPACE APPLICATIONS
E. VALLERANI, P. MARCHESE, and G. BANINO *In* AGARD Environ. Effects on Mater. for Space Appl. 19 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01

The basic concepts employed in selecting fatigue and fracture resistance materials for the Spacelab design are reviewed, and specific examples of the application of these concepts are presented. The importance of the consideration of the strength and stress corrosion resistence is addition to toughness and fatigue strength is emphasized, especially for the selection of the aluminum alloys that cover most of the pressurized shell and internal structure. Weld material behavior and welding processes were carefully evaluated prior to material selection, and after the selection largely tested to confirm the choice. The possibility of automatic or manual repair without changes fracture-resistance and strength properties is considered. Fracture mechanics and fatigue analysis is summarized as well as nondistructive inspection methodologies and their practical application. Full scale fatigue and fracture mechanics tests and component level tests on some Spacelab structural parts are considered. Author

N83-30481# Spar Aerospace Ltd., Weston (Ontario). Space and Electronics Group.
STRUCTURAL DESIGN AND TEST OF THE SHUTTLE RMS
D. M. GOSSAIN and P. J. SMITH *In* AGARD Environ. Effects on Mater. for Space Appl. 10 p Mar. 1983 refs Sponsored in part by the National Research Council of Canada
Avail: NTIS HC A10/MF A01

The 15.24 m (50 ft) long mechanical arm of the remote manipulator system (RMS) of the space shuttle orbiter was designed to meet stringent weight, stiffness and spatial envelope requirements. The design constraints on the arm structure and joints are described. Structural loads are evaluated and materials selection is considered. The design details of the structural elements and the joints are given. An extensive test program undertaken to qualify and verify the design at component, joint, subsystem and system level is discussed with emphasis on dynamic and static structural tests of structural elements and joints. Author

N83-30482# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
SPACECRAFT THERMAL CONTROL SELECTION FOR SEVEN YEARS LIFETIME IN SYNCHRONOUS ORBIT
L. PREUSS *In* AGARD Environ. Effects on Mater. for Space Appl. 9 p Mar. 1983
Avail: NTIS HC A10/MF A01

Nonconductive and conductive flexible secondary surface mirrors (SSMs) with interference filters on top are examined. The SSM composition is analyzed and defined and the optimization procedure is outlined. The qualification of the SSMs in laboratory scale for the synchronous orbit is demonstrated. The most essential characteristics of the improved SSMs are summarized. Specifications for handling, application, and performance are established for SSMs. Author

N83-32020# Los Alamos Scientific Lab., N. Mex.
CONCEPTUAL DESIGNS FOR 100-MW SPACE RADIATORS
F. C. PRENGER and J. A. SULLIVAN 1982 35 p refs Presented at the Am. Nucl. Soc. Winter Meeting, Advan. Nucl. Systems Symp., Washington, D.C., 14 Nov. 1982
(Contract W-7405-ENG-36)
(DE83-003542; LA-UR-82-3279; CONF-821103-50) Avail: NTIS HC A03/MF A01

A description and comparison of heat rejection systems for multimegawatt space-based power supplies is given. concepts are described, and through a common performance parameter, these are compared with three advanced radiator concepts. The comparison is based on a power system that rejects 100 MW of heat while generating 10 MW of electrical power. DOE

N83-32107# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
THERMAL-STRUCTURAL ANALYSIS OF LARGE SPACE STRUCTURES: A REVIEW OF RECENT ADVANCES Final Report, Aug. - Oct. 1981
E. A. THORNTON Wright-Patterson AFB, Ohio AFWAL Aug. 1982 46 p refs
(Contract F33601-81-M-B516; AF PROJ. 2401)
(AD-A128016; AFWAL-TR-82-3048) Avail: NTIS HC A03/MF A01 CSCL 20K

Recent advances in thermal-structural analysis of large space structures are reviewed. Thermal-structural analytical challenges faced by structural engineers are highlighted and uncertainties that arise in predictive analyses are identified and discussed. Current modeling techniques and characteristics of thermal-structural response are illustrated. Areas for further research are discussed, and the need for fundamental thermal-structural experiments is cited. Author (GRA)

N83-34226*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RADIANT HEATING TESTS OF SEVERAL LIQUID METAL HEAT-PIPE SANDWICH PANELS
C. J. CAMARDA and A. BASIULIS (Hughes Aircraft Co., Torrance, Calif.) Aug. 1983 9 p refs Presented at the AIAA 21st Aerospace Sci. Meeting, Reno, Nev., 10-13 Jan. 1983
(NASA-TM-85669; NAS 1.15:85669; AIAA-83-0319) Avail: NTIS HC A02/MF A01 CSCL 20D

Integral heat pipe sandwich panels, which synergistically combine the thermal efficiency of heat pipes and the structural efficiency of honeycomb sandwich construction, were conceived as a means of alleviating thermal stress problems in the Langley Scramjet Engine. Test panels which utilized two different wickable honeycomb cores, facesheets with screen mesh sintered to the internal surfaces, and a liquid metal working fluid (either sodium or potassium) were tested by radiant heating at various heat load levels. The heat pipe panels reduced maximum temperature differences by 31 percent with sodium working fluid and 45 percent with potassium working fluid. Results indicate that a heat pipe sandwich panel is a potential, simple solution to the engine thermal stress problem. Other interesting applications of the concept include: cold plates for electronic component and circuit card cooling, radiators for large space platforms, low distortion large area structures (e.g., space antennas) and laser mirrors. Author

05

STRUCTURAL DYNAMICS AND CONTROL

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

A83-29995* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYSTEM IDENTIFICATION OF LARGE FLEXIBLE STRUCTURES BY USING SIMPLE CONTINUUM MODELS
J. N. JUANG (NASA, Langley Research Center, Hampton, VA) and C. T. SUN (Purdue University, West Lafayette, IN) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 31, Jan.-Mar. 1983, p. 77-98. refs

Simple continuum models for the representation of large truss beams and truss platforms are constructed and employed in the solution of system identification problems permitting the significant reduction of the number of structural parameters. Two simple and easily computer-implemented algorithms are presented for the estimation of a simple model's equivalent structural parameters, and analytical and numerical solutions are given for the truss beam and truss platform cases in order to illustrate the basic concepts. It is found that model simplicity, in conjunction with the principle of least square erors, yields a feasible integration of structural and identification problems. Author

A83-30165*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXPERIMENTAL DEMONSTRATION OF STATIC SHAPE CONTROL
D. ELDRED and D. SCHAECHTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 6, May-June 1983, p. 188-192. NASA-supported research.

Previously cited in issue 03, p. 344, Accession no. A82-13998

A83-30650#
SUBOPTIMAL CONTROL OF LARGE-SCALE MECHANICAL SYSTEMS
M. VUKOBRATOVIC Academie Serbe des Sciences et des Arts, Bulletin, vol. 78, Classe des Sciences Techniques, no. 19, 1981, p. 27-38. refs

An engineering approach to large-scale mechanical systems control synthesis is considered. The control synthesis is performed in two stages. In the first stage nominal programmed control is synthesized, realizing the desired motion of the system under ideal conditions when no perturbation is acting on the system. This synthesis takes place on the centralized model of the system for some particular, nominal initial condition. In the second stage the decentralized control structure is considered. Since the destabilizing influence of coupling among subsystems can be strong, global control is introduced in order to decrease suboptimality of the decentralized control. Different forms of the global control are discussed, and the parameters of the control law are synthesized by minimizing estimation of the control suboptimality. C.D.

A83-31624
ROBUST ACTIVE VIBRATION DAMPING OF FINITE ELEMENT STRUCTURES IN SPACE FLIGHT [ROBUSTE AKTIVE SCHWINGUNGSDAEMPFUNG VON FINITE-ELEMENTE-STRUKTUREN IN DER RAUMFAHRT]
G. SCHULZ (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Institut fuer Dynamik der Flugsysteme Oberpfaffenhofen, West Germany) and G. HEIMBOLD (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 7, Mar.-Apr. 1983, p. 91-99. In German. refs

In this paper a new method for the design of robust active vibration dampers for finite element structures is presented. A detailed description of the elastic truss structure investigated is first given. Starting from eigenvalue/eigenvector data of a Nastran finite element program, a controller design model is developed. After formulating the design specifications for the robust controller, an appropriate controller structure for vibration damping is chosen. The design procedure for a robust controller is then developed. This procedure represents numerical optimization of a dominant design criterion for the basic system (nominal model of the truss structure). Further design requirements for the basic system and the modified systems are formulated as constraints, i.e. additional design requirements. Finally, the results obtained from this method for vibration damping of the elastic truss structure are discussed. Author

A83-32796*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL MEASUREMENTS OF MATERIAL DAMPING IN FREE FALL WITH TUNEABLE EXCITATION
E. F. CRAWLEY and D. G. MOHR (MIT, Cambridge, MA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, Lake Tahoe, NV, May 2-4, 1983. 7 p. Research supported by Aerospace Corp. refs
(Contract NAGW-21)
(AIAA PAPER 83-0858)

An experimental method of measuring material damping of a specimen in free fall has been developed. An initially simply-supported test specimen was simultaneously excited and lofted into free fall with a spring-mass launcher. The launcher could be tuned to produce varying initial stress amplitude levels in the specimens. Damping information was obtained from the transient response of the specimens while in free fall in a vacuum. A dynamic model of the launch process was developed which indicates the range of frequency and initial specimen stress amplitude over which tests can be performed. To verify the facility, material damping was measured in 2024-T3 aluminum, and (+ or - 45)2s AS1/3501-6 graphite/epoxy. Free-free frequencies ranged from 20-357 Hz in aluminum, and from 18-171 Hz in the (+ or - 45)2s specimens. Damping values in aluminum were found to be close to theoretical values and independent of stress levels below 130 MPa (18.7 Ksi). Damping ratios in the (+ or - 45)2s graphite/epoxy specimens were found to be largely independent of stress levels below 43.8 MPa (6.35 Ksi) and only slightly dependent on frequency. A small dependence of the frequency of free vibration on specimen stress amplitude was also noted. Author

A83-33474#
DYNAMIC QUALIFICATION OF SPACECRAFT BY MEANS OF MODAL SYNTHESIS. II
A. BERTRAM and P. CONRAD (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, West Germany) ESA Journal (ISSN 0379-2285), vol. 7, no. 1, 1983, p. 45-61. Sponsorship: European Space Research and Technology Centre. refs
(Contract ESTEC-2998; ESTEC-3287; ESTEC-3347; ESTEC-3690; ESTEC-4350)

Two modal-synthesis methods are applied to the dynamic qualification procedures for spacecraft structures. These are modal correction and modal coupling, and they both allow measured modal data to be used. The experience gained in applying these methods is summarized. In particular, information on test-data requirements is presented, and the influences of measuring errors and mode truncation are discussed. It is then shown how the coupling analyses can be improved by precise consideration of the coupling conditions in substructure tests and in calculations. The importance of simulating the actual interface conditions during testing and in the coupling approach is stressed, as is a careful choice of the number of modes and the type of mode sets. C.R.

A83-33968*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL CONTROL RESEARCH AND EXPERIMENTS AT NASA/LARC
R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) SPIE - The International Society for Optical Engineering, Technical Symposium, Los Angeles, CA, Jan. 17-21, 1983, Paper. 11 p. refs
The advances made in the area of structural dynamics and control using the flexible beam facility at the NASA Langley Research Center are surveyed. Spectral attention is given to the progress in adaptive control and reliability improvements using advanced control concepts. Both theoretical and experimental results are given to delineate the nature of the work being undertaken. With regard to adaptive control, emphasis is placed on parameter and system identification and on comparisons between competing on-line algorithms. In addition, results are presented for on-line modal control laws that are interfaced to a parameter identification scheme. This gives an on-line distributed adaptive control system. With regard to reliability, a design process is outlined that incorporates reliability over the design mission life. C.R.

A83-36556
DYNAMIC ANALYSIS OF GEOMETRICALLY NONLINEAR TRUSS STRUCTURES
S. ABRATE and C. T. SUN (Purdue University, West Lafayete, IN) Computers and Structures (ISSN 0045-7949), vol. 17, no. 4, 1983, p. 491-497. refs
Beam-like truss structures undergoing large deflections when subjected to static and dynamic loadings are studied by using the matrix method and equivalent continuum models. For the matrix method, an incremental procedure with equilibrium iterations are used. Equivalent continuum beam models are derived based on the properties of a typical substructure of the truss. Solutions obtained by using both methods are compared for a number of examples. Author

A83-37070#
A COMPARISON OF CONTROL TECHNIQUES FOR LARGE FLEXIBLE SYSTEMS
L. MEIROVITCH, H. BARUH, and H. OZ (Virginia Polytechnic Institute and State University, Blacksburg, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 6, July-Aug. 1983, p. 302-310. refs
Previously cited in issue 22, p. 3829, Accession no. A81-45847

A83-37077
PARAMETER ESTIMATION AND CONTROL OF DISTRIBUTED SYSTEMS WITH APPLICATION TO LARGE DEPLOYABLE ANTENNAE
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 1-6. refs
This paper will examine the estimation and control of distributed parameter systems which have application to the shape control of a large deployable communications antenna (approximately 100 meters in diameter). Such an antenna would be collapsed and carried into orbit by the NASA Space Shuttle. Once in orbit, the antenna would automatically deploy like a collapsable umbrella. The antenna surface would be quite flexible and its shape would be adjusted by several attached cords or stringers. After long periods of operation, the antenna surface would require refocusing due to changes in the elastic properties of structure and thermal loads. This fine-tuning would be accomplished by an on-line control system which would process sensor measurements at various locations on the structure to estimate the present antenna shape and then generate control commands to the stringers to bring the antenna back to the desired shape. This is an example of a quasi-static parameter estimation and control problem for a distributed parameter system. Procedures will be developed for synthesis of implementable (finite-dimensional) parameter estimation and control algorithms for this type of problem based on finite element structure analysis. Author

A83-37078
NUMBER AND PLACEMENT OF CONTROL SYSTEM ACTUATORS CONSIDERING POSSIBLE FAILURES
W. E. VANDERVELDE (MIT, Cambridge, MA) and C. R. CARIGNAN IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 7-15. refs
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. Previously announced in STAR as N82-25277 T.M.

A83-37079* City Univ. of New York, N. Y.
LEAST-SQUARES SEQUENTIAL PARAMETER AND STATE ESTIMATION FOR LARGE SPACE STRUCTURES
F. E. THAU, T. ELIAZOV (New York, City University, New York, NY), and R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 16-21. refs
This paper presents the formulation of simultaneous state and parameter estimation problems for flexible structures in terms of least-squares minimization problems. The approach combines an on-line order determination algorithm, with least-squares algorithms for finding estimates of modal approximation functions, modal amplitudes, and modal parameters. The approach combines previous results on separable nonlinear least squares estimation with a regression analysis formulation of the state estimation problem. The technique makes use of sequential Householder transformations. This allows for sequential accumulation of matrices required during the identification process. The technique is used to identify the modal prameters of a flexible beam. Author

A83-37081
DYNAMIC ANALYSIS OF THE ELECTROSTATICALLY CONTROLLED MEMBRANE MIRROR USING MULTIPLE SCALES
R. V. RAMNATH (Charles Stark Draper Laboratory, Inc.; MIT, Cambridge, MA) and S. D. JENIE (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 28-33. refs
(Contract N00014-79-C-0462)
The vibrational dynamics of an electrostatically controlled membrane mirror are investigated. The motion is described by a nonlinear partial differential equation with nonconstant coefficients. The system equation is first linearized and then parameterized. The resulting equation is a singularly perturbed linear partial differential equation with variable coefficients. Asymptotic approximations are then developed systematically by the generalized multiple scales method. Thus, the rapid and slow aspects of the membrane dynamics in both the spatial and temporal sense are separated systematically. The results of the approach are compared with direct numerical integration. An excellent agreement between the two solutions is seen in the comparisons. Further reduction of the errors by including higher order approximations is discussed. Author

A83-37106
MINIMUM INFORMATION STOCHASTIC MODELLING OF LINEAR SYSTEMS WITH A CLASS OF PARAMETER UNCERTAINTIES
D. C. HYLAND (MIT, Lexington, MA) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 620-627. USAF-sponsored research. refs
This paper considers the problem of mean-square optimal control for a linear system with stochastic parameters and limited prior information. For specific application to flexible mechanical systems, consideration is limited to the class of multiplicative parameter perturbations of skew-hermitian type. To avoid ad hoc assumptions regarding a priori statistics, a prior probability assignment is induced from available data through use of a maximum entropy principle. Moreover, we discern a minimum set of a priori data which is just sufficient to induce a well-defined maximum entropy probability assignment. The statistical description induced by this minimum data set is tantamount to a form of Stratonovich state-dependent noise. Author

A83-37108
MODELING ROTATIONAL DYNAMICS OF A FLEXIBLE SPACE PLATFORM FOR APPLICATION OF MULTILEVEL ATTITUDE CONTROL
F. D. CHICHESTER (Bendix Simulation Center, Teterboro, NJ) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 636-642. refs
Chichester (1981) has developed a three-axis five-body multilevel state variable model of a typical flexible spacecraft to facilitate later application of multilevel attitude control. The approach utilized in constructing the mathematical model of the rotational dynamics of the spacecraft was based on augmented body techniques presented by Cornell (1977) and by Lipski (1979, 1981). In the present investigation the considered techniques were applied to a three-axis model of the rotational dynamics of a ten-body approximation of a typical space platform. The considered space platform consisted of the flexible spacecraft described by Chichester and another spacecraft. The two objects were connected via a deployable truss. The considered assembly was approximated by ten rigid bodies interconnected by a spring hinge suspension. The equations and characteristics of the model are discussed. G.R.

A83-37114
MAXIMUM ENTROPY STOCHASTIC APPROACH TO CONTROL DESIGN FOR UNCERTAIN STRUCTURAL SYSTEMS
D. C. HYLAND (MIT, Lexington, MA) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 680-688. USAF-sponsored research. refs
This paper applies the minimum data/maximum entropy modelling approach to the mean-square optimal control of flexible mechanical systems having a priori uncertainties in the structural elastic operator. With appropriate choice of the state variables, these uncertainties may be modelled as random skew-hermitian perturbations of the system dynamics map. After formulating the maximum entropy stochastic model for such a system we consider the specific problem of mean-square optimal, full-state feedback regulation. Various properties of the resulting stochastic Riccati equation are investigated. In particular it is shown that for sufficiently large levels of modelled uncertainty, the mean-square optimal design under the maximum entropy model directly produces an inherently robust rate-feedback control. Moreover, the burden of design computations is shown to be dictated by the number of 'well-known' or 'coherent' modes, and the maximum entropy approach is seen to be particularly suited to the treatment of large order systems. Author

A83-37157
SPILLOVER PREVENTION VIA PROPER SYNTHESIS/PLACEMENT OF ACTUATORS AND SENSORS
G. J. KISSEL and J. G. LIN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: American Control Conference, 1st, Arlington, VA, June 14-16, 1982, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, 1982, p. 1213-1218. refs
(Contract F30602-80-C-0096)
A central problem in the control of lightly damped, flexible large space structures is control and observation spillover of reduced-order controllers which can produce destabilizing interactions with unmodeled modes of vibration. Techniques for preventing control spillover by proper synthesis of the influences of existent actuators on a structure and by proper initial placement of the actuators are applied to two representative numerical models of large space structures. This paper focuses on control spillover, because these techniques can be dualized for the prevention of observation spillover. For both models synthesis is shown to prevent control spillover to a significant number of unmodeled modes of vibration. The synthesis algorithm is also extended to determine how actuators should be placed on these models initially for total spillover prevention. Author

A83-37434* Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE TELESCOPE POINTING CONTROL
H. DOUGHERTY, C. RODONI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA), K. TOMPETRINI, and A. NAKASHIMA (Bendix Corp., Guidance Systems Div., Teterboro, NJ) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 15-24. refs
(Contract NAS8-32697)
The Space Telescope Pointing Control System is used to slew the optical axis of the telescope from one target star region of the celestial sphere to the next, and to maintain precision pointing on the target star. A digital computer is employed in the processing of attitude and rate sensor data, in order to generate torque commands for the reaction wheels. The System comprises four major elements: a command generator, the electronic control system, attitude update processing, and momentum management. Emphasis is given to control-related flexibility effects of the Space Telescope's solar cell array and vehicle, and the acquisition methodology and development testing employed, in addition to Pointing Control System design features. O.C.

A83-37436* Bendix Corp., Teterboro, N. J.
SPACE PLATFORM ATTITUDE CONTROL SYSTEM
J. LEVINTHAL (Bendix Corp., Guidance Systems Div., Teterboro, NJ), L. MORATA (McDonnell Douglas Astronautics Co., Huntington Beach, CA), and L. POWELL (NASA, Marshall Space Flight Center, Huntsville, CA) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 39-45.
A discussion is presented of the preliminary design of the Space Platform System, which is being developed to support the Shuttle Orbiter in a sortie configuration with power, communications, and thermal and attitude control capability for up to 30 days while supporting payloads within the Shuttle bay or mounted directly on the platform. Three payload pallets can be supported for indefinite periods of time by the platform in a free flier mode. The vehicle is stabilized against gravity gradients and aerodynamic disturbance torques by the attitude control system. The attitude control system requirements are stringent, due to the need to counteract large aerodynamic disturbances despite the large platform size and low earth orbit altitude. The design of the control system allows it to control both free fly and sortie configurations, with differing inertias as payload pallets are changed. N.B.

A83-37438
SAMPLED CONTROL STABILITY OF THE ESA INSTRUMENT POINTING SYSTEM
G. THIEME (Dornier System GmbH, Friedrichshafen, West Germany), P. ROGERS (Logica, Ltd., London, England), and D. SCIACOVELLI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 57-65.

Stability analysis and simulation results are presented for the ESA Instrument Pointing System (IPS) that is to be used in Spacelab's second launch. Of the two IPS plant dynamic models used in the ESA and NASA activities, one is based on six interconnected rigid bodies that represent the IPS and plant dynamic models used in the ESA and NASA activities, one is based on six interconnected rigid bodies that represent the IPS and its payload, while the other follows the NASA practice of defining an IPS-Spacelab 2 plant configuration through a structural finite element model, which is then used to generate modal data for various pointing directions. In both cases, the IPS dynamic plant model is truncated, then discretized at the sampling frequency and interfaces to a PID-based control law. A stability analysis has been carried out in discrete domain for various instrument pointing directions, taking into account suitable parameter variation ranges. A number of time simulations are presented. O.C.

A83-37439
VALIDATION TECHNIQUES FOR SPOT ATTITUDE CONTROL SYSTEM DEVELOPMENT
P. E. BOURG (Matra, S.A., Velizy-Villacoublay, Yvelines, France) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 67-73.

Attention is given to the design methodology of the Attitude and Orbits Control System (AOCS) algorithms employed in the French earth observation satellite SPOT. Algorithm design and validation has involved two complementary techniques: theoretical analyses and simulations of gradually increasing sophistication, and closed loop tests employing all AOCS elements together with the satellite's onboard computer. Algorithm development has proceeded through functional definition theoretical studies, simulation-based performance assessment, and closed loop tests, employing all AOCS equipment (together with the data handling network), in which solar array flexing modes are physically introduced by a torque motor. O.C.

A83-37441
THE ATTITUDE AND ORBIT CONTROL SUBSYSTEM OF THE TV-SAT/TDF1 SPACECRAFT
H. BITTNER, A. BRAUCH, E. BRUEDERLE, CH. ROCHE, A. SCHEIT, J. STARKE, and M. SURAUER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 83-102.

Attention is given to the design features of the TV-SAT/TDF1 spacecraft's Attitude and Orbit Control Subsystem (AOCS), which is based on the control concepts developed for the INTELSAT V satellite. Apart from the different attitude measurement equipment employed, the main design changes undertaken for the TV-SAT/TDF1 AOCS were stipulated by the need for (1) three-axis stabilization in transfer orbit as well as during apogee maneuver, (2) a digital control concept, and (3) antenna fine pointing with RFS sensing as well as with coarse spacecraft control. O.C.

A83-37444
LUMPED PARAMETER DYNAMIC MODELS FOR LARGE SPACE STRUCTURES WITH FLEXIBLE AND RIGID PARTS
G. BERTONI and M. E. PENATI (Bologna, Universita, Bologna, Italy) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 125-131. refs

The parameters involved in the active control of large flexible space structures are intrinsically distributed, so that their mathematical models must use partial differential equations. Because the design of active system model controls requires the use of ordinary differential equations have lumped rather than distributed parameters, an attempt is presently made to demonstrate a procedure yielding a lumped parameter model for systems that are described by sets of ordinary and partial differential equations (systems having both flexible and rigid parts). The procedure proposed relies on an ad hoc application of the solution of partial differential equations employing Fourier series expansions. O.C.

A83-37468
RECENT ADVANCES IN THE CONTROL OF LARGE FLEXIBLE SPACECRAFT
M. G. LYONS (Integrated Systems, Inc., Palo Alto, CA) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 341-346. refs

Control of flexible spacecraft is reviewed in the context of high performance control objectives. Some achievable results are indicated via a high-order design example. Hardware aspects are discussed with respect to current achievements. Author

A83-37469
DAMPING-AUGMENTATION MECHANISM FOR FLEXIBLE SPACECRAFT
M. INOUE and K. TSUCHIYA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 347-352.

A new design for an attitude control system is developed for flexible spacecraft. The spacecraft is designed such that the flexible appendages are loosely connected with the rigid main body. The two parts, the rigid main body and the flexible appendages, are controlled separately by a rigid body attitude controller and a hinge controller which suppresses the oscillation of the flexible appendages. The main body is controlled accurately with high gain and the appendages are controlled by the hinge controllers with low gain and enough damping so that the hinge control torque does not interfere with the attitude motion. Classical control theory is used to model and analyze a simplified one axis attitude motion of a spacecraft whose flexible appendage is connected by a hinge. N.B.

A83-37470
THE EFFECT OF FLEXIBLE SATELLITE ELASTICITY ON ORIENTATION ACCURACY
V. IU. RUTKOVSKII and V. M. SUKHANOV (Institut Problem Upravleniia, Moscow, USSR) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 353-360.

It is shown that an area in the state space for controlled motion of a flexible satellite can be isolated where the structural flexibility permits better accuracy to be obtained as compared to an equivalent absolutely rigid structure. The isolation of this area is investigated and the potential applications of this effect are examined. A technique is developed for computing the deformable satellite accuracy estimates using a density distribution function developed by Rutkovskii and Sukhanov (1979) for random values of the structural elastic oscillations at the controller switch times at the characteristic point. The phase double plane technique developed by Rutkovskii and Sukhanov (1972) is employed in solving this problem. N.B.

A83-37471
DESIGN OF REACTION JET ATTITUDE CONTROL SYSTEMS FOR FLEXIBLE SPACECRAFT
H. BITTNER, H. D. FISCHER, and M. SURAUER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 373-398. refs

A numerical model is presented to demonstrate generalization of the use of the simple equivalence relation between pulse-width-pulse-frequency (PWPF) and pseudo-rate loops for reaction jet attitude control systems (ACS) on satellites with large solar arrays. The relation is exploited for control loop design and for an analysis of the stability and cycle conditions at the structural oscillation conditions. Stability functions and worst case conditions are derived from normalized modulator performance parameters, and an example is worked out for simple control loop configurations in spacecraft axes. Consideration is given to the interaction of the central body motion and the solar array oscillation modes. Restrictions are imposed on the choice of free parameters by the minimum pulse bit size, the limit cycle rates, the admissible number of thruster operations, and the disturbance torque variation over the mission lifetime. M.S.K.

A83-37472* Howard Univ., Washington, D. C.
ON THE SHAPE AND ORIENTATION CONTROL OF ORBITING SHALLOW SPHERICAL SHELL STRUCTURE
P. M. BAINUM and A. S. S. R. REDDY (Howard University, Washington, DC) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 399-408. refs
(Contract NSG-1414)

The dynamics of orbiting shallow flexible spherical shell structures under the influence of control actuators was studied. Control laws are developed to provide both attitude and shape control of the structure. The elastic modal frequencies for the fundamental and lower modes are closely grouped due to the effect of the shell curvature. The shell is gravity stabilized by a spring loaded dumbell type damper attached at its apex. Control laws are developed based on the pole clustering techniques. Savings in fuel consumption can be realized by using the hybrid shell dumbbell system together with point actuators. It is indicated that instability may result by not including the orbital and first order gravity gradient effects in the plant prior to control law design.
Previously announced in STAR as N82-17243 *Author*

A83-37473
DYNAMICS OF SPACE CABLE SYSTEMS
V. V. BELETSKII (Akademiia Nauk SSSR, Institut Prikladnoi Matematiki, Moscow, USSR) and E. M. LEVIN (Akademiia Nauk SSSR, Institut Mashinovedeniia, Moscow, USSR) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 409-416. refs

The stationary motions of a cable system orbiting the earth are studied. The cable system consists of a vehicle with an engine, a connecting thin cable, and a satellite. The cable weight and the aerodynamic forces acting on the vehicle, the satellite, and the cable are considered. Low altitude cable systems are examined in detail including the heating regimes of the satellite and the cable, the cable parameters permissible by strength, the equilibrium cable system configurations, and the required thrust of the vehicle engine. In addition, the dynamics of the lunar cable system are studied. The lunar cable system consists of an orbital station bound to the surface of the moon by a long thin cable. It is shown that the orbital station may be stabilized by a long cable near the collinear libration point L1 or L2 of the earth-moon system. N.B.

A83-39094
PROGRESS IN MODELLING AND CONTROL OF FLEXIBLE SPACECRAFT
T. L. JOHNSON (Bolt, Beranek, and Newman, Inc., Cambridge, MA) Franklin Institute, Journal (ISSN 0016-0032), vol. 315, May-June 1983, p. 495-520. refs

Large flexible spacecraft are required for several planned space missions. A proposal that active feedback control be employed to reduce the effects of structural bending and vibration in such spacecraft has provided a significant practical challenge to the theory of control of distributed parameter systems, and particularly hyperbolic systems. This limited survey provides an assessment of the contributions of this theory toward the general solution of problems in active control of flexible spacecraft, and elucidates open questions which still require further research. The development of a useful design methodology is found to require a close interplay between control theory and related areas such as modelling, aggregation, and sensor-actuator election. Author

A83-39095* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL OF LARGE SPACEBORNE ANTENNA SYSTEMS WITH FLEXIBLE BOOMS BY MECHANICAL DECOUPLING
P. K. C. WANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; California, University, Los Angeles, CA) Franklin Institute, Journal (ISSN 0016-0032), vol. 315, May-June 1983, p. 469-493. refs

A simple practical method for designing antenna-feed attitude control systems for large deployable spaceborne antenna systems with long flexible booms is proposed. The basic idea is to mechanically decouple the antenna-feed from the boom so that the feed-attitude control system can be designed without taking the boom dynamics into consideration, thus avoiding a complex control problem involving an infinite-dimensional distributed parameter system. The validity of the proposed method is substantiated by analytical and numerical studies using a mathematical model for the flexible boom which could undergo both bending and torsional vibrations. This approach leads to simple antenna-feed attitude control systems which are amenable to physical implementation. Author

A83-40673
HIGH-ORDER NECESSARY OPTIMALITY CONDITIONS FOR CONTROL PROBLEMS WITH TERMINAL CONSTRAINTS
V. V. GOROKHOVIK (Belorussian Academy of Sciences, Institute of Mathematics, Minsk, Belorussian SSR) Optimal Control Applications and Methods (ISSN 0143-2087), vol. 4, Apr.-June 1983, p. 103-127. refs

This is a survey of high-order necessary optimality conditions for control problems with inequality and equality terminal constraints. Both classical and Pontryagin extremals are considered. For classical extremals, the characteristics of necessary optimality conditions in terms of variations are given, and the investigations devoted to Kelley's conditions are discussed in detail. For Pontryagin extremals, two types of results are given: generalizations and extensions of matrix impulse optimality condition and high-order maximum principle. Author

A83-41670*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMIC ISOLATION VIA MOMENTUM COMPENSATION FOR PRECISION INSTRUMENT POINTING
D. BOUSSALIS (California Institute of Technology, Jet Propulsion Laboratory, Guidance and Control Section, Pasadena, CA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 111-119.
(Contract NAS7-100)
(AIAA PAPER 83-2176)

The concept of a momentum-compensated inertially stabilized platform (IPPADS) for carrying scientific instruments is presented, the platform's function as a mechanical diode is explained, and the implications of momentum compensation for platform pointing and cost are discussed. The equations of motion for momentum compensation in the IPPADS five-body system are derived, and the results are used to computer simulate the system under consideration with two examples. C.D.

A83-41671#

ATTITUDE STABILITY OF FLEXIBLE ASYMMETRIC DUAL SPIN SPACECRAFT

B. N. AGRAWAL (International Telecommunications Satellite Organization, Washington, DC) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 120-127. refs
(AIAA PAPER 83-2177)

This paper deals with the attitude motion of a dual-spin spacecraft which consists of an asymmetric rigid platform and an asymmetric rigid rotor connected together by a flexible joint. The equations of motion represent a flexible multiple-degree-of-freedom gyroscopic system with periodic coefficients due to asymmetries. The equations are analyzed for possible resonances and associated instability regions by using first asymptotic approximation. The resonances occur when either the rotor spin frequency or the platform spin frequency is in the neighborhood of a natural frequency or half the sum of any two natural frequencies. The instability regions associated with these resonances are given explicitly. Author

A83-41672*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

STABILITY OF THE SHUTTLE ON-ORBIT FLIGHT CONTROL SYSTEM FOR A CLASS OF FLEXIBLE PAYLOADS

C. B. KIRCHWEY and L. L. SACKETT (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 128-141.
(Contract NAS9-16023)
(AIAA PAPER 83-2178)

The stability of the Space Shuttle on-orbit flight control system is determined for a class of payloads for which the payload is tilted out of the orbiter bay and the bending can be modeled as localized at a pivot. Examples are the Inertial Upper Stage or the Centaur with attached spacecraft during deployment. The many inertial, geometric, and jet option parameters are reduced to a smaller set which allows the determination of stability or instability as a function of bending frequency and the other elements of the set. The resulting stability charts, which are presented, can be used by payload designers and misssion planners to predict possible instability without elaborate analysis or simulation. Author

A83-41673#

THE EARTH'S HORIZON - A REFERENCE FOR SUB ARC MINUTE ATTITUDE SENSING ON FLEXIBLE SPACE STRUCTURES

F. Z. FOWLER (Ithaco, Inc., Ithaca, NY) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 142-146.
(AIAA PAPER 83-2179)

A concept for determining the relative attitude of payloads on flexible appendages of large space structures such as a space station is described. The concept involves a distributed sensing system with the potential for referencing pitch and roll attitude of a remote payload to a central stellar-based attitude and control system (ACDS) to an accuracy of 0.01 degree in pitch and roll and to the same order in yaw. The space station is assumed to keep the same face toward the earth at all times. Horizon sensors on each payload are used as the basic relative attitude sensor for the payload and referenced to an identical horizon sensor on the ACDS. By viewing essentially the same points on the horizon, the error sources that normally limit horizon sensor accuracy are greatly attenuated. The extension of the concept to a gimballed platform is discussed. C.D.

A83-41705#

SCALE MODEL TESTING FOR CONTROL SYSTEM PARAMETERS

S. M. BROWN, D. A. ERCHINGER, and B. J. SIMMONS (U.S. Air Force, Frank J. Seiler Research Laboratory, Colorado Springs, CO) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 450-456.
(AIAA PAPER 82-2225)

The employment of suitable approaches for predicting the performance of large complex structures in space is a prerequisite for the successful construction and the use of such structures. Theoretical analyses, utilizing finite element models, have been employed in the past to provide the modal characteristics of structures. A feasible alternative for acquiring the vital modal parameters is related to the fabrication and ground testing of small scale models. The use of ground testing of scale models for future large complex space structure analysis would be encouraged, if the functional relationship between the modal characteristics of small scale models and the large complex structures can be verified. The present investigation is concerned with such a possibility. It is concluded that reinforced concrete models do exhibit a linear relationship between size and modal frequency to a high degree of confidence. G.R.

A83-41706#

ATTITUDE STABILIZATION OF FLEXIBLE SPACECRAFT DURING STATIONKEEPING MANEUVERS

B. WIE and C. T. PLESCIA (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 457-465. refs
(AIAA PAPER 83-2226)

This paper presents the analysis and design of reaction jet attitude control system for a spacecraft having large flexible solar arrays. During translational thrusting maneuvers, the solar array flexibility strongly interacts with the Pulse-Width and Pulse-Frequency (PWPF) modulator. A simple transfer function model of flexible spacecraft is used for the preliminary control design. The static and dynamic characteristics of the PWPF modulator are discussed in detail. Nonlinear stability analysis is performed using the describing function of the modulator. Relative stability margin with respect to the limit cycle condition of a structural mode is used as a measure of the nonlinear control system robustness. The performance and stability margin predicted by classical single-axis design, are verified from the 3-axis nonlinear digital simulations. Author

A83-41707*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

DYNAMICS AND CONTROL OF A SHUTTLE ATTACHED ANTENNA EXPERIMENT

S. J. WANG, Y. H. LIN, and C.-H. C. IH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 466-477. NASA-supported research. refs
(AIAA PAPER 83-2227)

Study results obtained to date identify the requirements for a large space system flight experiment. This paper considers the dynamics and control of an offset feed wrap-rib antenna attached to the Shuttle for such an experiment. Results reported in this paper are primarily based on the analysis and simulation of the combined Shuttle and antenna flexible dynamics model, and the Shuttle Vernier Reaction Control Subsystem. These results establish the technical feasibility of the Shuttle attached antenna flight experiment. Static and dynamic disturbances examined do not cause significant dynamic interactions to the experiment. Shuttle

Vernier jets can be used for control purpose or as controlled excitation sources for experiment. Interface between the Shuttle and the antenna can be rigid or actively decoupled depending on the experiment objective. Key large space systems control technologies such as distributed sensing and actuation, system identification, figure estimation and control, and control for slew or reconfiguration can be validated with the experiment configuration described in this paper. Author

A83-41708#

REDUCED ORDER CONTROL DESIGN BENEFITS AND COSTS OF FREQUENCY-SHAPED LQG METHODOLOGY

D. B. RIDGELY, S. S. BANDA, and D. V. PALMER (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 478-490. refs

(AIAA PAPER 83-2229)

This paper discusses the step-by-step application of frequency-shaped Linear-Quadratic-Gaussian methodology, as well as payoffs and costs of this method, to large scale systems, particularly large space structures. The procedure for choosing and forming both state and control frequency-weightings is shown. The results of using such weightings, independently and in combination, are analyzed. It is shown that this method can be used to effectively eliminate the destabilizing effect of spillover. The methodology is shown in two examples consisting of small and medium size finite element models characteristic of large space structures. Author

A83-41720#

ADAPTIVE PARAMETER ESTIMATION FOR A FLEXIBLE STRUCTURE EFFECTS OF SPILLOVER

K. TSUCHIYA and K. YAMADA (Mitsubishi Electric Corp., Central Research Laboratory, Hyogo, Japan) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 594-598. refs

(AIAA PAPER 83-2244)

The asymptotic behavior of a reduced order series-parallel identifier is analyzed for an oscillatory distributed parameter system. The modelling error is caused by neglecting uncontrolled vibration modes. Convergence rates and parameter estimate error bounds are established by an analytical method based on the method of averaging. The proper choice of frequency components of the input signal is crucial for reducing the parameter estimate errors and improving the convergence rate. For the input signal with frequencies close to the vibration frequencies, the corresponding modes are excited resonantly and this, in turn, degrades the performance of the identifier. Author

A83-41721*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

PARAMETER TESTING FOR LATTICE FILTER BASED ADAPTIVE MODAL CONTROL SYSTEMS

N. SUNDARARAJAN, J. P. WILLIAMS, and R. C. MONTGOMERY (NASA, Langley Research Center, Flight Dynamics and Control Div., Hampton, VA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 599-605. refs

(AIAA PAPER 83-2245)

For Large Space Structures (LSS), an adaptive control system is highly desirable. The present investigation is concerned with an 'indirect' adaptive control scheme wherein the system order, mode shapes, and modal amplitudes are estimated on-line using an identification scheme based on recursive, least-squares, lattice filters. Using the identified model parameters, a modal control law based on a pole-placement scheme with the objective of vibration suppression is employed. A method is presented for closed loop adaptive control of a flexible free-free beam. The adaptive control scheme consists of a two stage identification scheme working in series and a modal pole placement control scheme. The main conclusion from the current study is that the identified parameters cannot be directly used for controller design purposes. G.R.

A83-41722#

ADAPTIVE CONTROL FOR LARGE SPACE STRUCTURES

D. B. SCHAECHTER (Lockheed Research Laboratories, Palo Alto, CA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 606-611.

(AIAA PAPER 83-2246)

Adaptive control techniques are being studied for their future application to the real-time control of large space structures, where uncertain or changing parameters may stabilize standard control system designs. The approach used in this paper is to examine an extended Kalman filter design procedure, where the state vector is augmented with the parameters. The associated nonlinear Riccati equation, which is coupled to the state estimate, is linearized about the case of exact knowledge of the parameters. Still, the resulting equations are too complicated to implement in real time. Simplifying assumptions are made for reducing the filter complexity, and the results are demonstrated using simple systems. Author

A83-41723#

CONTROL OF NONCONSERVATIVE DISTRIBUTED-PARAMETER SYSTEMS

L. M. SILVERBERG and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 612-617. refs

(Contract AF-AFOSR-83-0017)

(AIAA PAPER 83-2247)

Systems involving viscous damping forces, circulatory forces and aerodynamic forces are nonconservative. A method capable of controlling nonconservative distributed systems is the independent modal-space control method whereby the natural coordinates of the uncontrolled system remain natural coordinates of the controlled system. In the case of optimal control, one must solve independent complex scalar Riccati equations. The transient solution of the Riccati equations can be found with relative ease and the steady-state solution can be found in closed-form. A numerical example demonstrates the effectiveness of the method. Author

A83-41730*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

RELIABILITY CONSIDERATIONS IN THE PLACEMENT OF CONTROL SYSTEM COMPONENTS

R. C. MONTGOMERY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 660-664. refs

(AIAA PAPER 83-2260)

This paper presents a methodology, along with applications to a grid type structure, for incorporating reliability considerations in the decision for actuator placement on large space structures. The method involves the minimization of a criterion that considers mission life and the reliability of the system components. It is assumed that the actuator gains are to be readjusted following failures, but their locations cannot be changed. The goal of the design is to suppress vibrations of the grid and the integral square of the grid modal amplitudes is used as a measure of performance of the control system. When reliability of the actuators is considered, a more pertinent measure is the expected value of the integral; that is, the sum of the squares of the modal amplitudes for each possible failure state considered, multiplied by the probability that the failure state will occur. For a given set of actuator locations, the optimal criterion may be graphed as a function of the ratio of the mean time to failure of the components and the design mission life or reservicing interval. The best location of the actuators is typically different for a short mission life than for a long one. Author

A83-41743#

DESIGN OF REDUCED ORDER OPTIMAL STATE ESTIMATORS WITH APPLICATIONS TO STOCHASTIC LINEAR OPTIMAL REGULATORS

M. H. DWARAKANATH (Boeing Aerospace Co., Seattle, WA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 750-757. refs
(AIAA PAPER 83-2277)

A unified procedure for designing reduced order, optimal state estimators for linear, discrete-time, time-varying, deterministic and stochastic systems is presented in this paper. The unified design procedure provides a general framework to derive the two well-known results, namely, the Kalman Filter and the Luenberger Observer as special cases. The structure of the observer-estimator clearly brings out the various design freedom the control system designer has at his disposal. Author

A83-41749#

ROBUST ACTIVE VIBRATION DAMPING OF FLEXIBLE SPACECRAFT

G. SCHULZ and G. HEIMBOLD (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 787-793. refs
(AIAA PAPER 83-2289)

A method for improving modal damping of flexible spacecraft is presented, which solves the problems of fulfilling specified design requirements for different models of the spacecraft. This robust controller design is achieved via numerical optimization of the controller induced dissipation energy considering the design requirements of the different models as constraints. The nonlinearly constrained optimization is performed using an efficient recursive quadratic programming algorithm. The method successfully is applied to modal control of the 'Draper Model No 1', implementing different feedback strategies. Author

A83-41750*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

OPTIMAL DESIGN OF A PASSIVE VIBRATION ABSORBER FOR A TRUSS BEAM

J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 794-804. refs
(AIAA PAPER 83-2291)

The selection of the design parameters of passive vibration absorbers attached to a long cantilevered beam is studied. This study was motivated by the need for conducting parametric analysis of dynamics and control for Space-Shuttle-attached long beams. An optimization scheme using a quadratic cost function is introduced yielding the optimal sizing of the tip vibration absorber. Analytical solutions for an optimal absorber are presented for the case of one beam vibrational mode coupled with the absorber dynamics, and results are extended to cover the multiple mode case. An algorithm is developed to make an initial estimate of optimal tuning parameters which minimize the quadratic error cost function. Examples are given to illustrate the design concept. Author

A83-41751#

REDUCTION OF LARGE FLEXIBLE SPACECRAFT MODELS USING INTERNAL BALANCING THEORY

C. Z. GREGORY, JR. (Integrated Systems, Inc., Palo Alto, CA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 805-814. refs
(AIAA PAPER 83-2292)

A new and computationally simple method for flexible spacecraft model reduction is presented. Using an internal balancing approximation shown to be valid when natural damping is small, the method provides quantitative modal rankings with respect to disturbance environment, actuator authority, sensor observability, and performance objective. These rankings are used to select a reduced set of structural modes for controller design, and also to anticipate potential closed-loop performance and stability problems resulting from modal truncation. The method is demonstrated using a 54-mode spacecraft example. Author

A83-41752#

TIME DOMAIN ANALYSIS FOR STABILITY ROBUSTNESS OF LARGE SCALE LQG REGULATORS

R. K. YEDAVALLI (Stevens Institute of Technology, Hoboken, NJ), S. S. BANDA, and D. B. RIDGELY (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 815-822. refs
(AIAA PAPER 83-2293)

In this paper the aspect of 'Stability Robustness' of Linear Quadratic Gaussian (LQG) regulators is analyzed in the time domain. The perturbations which cause instability in the system are viewed as consisting of two types of modeling errors: namely parameter variations and truncated models. Conditions are derived for 'Stability Robustness' for various combinations of these two types of modeling errors. A simple 'measure' of stability robustness is derived and based on this measure a control design algorithm is presented to maximize this measure for given perturbations. Applications in the field of Large Space Structures (LSS) control are discussed and simple examples are presented to illustrate the proposed concepts. Author

A83-41753#

ROBUST CONTROL SYSTEM DESIGN TECHNIQUES FOR LARGE FLEXIBLE SPACE STRUCTURES HAVING NON-COLOCATED SENSORS AND ACTUATORS

R. S. EDMUNDS (Sperry Corp., Defense Systems Div., Albuquerque, NM) and D. L. MINGORI (California, University, Los Angeles, CA) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 823-830. refs
(AIAA PAPER 83-2294)

This paper addresses the problem of designing robust controllers for elastic systems having non-colocated actuators and sensors. Controllers are found which minimize output error subject to robustness and control effort constraints. The design procedure used identifies standard optimal controllers which satisfy robustness and control effort constraints. These designs are evaluated using frequency domain methods; alternate designs are found which retain robustness and improve performance. Examples are presented which show that the controllers produced using this design method have characteristics superior to those of standard optimal controllers. Both minimum and non-minimum phase systems are considered. Author

A83-41825

SPACECRAFT DYNAMICS

T. R. KANE (Stanford University, Stanford, CA), P. W. LIKINS (Lehigh University, Bethlehem, PA), and D. A. LEVINSON (Lockheed Research Laboratories, Palo Alto, CA) New York, McGraw-Hill Book Co, 1983, 445 p.

The dynamics of spacecraft attitude control are presented in a text designed for use in a two-semester graduate-level course. The focus is on the formulation of equations governing the parameters of mathematical models of spacecraft dynamics. Each section consists of a statement of a principle, its derivation, and a sample practical application. Four sets of problems, which can be worked with or without the use of computers, are appended. The kinematical relationships underlying rigid-body dynamics are considered, and the effects of gravitational forces are discussed in detail; single-rigid-body or gyrostat spacecraft are treated using the angular-momentum principle. A more refined method for the solution of complex-spacecraft problems is developed, including consideration of generalized active and inertial forces, linearized dynamical equations, discrete multi-degree-of-freedom systems, lumped-mass models, spacecraft with continuous elastic components, and the use of the finite-element method for the construction of modal functions. T.K.

A83-42543#

A COMPUTER PROGRAM FOR SYSTEM DYNAMIC SYNTHESIS OF FLEXIBLE STRUCTURES FROM COMPONENT DATA

M. L. SONI (Dayton, University, Dayton, OH) IN: Annual Mini-Symposium on Aerospace Science and Technology, 9th, Wright-Patterson AFB, OH, March 22, 1983, Proceedings . New York, American Institute of Aeronautics and Astronautics, 1983, p. 5-9-1 to 5-9-5. Research supported by the International Telecommunication Satellite Organization.

This paper describes the development of a synthesis procedure for computing system modal and damping characteristics from component data. Exact coupling transformation valid for arbitrary interface boundary conditions, various types of component damping specifications, and compatibility of test data with the synthesis procedure are considered. Example problems are presented to demonstrate the application of the developed program. It is shown that the methods of synthesis such as fixed-interface methods, free-interface methods, or hybrid methods are particular cases of the general procedure developed in this paper, and that the system dynamics is synthesized with satisfactory accuracy. Author

A83-43891*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

AN ANALYTICAL INVESTIGATION OF SHAPE CONTROL OF LARGE SPACE STRUCTURES BY APPLIED TEMPERATURES

R. T. HAFTKA (Virginia Polytechnic Institute and State University, Blacksburg, VA) and H. M. ADELMAN (NASA, Langley Research Center, Loads and Aeroelasticity Div., Hampton, VA) Virginia Polytechnic Institute and State University and American Institute of Aeronautics and Astronautics, Symposium on Dynamics and Control of Large Structures, 4th, Blacksburg, VA, June 6-8, 1983, Paper. 36 p. refs

An analytical procedure for the static shape control of flexible space structures subjected to thermal distortions is developed which is based on prescribing temperatures in control elements having much higher coefficients of thermal expansion than the main structure. The temperatures at the control elements are defined so as to minimize the overall thermal distortion of the structure from its ideal shape, and a matrix equation is obtained which can be solved for the set of optimum control temperatures. A formulation of the procedure for continuous structures governed by differential equations and a formulation for discrete (finite element modeled) structures governed by matrix equations are presented. The equations from the continuous formulation are employed for the shape control of a simple beam distorted by nonuniform heating, and the discrete formulation is applied in a general purpose finite-element structural analysis computer program for the shape control of a 750 m radiometer antenna reflector dish subjected to orbital heating. A reduction in thermal distortion by a factor of nearly 50 was obtained with the use of only seven control elements. Results for four different sets of control locations for the antenna are presented in which reductions in distortion of up to a factor of four were obtained. N.B.

A83-43982#

MATHEMATICAL MODELLING OF A FLEXIBLE BEAM UNDER GRAVITY

F. JANSSENS (ESA, Mathematical Support Div., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 7, no. 2, 1983, p. 195-208. refs

The differential equations describing the static deflections of a Bernoulli beam under gravity and a concentrated tip load are derived and solved. The solutions are used to predict tip deflections as a function of bending stiffness for a constant tip load. This relationship is then applied to the results of the static bending tests performed on the ISPM satellite's axial antenna to determine its bending stiffness. The results show clearly the importance of modeling gravity as a distributed load, even for light structural elements. Author

A83-44002

PRINCIPLES OF SENSOR AND ACTUATOR LOCATION IN DISTRIBUTED SYSTEMS

T. L. JOHNSON (Bolt Beranek and Newman, Inc., Cambridge, MA) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 1-14. refs

It is pointed out that in distributed parameter systems the locations also may be considered as part of the specification of an actuator/sensor complement (ASC). So long as the ASC doesn't change with time, its free parameters may be selected, for any specified controller design algorithm, by a conventional parameter optimization method such as gradient search, linear programming, or integer programming. Finite-element models of elastic structures undergoing small displacements and subject to gyroscopic torques are considered, and aspects of control system design and analysis are explored, taking into account questions of tracking and disturbance rejection as the primary objectives of control system design, stability, and transient response. Problems related to the specification of the actuator-sensor complement are also discussed, giving attention to a description of strategy, stability achievement, the achievement of static tracking and disturbance rejection, and the achievement of transient response. G.R.

A83-44003

MODEL REDUCTION BY COST DECOMPOSITION - IMPLICATIONS OF COORDINATE SELECTION

D. L. MINGORI (California, University, Los Angeles, CA) and A. L. DORAN IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 15-34. refs

A number of different approaches exist to reduce the number of equations in linear systems. The present investigation is concerned with an approach considered by Skelton (1980, 1981) which approach, called the method of 'cost decomposition', takes into account all three of the major effects on model fidelity, including input coupling, output coupling, and the frequency spectrum. The performance of this method in the case of a particular class of coordinate selections is studied, giving attention to those which uncouple the cost function. A classification of all cost uncoupling coordinate transformations is presented. G.R.

A83-44005

MODAL COST ANALYSIS AS AN AID IN CONTROL SYSTEM DESIGN FOR LARGE SPACE STRUCTURES

P. C. HUGHES (Toronto, University, Toronto, Canada) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 66-76. refs

Large Space Structures are vibrating systems that have small, but nonzero, damping. These special circumstances make it possible to develop an important extension to linear-quadratic multivariable control theory as applied to such systems: the cost functional can be expanded as a sum of terms each of which depends on the parameters of only one mode. Hence 'modal cost analysis'. The theory is described here for two types of input-control actions and noisy disturbances - and each is justified in the context of LSS control. The general remarks are illustrated by a discussion of a large, flexible, multibeam communications satellite. Author

A83-44009* Rensselaer Polytechnic Inst., Troy, N. Y.
FINITE-DIMENSIONAL DISCRETE-TIME CONTROL OF LINEAR DISTRIBUTED PARAMETER SYSTEMS
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 178-195. refs
(Contract NSF ECS-80-16173; NAG1-171)

Systems described by partial differential equations have an infinite-dimensional state space. Feedback control of such distributed parameter systems must be accomplished by finite-dimensional controllers to be implemented by on-line digital computers. A further practical constraint is that the controller must operate in discrete (rather than continuous) time. This paper investigates the stability of such distributed parameter feedback controllers in closed-loop with the actual system. Author

A83-44011
CONTROL OF DISTRIBUTED HYPERBOLIC SYSTEMS - 'WHAT DOES A TOKAMAK AND A LARGE SPACECRAFT HAVE IN COMMON'?
R. J. GRAN (Grumman Research and Development Center, Bethpage, NY) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 208-220. refs

In controlling the vibrational motion of a spacecraft, it is generally necessary to take into account a number of diverse phenomena. The complete model for the study of a spacecraft's vibration may, therefore, involve many coupled parabolic and hyperbolic partial differential equations. It is pointed out that the complex motions of a plasma moving freely within a magnetic bottle are similar to those of a large space structure. On account of this similarity a common approach for both cases is considered. The design procedure discussed in the present investigation consists of three steps. The first step involves the development of a large order (but finite) design model, while the second step is concerned with the design of a reduced order controller by means of a reduced state feedback optimization algorithm. The verification of the robustness of the resulting design represents the last step. G.R.

A83-44015
EFFECT OF DEPLOYING ACCELERATION ON A FLEXIBLE ANTENNA OF A SPIN-SATELLITE
H. FUJII and S. TASHIRO (Tokyo Metropolitan College of Technology, Tokyo, Japan) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 409-419. refs

Effect of deploying acceleration on a flexible antenna is studied in this paper. This is analysed from three different approaches: the Galerkin method; method of matched asymptotic expansion; and method of numberical analysis. A critical deploying acceleration of the flexible antenna for its stable motion is obtained from these analyses showing a good agreement with each other. Characteristics of the antenna motion with the deploying acceleration is also discussed from three aspects of these analyses. Author

A83-44016* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
DYNAMICS OF TISSERAND'S FRAME FOR AN ELASTIC SPACECRAFT WITH STORED ANGULAR MOMENTUM
H. B. HABLANI (NASA, Johnson Space Center, Houston, TX) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronomical Society, 1983, p. 420-450. Research supported by the National Research Council. refs

Tisserand's frame represents a frame in which the deformations in elastic members and the motions in a central rigid body add zero translational and angular momenta to the overall momentum of the vehicle. The considered relations have been known for some time in the case of nongyroscopic spacecraft. The present investigation is concerned with an extension of the relations to gyroscopic systems, taking into account an entirely elastic spacecraft with significant stored angular momentum. A two-dimensional free, rectangular, elastic structure with axisymmetric rotors is considered. Equations of motion are obtained with the aid of the Newton-Eulerian technique and Hamilton's principle. An analysis is conducted of the dynamics of an elastic gyroscopic free vehicle, and the dynamics of the Tisserand's frame in response to external stimuli is examined. G.R.

A83-44018
SOLUTION METHODS FOR THE ENHANCED MODAL CONTROL RICCATI EQUATION
J. J. OUYANG and M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 1 . San Diego, American Astronautical Society, 1983, p. 478-492. refs

A number of different large, flexible structures have been proposed for future spacecraft and satellite applications. Problems arise in connection with the feedback control of such structures. These problems are partly related to the large dimensions of the structure and the comparatively rather limited capacity of the available computer. Modern Model Control (MMC) approaches have been developed to deal with this active structure problem. Initial difficulties regarding the employment of MMC methods can now be largely overcome with the aid of enhanced MMC. However, the employment of the enhancement approach requires the solution of a nonlinear equation which is a nonsymmetric Riccati equation. The present investigation is concerned with the possibilities for solving this equation. The two most basic algorithms considered are the Newton-Raphson algorithm and the contraction mapping algorithm. G.R.

A83-44024* Duke Univ., Durham, N. C.
FINITE ELEMENT APPROXIMATIONS IN TRANSIENT ANALYSIS
R. J. MELOSH (Duke University, Durham, NC) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 671-693. refs

Alternative techniques for finite element models for transient analyses are explored, using as an example a pinned-pinned beam. Attention is given to the relationships between desired accuracy and the available computer resources. Stiffness, mass, damping, and loading components approximations are examined with note taken of optimization methods. Generation of regular grid results indicates a linear relationship between the number of elements or degrees of freedom and the number of eigenvalues for a given accuracy. Comparisons of the finite element models in terms of accuracy/element or accuracy/degree of freedom were found to be inaccurate for determining model efficiency. Higher accuracies were available from lumped mass and damping models than assumptions of consistent loading, which was preferred to statically equivalent loading. M.S.K.

A83-44032
ON MODERN MODAL CONTROLLER FOR FLEXIBLE SPACE STRUCTURES - A SENSITIVITY ANALYSIS
T. KIDA, O. OKAMOTO, and Y. OHKAMI (National Aerospace Laboratory, Chofu, Tokyo, Japan) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 938-948. refs

The element of sensitivity vector is explicitly derived for a damped system, such as those envisioned for attitude and shape control of large flexible structures. The analysis is performed in terms of eigenvalues or eigenvectors, with the flexible structure modeled by a set of second order vibrational equations with modal damping. Three approaches are employed to formulate the case when the modal parameters change, i.e., an analysis of the eigenvalues and eigenvectors for a generalized feedback controller, a cost function evaluation of transient and steady-state errors, and Simon Mitter's method using closed-loop poles. The last method is shown to yield a simplified form for the eigenvalue sensitivity. M.S.K.

A83-44033
GENERAL CONDITIONS ON REDUCED-ORDER CONTROL FOR ENSURING FULL-ORDER CLOSED-LOOP ASYMPTOTIC STABILITY
J. G. LIN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 973-1000. refs
(Contract F30602-80-C-0096)

Various conditions are defined for designing closed-loop asymptotic stability for large space structures. Reduced order controllers are noted to be necessary because of limitations in control systems. Several stability conditions are formulated for implementation in the early design phase for reduced order controllers. The conditions cover inclusion of all rigid, undamped, or unstable modes in the reduced order design model, individual stabilization of all unstable modes, constraints on the feedback gain, and the necessity of adding robustness to the full-order closed-loop system with regard to parameter errors or variations. The designer is required to select the number, size, and location of dashpots and springs necessary to assure that the damping and stiffness added to the modeled modes are positive definite. M.S.K.

A83-44034
OPTIMAL INDEPENDENT MODAL SPACE CONTROL OF A FLEXIBLE SYSTEM INCLUDING INTEGRAL FEEDBACK
S. RAJARAM (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 1001-1011.

A method for optimal control of a flexible system including integral feedback of modal coordinates is presented. The method is based upon independent modal space control method, whereby each mode is controlled independently. The optimal control problem involves the solution of independent third-order matrix Riccati equations. The proposed scheme is compared with the well known linear regulator design. A simply supported Euler-Bernoulli beam is considered as an example and simulation results show that the proposed scheme performs well even in the presence of constant disturbance forces. The scheme is insensitive to parameter variations of the system and thus exhibits a fair degree of robustness. Author

A83-44036
STATE ESTIMATION/PARAMETER IDENTIFICATION - GUARANTEED ERROR APPROACH
Y. W. A. WU (Hughes Aircraft Co., Culver City, CA) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 1041-1057. refs

The problem of state estimation/parameter identification is considered in this paper for a class of continuous nonlinear system where the uncertainty in the initial state, the plant and the measurement disturbances are modeled as unknown - but - bounded. The estimate of the system state and identification of system uncertain parameters consist of a set that is consistent with the measurements, the model of the system dynamics and the sets that characterize the uncertainties. Using the concept of fuzzy dynamic programming, guaranteed error estimation/identification is developed for a class of nonlinear system by performing an appropriate outer bound on the smallest set that contains the true system states as well as system parameters. The resultant filter is shown to be almost linear, on-line estimator. The concepts presented are illustrated by computer simulations of the linear feedback control design for a champed-free beam where the mode frequencies and mode shapes are simultaneously identified while controlling the system. Author

A83-44039
THE DETERMINATION OF THE DEGREE OF CONTROLLABILITY FOR DYNAMIC SYSTEMS WITH REPEATED EIGENVALUES
C. N. VISWANATHAN (RCA, Astro Electronics Div., Princeton, NJ) and R. W. LONGMAN (Columbia University, New York, NY) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 1091-1111.

An approach is developed for approximating a recovery region is the case of repeated eigenvalues in control problems. Two examples are provided to demonstrate the intricacy and complexity of calculations involved in assessing the degree of controllability in a case of multiple eigenvalues. The recovery region, however, can be approximated using associated Jordan blocks from one up to the multiplicity of the eigenvalue. It is shown that the recovery region can be characterized with real values quantities and the n canonical directions, i.e., a possibly degenerate n-dimensional parallelopiped. The formulation satisfies the criteria that the calculated approximate degree of controllability is zero if and only if the actual degree of controllability is zero. M.S.K.

A83-44040
FIRST ORDER SOLUTION OF THE OPTIMAL CONTROL PROBLEM FOR DISTRIBUTED PARAMETER ELASTIC SYSTEM
J.-N. JUANG (Martin Marietta Aerospace, Denver, CO) IN: Engineering science and mechanics; Proceedings of the International Symposium, Tainan, Republic of China, December 29-31, 1981. Part 2 . San Diego, American Astronautical Society, 1983, p. 1112-1130. refs

Linear operator's theory is applied to defining an optimal control for a distributed parameter elastic system. Attention is given to development of analytical solutions to the Riccati equations for self-adjoint systems such as beams, plates, strings, and membranes. The operator's expansion theory is employed to decompose nonlinear operator solutions into simpler form. A technique for obtaining first-order solutions to the Riccati equation and to identify a symmetrically positive definite solution for a self-adjoint system is presented. An example is furnished in terms of a simply supported beam. The method is applicable to satellite power systems, specifically solar arrays, as well as satellite transmitter antennas. M.S.K.

A83-44174* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
POINTING REQUIREMENTS FOR SPACE STATION SCIENCE
S. J. PADDACK (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 247-256. refs
(AAS PAPER 83-061)

It appears that man's next evolutionary step in spaceflight will involve his permanent presence in space with a station in earth orbit. For the purpose of discussing pointing requirements for science and applications studies, a space station with certain characteristics is considered, taking into account a low earth orbit station. It is assumed that the space station will be a system with a permanently manned core facility for conducting science, applications, and technical activities in space. Certain problems can best be solved by utilizing platforms or associated free flying spacecraft which would be part of the space station system, but not part of the space station core. Four classes of pointing requirements are defined, including those which can be satisfied by directly using the space station core, two classes which can be stisfied by gimbal systems, and finally a class which can be satisfied by making use of associated free flying spacecraft or platforms. G.R.

A83-44175* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PLANNING FOR LONG TERM CONTROL OF SPACE STATION
H. BUCHANAN (NASA, Marshall Space Flight Center, Huntsville, AL) and S. M. SELTZER (Control Dynamics Co., Huntsville, AL) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 257-272.
(AAS PAPER 83-062)

The National Aeronautics and Space Administration (NASA) is conducting conceptual studies concerning the development of a future U.S. Space Station. The Space Station navigation, guidance, and control functions must be performed over the projected long lifetime of the station. After examining the pertinent history of U.S. spacecraft, this paper examines how these long-term operations can be achieved, settling on autonomous operations as a desirable goal. The paper concludes with a recommended development approach. Author

A83-44176
DECENTRALIZED CONTROL OF THE SPACE STATION FOR EVOLUTIONARY SYSTEM GROWTH AND DOCKING
J. R. SESAK (General Dynamics Corp., Convair Div., San Diego, CA) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 273-284. refs
(AAS PAPER 83-063)

It is pointed out that the control of the space station presents a challenge to the control engineer. Problems are mainly related to attitude control, stabilization, and pointing during periods of evolutionary growth. In addition, station control must be maintained during berthing and docking of such space vehicles as the shuttle and orbital transfer vehicles. It is envisioned that an evolutionary growth of the space station will occur in connection with the addition of sections and elements. Problems arising as a consequence of docking activities and growth developments are related to the occurrence of large perturbations in dynamical characteristics. In order to obtain solutions for these problems, an optimal control methodology is advanced which provides decentralized modular control for large satellites. Attention is given to space station control system characteristics, aspects of centralized versus decentralized control, and a design example involving a space platform. G.R.

A83-44178* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ATTITUDE CONTROL AND STABILITY OF A SPACE STATION
W. H. PETERS and J. W. SUNKEL (NASA, Johnson Space Center, Avionics Systems Div., Houston, TX) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 317-333.
(AAS PAPER 83-065)

Certain problems arise in connection with the design and construction of a Space Station. These problems are partly related to the impossibility to predict in advance the ultimate form and size which the Space Station will assume. Due to the abatement of volume and strength constraints it will be desirable (for maximum utility of mass) to permit very low structural resonance frequencies, and due to complexity of the configuration there will be an extremely high density of modal frequencies. The basic approaches available to an attitude control system designer for coping with the dynamics of a plant with the considered characteristics are examined. In order to overcome difficulties related to a use of currently widely considered approaches, a technique is proposed whereby the degrees of freedom requiring active control are isolated mechanically from other superfluous vibratory modes. G.R.

A83-44179
SPACE STATION ATTITUDE CONTROL - CHALLENGES AND OPTIONS
R. E. OGLEVIE (Rockwell International Corp., Downey, CA) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 335-349. refs
(AAS PAPER 83-066)

This paper addresses the potential problems, challenges, and some options in the development of an Attitude Control System (ACS) architecture for a future manned Space Station (SS). Potential SS applications are examined to identify ACS functional requirements. Control and momentum management in the presence of large environmental disturbances are found to impose new challenges to efficient control system design. The control of the dynamically complex system with multiple articulated bodies, propellant slosh, and flexible solar arrays with many modes within the attitude control system bandwidth will also challenge the designer. System design to accommodate the evolutionary growth and maintainability of systems for long missions also adds another new dimension to this problem. Author

A83-44180* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON-BOARD ESTIMATION TECHNOLOGY FOR SPACE STATION - CURRENT STATUS AND FUTURE DEVELOPMENTS.
G. RODRIGUEZ, Y. H. LIN, J. M. CAMERON, and S. Z. SZIRMAY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 351-370.
(AAS PAPER 83-067)

Design considerations and projected solutions to on-board automated estimation techniques for advanced technology controls on a space station are described, with emphasis on the state estimator. The space station is modelled as a collection of rigid and flexible bodies connected at a finite number of hinges. The systems dynamics are characterized by angular velocities of the base body, gimbal angles, and deflections of the flexible appendages. The state estimator evolution is projected to occur in four generations, with the first being control logic in the Viking and Voyager spacecraft, the second in the Shuttle and Galileo probe, the third being large antennas and the prototype space station, the last, around the year 2000, for the actual space station. Considerations for attitude, ephemeris, shape determination, and position estimation through each generation are discussed. M.S.K.

A83-44183* Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
APPLICATION OF IDENTIFICATION TECHNIQUES TO REMOTE MANIPULATOR SYSTEM FLIGHT DATA
G. D. SHEPARD, J. A. LEPANTO, R. W. METZINGER, and E. FOGEL (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Guidance and control 1983; Proceedings of the Annual Rocky Mountain Conference, Keystone, CO, February 5-9, 1983 . San Diego, CA, Univelt, Inc, 1983, p. 405-420. refs
(Contract NAS9-16023)
(AAS PAPER 83-083)

This paper addresses the application of identification techniques to flight data from the Space Shuttle Remote Manipulator System (RMS). A description of the remote manipulator, including structural and control system characteristics, sensors, and actuators is given. A brief overview of system identification procedures is presented, and the practical aspects of implementing system identification algorithms are discussed. In particular, the problems posed by desampling rate, numerical error, and system nonlinearities are considered. Simulation predictions of damping, frequency, and system order are compared with values identified from flight data to support an evaluation of RMS structural and control system models. Finally, conclusions are drawn regarding the application of identification techniques to flight data obtained from a flexible space structure. Author

A83-45102#
A DEFINITION OF THE DEGREE OF CONTROLLABILITY FOR FUEL-OPTIMAL SYSTEMS
R. A. LASKIN, R. W. LONGMAN, and P. W. LIKINS (Columbia University, New York, NY) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 1-14. refs

This paper offers a new concept of the degree of controllability, one which places its emphasis on the fuel required to return a system to equilibrium after a disturbance. This has an obvious appeal for spacecraft applications in which fuel limitations govern mission lifetimes. The definition is first developed and then computational methods are generated for evaluating the degree of controllability. The use of the method is illustrated by application to simple standard problems and to a typical set of spacecraft modal equations. Author

A83-45103#
CONTROL OF A FLEXIBLE SATELLITE VIA ELIMINATION OF OBSERVATION SPILLOVER
R. A. CALICO, JR. (U.S. Air Force Institute of Technology, Wright-Patterson AFB, OH) and A. M. JANISZEWSKI IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981.

The employment of a new generation of satellites has been possible in connection with the introduction of the space transportation system. These satellites are large, distributed parameter systems which typically have tens to hundreds of relatively low frequency structural modes. These satellites present special control problems. In a typical application, a structural model of the satellite is available to the control designer. Of the modelled modes, active control must be restricted to a relatively small number of critical modes due primarily to on-board computer limitations. While the controller is based on a subset of critical modes, the control inputs and the sensor outputs are contaminated by the remaining residual modes, and the feedback controller excites these modes. Balas (1977) labels these effects 'control spillover' and 'observation spillover' respectively. Attention is given to an approach in which the spillover problems are solved by means of a suppression transformation which is included in the problem formulation. G.R.

A83-45104#
SPILLOVER AND MODEL ERROR BOUNDING TECHNIQUES FOR LARGE SCALE SYSTEMS
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) and T. L. MEISNER IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 35-47. refs

In designing a practical controller for a large-scale system, it is necessary to choose a reduced order model of the system by selecting the modes which should be retained. The dimension of the controller is limited by the capacity of on-line computers and the cost and availability of sensors and actuators. Bounds are developed on the effects of spillover and model error for the closed-loop system. The procedure is illustrated with the aid of a simple problem. The closed-loop must be analyzed by taking into account the residual modes which were neglected during the design of the controller. G.R.

A83-45105#
NUMERICAL IMPLEMENTATION OF SUBOPTIMAL OUTPUT FEEDBACK CONTROL FOR LARGE SPACE STRUCTURES
D. R. HEGG (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 65-78. refs
(Contract F30602-78-C-0268)

The possibility of increasing the freedom of choice available in the process of control system design is considered, taking into account the problem of closed-loop pole assignment in linear multivariable systems. Hegg (1980) has discussed extensions of suboptimal output feedback control with application to large space structures. The present investigation has the objective to provide a basis which will make it possible to take advantage of the design freedom inherent in the considered extensions to the Kosut (1970) method of suboptimal output feedback. A numerical procedure is developed to compute the general solution to the gain equation in the rank-deficient case. The procedure is based upon a computation of the singular value decomposition for the coefficient matrix and expresses the solution in a form which facilitates the design freedom available. G.R.

A83-45106#
AN ALTERNATIVE VIEW OF THE OPTIMAL OUTPUT FEEDBACK COMPENSATOR PROBLEM
R. K. PEARSON (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and T. L. JOHNSON (Bolt, Beranek and Newman, Inc., Cambridge, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 79-88. refs
(Contract F30602-80-C-0096)

This paper presents an alternative view of the optimal constant gain output feedback compensator described in Levine and Athans (1970), and Levine et al. (1971). Specifically, it is shown that solutions of the necessary conditions for the optimal gain satisfy a constrained least squares minimization problem. In addition to providing insight into computational issues, this point of view is useful in developing suboptimal approximations to this compensator and in examining its relationship to the optimal full state feedback compensator. Author

A83-45107#
APPROXIMATION TECHNIQUES FOR OPTIMAL MODAL CONTROL OF FLEXIBLE SYSTEMS
H. F. VANLANDINGHAM, J. B. FLOYD (Virginia Polytechnic Institute and State University, Blacksburg, VA), and A. K. CAGLAYAN (Bolt, Beranek and Newman, Inc., Cambridge, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 89-99. refs

Recent results on modal control of a flexible surface are presented. Whereas N modes can be optimally controlled with N actuators and N sensors in a decoupled manner, this paper presents the results of a study of the degree of suboptimality achievable when M (less than N) actuators and P (less than N) sensors are employed. The general decoupled control method is developed in detail as followed by specific results obtained from the simulation of the method applied to shape regulation of a surface, whereby a specific shape can be maintained in a disturbance environment. Author

A83-45108#
MINIMUM INFORMATION APPROACH TO REGULATOR DESIGN - NUMERICAL METHODS AND ILLUSTRATIVE RESULTS
D. C. HYLAND and A. N. MADIWALE (MIT, Lexington, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 101-118. USAF-sponsored research. refs

Hyland (1981) has presented the theoretical basis for a new approach to mean-square optimal regulation of structural systems with uncertainties in the modal parameters. The present investigation is concerned with computational procedures and various theoretical predictions with appropriate numerical results. The numerical results obtained with the considered computational procedures illustrate various theoretical properties of the minimum information stochastic design approach as applied to full-space feedback regulation of structural systems with uncertainties in the open-loop frequencies. The example problems considered demonstrate that the stochastic Riccati equation automatically provides a robust rate-feedback control for those modes having large a priori frequency uncertainties. G.R.

A83-45109#
APPLICATION OF CLASSICAL TECHNIQUES TO CONTROL OF CONTINUOUS SYSTEMS
F. H. LUTZE and R. M. A. GOFF (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 119-136. refs

The conventional procedure used in designing controllers for structural systems is based on an application of modern control theory to a reduced linear system obtained from finite element analysis or from a truncated modal analysis. In most of the designs the sensor signal must be processed to separate the contributions from each mode. The present investigation has the objective to provide an alternative approach to the problem of designing controllers for systems governed by partial and ordinary differential equations. The approach is based on the classical concept of transfer functions which relate the output or response of a system to the input. For simple structures, the displacement (velocity or slope) at one point can be related to the force applied at another point by an exact transfer function. G.R.

A83-45110#
THE CONTROL OF A FLEXIBLE SQUARE PLATE IN SPACE
K. NAJMABADI (Stanford University, Standford, CA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 137-152. refs

Advances concerning the space transportation system will soon provide the means for the construction of large structures in space. If the number of modules is very large, the actual structure can be models as an equivalent distributed parameter structure. The present investigation is concerned with the control of the shape and orientation of a free square plate with no internal damping. The conducted analysis makes use of the finite element method, and three discretized models. The models include a coarse grid size model consisting of 25 grid points, a medium grid size model consisting of 49 grid points, and a fine grid size model consisting of 81 grid points. G.R.

A83-45111*# Stanford Univ., Calif.
MODELING AND CONTROL OF FLEXIBLE SPACE STRUCTURES
B. WIE and A. E. BRYSON, JR. (Stanford University, Stanford, CA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 153-174. refs
(Contract NGL-05-020-007; NAG1-97)

The effects of actuator and sensor locations on transfer function zeros are investigated, using uniform bars and beams as generic models of flexible space structures. It is shown how finite element codes may be used directly to calculate transfer function zeros. The impulse response predicted by finite-dimensional models is compared with the exact impulse response predicted by the infinite dimensional models. It is shown that some flexible structures behave as if there were a direct transmission between actuator and sensor (equal numbers of zeros and poles in the transfer function). Finally, natural damping models for a vibrating beam are investigated since natural damping has a strong influence on the appropriate active control logic for a flexible structure. Author

A83-45112*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON THE RIGID BODY MOTION AND SHAPE DISTORTION EVALUATION FOR LARGE FLEXIBLE SPACECRAFT
M. HAMIDI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 191-201.

A procedure is described for evaluating and subtracting the contribution of the rigid body motion from the general displacement of a Large Space Structure. The shape distortions are thus exhibited and their root mean square calculated. It is well known that a rigid body motion is composed of a rotation and a translation. To evaluate the rotation matrix M, use is made of the fact that unitary matrices can be expressed as $M = (I-B)/(I+B)$ where B is computed using the coordinates, before and after the displacement, of three rigidly attached points. The translation vector is then deduced from the same coordinates. Author

A83-45113#
DAMPED RESPONSE OF SPACECRAFT WITH FLEXIBLE DEPLOYING APPENDAGES
K. W. LIPS and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 203-220. Sponsorship: National Sciences and Engineering Research Council. refs
(Contract NSERC-A-2181)

The paper studies attitude dynamics of spacecraft with deploying flexible appendages accounting for both structural and librational damping. Also investigated are control strategies ensuring a stable response in the presence of deployment. The results suggest that conclusions based on a simpler planar analysis may fail to predict instability. Even a small excitation of the yaw degree of freedom appears to be sufficient to trigger unstable response. Deployment of booms in two or more stages can be used to achieve a tuned inertia ratio of 0.5 to reduce pitch oscillations as suggested by a simple momentum analysis. Author

A83-45114*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
ON ADAPTIVE REGULATION OF FLEXIBLE SPACECRAFT
D. A. LAWRENCE and C. R. JOHNSON, JR. (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 237-254. refs
(Contract NAG1-7)

It is pointed out that the regulation of shape and attitude disturbances in large space structures (LSS) using adaptive control remains an actively studied, yet controversial approach, just as adapative control itself. The controversy arises because the utility of many methods of adapatively controlling distributed parameter systems (DPS) is unsubstantiated. However, it appears that adaptive control can be applied to solve problems in LSS control which are not amenable to more common control methods. The present investigation has the objective to clarify the application of adaptive control to LSS. Attention is given to the characteristics of adaptive model control, aspects of simultaneous mode shape adaption, questions of multivariable simultaneous identification and control, and direct adaptive multivariable control. G.R.

A83-45115#
FINITE ELEMENT MODELS AND SYSTEM IDENTIFICATION OF LARGE SPACE STRUCTURES
F. C. TUNG (TRW Defense and Space Systems Group, Redondo Beach, CA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 255-267.

A system identification technique that can improve the flexible structure finite element model by means of adjusting the physical parameters to fit the experimental measurements is presented. This technique can also handle structural input-output data with non-zero initial dynamic conditions. Because a finite-element model can never match the structural dynamics exactly, the parameters producing the best fit may not be the true parameters. The purpose of this technique is to obtain a better description of the LSS dynamics rather than finding the true physical parameters of the structure. A simply supported plate is used as an example to demonstrate the method. The effects of data length are also discussed. Author

A83-45116#
AN APPROXIMATION TECHNIQUE FOR THE CONTROL AND IDENTIFICATION OF HYBRID SYSTEMS
J. A. BURNS and E. M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 269-284. refs
(Contract AF-AFOSR-80-0068; DAAG29-78-G-0125)

In this paper we consider control and identification problems for a mathematical model of a flexible cable with boundary control. A state space model is formulated and used to develop a general approximation scheme. Although this paper concentrates on this particular physical problem, the methods are applicable to a wide class of 'hybrid' control systems. Author

A83-45117#
OPTIMAL POSITIVE REAL CONTROLLERS FOR LARGE SPACE STRUCTURES
G. SEVASTON (Pratt Institute, Brooklyn, NY) and R. W. LONGMAN (Columbia University, New York, NY) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 285-300. refs

A systematic procedure is proposed and developed for the design of optimal controllers which are robust in the sense that they are assured of being stable even in the presence of gross modelling errors. These errors can include the effects of spillover from unmodelled residual modes that plague the large space structures control problem. The method takes full advantage of the work of Benhabib, Iwens, and Jackson which suggested the use of positivity concepts in the design of spacecraft controllers. The approach suggested by those authors involved design of the controller by standard methods, such as linear quadratic optimal control, adaptive control and pole placement, followed by a test for positivity. The approach used here is a constructive method for generating optimal dynamic regulators of predetermined size and structure subject to positive real constraints. Author

A83-45118#
FINITE-DIMENSIONAL CONTROLLERS FOR HYPERBOLIC SYSTEMS
R. GRAN (Grumman Aerosopace Corp., Bethpage, NY) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 301-317.

The characteristics of a hyperbolic system are discussed along with the issues involved in the development of a controller. The external disturbances are found to create a requirement for the retention of more modes than would be needed if the only disturbances present were those generated by the controller. Attention is given to aspects of order reduction, stability as a criterion for mode selection, the frequency response characteristics of an LQG design, and an example involving a spacecraft for the illustration of some of the results of the investigation. G.R.

A83-45120*# Virginia Univ., Charlottesville.
OPTIMAL DAMPER LOCATION IN THE VIBRATION CONTROL OF LARGE SPACE STRUCTURES
B. P. WANG and W. D. PILKEY (Virginia, University, Charlottesville, VA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 379-392. NASA-supported research. refs

The problem of finding the optimal location of active dampers for the vibration control of space structures is investigated. The optimal location is where maximum damping can be introduced to a particular vibration mode. To this end, classical root locus techniques are used to study the effect on eigenvalues of placing a damper on an undamped structure. An efficient formulation is derived which avoids the solution of the damped eigenvalue problem. Based on the observation of the results for a free-free beam model, a Minimum Constrained Frequency Criterion (MCFC) for locating the optimal damper location is proposed. Author

A83-45121#
STABILITY AUGEMENTATION FOR LARGE SPACE STRUCTURES BY MODAL DASHPOTS AND MODAL SPRINGS
J. G. LIN, Y. H. LIN, and R. B. PRESTON (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 393-408. refs
(Contract F30602-80-C-0096)

A large flexible space structure is commonly modeled as a system containing a large number of rigid bodies interconnected by massless elastic structural elements. It small motions are described with the aid of a highly coupled system of linear second-order differential equations. The modal-dashpot design concept has undergone some changes since its introduction by Canavin (1978). Attention is given to the modal-dashpot design concept and the associated bi-objective design optimization problem, a brief review of Pareto optimization, a bi-objective modal-dashpot design optimizer, aspects of velocity and displacement output feedback control, and full-order closed-loop asymptotic stability. G.R.

A83-45122#

DYNAMICS OF FLEXIBLE HYBRID SATELLITES - EVALUATION AND COMPUTATION OF A SYMBOLIC FORMALISM

H. BREMER (Muenchen, Technische Universitaet, Munich, West Germany) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 409-424.

Multiaxial hybrid systems which undergo a nonstationary rigid body motion are for a certain time often uncontrollable. In terrestrial applications, the problems produced by such phenomena are usually not too serious. The situation is, however, very different with respect to applications in space, and special efforts should be made to avoid such a loss of controllability. Such efforts require the employment of a comprehensive model of the actual system. The present investigation is concerned with the evaluation of a formalism for hybrid multibody models. The hybrid multibody system combines the advantages of continuous models and the multibody system. The investigation has the aim to reduce the effort involved in using the model. A representative hybrid system which consists of beamlike elastic substructures is considered. All singularities are avoided by deriving a suitable 'quasi-synthetic' formalism. G.R.

A83-45123#

MULTI-BODY DYNAMICS ANALYSIS ON SMALL COMPUTERS

J. R. GLAESE, S. M. SELTZER, and H. E. WORLEY (Control Dynamics Co., Huntsville, AL) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 425-438.

The present investigation is concerned with a new technique for the structural analysis of complex space structures. The considered technique attempts to utilize the computing power of sophisticated computer systems, while limiting the size and complexity of the computer code and required input data to a level which can easily be implemented on modern desk-top computers. It was decided to formulate the equations from the beginning in a manner consistent with eventual computer implementation. Computer implementation was facilitated by developing a new technique of handling system constraints. All system degrees of freedom are initially constrained. The engineer is able to add complexity gradually to the model by removing the constraints. G.R.

A83-45125#

THREE-DIMENSIONAL CONTROL OF THE SHUTTLE SUPPORTED TETHERED SATELLITE SYSTEMS DURING RETRIEVAL

D. M. XU, A. K. MISRA (McGill University, Montreal, Canada), and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 453-469. Sponsorship: Natural Sciences and Engineering Research Council. refs

(Contract NSERC-A-0967; NSERC-A-2181)

Dynamics of the Shuttle supported tethered satellite systems during retrieval is considered. Length rate laws that may be used in conjunction with the nonlinear equations of motion to attain three dimensional control are proposed. Numerical simulation indicates successful control of the librational motion in the absence of vibrations. The results provide a background for a subsequent more general analysis. Author

A83-45126#

OPTIMAL DISTRIBUTED CONTROL OF A FLEXIBLE SPACECRAFT DURING A LARGE-ANGLE ROTATIONAL MANEUVER

J. D. TURNER and H. M. CHUN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 471-485.

In this paper the solution of the necessary conditions obtained from Pontryagin's principle is discussed, for the problem of optimal large-angle single-axis maneuvers of a flexible spacecraft possessing a distributed control system. A single-stage continuation method is proposed for the solution of the resulting two-point boundary-value problem. Starting iteratives for the initial costate variables are obtained by zeroing the kinematic nonlinearity in the state equation leading to a closed form solution algorithm. The continuation process then increases the participation of the kinematic nonlinearity in a sequence of neighboring optimal solutions (in essence a method of successive linearizations); converging finally to the nonlinear problem of interest. Author

A83-45127#

A VARIATIONAL PERTURBATION METHOD FOR PROBLEMS IN NONLINEAR STRUCTURAL DYNAMICS

M. RAJAN and J. L. JUNKINS (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 487-509. refs

An integral variational statement, derived from the principle of invariance of the action integral serves as the basic equation for continuous systems. This integral variational statement permits arbitrary variations at the terminal times and at the boundaries of the system, and is used to obtain direct solutions for the motion of the system. It is demonstrated that exact solutions for linear systems can be obtained directly from this variational statement, in contrast to the more restrictive variational principle of Hamilton from which one must first derive differential equations in order to determine the solution for the system's motion. A direct variational perturbation procedure for nonlinear structural dynamics is developed. Examples are used to illustrate these concepts. Author

A83-45128#

GENERALIZED FREQUENCY-SHAPED KTC AND RICCATI APPROACHES FOR SPACE STRUCTURE CONTROL

R. D. HEFNER, W. P. HALLMAN, and G. T. TSENG (Aerospace Corp., El Segundo, CA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 511-526. Research sponsored by the Aerospace Corp. refs

This paper discusses two linear control design techniques for minimizing the effects of the control on residual flexible modes of the system. The first approach involves directly building pre-selected frequency domain characteristics into the solutions of the Kelvin-Tait-Chataev (KTC) stability equations. The second approach involves building a similar set of frequency domain characteristics into the solutions of the time-invariant and deterministic Riccati equation. Either problem can be reduced to solving a set of nonlinear algebraic equations. These equations are cast into a functional minimization framework and parameter optimization techniques are used to determine the solution. Through proper formulation, the computational requirements are greatly reduced, permitting application of the two methods to higher dimensioned systems. Author

A83-45129#
CONTROL OF A LARGE CLASS OF FLEXIBLE SYSTEMS
A. A. GOLDENBERG and A. SHARPE (Spar Aerospace, Ltd., Toronto, Canada) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 541-554. refs

Control of interactions between attitude control system and a large solar array drive and track system for a three-axis stabilized geosynchronous satellite is discussed. The problem considered is to find a controller such that the closed loop system provides regulation of the attitude angle (only motion about pitch axis is considered) independently of torque disturbances induced by the solar array sun-tracking motion. The controller is synthesized using a robust servomechanism approach which ensures that the performance of the attitude controller is not affected by modeling errors and by a certain class of parameter perturbations. The paper indicates that asymptotic rejection of the disturbance torque for any perturbation of the given class in the system parameters can be obtained if a certain model of the disturbance torque is incorporated in the attitude controller structure. Author

A83-45130#
ON THE UNIQUENESS OF THE INDEPENDENT MODAL-SPACE CONTROL METHOD
L. MEIROVITCH and S. RAJARAM (Virginia Polytechnic Institute and State University, Blacksburg, VA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 555-570. refs

Two modal approaches to the design of large space structures control are considered. The independent modal space control (IMSC) method decouples the system completely by block-diagonalizing the coefficient matrix, where each block is 2 x 2, and it requires as many actuators as the number of modeled modes for control. The coupled modal controls, on the other hand, couple the modes of the system via the feedback and control spillover into the residual modes is not eliminated. To achieve control characteristics comparable to that of IMSC, i.e., block-diagonalization of the system, the coupled modal controls require more actuators than the number of modeled modes. Author

A83-45131#
AN INTEGRATED APPROACH TO OPTIMAL REDUCED ORDER CONTROL THEORY
P. T. KABAMBA and R. W. LONGMAN (Columbia University, New York, NY) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 571-585. refs

The most often applied result of modern control theory is the linear-quadratic-Gaussian result. There are, however, complications, and for large scale systems the procedure quickly becomes impractical. To date nearly all approaches concerned with the attitude and shape control of future very large spacecraft have employed truncation or model reduction methods. A number of difficulties arise in connection with these approaches. The present investigation is concerned with the development of a procedure for overcoming these difficulties. The general formulation of reduced order controllers is introduced, and the problem of optimizing controllers for deterministic systems with known or with unknown initial conditions is solved. The problem is also solved for stochastic systems, and the stochastic infinite time problem with transient penalty is considered. The optimal reduced order control problems solved are generalized to time varying systems with finite time cost functionals. G.R.

A83-45132#
PARTITIONING CONTROL OF LARGE SPACE STRUCTURES
G. CAMPION and P. Y. WILLEMS (Louvain, UniversiteCatholique, Louvain-la-Neuve, Belgium) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 587-598. refs

This paper proposes a partitioning solution for the control of Large Space Structures. Its advantage is that it does not need an a priori complete modelization of the system, but it appears as a self-learning method, detecting and identifying the modes as soon as they influence the output signals. The solution structure is a collection of low order estimator-regulator subsystems. Author

A83-45133#
ACTIVE CONTROL OF LARGE FLEXIBLE SPACECRAFT - A NEW DESIGN APPROACH BASED ON MINIMUM INFORMATION MODELLING OF PARAMETER UNCERTAINTIES
D. C. HYLAND (MIT, Lincoln Laboratory, Lexington, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 631-646. USAF-sponsored research. refs

Two fundamental problems arise concerning the application of modern control theory to the design of active structural control. The first problem is related to the sensitivity of control effectiveness to errors in modelling plant dynamics. There arises, therefore, a problem of 'robustness'. The second problem is caused by the large dimension of the dynamic model which must be employed. The present investigation is concerned with the basis of a formulation which, it is hoped, will ultimately circumvent the difficulties faced by current design methods. In addressing the problem of optimal control of uncertain structural systems, an approach which is an explicit expression of a general design philosophy is developed. The formulation proposed differs from the traditional procedure which presumes complete and accurate knowledge of system parameters. Attention is given to the identification of the minimum set of a priori data needed to preserve any measure of modelling fidelity. G.R.

A83-45134*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MODEL ERROR ESTIMATION FOR LARGE FLEXIBLE SPACECRAFT
G. RODRIGUEZ (Caliifornia Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 647-665. refs

The basic model obtained for spacecraft control system design applications is used to develop the control and estimation algorithms which constitute integral elements of the control system. The performance of this system is limited on account of modeling errors. The presence of such errors is inevitable in connection with truncated dynamics, parameter uncertainties, neglected nonlinearities, and external disturbances. In many cases, an approximate knowledge of the model errors can only be established by means of an estimation procedure. The present investigation has the objective to outline an approach to estimate errors inherent in a reduced-order model and to illustrate its application to modeling problems arising in spacecraft control system design. The considered procedure makes use of the principle of least-squares. In the discussed application this principle is employed to minimize a quadratic functional of the model errors. G.R.

A83-45135#
EXACT POLE ASSIGNMENT USING DIRECT OR DYNAMIC OUTPUT FEEDBACK
P. T. KABAMBA and R. W. LONGMAN (Columbia University, New York, NY) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 667-681. refs

In a study regarding pole assignment in linear time-invariant systems, Wonham (1967) has found that the closed loop poles of any controllable system may be arbitrarily assigned by state feedback. However, in most practical situations the state is not available directly. The conditions for a system controlled by a direct output feedback law are considered. The approach used in the present investigation is different from procedures employed in studies conducted after Wonham's original work. The obtained results appear reminiscent of those reported by Wonham for full state feedback. Attention is given to the main theorem on local complete assignability by direct output feedback, and links between assignability, controllability, and observability. It is shown that direct output feedback and dynamic compensation are covered by the same formalism so that the results of this investigation apply to the latter case as well. G.R.

A83-45136#
SUBOPTIMALITY AND STABILIITY OF LINEAR DISTRIBUTED PARAMETER SYSTEMS WITH FINITE-DIMENSIONAL CONTROLLERS
M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 683-699. refs

Many current engineering systems display distributed parameter characteristics, and their dynamical behavior can best be modeled by partial differential equations. In the development of feedback control theory for such systems, it is necessary that the infinite-dimensional distributed parameter system (DPS) be controlled by a finite-dimensional system. The present investigation is concerned with the application of a new approach, called the 'imbedding method', for the finite-dimensional control of linear DPS. In addition to new stability bounds, this approach provides bounds on the suboptimality of quadratic performance indices for DPS. Attention is given to the DPS optimal quadratic regulator problem, reduced-order models and finite-dimensional controllers for DPS, the improvement of the stability and performance of finite-dimensional DPS controllers, and the achievement of closed-loop stability and suboptimality via the imbedding method. G.R.

A83-45137#
OPTIMAL REGULATOR DESIGN USING MINIMUM INFORMATION MODELLING OF PARAMETER UNCERTAINTIES - RAMIFICATIONS OF THE NEW DESIGN APPROACH
D. C. HYLAND (MIT, Lexington, MA) IN: Dynamics and control of large flexible spacecraft; Proceedings of the Third Symposium, Blacksburg, VA, June 15-17, 1981 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, p. 701-716. USAF-supported research. refs

Properties of solutions to the stochastic Riccati equation arising from the minimum information modeling approach of Hyland (1981) are explored. Limiting consideration to full state feedback regulation of structural systems with uncertainties in the open-loop frequencies, sufficient conditions for existence of a unique positive semi-definite solution to the time-independent equation are given and closed-loop stochastic stability is established. For the constant gain case, asymptotic properties for large uncertainty levels and for high order modes are presented. The structure of the stochastic Riccati equation suggests a modal aggregation based upon the levels of modal frequency uncertainty. As a consequence, it is found that the burden of design computation may be reduced to that associated with the relatively few well-known or 'coherent' modes. Author

A83-45465#
DISLOCATED ACTUATOR/SENSOR POSITIONING AND FEEDBACK DESIGN FOR FLEXIBLE STRUCTURES
G. SCHULZ and G. HEIMBOLD (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen, West Germany) (Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers, p. 476-483) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 6, Sept.-Oct. 1983, p. 361-367. refs

Previously cited in issue 19, p. 2998, Accession no. A82-38976

A83-45467*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IDENTIFICATION OF STRUCTURAL DYNAMICS SYSTEMS USING LEAST-SQUARE LATTICE FILTERS
N. SUNDARARAJAN and R. C. MONTGOMERY (NASA, Langley Research Center, Flight Dynamics and Control Div., Hampton, VA) (Guidance and Control Conference, San Diego, CA, August 9-11, 1982, Collection of Technical Papers, p. 379-387) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 6, Sept.-Oct. 1983, p. 374-381. refs

Previously cited in issue 19, no. 2987, Accession no. A82-38965

A83-45471*# Lockheed Missiles and Space Co., Palo Alto, Calif.
CLOSED-LOOP CONTROL PERFORMANCE SENSITIVITY TO PARAMETER VARIATIONS
D. B. SCHAECHTER (Lockheed Research Laboratories, Palo Alto, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 6, Sept.-Oct. 1983, p. 399-402. Research supported by the Lockheed Missiles and Space Co. refs
(Contract NAS7-100)

Previously cited in issue 19, p. 2994, Accession no. A82-38877

A83-46099*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADAPTIVE CONTROL OF A FLEXIBLE BEAM USING LEAST SQUARE LATTICE FILTERS
N. SUNDARARAJAN and R. C. MONTGOMERY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) Virginia Polytechnic Institute and State University and American Institute of Aeronautics and Astronautics, Symposium on Dynamics and Control of Large Structures, 4th, Blacksburg, VA, June 6-8, 1983, Paper. 17 p. refs

This paper presents an indirect adaptive control scheme for the control of flexible structures using recursive least square lattice filters. The identification scheme uses lattice filters which provide an on-line estimate of the number of modes, mode shapes and modal amplitudes. These modes are coupled and a transformation to decouple them in order to obtain the natural modes is presented. The decoupled modal amplitude time series are then used in an equation error identification scheme to identify the model parameters in an autoregressive moving average (ARMA) form. The control is based on modal pole placement scheme with the objective of vibration suppression. The control gains are calculated based on the identified ARMA parameters. Before using the identified parameters for control, detailed testing and validation procedures are carried out on the identified parameters. The full adaptive control scheme is demonstrated using the simulation for the 12 foot free-free beam apparatus at NASA Langley Research Center. Author

A83-46100*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENTAL IMPLEMENTATION OF PARAMETER ADAPTIVE CONTROL ON A FREE-FREE BEAM
J. P. WILLIAMS and R. C. MONTGOMERY (NASA, Langley Research Center, Spacecraft Control Branch, Hampton, VA) Virginia Polytechnic Institute and State University and American Institute of Aeronautics and Astronautics, Symposium on Dynamics and Control of Large Structures, 4th, Blacksburg, VA, June 6-8, 1983, Paper. 13 p. refs

A method for identifying modal parameters has been integrated with a modal control scheme and implemented on an experimental beam at the NASA Langley Research Center. This work is the culmination of several studies to develop adaptive control schemes for large flexible spacecraft. The identification scheme is an equation-error technique which generates modal frequency and damping estimates on-line from a set of distributed displacement measurements. The control law is a modal pole placement technique with the objective of vibration suppression. Integration of the identification and control schemes is achieved through a series of tests which validate the identified parameters before they are used for control gain updating. Results using a low order controller show that control gains can be updated in real time based on the validated parameters to improve the performance of the closed loop system. Important factors in the implementation are the test criterion and the a priori assumption of mode shapes.
Author

A83-47249#
A CONTROL METHOD OF ANTENNA POINTING ERROR DUE TO ORBITAL INCLINATION FOR A SPIN-STABILIZED SATELLITE
T. IZUMISAWA, S. SAMEJIMA, and M. SHIBAYAMA (Nippon Telegraph and Telephone Public Corp., Yokosuka Electrical Communication Laboratory, Yokosuka, Kanagawa, Japan) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 8 p. refs
(IAF PAPER 83-67)

A method is developed to remove the antenna pointing error due to increased orbit inclination for a spin-stabilized satellite with a despin antenna, after the orbit plane control becomes impossible because of fuel shortage. This method can be used to keep the satellite antenna pointing error within a permissible range by adjusting the satellite attitude and antenna despin bias under such conditions. Results are presented of experiments carried out using the Medium Capacity Communications Satellite for Experimental Purposes in order to measure the diurnal carrier power to noise power density ratio variation of the overall K-band (30/20 GHz) satellite link. It is determined that this method is effective for reducing the satellite antenna pointing error under these conditions.
N.B.

A83-47250#
AN OPTIMAL ACTIVE CONTROL SYSTEM WITH FOURIER TRANSFORMED STATES FOR A FLEXIBLE STRUCTURE IN SPACE
A. DANESI (Roma, Universita, Rome, Italy) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 10 p.
(IAF PAPER 83-68)

A modal control strategy is developed in order to improve the LOS pointing accuracy of large communication antennas in space. The strategy utilizes an active control system to regulate the angular displacements of a reference section of a flexible mast supporting the antenna mounting pad. The control system consists of a decentralized configuration of a discrete number of servo modal control units (MCU) distributed along the mast. The control efforts generated by the MCUs are designed to be proportional to the spectral power density relative to the time information delivered by an electrooptical sensor and computed by a microprocessor, contained on one MCU and linked to the mast reference section. This MCU functions as a master unit for the other MCUs, and all the servos act simultaneously to reduce the angular displacements of the antenna. Results of simulation studies are presented which show that this modal control strategy is capable of improving the antenna pointing accuracy within the LSS design requirements.
N.B.

A83-47346#
DYNAMICS OF THE ORBITAL CABLE SYSTEM
V. V. BELETSKII (Akademiia Nauk SSSR, Institut Prikladnoi Matematiki, Moscow, USSR) and E. M. LEVIN (Akademiia Nauk SSSR, Institut Mashinovedeniia, Moscow, USSR) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 9 p. refs
(IAF PAPER 83-336)

The dynamical role of the cable in the proposed Orbital Cable System (OCS), consisting of a large powered vehicle in a 200-250-km orbit attached by a cable to a small probe in a 100-150-km orbit, is investigated analytically, and OCS deployment algorithms are developed. The dynamic effects of a realistic cable with mass, air drag, and elasticity are taken into account in the analysis of the equations of motion. A stability analysis is performed, and expressions for the periodic motions of the system are derived. It is shown that the cable may assume a wavelike configuration and cause altitude-inhomogeneous destabilization of OCS motion. Within the regions of stationary-motion stability, the cable can be treated as an approximately rigid body. The dynamics of deployment procedures based on vertical descent of the probe during about two orbital revolutions are described.
T.K.

A83-47348#
DYNAMIC MODELING OF FLEXIBLE SPACECRAFT - A GENERAL PROGRAM FOR SIMULATION AND CONTROL
L. R. PASSERON (SocieteNationale Industrielle Aerospatiale, Division Systemes Balistiques et Spatiaux, Cannes, France) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 10 p. refs
(IAF PAPER 83-339)

A comprehensive mathematical model for a generalized flexible system of any number of bodies is derived. A finite-element approach using quasi-coordinates and vectorial quantities in the system parameterization is employed to develop a nonlinear dynamic model; individual-component eigenfunctions are replaced by admissible functions to improve the accuracy of the system-eigenfunction computation. The model is found to be efficient in simulating system behavior, and a modified fourth-order Runge-Kutta algorithm can be used to numerically integrate the differential equations, which involve Lagrange multipliers and nonholonomic constraints. The model is then linearized around defined pseudonominal behavior to facilitate stability analysis and control-system design. The application of the nonlinear and linearized models, with appropriate software, to the design of large spacecraft is considered feasible.
T.K.

A83-47349*# Howard Univ., Washington, D. C.
ON THE CONTROLLABILITY AND CONTROL LAW DESIGN FOR AN ORBITING LARGE FLEXIBLE ANTENNA SYSTEM
P. M. BAINUM, A. S. S. R. REDDY, and R. KRISHNA (Howard University, Washington, DC) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 12 p. refs
(Contract NSG-1414)
(IAF PAPER 83-340)

The controllability and control law synthesis based on a finite element model of the Hoop/Column orbiting antenna system is considered. Graph theoretic techniques are employed to analyze the controllability of the system for posible proposed actuator arrangements which include torquers and point actuators along the mast and a single actuator placed on the hoop assembly. Once controllability is established for a given combination of number and location of actuators, the synthesis of control laws is based on an application of the linear regulator theory and also pole placement techniques. In general, surface torsion and feed mast torsion are among modes having the longest time constants.

System transient performance is noticeably degraded when the hoop actuator is not included. Author

A83-47350#
CONTROLLABILIZATION AND OBSERVABILIZATION OF THE ATTITUDE CONTROL SYSTEM WITH FLYWHEEL
H. YAMAMOTO, H. AOYAMA, and F. KAJU (Nippon Electric Co., Ltd., Yokohama, Japan) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 9 p.
(IAF PAPER 83-341)

The controllabilities and observabilities of the four classes of single-axis attitude control systems with flywheels are investigated. It is determined that these four classes are not controllable and that two of these classes are not observable. A unified method is developed to make all four of these classes both controllable and observable. This method utilizes a physical interpretation in which the generalized angular momentum, the uncontrollable state, and the unobservable state are separated from the other system states. A comparison of this method with one based upon the canonical decomposition method indicates that these two methods are equivalent. It is concluded that this method can be employed to apply modern control theories to the synthesis of attitude control systems with flywheels. N.B.

A83-47375*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TECHNICAL ISSUES IN DYNAMICS AND CONTROL OF LARGE SPACE STRUCTURES
M. F. CARD and W. W. ANDERSON (NASA, Langley Research Center, Hampton, VA) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 10 p. refs
(IAF PAPER 83-403)

Examples of large space systems currently being considered by NASA include a large communications antenna system (the Land Mobile Satellite System), a precision antenna system (the Large Deployable Reflector System), and a preliminary concept for NASA's space station. Each system has low natural vibration frequencies, stringent pointing requirements, and, for the antennas, demanding surface accuracy requirements. A review is provided of the progress being made in structural ground tests with respect to surface accuracy, deployment, and erection of large structures. Attention is given to the dynamic loads on large space structures, on-orbit testing, space vibration control devices, and the characteristics of distributed control. G.R.

A83-47376#
A NEW APPROACH TO THE DYNAMICS AND CONTROL ANALYSIS OF A CLASS OF LARGE FLEXIBLE SPACECRAFT
R. V. RAMNATH (Raytheon Co., Missile Systems Div.; MIT, Cambridge; Boston, University, Boston, MA) and S. JENIE (MIT, Cambridge, MA) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 6 p. refs
(IAF PAPER 83-408)

The transportation of the components of a large spacecraft into space by means of the Space Transportation System for a subsequent assembly in orbit provides a convenient and economic aproach for the installation of such spacecraft. However, in the case of large structures, the resulting highly flexible systems lead to difficult problems in the dynamics analysis and control of the spacecraft. In general, analytical solutions cannot be found and numerical solutions are the only resort. The present investigation is concerned with a novel approach and the development of analytical solutions by the method of Generalized Multiple Scales (GMS). The Electrostatically Controlled Membrane Mirror (ECMM) considered represents a new method for the realization of a light weight and very accurate antenna. It obtains its form by means of Coulomb pressures generated by a distribution of a ring of electrodes at the back of the membrane. The GMS is used to obtain analytical solutions to the ECMM and, in addition, to a helio-gyro spacecraft. G.R.

A83-47377#
THE FEATURES OF THE SPACE STRUCTURES DYNAMIC DESIGN
A. S. GVAMICHAVA, N. V. MYSHONKOVA, A. G. SOKOLOV, and V. M. SPYVAK (Akademiia Nauk SSSR, Sovet Interkosmos, Moscow, USSR) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 7 p. refs
(IAF PAPER 83-409)

Design considerations for the deployment and continued monitoring and control of foldable space structures are explored. the unfolding process requires that resistance is always instantaneously exceeded, and that no stresses occur beyond those predicted. Limiting the designs to one degree of freedom reduces the necessary design computations, which can be verified with designs involving multiple degrees of freedom. Bounds are placed on the rigidities of the structural members, and the velocity, acceleration, and the time elapsed for each trajectory are accounted for. The interaction between deployed and as-yet-unfolded parts, longitudinal oscillations, and lateral oscillations must also be calculated. Energy exchanges between lateral and longitudinal oscillations can increase stresses by factors of 6-8. Expressions are provided for the moments and lateral forces of a cantilever beam rotating about an axis. M.S.K.

A83-47388#
ACTIVE VIBRATION CONTROL OF A CANTILEVERED BEAM - A STUDY OF CONTROL ACTUATORS
R. A. MILLS (Virginia Polytechnic Institute and State University, Blacksburg, VA) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 9 p.
(IAF PAPER 83-ST-11)

Most of the large space structures which are being considered, require a high degree of pointing accuracy. The inherent flexibility of these structures makes it, therefore, necessary to control the vibrations which can be excited. The problem is aggravated by the absence of aerodynamic damping and by low hysteresis damping. Aubrun (1980) has shown that a low authority control technique is stable. Limited modal damping is achieved over a broad frequency range by direct feedback from sensors to actuators. The present investigation is concerned with two types of low authority velocity feedback actuators, taking into account a reaction mass actuator and a reaction wheel actuator. Attention is given to a description of models, a numerical frequency response analysis, and the obtained results. It is found that the reaction wheel actuator is clearly superior to the reaction mass actuator in controlling the vibrations of the cantilevered beam. G.R.

A83-47598*# California Univ., Los Angeles.
CONTROL OF REFLECTOR VIBRATIONS IN LARGE SPACEBORNE ANTENNAS BY MEANS OF MOVABLE DAMPERS
P. K. C. WANG (California, University, Los Angeles, CA) and J. C. SARINA ASME, Transactions, Journal of Applied Mechanics (ISSN 0021-8936), vol. 50, Sept. 1983, p. 669-673. NASA-supported research. refs

A simple approach to the design of feedback controls for damping the vibrations in large spaceborne antennas with flexible dish reflectors is proposed. The feedback controls consist of movable velocity-feedback dampers whose positions are determined by minimizing the rate of change of total vibrational energy at any time. The performance of the proposed feedback controls is studied via computer simulations. Author

A83-48888*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE STRUCTURES RAISE TESTING CHALLENGES
B. R. HANKS and L. D. PINSON (NASA, Langley Research Center, Hampton, VA) Astronautics and Aeronautics (ISSN 0004-6213), vol. 21, Oct. 1983, p. 34-40, 53.

The testing approaches and techniques necessary for combined ground and space verification for large space structures (LSS) to be deployed and assembled in space are explored. The size of LSS precludes full ground tests, thereby requiring assemblies, components, and their interactions to be examined on orbit. Ground tests involving drop tests and zero-g aircraft flights can be performed with scale models, but need computational compensation to eliminate gravitational and torque effects that do not occur in space. Structural rigidity also varies from ground to space, and can partly be accounted for in ground tests by using cable supports, although numerical modelling must remove the effects of the cables' presence. Long-term funding is recommended for on-orbit tests of components in order to build a data base for later testing and actual construction of LSS. D.H.K.

A83-49670

MATHEMATICAL MODEL OF A MOVING SYSTEM WITH LOW-STIFFNESS ELASTIC ELEMENTS [MATEMATICHESKAIA MODEL' DVIZHUSHCHEISIA SISTEMY S UPRUGIMI ELEMENTAMI NIZKOI ZHESTKOSTI]

V. F. IASHCHENKO Kosmicheskie Issledovaniia na Ukraine (ISSN 0321-4508), no. 16, 1982, p. 74-78. In Russian. refs

An investigation is made of the motion of a mechanical system consisting of a rigid bearing body and attached elastic elements in the form of flat cantilever panels. Equations of motion are obtained with allowance for the deformation of the elastic elements. The system considered can serve as a model of a spacecraft body with a deployable-retractable thin-film solar array. B.J.

N83-23349# Toronto Univ. (Ontario). Inst. for Aerospace Studies.

GRAVITATIONAL ORBIT-ATTITUDE COUPLING AND PENUMBRAL SOLAR-GRADIENT TORQUES FOR VERY LARGE SPACECRAFT *Thesis*

G. B. SINCARSIN Nov. 1982 378 p refs

(UTIAS-265; ISSN-0082-5255) Avail: NTIS HC A17/MF A01

General equations of motion are derived that govern the gravitationally coupled orbit attitude motion of very large spacecraft. The force and torque caused by solar radiation pressure are also considered. The gravitational force and torque are expanded in Taylor series in the small ratio (spacecraft size/orbital radius) and terms up to fourth order are retained. The expressions are fully nonlinear in the attitude variables. Expressions derived for the solar force and torque include a light intensity function, expanded in a Taylor series, which models the effects of spacecraft eclipsing by the Earth. In particular, a solar gradient term is retained. The general equations are specialized to a planar form spacecraft configuration; however, they remain general enough to represent any triaxially symmetric spacecraft possessing a uniform mass distribution. A computer simulation based on these equations is prepared and shown to reproduce satisfactorily selected results from the literature. Author

N83-24541*# Bendix Corp., Teterboro, N. J. Guidance Systems Div.

MODULAR DESIGN ATTITUDE CONTROL SYSTEM Final Report, 16 Oct. 1981 - 31 Oct. 1982

F. D. CHICHESTER 18 Mar. 1983 65 p refs

(Contract NAS8-33979)

(NASA-CR-170736; NAS 1.26:170736) Avail: NTIS HC A04/MF A01 CSCL 22B

Application of modular control techniques to the attitude control of a prototype flexible spacecraft and a prototype flexible space platform was further developed by determining numerical values for the physical parameters of a four body approximation of the MSFC/hybrid deployable truss incorporated in the space platform model, generating sensitivity coefficients for the model of the flexible spacecraft, evaluating the changes in the digital computer simulation of the flexible spacecraft resulting from the addition of another rigid body to the model and comparing attitude control effectiveness with actuators on more than one rigid body of the model with that for the case in which the actuators were restricted to one body. Author

N83-24543*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.

ON PARAMETER IDENTIFICATION FOR LARGE SPACE STRUCTURES Progress Report, period ending 15 Feb. 1983

S. M. JOSHI and G. L. GOGLIA May 1983 7 p refs

(Contract NAG1-102)

(NASA-CR-170306; NAS 1.26:170306) Avail: NTIS HC A02/MF A01 CSCL 22B

The design of a controller for large space structures (LSS) based on the LQG theory requires the knowledge of the LSS parameters. Since apriori knowledge of the parameters is usually not reliable, the parameters must be identified prior to the controller synthesis, using methods such as the maximum likelihood technique. An expression is obtained for the Fisher information matrix for LSS, from which Cramer-Rao bounds can be obtained in order to determine the accuracy with which the parameters can be identified. Author

N83-24546# Honeywell Systems and Research Center, Minneapolis, Minn.

ACOSS-16 (ACTIVE CONTROL OF SPACE STRUCTURES) Final Technical Report, May 1981 - Jul. 1982

M. F. BARRETT and D. F. ENNS Griffiss AFB, N.Y. RADC Oct. 1982 264 p refs

(Contract F30602-81-C-0187; ARPA ORDER 3654; AF PROJ. C654)

(AD-A123540; RADC-TR-82-225; REPT-82SRC43) Avail: NTIS HC A12/MF A01 CSCL 22B

The objective of this effort is to develop, design and analyze techniques that can be used to meet future line of sight and jitter control requirements of large space structures that have onboard disturbances. This effort studied parameter identification on a representative large space structure and the impact of on-orbit identification on the design of a disturbance controller for the spacecraft. GRA

N83-24547# Control Dynamics Co., Huntsville, Ala.

ACOSS FIFTEEN (ACTIVE CONTROL OF SPACE STRUCTURES) Final Technical Report, 15 Apr. 1981 - 1 May 1982

S. M. SELTZER, E. H. WORLEY, and R. J. YORK Griffiss AFB, N.Y. RADC Oct. 1982 106 p

(Contract F30602-81-C-0179; AF PROJ. C654)

(AD-A123530; RADC-TR-82-198) Avail: NTIS HC A06/MF A01 CSCL 22B

To study active structure control technology as applied to Large Space Structures (LSS). In particular, to develop analysis and design techniques for utilization of practicing control system engineers in their investigations of future Large Space Structures (LSS). These techniques will be use qualified through application to a representative model of a LSS. This objective is in support of the overall ACOSS objective which is to develop and understand a generic, unified structural dynamics and control technology base for LSS with stringent Line-of-Sight (LOS) and figure performance requirements that must be maintained in the presence of onboard and natural disturbances. This effort will be restricted to theory development, experiment design, demonstration and documentation of structural dynamics and control technology for large precision spacecraft. GRA

N83-24882*# Martin Marietta Corp., Denver, Colo.

TETHERED SATELLITE CONTROL MECHANISM

G. M. KYRIAS *In* JPL The 17th Aerospace Mech. Symp. p 1-18 May 1983

Avail: NTIS HC A17/MF A01 CSCL 22B

The tethered satellite control mechanisms consist of four major subsystems. The reel drive mechanism stores the tether. It is motor driven and includes a level wind to uniformly feed the tether to the reel. The lower boom mechanism serves two primary functions: (1) it measures tether length and velocity as the tether runs through the mechanism, and (2) it reads the tether tension at the reel. It also provides change the direction for the tether from the reel to the upper boom mechanism. The deployment boom positions the upper boom mechanism with satellite out of the cargo bay. The deployment function places the 500-kg satellite 20 m away from the Space Shuttle (producing a small natural gravity gradient force), impacts an initial velocity to the satellite for deployment, and allows for satellite docking at a safe distance from the body of the Space Shuttle. The upper boom mechanism (UBM) services three functions: (1) it provides tether control to the satellite as the satellite swings in and out of plane; (2) it reads tether tension in the low range during the early deployment and final retrieval parts of the mission; and (3) it produces additional tether tension at the reel when tether tension to the satellite is in the low range. S.L.

N83-24885*# Schaeffer Magnetics, Inc., Chatsworth, Calif.
A BROADBASED ACTUATOR CONCEPT FOR SPACEFLIGHT APPLICATION
J. C. HAMMOND *In* JPL The 17th Aerospace Mech. Symp. p 55-80 May 1983 refs
Avail: NTIS HC A17/MF A01 CSCL 13I

An electromechanical actuator is applicable to a variety of spaceflight requirements. Characterized by high torque and a small output step angle, the device is comprised of a coaxial, symmetrical arrangement in which a cup type harmonic drive is directly coupled to a pancake configuration drive motor. The motor, with its dual stator driving a common rotor, is one illustration of the concept of selective redundacy. Selective redundancy promotes the idea that redundancy, to be effective, must not compromise inherent design simplicity nor introduce new failure modes. The usefulness of the actuator is exemplified by its selection for a broad range of positioning and driving applications including TDRSS gimbal drives, Space Telescope deployment and latching machanisms, and Space Telescope secondary mirror drive, as well as others. S.L.

N83-24895*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NUTATION DAMPER SYSTEM
D. R. SEVILLA *In its* The 17th Aerospace Mech. Symp. p 209-226 May 1983 refs
Avail: NTIS HC A17/MF A01 CSCL 03A

The Nutation Damper System is a three function mechanism designed for the Galileo Spacecraft, a spin stabilized deep-space probe to Jupiter. By damping the movement of a large deployable science boom acting as an outboard pendulum, the nutation damper rapidly stabilizes the spacecraft from dynamic irregularities. The system includes the boom deployment device and the ultra-low friction boom hinge. This paper describes the mechanism, the degree to which friction, stiction and lost motion have been eliminated, and the unique test methods that allow its performance to be measured. Author

N83-25751*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ORBITAL TRANSFER AND RELEASE OF TETHERED PAYLOADS. CONTINUATION OF INVESTIGATION OF ELECTRODYNAMIC STABILIZATION AND CONTROL OF LONG ORBITING TETHERS MARTINEZ-SANCHEZ, MANUEL Final Report, 1 Sep. 1979 - 28 Feb. 1983
G. COLOMBO, M. D. GROSSI, and D. ARNOLD (MIT) Mar. 1983 66 p refs
(Contract NAS8-33691)
(NASA-CR-170779; NAS 1.26:170779) Avail: NTIS HC A04/MF A01 CSCL 22B

The effect of reeling operations on the orbital altitude of the tether system and the development of control laws to minimize tether rebound upon payload release were studied. The use of the tether for LEO/GEO payload orbital transfer was also investigated. It was concluded that (1) reeling operations can contribute a significant amount of energy to the orbit of the system and should be considered in orbit calculations and predictions, (2) deployment of payloads, even very large payloads, using tethers is a practical and fully stable operation, (3) tether augmented LEO/GEO transfer operations yield useful payload gains under the practical constraint of fixed size OTV's, and (4) orbit to orbit satellite retrieval is limited by useful revisit times to orbital inclinations of less than forty-five degrees. S.L.

N83-25771# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
DECENTRALIZED CONTROL OF A LARGE SPACE STRUCTURE AS APPLIED TO THE CSDL 2 MODEL M.S. Thesis
E. S. ALDRIDGE Dec. 1982 141 p refs
(AD-A124702; AFIT/GA/AA/82D-1) Avail: NTIS HC A07/MF A01 CSCL 22B

Modern optimal control methods are used to develop a multiple, input multiple output controller which is applied to two models: CSDL 1 and CSDL 2. NASTRAN is employed to generate modal approximations of both models. Twelve selected modes are analyzed in both models. The control problem is formulated in state vector form and full state feedback is implemented. The state is represented as modal amplitudes and rates and the feedback gains are generated using steady state optimal regulator theory. State estimates are provided by means of a deterministic observer. System outputs are obtained by position sensors and control is applied by point force actuators. Control and observation spillover are eliminated using singular value decomposition. Decentralized control is accomplished using three and four controllers on both models. Conditions for which the stability of each model is asured are developed. On both models, there is a significant increase in the closed loop damping achieved. Losses in controllability and observability are noticed during spillover elimination. Full controller decoupling is achieved and stability is maintained. Author (GRA)

N83-25772# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS-11 (ACTIVE CONTROL OF SPACE STRUCTURES), VOLUME 1 Interim Report, Nov. 1981 - Apr. 1982
T. H. BROOKS and V. N. MAHAJAN Griffiss AFB, N.Y. RADC Nov. 1982 62 p 2 Vol.
(Contract F30602-81-C-0180; ARPA ORDER 3655; AF PROJ. C655)
(AD-A124745; CSDL-R-1538-VOL-1; RADC-TR-82-295-VOL-1)
Avail: NTIS HC A04/MF A01 CSCL 09B

In analysis and simulation of space-based surveillance system performance, a key variable is the scene/sensor integration. Photon Research Associates is developing a software package capable of generating a manipulating terrestrial scene data sets as a function of major surveillance system and mission parameters. This package, when incorporated into the Draper Integrated Simulations, will result in a broad and comprehensive tool for the analysis and simulation of space based surveillance system performance. GRA

N83-26684# Los Alamos Scientific Lab., N. Mex.
IDENTIFICATION OF FUTURE ENGINEERING-DEVELOPMENT NEEDS OF ALTERNATIVE CONCEPTS FOR MAGNETIC-FUSION ENERGY
R. A. KRAKOWSKI 1982 39 p refs Presented at the Future Eng. Dev. Needs for Magnetic Fusion Workshop, Washington, D.C., 3-4 Aug. 1982
(Contract W-7405-ENG-36)
(DE82-019566; LA-UR-82-1973; CONF-820838-1) Avail: NTIS HC A03/MF A01

The future engineering needs of alternative fusion concepts (AFCs) are assessed relative to the similar needs of the Tokamak in order to emphasize differences in required technology with respect to the well documented mainline approach. Although nearly thirty AFCs can be identified as being associated with some level of reactor projection redirection, refocusing, and general similarities can be used to generate a reduced AFC list that includes only the bumpy tori, stellarators, reversed-field pinches, and compact toroids. Furthermore, each AFC has the potential of operating as a conventional (low power density, superconducting magnets) or a compact, high-power-density (HPD) system. Hence, in order to make tractable an otherwise difficult task, the future engineering needs for the AFCs are addressed for conventional versus compact approaches, with the latter being treated as a generic class and the former being composed of bumpy tori, stellarators, reversed-field pinches, and compact toroids. DOE

N83-26870*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NASA/USAF RESEARCH IN STRUCTURAL DYNAMICS
L. D. PINSON and A. K. AMOS (AFOSR) *In its* Large Space Antenna Systems Technol., Pt. 1 p 301-344 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Research in the structural dynamics of large space structures is discussed. The problems of structural response are emphasized. Dynamic modeling, structural members, finite element techniques, axial loads, and vibration tests are among the topics discussed. R.J.F.

N83-26880*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL OF LARGE SPACE ANTENNAS
A. F. TOLIVAR and S. J. WANG *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 583-608 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The NASA large space antenna missions, the performance requirements, and the resulting control technology requirements are summarized. Author

N83-26881*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ENABLING TECHNOLOGIES FOR LARGE PRECISION SPACE SYSTEMS
R. R. STRUNCE, JR. and J. D. TURNER *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 601-624 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Modeling accuracy, system identification, control law design methodology, sensors and actuators, and avionics are addressed. Author

N83-26882*# Grumman Aerospace Corp., Bethpage, N.Y.
REDUCED ORDER CONTROL DESIGN FOR LARGE SPACE STRUCTURES: A COMMUNICATION SATELLITE EXAMPLE
R. GRAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 625-648 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Large flexible communication satellite controller design is considered. The satellite that was developed for a 'straw man' was configured as an offset fed paraboloid with a set of masts and booms that carry the antenna. The controllers were both a boom and mast actuator and a set of two degree of freedom actuators at the antenna to move it in order to satisfy both line of sight and defocus control. Author

N83-26883*# Scientific Systems, Inc., Cambridge, Mass.
CURRENT STATUS OF SYSTEM IDENTIFICATION METHODOLOGY
W. E. LARIMORE, R. K. MEHRA, D. E. GUSTAFSON, and J. BAILLIEUL *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 649-664 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Large space structures, system identification, model formulation, experimental design, model order and structure determination, parameter estimation, reduced order modeling, and closed loops are considered. Author

N83-26885*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SHAPE DETERMINATION/IDENTIFICATION FOR LARGE SPACE ANTENNAS
G. RODRIGUEZ, J. M. CAMERON, and M. H. MILMAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 687-708 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

An integrated hardware/software system, SHADES, for shape determination and identification; a three dimensional multipoint sensor; multipoint sensor data; batch processing; and scanning algorithms are discussed. Author

N83-26886*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PRACTICAL APPROACHES TO THE DESIGN OF CONTROL SYSTEMS FOR LARGE SPACE STRUCTURES
H. J. BUCHANAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 709-719 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Future space systems, flexible spacecraft, modular control, design-test-revise cycle, and control technique verification are discussed. Author

N83-26887*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESULTS OF STUDIES AT LANGLEY RESEARCH CENTER ON THE CONTROL OF LARGE SPACE SYSTEMS
R. C. MONTGOMERY and L. W. TAYLOR, JR. *In its* Large Space Antenna Systems Technol., Pt. 2 p 721-742 May 1983 refs
Avail: NTIS HC A20/MF A01

A control moment gyro, an integrated power/attitude control system, and distributed adaptive control are discussed. Author

N83-26899*# Grumman Aerospace Corp., Bethpage, N.Y.
A ROBOT IN SPACE AS A LARGE SPACE STRUCTURES CONTROL EXPERIMENT
R. GRAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 941-947 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The control systems design issues for large space structures can be addressed by a robotics experiment which defines a teleoperator or a robot or uses the RMS. The robotics control demonstration brings the large space structures control technology to an effective state of readiness and provides a useful robot when the experiment is finished. Three major options in such an experiment are the RMS, a flexible arm that is going to be put on the Shuttle for other reasons, or a dexetrous manipulator or teleoperator. S.L.

N83-26902*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SAFE ON-ORBIT EXPERIMENT FOR MEASUREMENT OF LARGE STRUCTURES DYNAMICS
R. W. SCHOCK *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 981-989 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The Solar Array Flight Experiment (SAFE) on-orbit experiment for measurement of large structures dynamics consists of a dynamic sensing system designed to record and analyze the dynamic characteristics of the SAFE. The early availability of the SAFE and its basic large space structure characteristics make it a logical candidate for verification of the sensing system and the evaluation technique. The characteristics of the solar array which place it well within the generic class of large space structures are: (1) large size, (2) low natural frequencies, (3) mechanical complexity of its extendable/retractable mast, and (4) the inability to dynamically test in the Earth's atmosphere and in one g. The fourth characteristic is due to its size, air damping dominance of the blanket, and structural instability in one g. The specific characteristics of the solar array are shown and the applicability to large space structures is illustrated. S.L.

N83-27259*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. Joint Inst. for Advancement of Flight Sciences.
POTENTIAL OF MINICOMPUTER/ARRAY-PROCESSOR SYSTEM FOR NONLINEAR FINITE-ELEMENT ANALYSIS
G. A. STROHKORB (George Washington Univ. Hampton, Va.) and A. K. NOOR (George Washington Univ., Hampton, Va.) Jun. 1983 71 p refs
(NASA-TM-84566; L-15532; NAS 1.15:84566) Avail: NTIS HC A04/MF A01 CSCL 20K

The potential of using a minicomputer/array-processor system for the efficient solution of large-scale, nonlinear, finite-element problems is studied. A Prime 750 is used as the host computer, and a software simulator residing on the Prime is employed to assess the performance of the Floating Point Systems AP-120B array processor. Major hardware characteristics of the system such as virtual memory and parallel and pipeline processing are reviewed, and the interplay between various hardware components is examined. Effective use of the minicomputer/array-processor system for nonlinear analysis requires the following: (1) proper selection of the computational procedure and the capability to vectorize the numerical algorithms; (2) reduction of input-output operations; and (3) overlapping host and array-processor operations. A detailed discussion is given of techniques to accomplish each of these tasks. Two benchmark problems with 1715 and 3230 degrees of freedom, respectively, are selected to measure the anticipated gain in speed obtained by using the proposed algorithms on the array processor. S.L.

N83-27954 Purdue Univ., Lafayette, Ind.
APPROXIMATE METHODS FOR DYNAMIC ANALYSIS OF LARGE STRUCTURES Ph.D. Thesis
B. J. KIM 1982 227 p
Avail: Univ. Microfilms Order No. DA8225729

Many large frame and truss structures, although large in size and complex in detail, appear grossly as beams, plates, or shells. The dynamic behavior of these structures may be governed by the beam, plate or shell equations. Procedures for evaluating the equivalent beam and plate stiffness and masses based on the typical substructures of the original system are developed. The Shear beam, the Bernoulli-Euler beam, and the Timoshenko beam models are used to represent the beam-like frame and truss structures; the Mindlin type of plate theory is used to model truss platforms. A number of structures are studied for free vibration characteristics by using the full scale finite element method and by using the simple equivalent models. It was found that the simple models are very accurate in predicting the natural frquencies and mode shapes. In general, the Timoshenko beam is more accurate than the shear beam and the Bernoulli-Euler beam models in the analysis of beam-like structures. Dissert. Abstr.

N83-28067# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS-11 (ACTIVE CONTROL OF SPACE STRUCTURES, VOLUME 2 Interim Report, Nov. 1981 - Apr. 1982
R. R. STRUNCE, E. FOGEL, D. R. HEGG, J. G. LIN, and J. D. TURNER Griffiss AFB, N.Y. RADC Nov. 1982 57 p refs 2 Vol.
(Contract F30602-81-C-0180; ARPA ORDER 3655; AF PROJ. C655)
(AD-A124746; RADC-TR-82-295-VOL-2; CSDL-R-1538-VOL-2) Avail: NTIS HC A04/MF A01 CSCL 09B

Volume 2 of this report describes progress in the application of active controller design methods to the ACOSS Model No. 2 structure. Attention is focused on attenuation of the effects of a broad-band disturbance input upon line-of-sight rotation error, and upon the generation of smooth large-angle slew maneuvers. A ten-mode design model is used. For disturbance attenuation, a new method for sensor/actuator selection based directly on line-of-sight considerations is proposed. Three disturbance-attenuation designs are described. The first assumes a complete knowledge of the disturbance statistics, while the others assume no such explicit knowledge. All three designs indicate convincingly that damping augmentation alone is not sufficient to attenuate effects of the disturbance; augmentation of stiffness is also required. Extensions of large-angle slew control to incorporate feedback are also presented. GRA

N83-28491*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
VIBRATION CHARACTERISTICS OF A DEPLOYABLE CONTROLLABLE-GEOMETRY TRUSS BOOM
J. T. DORSEY Jun. 1983 30 p refs
(NASA-TP-2160; L-15580; NAS 1.60:2160) Avail: NTIS HC A03/MF A01 CSCL 20K

An analytical study was made to evaluate changes in the fundamental frequency of a two dimensional cantilevered truss boom at various stages of deployment. The truss could be axially deployed or retracted and undergo a variety of controlled geometry changes by shortening or lengthening the telescoping diagonal members in each bay. Both untapered and tapered versions of the truss boom were modeled and analyzed by using the finite element method. Large reductions in fundamental frequency occurred for both the untapered and tapered trusses when they were uniformly retracted or maneuvered laterally from their fully deployed position. These frequency reductions can be minimized, however, if truss geometries are selected which maintain cantilever root stiffness during truss maneuvers. Author

N83-28879*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MODELING OF FLEXIBLE SURFACES: A PRELIMINARY STUDY Final Report
H. T. BANKS (Brown Univ., Providence) and G. MAJDA (Brown Univ., Providence) Jun. 1983 26 p refs
(Contract NAS1-15810; NAS1-16394; NAG1-258; AF-AFOSR-0198-81)
(NASA-CR-172147; NAS 1.26:172147; ICASE-83-19) Avail: NTIS HC A03/MF A01 CSCL 12A

The one-dimensional classical scalar string equation which involves linearization about a horizontal reference or equilibrium position is derived. We then derive a model for small motion about a nonhorizontal reference. The implications of our findings to modeling of flexible antenna surfaces such as that in the Maypole Hoop/Column antenna are discussed. Author

N83-28934*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va. Inst. for Computer Applications in Science and Engineering.
PARAMETER IDENTIFICATION IN CONTINUUM MODELS Final Report
H. T. BANKS and J. M. CROWLEY May 1983 8 p refs
(Contract NAS1-15810; NAS1-16394; DAAG29-79-C-0161; NSF MCS-82-05335; AF-AFOSR-0198-81)
(NASA-CR-172132; NAS 1.26:172132; REPT-83-13) Avail: NTIS HC A02/MF A01 CSCL 12A

Approximation techniques for use in numerical schemes for estimating spatially varying coefficients in continuum models such as those for Euler-Bernoulli beams are discussed. The techniques are based on quintic spline state approximations and cubic spline parameter approximations. Both theoretical and numerical results are presented. M.G.

N83-29307# Lockheed Missiles and Space Co., Sunnyvale, Calif. Space Systems Div.
ACOSS TWELVE (ACTIVE CONTROL OF SPACE STRUCTURES) Interim Report, Aug. 1981 - Apr. 1982
J. N. AUBURN Griffiss AFB, N.Y. RADC Dec. 1982 100 p
(Contract F30602-81-C-0260; ARPA ORDER 3654; AF PROJ. C654)
(AD-A126053; RADC-TR-82-320) Avail: NTIS HC A05/MF A01 CSCL 13C

The objective of ACOSS is to develop and demonstrate the technology required to suppress vibrational disturbances (damping augmentation and elastic mode control) of large space structures so that they can meet the required line-of-sight and jitter control requirements. In this effort a control methodology is developed for disturbance rejection and an analysis is done for a sample surveillance structure, ACOSS-2. The work includes looking at robustness and assessing system identification methods. The theory is being applied to several bench top brassboards and these experiments are reported in detail. A proof-of-concept experiment will be conducted at RF tolerances and this five meter structure is reported on. GRA

N83-29729 Howard Univ., Washington, D. C.
ATTITUDE DYNAMICS AND STABILITY OF LARGE FLEXIBLE STRUCTURES IN ORBIT Ph.D. Thesis
V. K. KUMAR 1981 235 p
Avail: Univ. Microfilms Order No. DA8301046

The equations of motion of an arbitrary flexible body in orbit are derived. The model includes the effects of gravity with all its higher harmonics. As specific examples, the motion of some simple structures, i.e., flexible beam, flat circular plate and shallow spherical shell in orbit are analyzed. A passive gravity gradient stabilization scheme using an articulated light weight dumbbell is considered to stabilize those structures which would be gravitationally unstable in the absence of any control. The dumbbell is found to excite only antisymmetric modes in the case of the beam and axisymmetric modes in the case of the circular plate and shallow spherical shell. In addition, the shallow spherical shell is found to undergo a small static deformation under the influence of gravity and orbital motion. A parametric study of the sensitivity of the lowest frequency mode characteristics of the system at very low natural frequencies is studied in all the cases. The effects of environmental disturbances such as gravity-gradient and solar radiation on these structures are also investigated. Dissert. Abstr.

N83-30511# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Dept. of Aeronautics and Astronautics.
A METHOD OF ACTUATOR PLACEMENT FOR VIBRATION CONTROL OF LARGE SPACE STRUCTURES M.S. Thesis - MIT
R. E. ORT Feb. 1983 90 p refs
(AD-A126940; AFIT-CI-NR-83-1T) Avail: NTIS HC A05/MF A01 CSCL 22B

This thesis presents several computationally simple techniques for choosing actuator placement on large space structures. Actuator and performance information can be represented as vectors (node shapes) in modal coordinates. The placement problem is stated as choosing a set of actuator node shapes to match the performance node shape. One method sequentially selects a set of actuator node shapes such that the norm of the component orthogonal to the already selected set is large. Another method sequentially selects actuator node shapes such that a large projection is obtained along the least squares residual vector resulting from the fit of the previously selected set to the performance node shape. These techniques are applied to a 100 meter cantilever beam. Good control authority over the primary modes is demonstrated. The second technique is modified to place actuators to achieve good control authority on primary modes while minimizing spillover effect. It is demonstrated that proper placement of actuators can limit spillover effect to selected modes. GRA

N83-30729# State Univ. of New York at Buffalo, Amherst. Dept. of Civil Engineering.
ACTIVE VIBRATION CONTROL OF LARGE FLEXIBLE STRUCTURES
T. T. SOONG and J. C. H. CHANG *In* Shock and Vibration Inform. Center The Shock and Vibration Bull., No. 52. Part 4 p 47-54 May 1982 refs
(Contract NSF CEE-80-10891)
Avail: NTIS HC A08/MF A01 CSCL 20K

Active vibration control of large and complex structures is described. An important problem of actively controlling large flexible structures is one of compensating for control and observation spillover when a large dimensional system must be controlled by a much smaller dimensional controller. A modal control design procedure is developed which not only insures that the controlled structural modes stay close to the designed values but also preserves stability in the uncontrolled modes. The sensitivity of spillover compensation to the placement of controllers and sensors is also studied. Author

N83-31375 Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Electrcal, Computer, and Systems Engineering.
SINGULAR PERTURBATIONS IN STABLE FEEDBACK CONTROL OF DISTRIBUTED PARAMETER SYSTEMS
M. J. BALAS *In* International Center for Mechanical Sciences Singular Perturbations in Systems and Control p 241-268 1983 refs
Avail: Issuing Activity

A singular perturbation formulation of linear time-invariant distributed parameter systems is used to develop a method to design finite-dimensional feedback compensators of any fixed order which will stabilize the infinite-dimensional distributed parameter system. The synthesis conditions are given entirely in terms of a finite-dimensional reduced-order model; the stability results depend on an infinite-dimensional version of the Klimushchev-Krasovskii lemma also presented. M.G.

N83-31720# Naval Research Lab., Washington, D. C. Advanced Systems Branch.
ACTUATOR-PLACEMENT CONSIDERATIONS FOR THE CONTROL OF LARGE SPACE STRUCTURES Final Report
R. E. LINDBERG, JR. 11 May 1983 59 p refs
(Contract RR0140241)
(AD-A128241; NRL-8675) Avail: NTIS HC A04/MF A01 CSCL 22A

Actuator placement for the control of distributed-parameter systems such as large flexible space structures is considered in detail. The first focus is on the degree of controllability as defined in a previous work. Its behavior and approximation is considered via simple problems for which the exact value may be computed. The upper-bound approximation is found to be periodically exact for harmonic systems and acceptable for lightly damped systems. A method is proposed for avoiding the unacceptable behavior of the approximation when a problem has nearly repeated roots. Because the upper-bound approximation in the problem of a double-integral plant diverges, a new lower-bound approximation is developed based on discretization of the continuous-time system. The approximate degree of controllability in three forms (for time-optimal, energy-optimal, or fuel-optimal control policy) is applied to the problem of optimal actuator placement for control of transverse oscillation of a simply supported beam. Both predictable and unanticipated optimal solutions are encountered. The concept of a degree of control spillover is then developed, motivated by the limited fidelity inherent in structural models. A composite criterion incorporating both degree of controllability and degree of control spillover is again applied to the simply-supported-beam problem. Design freedom involving number and placement of actuators is next examined for the computationally simple Independent Modal Space Control (IMSC) design method. Actuator placement is then of prime importance in physically realizing the optimal control laws. Methods for actuator-placement optimization are developed for use with ISMC. GRA

N83-33932*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
ON IDENTIFIABILITY OF FLEXIBLE STRUCTURE PARAMETERS Final Report, period ending 5 Jul. 1983
S. M. JOSHI and G. L. GOGLIA Jul. 1983 15 p
(Contract NAG1-102)
(NASA-CR-173049; NAS 1.26:173049) Avail: NTIS HC A02/MF A01 CSCL 22B

This report investigates the identifiability of modal parameters of flexible structures. Expressions are derived for Cramer-Rao lower bounds for the modal parameters, that is, frequencies, damping ratios and mode shapes or slopes. The optimal initial state, which maximizes the trace of the Fisher information matrix in the absence of persistent input, is obtained. The concepts discussed are applied to a finite-element model of the 122 meter hoop/column antenna. The numerical results show that the identifiability of the structural frequencies is excellent, followed by that of the damping ratios and the mode-slopes. Author

N83-36062*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
MODELING AND CONTROL OF DISTRIBUTED STRUCTURES
L. MEIROVITCH *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 1-29 1 Jul. 1983 refs
(Contract NAG1-225)
Avail: NTIS HC A99/MF A01 CSCL 22B

An inherent incongruity in the modeling of controls for structures is discussed. Structures are basically distributed-parameter systems, described by partial differential equations, and control theory is concerned almost exclusively with discrete (in space) systems, described by ordinary differential equations. The standard approach to solving this dilemma is to discretize the system in space, which precludes the use of distributed controls. A different approach, known as the independent modal-space control method, is designed to eliminate the incongruity by bringing about a closer correspondence between modeling and control theory. The independent modal-space control method can treat distributed structures as well as discretized models and it permits design of both distributed and discrete-point controls. M.G.

N83-36063*# Toronto Univ. (Ontario).
SPACE STRUCTURE VIBRATION MODES: HOW MANY EXIST? WHICH ONES ARE IMPORTANT?
P. C. HUGHES *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 31-47 1 Jul. 1983 refs Sponsored in part by Natural Sciences and Engineering Research Council of Canada
Avail: NTIS HC A99/MF A01 CSCL 22B

Several assertions are argued regarding mode analysis of structural vibration. The idea of a 'mode' is, in essence, a mathematical one. It is highly unlikely that any real structure can vibrate exactly so that all its points move in unison; in other words, it is highly unlikely that any structure has any modes. As an approximation, however, the use of a mode is an excellent one for many structures, especially for the 'lower modes'. The agreement between experiment and theory for the 'higher modes' tends to become weaker. In this approximate sense, most structures have a very large number of modes. It is elementary to show, however, that no real structure has an infinite number of modes. The only utility of the 'infinite modes' idea is within the purely mathematical domain. Many 'error indices' can be defined as guidelines for structural modal order reduction. Simple modal truncation, although suggested by experience with slender rods, is naive. The proper process is mode selection, based on a appropriate error criterion. M.G.

N83-36064*# Grumman Aerospace Corp., Bethpage, N.Y. Research and Development Center.
CONTROL OF FLEXIBLE STRUCTURES: A SYSTEMATIC OVERVIEW OF THE PROBLEM
R. GRAN *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 49-61 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

A way of designing a control system using a finite model that accounts for the distributed nature of the control problem in a systematic way is described. This is accomplished by using a mode description of the system and from that description determining the number of modes that must be retained based on the performance and the disturbance descriptions. The design then uses a full order model that includes all of the dynamics: sensor, actuator, disturbance and flexible motion. The designs that result are simple, robust, perform well and have the added distinction of being easy to implement. M.G.

N83-36065*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
INTRODUCTION AND SURVEY ON CONTINUUM MODELS FOR REPETITIVE LATTICE STRUCTURES
L. S. WEISSTEIN *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 63-70 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

A brief introduction and survey to aid and familiarize researchers interested in the use of continuum modeling procedures applied towards large space structure technology are presented. The use of such structural models for the distributed control of large flexible lattice structures offers a significant advantage over a numerical approach. M.G.

N83-36066*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
MINIMUM INFORMATION MODELLING OF STRUCTURAL SYSTEMS WITH UNCERTAIN PARAMETERS
D. C. HYLAND *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 71-88 1 Jul. 1983 refs Sponsored by AF
Avail: NTIS HC A99/MF A01 CSCL 22B

Work is reviewed wherein the design of active structural control is formulated as the mean-square optimal control of a linear mechanical system with stochastic parameters. In practice, a complete probabilistic description of model parameters can never be provided by empirical determinations, and a suitable design approach must accept very limited a priori data on parameter statistics. In consequence, the mean-square optimization problem is formulated using a complete probability assignment which is made to be consistent with available data but maximally unconstrained otherwise through use of a maximum entropy principle. The ramifications of this approach for both robustness and large dimensionality are illustrated by consideration of the full-state feedback regulation problem. M.G.

N83-36067*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DISTRIBUTED SYSTEM MODELING OF A LARGE SPACE ANTENNA
M. HAMIDI, G. RODRIGUEZ, and D. B. SCHAECHTER *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 89-102 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

A general approach for distributed parameter modeling of complex dynamical systems is described. The method consists of dividing the system in parts which can be modeled by simple partial differential equations and coupling the equations thus obtained by applying Hamilton's variational formalism to the entire system. The modeling of a large, offset-fed, wrap-rib antenna is presented to illustrate the approach. Although such models are perhaps not as precise as finite element models, they can be useful for initial physical insight and parametric design. M.G.

N83-36068*# Stanford Univ., Calif.
MODELING OF FLEXIBLE STRUCTURES FOR ACTIVE CONTROL
A. E. BRYSON, JR. *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 103-118 1 Jul. 1983 refs
(Contract NAG1-236)
Avail: NTIS HC A99/MF A01 CSCL 22B

If a flexible structure has a plane of symmetry, the equations of motion can be split into two uncoupled sets, one for symmetrical motions and one for anti-symmetric motions. If there are m controls, it is often convenient to assign the linear combinations of controls that enter into the m lowest frequency modes and new controls. As an example the feed-support structure of a spacecraft antenna is considered. It is modeled as a tetrahedron made up of flexible bars and connected to the spacecraft by six short flexible legs containing force actuators and displacement sensors. Due to the three-sided symmetry of this structure, both the symmetric and the anti-symmetric equations of motion can be decoupled into two subsystems. The resulting four subsystems are: (1) pitch/fore-aft motions with four degrees of freedom (DOF), two controls, and one output (the fore-aft motion of the feed); (2) vertical motions with three DOF, one control, and one output (the vertical motion of the feed); (3) roll/lateral motions with four DOF, two controls, and one output (the lateral motions of the feed); and (4) yaw motion with one DOF, one control, and no output (the feed does not move during yaw motion). M.G.

N83-36069*# California Inst. of Tech., Pasadena.
VIBRATION SUPPRESSION IN LARGE SPACE STRUCTURES
T. K. CAUGHEY and C. J. GOH *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 119-142 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

The problem of potential instability caused by actuator dynamics is examined. Two ways of overcoming it are discussed: rate feedback with compensation and position feedback with tuning filters. M.G.

N83-36070*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL OF ANTENNA-FEED ATTITUDE AND REFLECTOR VIBRATIONS IN LARGE SPACEBORNE ANTENNAS BY MECHANICAL DECOUPLING AND MOVABLE DAMPERS
P. K. C. WANG, E. C. HONG, and J. S. SARINA *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 143-161 1 Jul. 1983 refs Prepared in cooperation with California Univ., Los Angeles
Avail: NTIS HC A99/MF A01 CSCL 20N

Simple, practical methods for damping reflector vibrations and designing antenna-feed attitude control systems in large deployable spaceborne antennas are proposed. The former involves a movable damper which is positioned so that the rate-of-change of total vibrational energy is minimized. The latter introduces a mechanical decoupler between the flexible boom and the antenna-feed, whereby the feed-attitude control system can be designed independent of boom dynamics. The validity of these approaches are substantiated by analytical studies, computer simulation, and experimental studies. M.G.

N83-36071*# University of Southern California, Los Angeles. Dept. of Electrical Engineering.
A CLOSED-LOOP PRINCIPAL COMPONENT ANALYSIS OF A TETRAHEDRAL TRUSS
E. A. JONCKHEERE *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 163-180 1 Jul. 1983 refs
(Contract NSF ECS-81-12327)
Avail: NTIS HC A99/MF A01 CSCL 20K

A tetrahedral truss, representative of a fairly broad class of large space structures, is considered. A method, measuring the dynamical importance of each elastic mode when the structure is under feedback control, is presented. The main conclusion is that the closed-loop importance of each vibration mode depends on the robustness requirements. Also, there appears to be a conflict between precise control of a given node of the structure and stability margin, these two requirements leading to contradictory classifications of the modes by order of importance. M.G.

N83-36072*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL OF LARGE SPACE ANTENNAS BASED ON ELECTROMAGNETIC-STRUCTURAL MODELS
M. HAMIDI and F. MANSHADI *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 181-194 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 20N

A general approach to the optimal control of large space antennas based on their RF/structural characteristics is described. The approach consists of defining a cost functional based on the degradation of the RF performance of the antenna and using the structural model as the dynamic system. The method is applied to the design of an optimal controller for a 55-m, wrap-rib offset-fed antenna. The controller's goal is to minimize the variations of the peak electric field of the antenna due to feed displacements. M.G.

N83-36073*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACTIVE CONTROL OF SPACE STRUCTURES (ACOSS) MODEL 2
T. C. HENDERSON *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 195-210 1 Jul. 1983
Avail: NTIS HC A99/MF A01 CSCL 22B

A complete description of the active control of space structures model #2 which is a simple but realistic evaluation model is given. The design of this system was driven by the desire to incorporate certain attributes into the overall system characteristics. The desired features were structural design based on realistic sizes and weights; a simple unclassified optical system with associated performance measures and tolerance; and a set of disturbances typical of equipment vibration and attitude control (slew). The resulting model is described in detail along with the resulting mode shapes and natural frequencies of the system. A description of the line-of-sight performance measure including theory and implementation is given. R.J.F.

N83-36074*# Stanford Univ., Calif.
TRAVELLING WAVE EFFECTS IN LARGE SPACE STRUCTURES
A. VONFLOTOW *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 211-223 1 Jul. 1983 refs Sponsored in part by AFOSR
(Contract NAG1-97)
Avail: NTIS HC A99/MF A01 CSCL 22B

Several aspects of travelling waves in Large Space Structures(LSS) are discussed. The dynamic similarity among LSS's, electric power systems, microwave circuits and communications network is noted. The existence of time lag between actuation and response is illuminated with the aid of simple examples, and their prediction is demonstrated. To prevent echoes, communications lines have matched terminations; this idea is applied to the design of dampers of one dimensional structures. Periodic structures act as mechanical band pass filters. Implications of this behavior are examined on a simple example. It is noted that the implication is twofold; continuum models of periodic lattice structures may err considerably; on the other hand, it is possible to design favorable transmission (and resonance) characteristics into the structure. Author

N83-36075*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DISTRIBUTED CONTROL OF LARGE SPACE ANTENNAS
J. M. CAMERON, M. HAMIDI, Y. H. LIN, and S. J. WANG *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 225-247 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 09C

A systematic way to choose control design parameters and to evaluate performance for large space antennas is presented. The structural dynamics and control properties for a Hoop and Column Antenna and a Wrap-Rib Antenna are characterized. Some results of the effects of model parameter uncertainties to the stability, surface accuracy, and pointing errors are presented. Critical dynamics and control problems for these antenna configurations are identified and potential solutions are discussed. It was concluded that structural uncertainties and model error can cause serious performance deterioration and can even destabilize the controllers. For the hoop and column antenna, large hoop and long meat and the lack of stiffness between the two substructures result in low structural frequencies. Performance can be improved if this design can be strengthened. The two-site control system is more robust than either single-site control systems for the hoop and column antenna. R.J.F.

N83-36076*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
NUMBER AND PLACEMENT OF CONTROL SYSTEM SENSORS CONSIDERING POSSIBLE FAILURES
W. E. VANDERVELDE and C. R. CARIGNAN *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 253-268 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

A methodology has been presented which is intended to assist the designer of a control system for a large space structure to decide how many sensors should be incorporated in the system and where they should be placed on the structure. This approach is intended to be especially useful in the early stages of the evolution of the system, before a complete control system concept has been defined. This methodology is based on a quantitative measure of the observability of the system for a given set of sensors. The effect of possible component failures during the mission period was incorporated in the measure. The question of sensor placement is then resolved by finding the locations which maximize the performance measure. The number of components to use cannot be determined by optimizing the measure because the observability always improves with increased number of sensors if they are optimally located. However, the improvement in the measure with component number can be determined, and this information can be used along with data on cost, power required, etc., to decide how many sensors to use. Author

N83-36077*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
THE TOYSAT STRUCTURAL CONTROL EXPERIMENT
J. A. BREAKWELL and G. J. CHAMBERS *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 269-285 1 Jul. 1983
Avail: NTIS HC A99/MF A01 CSCL 22B

The Lockheed TOYSAT experiment is described. The experiment was designed to test hypothesis concerning the application of optimal control theory to flexible spacecraft. The theory is presented, and results described. Author

N83-36078*# Massachusetts Inst. of Tech., Cambridge. Research Lab. of Electronics.
LARGE SPACE STRUCTURE MODEL REDUCTION AND CONTROL SYSTEM DESIGN BASED UPON ACTUATOR AND SENSOR INFLUENCE FUNCTIONS
Y. YAM, J. H. LANG, T. L. JOHNSON, S. SHIH, and D. H. STAELIN *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 287-304 1 Jul. 1983 refs
(Contract DAAG29-78-C-0020)
Avail: NTIS HC A99/MF A01 CSCL 22B

A model reduction procedure based on aggregation with respect to sensor and actuator influences rather than modes is presented for large systems of coupled second-order differential equations. Perturbation expressions which can predict the effects of spillover on both the aggregated and residual states are derived. These expressions lead to the development of control system design constraints which are sufficient to guarantee, to within the validity of the perturbations, that the residual states are not destabilized by control systems designed from the reduced model. A numerical example is provided to illustrate the application of the aggregation and control system design method. Author

N83-36079*# Georgia Inst. of Tech., Atlanta. Dept. of Mechanical Engineering.
A DESIGN PROCEDURE FOR ACTIVE CONTROL OF BEAM VIBRATIONS
S. L. DICKERSON and G. JAROCKI *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 305-316 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

The transverse vibrations of beams is discussed and a methodology for the design of an active damping device is given. The Bernoulli-Euler equation is used to derive a transcendental transfer function, which relates a torque applied at one end of the beam to the rotational position and velocity at that point. The active damping device consists of a wire, a linear actuator and a short torque arm attached to one end of the beam. The action of the actuator varies a tension in the wire and creates a torque which opposes the rotation of the beam and thus damps vibration. A design procedure for such an active damper is given. This procedure shows the relationships and trade-offs between the actuator stroke, power required, stress levels in the wire and beam and the geometry of the beam and wire. It is shown that by consideration of the frequency response at the beam natural frequencies, the aforementioned relationships can be greatly simplified. Similarly, a simple way of estimating the effective damping ratios and eigenvalue locations of actively controlled beams is presented. R.J.F.

N83-36080*# McGill Univ., Montreal (Quebec). Dept. of Mechanical Engineering.
ON VIBRATION CONTROL OF TETHERED SATELLITE SYSTEMS
D. M. XU, A. K. MISRA, and V. J. MODI (British Columbia Univ.) *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 317-327 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

The general dynamics of a shuttle supported tethered subsatellite system taking into account the longitudinal and three dimensional transverse vibrations is considered. It is noted that control of inherently unstable dynamics during retrieval of the subsatellite can be carried out by letting the rate of change length depend on the state variables in an appropriate manner. Control laws using linear feedback of inplane state variables and nonlinear feedback of out-of-plane state variables are proposed. Author

N83-36081*# Stanford Univ., Calif. Dept. of Aeronautics/Astronautics.
ORBITING CHAINS AND RINGS
J. V. BREAKWELL *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 329-336 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

Two very different, highly flexible, space structures proposed during the last decade which involve analytical solution of certain partial differential equations are discussed. The first structure is an array, or hanging chain of aluminum beads which would serve as a convenient communicator if, under the influence of the Earth's gravity gradient, it assumes a local vertical orientation as it circles the Earth. Two passive schemes have been proposed for damping the rigid modes: twist the wire at the ends to provide non-zero moment of inertia about the vertical, thereby inducing relative motion of the two tips during rigid pitch or roll, and thus exercising a damper; and introduce weak lossy springs between the end sections and the main section; thereby providing linear coupling between the springs and all the in-plane (pitch) modes. The second structure is a complete ring of satellites cabled together at synchronous altitude. By a slight increase in altitude, the cable is in tension. This configuration is, however, unstable, and an active feedback control scheme is required to stabilize it. A possible scheme involves local cable length adjustment based on measurement of local altitude and shape variations and their rates. R.J.F.

N83-36082*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HARDWARE VERIFICATION OF DISTRIBUTED/ADAPTIVE CONTROL
D. B. ELDRED and D. B. SCHAECHTER *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 337-350 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

Adaptive control techniques are studied for their future application to the control of large space structures, where uncertain or changing parameters may destabilize standard control system designs. The approach used is to examine an extended Kalman filter estimator, in which the state vector is augmented with the unknown parameters. The associated Ricatti equation is linearized about the case of exact knowledge of the parameters. By assuming that parameter variations occur slowly, the filter complexity is reduced further yet. Simulations on a two degree-of-freedom oscillator demonstrate the parameter-tracking capability of the filter, and an implementation on the JPL Flexible Beam Facility using an incorrect model shows the adaptive filter/optimal control to be stable where a standard Kalman filter/optimal control design is unstable. R.J.F.

N83-36083*# Wisconsin Univ., Madison. Dept. of Mathematics.
SOME REMARKS ON THE CURRENT STATUS OF THE CONTROL THEORY OF SINGLE SPACE DIMENSION HYPERBOLIC SYSTEMS
D. L. RUSSELL *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 351-381 1 Jul. 1983 refs
(Contract AF-AFOSR-0018-79)
Avail: NTIS HC A99/MF A01 CSCL 22B

Various aspects of the control theory of hyperbolic systems, including controllability, stabilization, control canonical form theory, etc., are reviewed. To allow a unified and not excessively technical treatment, attention is restricted to the case of a single space variable. A newly developed procedure of canonical augmentation is discussed. R.J.F.

N83-36084*# California Univ., Los Angeles.
APPROXIMATION IN CONTROL OF FLEXIBLE STRUCTURES, THEORY AND APPLICATION
J. S. GIBSON *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 383-389 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

The sense in which the feedback control law based on an approximate finite dimensional model of a continuous structure approximates a control law which is optimal for the distributed, or infinite dimensional, model of the structure is studied. From the analysis of the various control and stability issues associated with this basis question, useful information for designing finite dimensional compensators which produce near-optimal performance in infinite dimensional systems is gained. Some of the important predictions that can be made about large-order finite dimensional control laws, using the theory of infinite dimensional Riccati equations are indicated. R.J.F.

N83-36085*# West Virginia Univ., Morgantown. Dept. of Mathematics.
SIMULTANEOUS CONTROL AND OPTIMIZATION FOR ELASTIC SYSTEMS
V. KOMKOV *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 391-408 1 Jul. 1983 refs
(Contract NSF CMS-80-05677)
Avail: NTIS HC A99/MF A01 CSCL 22B

Studies are conducted to determine the dynamic response of beams and plates to loads which are extreme within a certain class of admissible loads. Two approaches to this problem are suggested. In approach one, Pontryagin's maximality principle is regarded as an additional constraint. The optimality of design is then determined by standard numerical techniques. The 'adjoint variable approach' to sensitivity of structural design is applied for a given inhomogeneous term. The inhomogeneous term is an extremal element of admissible load vectors, which constitute a closed subspace of a Sobolev space. Again, the maximality principle is invoked. While only beam and plate theory problems are used as examples, generalizations are easy to perceive. B.W.

N83-36086*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
FIXED-ORDER DYNAMIC COMPENSATION THROUGH OPTIMAL PROJECTION
D. C. HYLAND and A. N. MADIWALE *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 409-425 1 Jul. 1983 refs Sponsored by AF
Avail: NTIS HC A99/MF A01 CSCL 22B

This paper reviews a formulation for the design of fixed-order dynamic compensation for flexible mechanical systems which is based upon explicit optimality conditions derived under the minimum data/maximum entropy stochastic modelling approach. The optimality conditions give rise to the novel concept of 'optimal projection' which provides significant insight with regard to the compensator structure and permits earlier, more restricted and/or ad hoc design schemes to be seen as special cases of the present formulation. Author

N83-36087*# Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Electrical, Computer, and Systems Engineering.
STABLE FEEDBACK CONTROL OF DISTRIBUTED PARAMETER SYSTEMS: TIME AND FREQUENCY DOMAIN CONDITIONS
M. J. BALAS *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 427-449 1 Jul. 1983 refs
(Contract NAG1-171; NSF ECS-80-16173)
Avail: NTIS HC A99/MF A01 CSCL 22B

Large space structures, or any mechanically flexible structures, are inherently distributed parameter systems (DPS) whose dynamics are modeled by partial, rather than ordinary, differential equations. Such DPS are described by operator equations on an infinite-dimensional Hilbert (or Banach) space. However, any feedback controller for such a DPS must be a finite-dimensional (and discrete-time) system in order to be implemented with on-line digital computers and a finite (small) number of actuators and sensors. There are many ways to synthesize such controllers; the Galerkin or finite-element approach is emphasized. B.W.

N83-36088*# California Univ., Los Angeles.
APPROXIMATION OF THE OPTIMAL COMPENSATOR FOR A LARGE SPACE STRUCTURE
M. K. MACKAY *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 451-463 1 Jul. 1983 refs Revised
(Contract AF-AFOSR-3550-78)
Avail: NTIS HC A99/MF A01 CSCL 22B

This paper considers the approximation of the optimal compensator for a Large Space Structure. The compensator is based upon a solution to the Linear Stochastic Quadratic Regulator problem. Colocation of sensors and actuators is assumed. A small gain analytical solution for the optimal compensator is obtained for a single input/single output system, *i.e.*, certain terms in the compensator can be neglected for sufficiently small gain. The compensator is calculated in terms of the kernel to a Volterra integral operator using a Neumann series. The calculation of the compensator is based upon the C sub 0 semigroup for the infinite dimensional system. A finite dimensional approximation of the compensator is, therefore, obtained through analysis of the infinite dimensional compensator which is a compact operator. Author

N83-36089*# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.
ANALYSIS OF STRUCTURAL PERTURBATIONS IN SYSTEMS VIA COST DECOMPOSITION METHODS
R. E. SKELTON *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 465-475 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 22B

It has long been common practice to analyze linear dynamic systems by decomposing the total response in terms of individual contributions which are easier to analyze. Examples of this philosophy include the expansion of transfer functions using: (1) the superposition principle, (2) residue theory and partial fraction expansions, (3) Markov parameters, Hankel matrices, and (4) regular and singular perturbations. This paper summarizes a new and different kind of expansion designed to decompose the norm of the response vector rather than the response vector itself. This is referred to as 'cost-decomposition' of the system. The notable advantages of this type of decomposition are: (a) easy application to multi-input, multi-output systems, (b) natural compatibility with Linear Quadratic Gaussian Theory, (c) applicability to the analysis of more general types of structural perturbations involving inputs, outputs, states, parameters. Property (c) makes the method suitable for problems in model reduction, measurement/actuator selections, and sensitivity analysis. Author

N83-36090*# Pennsylvania State Univ., University Park. Dept. of Mathematics.
FINITE DIFFERENCE NUMERICAL METHODS FOR BOUNDARY CONTROL PROBLEMS GOVERNED BY HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS
G. CHEN, Q. ZHENG, M. COLEMAN, and S. WEERAKOON *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 477-495 1 Jul. 1983 refs
(Contract NSF MCS-81-01892)
Avail: NTIS HC A99/MF A01 CSCL 12A

This paper briefly reviews convergent finite difference schemes for hyperbolic initial boundary value problems and their applications to boundary control systems of hyperbolic type which arise in the modelling of vibrations. These difference schemes are combined with the primal and the dual approaches to compute the optimal control in the unconstrained case, as well as the case when the control is subject to inequality constraints. Some of the preliminary numerical results are also presented. B.W.

N83-36091*# Brown Univ., Providence, R. I. Center for Dynamical Systems.
ALGORITHMS FOR ESTIMATION IN DISTRIBUTED MODELS WITH APPLICATIONS TO LARGE SPACE STRUCTURES
H. T. BANKS *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 505-509 1 Jul. 1983 refs
(Contract NAG1-258; DAAG29-79-C-0161; AF-AFOSR-0198-81)
Avail: NTIS HC A99/MF A01 CSCL 09B

The author discussed the theoretical and computational results for spline based approximation schemes used in parameter estimation algorithms for distributed systems. Specific applications include beam-like structures described by the Euler-Bernoulli and Timoshenko theories and antenna surfaces such as that in the deployable Maypole Hoop/Column model. B.W.

N83-36092*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.
IDENTIFICATION OF LARGE FLEXIBLE STRUCTURES MASS/STIFFNESS AND DAMPING FROM ON-ORBIT EXPERIMENTS
S. L. HENDRICKS, S. RAJARAM, M. P. KAMAT, and J. L. JUNKINS *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 511-520 1 Jul. 1983 refs Submitted for publication
Avail: NTIS HC A99/MF A01 CSCL 20K

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. Author

N83-36093*# Warwick Univ. Coventry (England).
JOINT STATE AND PARAMETER ESTIMATION
N. CARMICHAEL and M. D. QUINN (Sheffield City Polytechnic, England) *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 521-529 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 12A

Recent results are described concerning the problem of state reconstruction for a class of nonlinear distributed systems. The methods are then applied to the problem of joint state and parameter estimation. An example with the wave equation is presented. Author

N83-36094*# Purdue Univ., Lafayette, Ind. School of Aeronautics and Astronautics.
PARAMETER ESTIMATION IN TRUSS BEAMS USING TIMOSHENKO BEAM MODEL WITH DAMPING
C. T. SUN and J. N. JUANG (Martin Marietta Aerospace, Denver) *In* JPL Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 531-545 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

Truss beams with members having viscous damping are modeled with a Timoshenko beam. Procedures for deriving the equivalent bending rigidity, transverse shear rigidity, and damping are presented. Explicit expressions for these equivalent beam properties are obtained for a specific truss beam. The beam model thus established is then used to investigate the effect of damping in free vibration. Finally, the beam is employed in the estimation of structural parameters in a simply-supported truss beam using a random search algorithm. Author

N83-36095*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A FUNCTION SPACE APPROACH TO STATE AND MODEL ERROR ESTIMATION FOR ELLIPTIC SYSTEMS
G. RODRIGUEZ *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 547-573 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 12A

An approach is advanced for the concurrent estimation of the state and of the model errors of a system described by elliptic equations. The estimates are obtained by a deterministic least-squares approach that seeks to minimize a quadratic functional of the model errors, or equivalently, to find the vector of smallest norm subject to linear constraints in a suitably defined function space. The minimum norm solution can be obtained by solving either a Fredholm integral equation of the second kind for the case with continuously distributed data or a related matrix equation for the problem with discretely located measurements. Solution of either one of these equations is obtained in a batch-processing mode in which all of the data is processed simultaneously or, in certain restricted geometries, in a spatially scanning mode in which the data is processed recursively. After the methods for computation of the optimal estimates are developed, an analysis of the second-order statistics of the estimates and of the corresponding estimation error is conducted. Based on this analysis, explicit expressions for the mean-square estimation error associated with both the state and model error estimates are then developed. B.W.

N83-36096*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STATE AND MODEL ERROR ESTIMATION FOR ELLIPTIC SYSTEMS: APPLICATIONS TO LARGE ANTENNA STATIC SHAPE DETERMINATION
G. RODRIGUEZ and R. E. SCHEID, JR. *In its* Proc. of the Workshop on Appl. of Distributed System Theory to the Control of Large Space Struct. p 575-603 1 Jul. 1983 refs
Avail: NTIS HC A99/MF A01 CSCL 12A

This paper outlines the application of various estimation approaches to the problem of static shape determination for large antenna systems. The problem consists of estimating the shape of an antenna surface from measurements of its static deflection. The estimation schemes are based on any one of the modeling options of a single PDE for early insight and understanding, coarse-resolution multiple-PDE models for parametric studies and fine-resolution piecewise-continuum models for detailed design. For any one of these three models, estimator design can be developed using an infinite-dimensional approach, where the necessary finite-element truncation and approximation is conducted after the analytical design has taken place, or it can be based on a finite-dimensional approach, where the model is truncated before the estimation problem is formulated. One of the main objectives of the paper is to develop both approaches while simultaneously investigating their differences and similarities. Simulation results of an application of the finite-dimensional approach to a large parabolic reflector are presented. B.W.

N83-36100# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
MODIFICATIONS TO ACOSS MODEL NUMBER 2 DESIGN Final Technical Report, Sep. - Dec. 1981
T. C. HENDERSON Griffiss AFB, N.Y. RADC Mar. 1983 71 p refs
(Contract F30602-81-C-0180; ARPA ORDER 3655)
(AD-A129701; CDSL-R-1585; RADC-TR-83-56) Avail: NTIS HC A04/MF A01 CSCL 22B

An updated version of the Active Control of Space Structure (ACOSS) Evaluation Model, ACOSS Model 2, has been designed and analyzed. This updated model reflects the need for closer correlation between model performance and actual system performance at the cost of increased model complexity. Using this updated model, two additional models have been created to fulfill the needs of the VCOSS program. The first VCOSS model is a minimum mass, flexible design. A vibration control system including hardware specifications will be designed for this model. This design will be compared with that based on the second VCOSS model. This model is a maximum mass, stiffness controlled design. The purpose of this design is to reduce control system requirements by stiffening the structure in order to raise critical modal frequencies. The MSC/NASTRAM finite element models for all three designs are listed in the appendices. Author (GRA)

06

ELECTRONICS

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

A83-23464
ON THE CHOICE OF THE OPTIMAL DENSITY OF VIBRATORS FOR A RECTENNA [K VOPROSU O VYBORE OPTIMAL'NOI PLOTNOSTI VIBRATOROV REKTENNY]
G. P. BOIAKHCHIAN, V. A. VANKE, and S. K. LESOTA Radiotekhnika i Elektronika, vol. 28, Feb. 1983, p. 362-365. In Russian. refs

Theoretical calculations relating to the optimization of vibrator density in a rectenna system are presented with particular reference to the development of the microwave transmission system in a satellite solar power system. It is shown that, when the microwave power density in the incident beam is 230 W/sq m or less, the vibrator density can be reduced to 80 per sq m when the width of the rectenna directivity pattern is 10 deg. The effect of load mismatch on the rectenna efficiency is insignificant, amounting to less than 1% for a pattern width of 10 deg. B.J.

A83-25753
A LARGE RF RADIATING MEMBRANE FOR SPACE APPLICATION
R. L. BOCCHICCHIO and J. A. QUADRINI (Grumman Aerospace Corp., Bethpage, NY) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 12th, San Diego, CA, July 19-21, 1982, SAE 16 p.
(Contract F30602-79-C-0129)
(SAE PAPER 820840)

A three-layer radiating membrane has been developed for a space-based radar system. The design consists of an electronic lens, planes of phased antenna elements for RF beam formation, and a ground plane for RF reflection and isolation. An 84-node thermal model was used to determine temperature distributions for thermal testing and structural deformation analysis. Test results show that worst case temperature gradients and excursions will result in significant, non-permanent deformation of the membrane structure. For example, uncoated Kapton antenna planes will reach about 44.4 C due to degradation during a five-year mission. Future research will evaluate coating materials. S.C.S.

A83-27152*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
OPTIMIZATION TECHNIQUE FOR IMPROVED MICROWAVE TRANSMISSION FROM MULTI-SOLAR POWER SATELLITES
G. D. ARNDT and E. M. KERWIN (NASA, Johnson Space Center, Houston, TX) In: IECEC '82; Proceedings of the Seventeenth Intersociety Energy Conversion Engineering Conference, Los Angeles, CA, August 8-12, 1982. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1982, p. 193-198. refs

An optimization technique for generating antenna illumination tapers allows improved microwave transmission efficiencies from proposed solar power satellite (SPS) systems and minimizes sidelobe levels to meet preset environmental standards. The cumulative microwave power density levels from 50 optimized SPS systems are calculated at the centroids of each of the 3073 counties in the continental United States. These cumulative levels are compared with Environmental Protection Agency (EPA) measured levels of electromagnetic radiation in seven eastern cities. Effects of rectenna relocations upon the power levels/population exposure rates are also studied. (Author)

A83-27153

INTEGRATION OF LARGE ELECTRICAL SPACE POWER SYSTEMS

J. H. HAYDEN (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) and A. KIRPICH (General Electric Co., Philadelphia, PA) In: IECEC '82; Proceedings of the Seventeenth Intersociety Energy Conversion Engineering Conference, Los Angeles, CA, August 8-12, 1982. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1982, p. 199-204.

Methods for combining solar/battery space power plants with space nuclear reactor power plants are discussed, noting the eventual application for a manned space station. The load will have both dc and ac components, and it is expected that solar/battery power will be used in the initial growth stages of the station. The battery power is regarded as a dc source only, and all power is inverted by equipment located near the end use. Shunt regulation can be implemented to handle excess power, especially with regard to a concept of an expanding power supply. A direct energy transfer system (DETS) is described, and involves channeling power directly to loads, with excess power radiated away by the shunt regulator. Power processing controls would respond to voltage deviations. A block diagram is furnished for a reliable high voltage battery modular array which would be capable of furnishing 28 kW demand. If the energy source is a constant speed alternator, then constant speed operation, load leveling, and adaptation of the alternator to different voltages would be necessary. M.S.K.

A83-27254* Rockwell International Corp., Seal Beach, Calif.

DESIGN OF LARGE, LOW-CONCENTRATION-RATIO SOLAR ARRAYS FOR LOW EARTH ORBIT APPLICATIONS

S. J. NALBANDIAN and E. P. FRENCH (Rockwell International Corp., Space Operations/Integration and Satellite Systems Div., Seal Beach, CA) In: IECEC '82; Proceedings of the Seventeenth Intersociety Energy Conversion Engineering Conference, Los Angeles, CA, August 8-12, 1982. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1982, p. 1613-1618. refs

(Contract NAS8-34214)

A83-29049* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

MULTIPLE BEAM MICROWAVE SYSTEMS FOR THE SOLAR POWER SATELLITE

G. D. ARNDT and E. M. KERWIN (NASA, Johnson Space Center, Houston, TX) Space Solar Power Review (ISSN 0191-9067), vol. 3, no. 4, 1982, p. 301-315. refs

An antenna optimization technique is applied to the environmental requirements pertaining to SPS (solar power satellite) systems to create high efficiency, multiple beams from a single antenna. Effects of rectenna spacings, subarray sizing, multiple beam degradations, antenna electrical and mechanical errors, and satellite motion are investigated. Advantages of multiple beam SPS systems include operational flexibility, lower power per rectenna, fewer satellites, smaller rectennas, and adherence to a 0.01 mW/sq cm environmental guidelines for sidelobe levels. These advantages suggest multiple beam systems are attractive alternatives to the present single beam system. Author

A83-31283

A HOLOGRAPHIC SURFACE MEASUREMENT OF THE TEXAS 4.9-M ANTENNA AT 86 GHZ

C. E. MAYER, J. H. DAVIS, W. L. PETERS, III, and W. J. VOGEL (Texas, University, Austin, TX) (Institute of Electrical and Electronics Engineers, National Bureau of Standards, and International Union of Radio Science, Conference on Precision Electromagnetic Measurements, Boulder, CO, June 28-July 1, 1982) IEEE Transactions on Instrumentation and Measurement (ISSN 0018-9456), vol. IM-32, March 1983, p. 102-109. refs

An instrument has been built which allows the electromagnetic measurement of the surface accuracy of a large millimeter-wavelength antenna. The University of Texas 4.9-m radio telescope has been measured with this technique at 86.1 GHz to an accuracy of 4 microns at the surface. The technique is an interferometric one which is fast, accurate, and able to measure the whole antenna surface at once. While the technique is illustrated by its use on a large antenna, it could be used in a near-field measurement of a smaller antenna. Several antenna surface maps are presented. A comparison of run-to-run repeatability was made. The technique itself was tested by deforming the antenna surface in a known way and subsequently detecting the deformation. Author

A83-41120* Lockheed Missiles and Space Co., Palo Alto, Calif.

ON THE INJECTION BOUNDARY MODEL AND DISPERSING ION SIGNATURES AT NEAR-GEOSYNCHRONOUS ALTITUDES

R. J. STRANGEWAY and R. G. JOHNSON (Lockheed Research Laboratories, Palo Alto, CA) Geophysical Research Letters (ISSN 0094-8276), vol. 10, July 1983, p. 549-552. refs

(Contract N00014-76-C-0444; NASW-3395; NSF ATM-81-19340)

A simple particle drift model is used to investigate the applicability of the injection boundary concept to the ion dispersion event observed on March 22 (day 81), 1979. The model consists of a dipole magnetic field with a uniform cross-tail electric field plus a corotation field. A full spectrum of particles from 100 eV to 32 keV is injected at the Kp = 6 - Mauk and McIlwain injection boundary at the time of substorm onset on this day (1100 UT). A new approach is presented for displaying the model-produced ion drift trajectories to make the large scale spatial characteristics of the evolving energy distributions easier to envision and to facilitate the comparison of the model results with experimental observations. The resultant prediction for the dispersion signature is compared with Scatha mass spectrometer measurements, and a 2.0 kV/Re cross-tail convection electric field is found to give a good fit to the observed dispersion signature. It is determined that for this particular event, injection only at that portion of the injection boundary close to 1800 local time is required to produce the dispersion curve. Author

A83-41724#

ELECTRO-STATIC SURFACE CONTROL OF A LARGE RADIOMETER SPACECRAFT

R. G. SELLAPPAN (RCA American Communications, Inc., Princeton, NJ) IN: Guidance and Control Conference, Gatlinburg, TN, August 15-17, 1983, Collection of Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1983, p. 618-621. refs

(AIAA PAPER 83-2248)

This paper formulates the problem of designing a control system to achieve and maintain a required surface accuracy, for a very large radiometer antenna. Control over the antenna's surface shape is maintained through the application of an electro-static force. This force is developed by applying an electric potential between the electro-static plates which are distributed over one side of the antenna surface and the antenna structure. With this control, the dynamic system is described by a set of bilinear partial differential equations which form the basis for analysis. For this distributed parameter system, the design of separable controllers as well as other methods of control are compared. Factors such as Coulomb drag, dynamic coupling, and external disturbances which are important in the design are discussed. Author

A83-43240* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
HISTORY, STATUS AND FUTURE APPLICATIONS OF SPACEBORNE CRYOGENIC SYSTEMS
A. SHERMAN (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Advances in cryogenic engineering. Volume 27 - Proceedings of the Cryogenic Engineering Conference, San Diego, CA, August 11-14, 1981 . New York, Plenum Press, 1982, p. 1007-1029. refs

Cryogenic cooling is employed for an increasing number of space instruments. Cryogenic cooling is needed to provide the required detector response, reduce preamplifier noise, and/or reduce background radiation. Cryogenic cooling is required by instruments employed for applications missions, gamma-ray and X-ray astronomy, cosmic ray measurements, space surveillance, IR astronomy, relativity measurements, superconductivity devices, and basic research experiments. The cooling is provided with the aid of radiant coolers, stored solid cryogen coolers, stored liquid-helium coolers, mechanical coolers, He-3 coolers, adiabatic demagnetization, refrigeration, and higher temperature adsorption and magnetic systems. Radiant coolers will continue to find widespread application for low cooling-load/high-temperature situation. It is pointed out that a long-lifetime closed-cycle, mechanical cooler is one of the most critical space technological needs. G.R.

A83-45688
DESIGNING AN UMBRELLA-TYPE FOLDING ANTENNA [SPOSOB POSTROENIIA SKLADNOI ANTENNY ZONTICHNOGO TIPA]
V. I. LOMAN and M. V. GRIANIK Radioelektronika (ISSN 0021-3470), vol. 26, Aug. 1983, p. 77-79. In Russian.

A method for improving the electrical characteristics of an umbrella-type antenna is proposed whereby use is made of the specific features of folding reflector geometries. It is shown that the use of elliptic, hyperbolic, and parabolic two-reflector antenna geometries in designing an umbrella-type antenna makes it posible not only to exploit the known advantages of these schemes but also to improve their performance. The latter is possible through a better matching of the shape of the partial phase center of the radiator system and that of the focal region of the umbrella reflector. The design proposed here makes it possible to achieve the required level of gain loss with considerably less ridges than in a conventionally designed umbrella-tye antenna. V.L.

A83-46633
RESEARCH IN INFRARED HOLLOW WAVEGUIDES
E. GARMIRE (Southern California, University, Los Angeles, CA) IN: Advances in infrared fibers II; Proceedings of the Second Meeting, Los Angeles, CA, January 26-28, 1982 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1982, p. 70-78. refs

The current status of hollow waveguides with metal walls for guidance of infrared radiation is reviewed, with emphasis placed on rectangular and circular geometries. It is shown that for straight-waveguide, confined-energy-density applications, the circular cross-section gives the lowest loss transmision per unit of cross-sectional area of the waveguide. For flexibility in one dimension, the rectangular geometry is ideal. Flexibility in two dimensions is obtained by incorporating a waveguide twist with two waveguide bends or by using the helical geometry. V.L.

A83-46748
A LARGE MILLIMETER WAVE ANTENNA
K. AKABANE (Nobeyama Radio Observatory, Nagano, Japan) International Journal of Infrared and Millimeter Waves (ISSN 0195-9271), vol. 4, Sept. 1983, p. 793-808.

Two of the problems faced by high-precision dishes for the millimeter wavelength region are discussed. These are gravitational deformation and the temperature of the structure that includes the reflector panels. The problems are treated in relation to the Nobeyama (Japan) 45-m dish. A reflecting surface accuracy of approximately 200 microns rms has been attained with this dish. The top and bottom of the back structure are covered with thermal insulators about 30 mm thick. C.R.

A83-47251#
RADIATION-PROOF SATELLITE TECHNOLOGY
V. POULEK (Ceske Vysoke Vceni Technicke, Prague, Czechoslovakia) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 7 p. refs
(IAF PAPER 83-69)

The damages to solar arrays sustained during use on satellites can be repaired by laser annealing. Regeneration of damaged solar arrays has been accomplished in the laboratory. It is proposed that laser equipment be included in satellites to perform this operation in orbit. Spin-stabilized satellites are particularly suited to this repair operation. Here, a laser device placed on the stabilized platform will irradiate the rotating surface of the satellite. During each revolution of the satellite, the laser on the stabilized platform will irradiate a narrow strip on the periphery of the satellite. By gradually shifting the laser from the upper end of the rotating covering to the lower end, the entire surface of the solar arrays will be irradiated. It is pointed out that the efficiency of the regenerated solar arrays can attain 95 percent of the initial value. C.R.

A83-47657* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTICAL DATA PROCESSING FOR AEROSPACE APPLICATIONS
R. L. STERMER (NASA, Langley Research Center, Hampton, VA) and M. SOKOLOSKI (NASA, Office of Aeronautics and Space Technology, Washington, DC) (International Optical Computing Conference, 10th, Cambridge, MA, Apr. 6-8, 1983) Optical Engineering (ISSN 0091-3286), vol. 22, Sept.-Oct. 1983, p. 146, 148, 150-153. refs

Optical data processing has a significant potential in future aerospace systems. In this paper, potential system applications are identified. One of the more important applications is the determination of errors of large antennas or reflector surfaces and the active control or compensation of the surface. Technological challenges to the application of optical data processing technology to aerospace systems are identified, and current NASA research efforts are discussed. Author

A83-48127#
SUMMARY OF ENVIRONMENTALLY INDUCED ELECTRICAL DISCHARGES ON THE P78-2 (SCATHA) SATELLITE
H. C. KOONS (Aerospace Corp., Space Sciences Laboratory, El Segundo, CA) Journal of Spacecraft and Rockets (ISSN 0022-4560), vol. 20, Sept.-Oct. 1983, p. 425-431. refs
(Contract F04701-82-C-0083)

Previously cited in issue 06, p. 823, Accession no. A82-17869

A83-48129#
A SUMMARY OF SPACECRAFT CHARGING RESULTS
P. F. MIZERA (Aerospace Corp., Space Sciences Laboratory, El Segundo, CA) Journal of Spacecraft and Rockets (ISSN 0022-4560), vol. 20, Sept.-Oct. 1983, p. 438-443. refs
(Contract F04701-82-C-0083)

Previously cited in issue 06, p. 823, Accession no. A82-17871

A83-48516
IMPROVED ESTIMATE OF THE CHANNEL CAPACITY OF THE GEOSTATIONARY ORBIT [UTOCHNENIE OTSENKI PREDEL'NOI PROPUSKNOI SPOSOBNOSTI GEOSTATSIONARNOI ORBITY]
L. IA. KANTOR Radiotekhnika (ISSN 0033-8486), Aug. 1983, p. 13-16. In Russian. refs

The present study estimates the maximum channel capacity of satellite communication systems utilizing geostationary satellites with highly directional antennas illuminating a given territory with a series of narrow beams. Corresponding radiation patterns for earth-station antennas are presented, and an expression showing the effect of main-beam narrowing of the earth-station and satellite antennas is derived. B.J.

N83-14721# Physikalisch-Technische Studien G.m.b.H., Freiburg (West Germany).
LOSS CURRENTS OF SOLAR CELLS UNDER LOW EARTH ORBIT (LEO) CONDITIONS
G. STASEK *In* ESA Photovoltaic Generators in Space p 173-177 Jun. 1982 refs
Avail: NTIS HC A15/MF A01

Loss currents through plasma for different solar cell samples were measured as a function of the potential difference, distance and angle against the plasma stream, in a plasma chamber. Loss currents of 2 micro A at 200 V for a solar panel, and a lower limit for typical discharge voltages of about 200 to 300 V for solar cells are reported. Dependencies of these quantities and test results show that current and discharge voltage are governed principally by the available charged particle densities, especially electrons, and the active sample surface. The area of these surfaces determines the current in the ohmic region whereas their geometry (edges, tips) governs the discharge voltage. In the discharge region secondary electron production increases the current. Author (ESA)

N83-24317# Los Alamos Scientific Lab., N. Mex.
SHIELDING CONSIDERATIONS FOR ADVANCED SPACE NUCLEAR REACTOR SYSTEMS
J. P. ANGELO, JR. (Florida Inst. of Tech.) and D. BUDEN 1982 19 p refs Presented at the IEEE Conf. on Nucl. and Space Radiation Effects, Las Vegas, Nev., 20-12 Jul. 1982
(Contract W-7405-ENG-36)
(DE82-019565; LA-UR-82-2002; CONF-820708-8) Avail: NTIS HC A02/MF A01

To meet the anticipated future space power needs, the Los Alamos National Laboratory is developing components for a compact, 100 kW/sub e/-class heat pipe nuclear reactor. The reactor uses uranium dioxide (UO2) as its fuel, and is designed to operate around 1500 k. Heat pipes are used to remove thermal energy from the core without the use of pumps or compressors. The reactor heat pipes transfer mal energy to thermoelectric conversion elements that are advanced versions of the converters used on the enormously successful Voyager missions to the outer planets. Advanced versions of this heat pipe reactor could also be used to provide megawatt-level power plants. The status of this advanced heat pipe reactor is reviewed and the radiation environments and shielding requirements for representative manned and unmanned applications are explored. DOE

N83-24552*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN CONSIDERATIONS FOR LARGE SPACE ELECTRIC POWER SYSTEMS
D. D. RENZ, R. C. FINKE, N. J. STEVENS, J. E. TRINER, and I. G. HANSEN Apr. 1983 23 p refs
(NASA-TM-83064; E-1535; NAS 1.15:83064) Avail: NTIS HC A02/MF A01 CSCL 22B

As power levels of spacecraft rise to the 50 to 100 kW range, it becomes apparent that low voltage (28 V) dc power distribution and management systems will not operate efficiently at these higher power levels. The concept of transforming a solar array voltage at 150 V dc into a 1000 V ac distribution system operating at 20 kHz is examined. The transformation is accomplished with series-resonant inverter by using a rotary transformer to isolate the solar array from the spacecraft. The power can then be distributed in any desired method such as three phase delta to delta. The distribution voltage can be easily transformed to any desired load voltage and operating frequency. The reasons for the voltage limitations on the solar array due to plasma interactions and the many advantages of a high voltage, high frequency at distribution system are discussed. S.L.

N83-25038*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CYCLE LIFE TEST AND FAILURE MODEL OF NICKEL-HYDROGEN CELLS
J. J. SMITHRICK 1983 16 p refs Proposed for presentation at the 18th Intersoc. Energy Conversion Eng. Conf., 21-26 Aug. 1983; sponsored by American Inst. of Chemical Engineers, IEEE, AIAA, American Chemical Society, ANS, ASME, and SAE
(NASA-TM-83375; E-1643; NAS 1.15:83375) Avail: NTIS HC A02/MF A01 CSCL 10C

Six ampere hour individual pressure vessel nickel hydrogen cells were charge/discharge cycled to failure. Failure as used here is defined to occur when the end of discharge voltage degraded to 0.9 volts. They were cycled under a low earth orbit cycle regime to a deep depth of discharge (80 percent of rated ampere hour capacity). Both cell designs were fabricated by the same manufacturer and represent current state of the art. A failure model was advanced which suggests both cell designs have inadequate volume tolerance characteristics. The limited existing data base at a deep depth of discharge (DOD) was expanded. Two cells of each design were cycled. One COMSAT cell failed at cycle 1712 and the other failed at cycle 1875. For the Air Force/Hughes cells, one cell failed at cycle 2250 and the other failed at cycle 2638. All cells, of both designs, failed due to low end of discharge voltage (0.9 volts). No cell failed due to electrical shorts. After cell failure, three different reconditioning tests (deep discharge, physical reorientation, and open circuit voltage stand) were conducted on all cells of each design. A fourth reconditioning test (electrolyte addition) was conducted on one cell of each design. In addition post cycle cell teardown and failure analysis were performed on the one cell of each design which did not have electrolyte added after failure. Author

N83-26875*# General Dynamics/Convair, San Diego, Calif.
STATUS OF DEPLOYABLE GEO-TRUSS DEVELOPMENT
J. A. FAGER *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 513-526 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The development of a deployable geo-truss spacetenna reflector is discussed. The design of the antenna is discussed. The proof of concepts development program is described. R.J.F.

N83-26876*# Martin Marietta Aerospace, Denver, Colo.
BOX TRUSS DEVELOPMENT AND APPLICATIONS
J. V. COYNER, JR. *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 527-544 May 1983
Avail: NTIS HC A25/MF A01 CSCL 22B

The development and applications of a box truss design for large space antennas are discussed. A kinematic model with a mesh reflector was constructed. A prototype cube is described. Details of fabrication are given. R.J.F.

N83-26877*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INFLATED ANTENNAS
G. J. FRIESE (L'Garde, Inc., Newport Beach, Calif.), M. THOMAS (L'Garde, Inc., Newport Beach, Calif.), and W. F. HINSON *In its* Large Space Antenna Systems Technol., Pt. 1 p 545-574 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

Inflatable space antennas are discussed. A brief history of inflatable structures is given. Several antenna configurations are described. The antenna configuration consisting of a thin film cone and parabolic held to the proper shape by internal pressure is discussed in detail. R.J.F.

N83-26889*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SCANNING BEAM ANTENNA CONCEPTUAL DESIGN FOR 20/30 GHZ SATELLITE SYSTEMS
J. SMETANA, R. SORBELLO (Communications Satellite Corp., Clarksburg, Md.), and W. F. CROSSWELL (Harris Corp., Melbourne, Fla.) *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 767-795 May 1983
Avail: NTIS HC A20/MF A01

The configuration described is one of four antenna system configurations developed using a variety of monolithic microwave integrated circuit module arrangements and optical systems. A parametric analysis is expected to produce a data base for the selection of design points for a variety of applications. Soon to be accomplished is the design concept of the active (lens) array, which will take into consideration such factors as, coupling effects, the space-fed power divider network design, input bias and control layout, investigation of thermal distribution, and analysis of module failure (graceful degradation). L.F.M.

N83-26890*# European Space Agency, Noordwikj (Netherlands).
MULTIMISSION ADVANCED CONFIGURATION
A. SAITTO and G. BERRETTA *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 797-807 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The proposed multimission configuration reduces the number of reflectors present on the spacecraft and their related supporting structure (masts, booms) and at the same time divides the feed system from the reflector system for possible maintenance and/or payload substitution. This implies: An antenna system that is split into two parts: (1) the reflector with the platform (2) the feed subsystem with the payload. Reuse of the same reflector at different frequencies (to achieve this, the reflector system will use additional *components, i.e., frequency sensitive subreflectors (FSS)).* In case of in-orbit refurbishment or maintenance, the reflector system may remain in orbit with the platform. The presence of the FSS allows separation of the focal position sufficiently for the multiple-contoured beam applications required by future missions. There are two of these reflectors (one for TX function, one for RV deployed) on the east and west sides of the spacecraft, and the solar panels are on the north and south sides. The payloads are aligned along the yaw axis. Apart from the size, this configuration looks like a conventional spacecraft. L.F.M.

N83-26891*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNA COMMUNICATIONS SYSTEMS: INTEGRATED LANGLEY RESEARCH CENTER/JET PROPULSION LABORATORY TECHNOLOGY DEVELOPMENT ACTIVITIES. 1: INTRODUCTION
T. G. CAMPBELL *In its* Large Space Antenna Systems Technol., Pt. 2 p 809-814 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

The Jet Propulsion Laboratory and the Langley Research Center have been developing technology related to large space antennas (LSA) during the past several years. The need for a communication system research program became apparent during the recent studies for the Land Mobile Satellite System. This study indicated the need for additional research in (1) electromagnetic analysis methods, (2) design and development of multiple beam feed systems, and (3) the measurement methods for LSA reflectors. L.F.M.

N83-26892*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNA COMMUNICATIONS SYSTEMS: INTEGRATED LANGLEY RESEARCH CENTER/JET PROPULSION LABORATORY DEVELOPMENT ACTIVITIES. 2: LANGLEY RESEARCH CENTER ACTIVITIES
T. G. CAMBELL, M. C. BAILEY, C. R. COCKRELL, and F. B. BECK *In its* Large Space Antenna Systems Technol., Pt. 2 p 815-832 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The electromagnetic analysis activities at the Langley Research Center are resulting in efficient and accurate analytical methods for predicting both far- and near-field radiation characteristics of large offset multiple-beam multiple-aperture mesh reflector antennas. The utilization of aperture integration augmented with Geometrical Theory of Diffraction in analyzing the large reflector antenna system is emphasized. L.F.M.

N83-26893*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE SPACE ANTENNA COMMUNICATIONS SYSTEMS: INTEGRATED LANGLEY RESEARCH CENTER/JET PROPULSION LABORATORY DEVELOPMENT ACTIVITIES. 3: JET PROPULSION LABORATORY ACTIVITIES
K. E. WOO, Y. RAHMAT-SAMII, and W. IMBRIALE *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 833-851 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

The portion of JPL antenna R/D work that is performed cooperatively with Langley Research Center in support of the demonstration and evaluation of the 15-m unfurlable antenna. The activities that will be performed during FY 83 and FY 84 are also indicated. L.F.M.

N83-26894*# Harris Corp., Melbourne, Fla.
THE EFFECTS OF MESH REFLECTING SURFACES UPON RADIOMETRIC MEASUREMENTS
W. F. CROSSWELL *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 853-866 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 20N

Reflector antennas with mesh surfaces have been used in ground and space applications primarily for communication systems. How the requirements for mesh surface reflectors are different for microwave radiometric applications is indicated, a method of measuring the anticipated small dissipation losses of gold-plated mesh using a radiometer system is proposed. L.F.M.

N83-26895*# North Carolina State Univ., Raleigh.
DEVELOPMENT OF IMPROVED ANALYTICAL MODELS FOR MESH REFLECTOR SURFACES
J. C. BRAND and J. F. KAUFFMAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 867-876 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 22B

Several methods for computing the reflection coefficients from mesh surfaces are discussed. Some methods mentioned have severe limitations, and the spectral approach appears to be the most attractive alternative. In spite of some inherent problems, the solutions obtained with this method will offer not only the reflection coefficients but also the currents carried on the mesh. This would allow separation of the power lost to resistive terms from that due to transmission loss. Overall, good results and rapid convergence should be obtained from this method when proper care is applied. L.F.M.

N83-26896*# National Bureau of Standards, Boulder, Colo.
A SURVEY OF NEAR-FIELD TESTING METHODS FOR LARGE APERTURE ANTENNAS AND FUTURE TRENDS
A. C. NEWELL *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 877-897 May 1983
Avail: NTIS HC A20/MF A01 CSCL 22B

In recent years, a near-field antenna measurements have progressed from theoretical concepts to a wide variety of operational measurement systems. The current status of this work is summarized and its possible application to large space antennas is discussed. L.F.M.

N83-26897*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NEAR-FIELD MEASUREMENT FACILITY PLANS AT LEWIS RESEARCH CENTER
R. G. SHARP *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 899-922 May 1983 refs
Avail: NTIS HC A20/MF A01 CSCL 20N

The direction of future antenna technology will be toward antennas which are large, both physically and electrically, will operate at frequencies up to 60 GHz, and are non-reciprocal and complex, implementing multiple-beam and scanning beam concepts and monolithic semiconductor devices and techniques. The acquisition of accurate antenna performance measurements is a critical part of the advanced antenna research program and represents a substantial antenna measurement technology challenge, considering the special characteristics of future spacecraft communications antennas. Comparison of various antenna testing techniques and their relative advantages and disadvantages shows that the near-field approach is necessary to meet immediate and long-term testing requirements. The LeRC facilities, the 22 ft x 22 ft horizontal antenna boresight planar scanner and the 60 ft x 60 ft vertical antenna boresight plant scanner (with a 60 GHz frequency and D/lamdba = 3000 electrical size capabilities), will meet future program testing requirements. L.F.M.

N83-28075# Oak Ridge National Lab., Tenn.
TECHNOLOGICAL LIMITATIONS ON NUCLEAR-ELECTRIC SPACE-POWER SYSTEMS
A. P. FRAAS 1982 11 p refs Presented at the Conf. on Prime Power for High-energy Space Systems, Norfolk, Va., 22-25 Feb. 1982
(Contract W-7405-ENG-26)
(DE82-011511; CONF-820228-1) Avail: NTIS HC A02/MF A01

Different types of space power reactors are compared. Information is presented concerning the choice of fluid circuit structural materials; fuel elements, comparison of one loop, two loop, and three loop systems; reliability of mechanical components; reliability of control systems; zero-g problems; and hazards problems. DOE

N83-29299# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INTERACTIONS MEASUREMENTS PAYLOAD FOR SHUTTLE (IMPS) Final Report, 1 Nov. 1981 - 30 Sep. 1982
H. B. GARRETT Hanscom AFB, Mass. AFGL Nov. 1982 70 p refs
(Contract AF PROJ. 7661)
(AD-A125841; AFGL-TR-82-0363) Avail: NTIS HC A04/MF A01 CSCL 22B

The Interactions Measurements Payload for Shuttle (IMPS) is being developed by the Air Force Geophysics Laboratory (AFGL) to study interactions between large space vehicles such as the Shuttle and the low-altitude plasma environment over the polar-caps and in the auroral zone. This report details that plan and presents a long-range program for studying spacecraft interactions. The specific technology questions addressed in the IMPS mission are: what are the limits within which high voltage/high power systems can be operated without arcing or significant power loss, what hazards might hamper astronaut EVA in the auroral and polar-cap regions, can the deleterious effects of plasma interactions be limited, does passage through the auroral and polar-cap regions affect the shuttle-induced bay environment, and how do material properties change during a shuttle mission and do these changes alter shuttle interactions with the environment. Three versions of the IMPS payload capable of addressing these issues are presented. GRA

N83-30493# Spar Aerospace Ltd., Weston (Ontario). Space and Electronics Group.
TESTING OF FLEXIBLE DEPLOYED SOLAR ARRAY (L-SAT)
P. A. MCINTYRE, A. S. JONES, J. RENSHALL, and G. W. MARKS *In* AGARD Environ. Effects on Mater. for Space Appl. 16 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01

The L-SAT solar array subsystem was subjected to qualification testing at both the integrated system, subassembly and component level. In addition, development testing was carried out on critical items of the design, specifically that associated with blanket behavior during deployment and Apogee Engine and RCS firing, L-SAT being the first flexible array to be operational during Apogee Engine firing. The test philosophy being adopted is similar to that used on the Communications Technology Satellite (Hermes), however, due to the size of the array and facilities available, array natural frequencies will be predicted by analysis and modal test methods. Electrical component subsystem testing covering solar cell, array blanket pyro-techniques and other electrical items are discussed and the status of development tests completed to date is reviewed. Author

N83-30500*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
INTERNATIONAL ULTRAVIOLET EXPLORER SOLAR ARRAY POWER DEGRADATION
J. H. DAY, JR. Jan. 1983 77 p refs
(NASA-TM-84989; NAS 1.15:84989) Avail: NTIS HC A05/MF A01 CSCL 22B

The characteristic electrical performance of each International Ultraviolet Explorer (IUE) solar array panel is evaluated as a function of several prevailing variables (namely, solar illumination, array temperature and solar cell radiation damage). Based on degradation in the current-voltage characteristics of the array due to solar cell damage accumulated over time by space charged particle radiations, the available IUE solar array power is determined for life goals up to 10 years. Best and worst case calculations are normalized to actual IUE flight data (available solar array power versus observatory position) to accurately predict the future IUE solar array output. It is shown that the IUE solar array can continue to produce more power than is required at most observatory positions for at least 5 more years. Author

N83-33939*# TRW Defense and Space Systems Group, Redondo Beach, Calif.
SPACE POWER DISTRIBUTION SYSTEM TECHNOLOGY. VOLUME 1: REFERENCE EPS DESIGN Final Report
D. K. DECKER, M. D. CANNADY, J. E. CASSINELLI, B. F. FARBER, C. LURIE, G. W. FLECK, J. W. LEPISTO, A. MASSNER, and P. F. RITTERMAN Mar. 1983 287 p refs 2 Vol.
(Contract NAS8-33198)
(NASA-CR-170852; NAS 1.26:170852; TRW-34579-6001-UT-00-VOL-1) Avail: NTIS HC A13/MF A01 CSCL 22B

The multihundred kilowatt electrical power aspects of a mannable space platform in low Earth orbit is analyzed from a cost and technology viewpoint. At the projected orbital altitudes, Shuttle launch and servicing are technically and economically viable. Power generation is specified as photovoltaic consistent with projected planning. The cost models and trades are based upon a zero interest rate (the government taxes concurrently as required), constant dollars (1980), and costs derived in the first half of 1980. Space platform utilization of up to 30 years is evaluated to fully understand the impact of resupply and replacement as satellite missions are extended. Such lifetimes are potentially realizable with Shuttle servicing capability and are economically desirable. S.L.

N83-34112*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELIMINARY DESIGN OF 19-ELEMENT FEED CLUSTER FOR A LARGE F/D REFLECTOR ANTENNA
M. C. BAILEY Aug. 1983 24 p refs
(NASA-TM-85666; NAS 1.15:85666) Avail: NTIS HC A02/MF A01 CSCL 09C

The design of a low sidelobe 19 element microstrip cluster and its distribution network is described. The problem of spillover illumination of an adjacent reflector in a multiple aperture reflector system is addressed. A practical implementation of the array is presented which requires only one printed circuit board for the distribution network with the potential for being easily tailored to a wide range of excitation distributions. Author

N83-35005*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE ROLE OF POTENTIAL BARRIER FORMATION IN SPACECRAFT CHARGING
C. K. PURVIS 1983 17 p refs Presented at the 17th ESLAB Symp., Noordwijk, Netherlands, 13-16 Sep. 1983; sponsored by ESA, ESTEC, and ESLAB
(NASA-TM-83500; E-1837; NAS 1.15:83500) Avail: NTIS HC A02/MF A01 CSCL 22B

The role of potential barrier formation in spacecraft charging at geosynchronous orbit is discussed. The evidence for, and understanding of, spacecraft charging and its hazards to spacecraft operation in the early 1970's are summarized. Theoretical and experimental advances which have changed the basic understanding of the role of barrier formation in charging phenomenology are described. Potential barriers are found to play a fundamental role in the dynamics of spacecrft charging. The consequences for structural and differential charging and for discharging are described. Author

07

ADVANCED MATERIALS

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

A83-29735#
SPACE RADIATION ENVIRONMENT EFFECTS ON SELECTED PROPERTIES OF ADVANCED COMPOSITE MATERIALS
V. F. MAZZIO (Boeing Vertol Co., Philadelphia, PA) and P. W. JUNEAU, JR. (General Electric CO., Space Div., Philadelphia, PA) IN: Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1983, p. 61-67.
(Contract F33615-79-C-5114)
(AIAA 83-0803)

Test equipment and techniques have been developed in order to describe the effects of the space environment on fiber-reinforced plastic composite materials. Attention is given to the features and performance of the vacuum chamber-Van de Graaff radiation facility employed, its exposure dosimetry, the preparation of the test specimens, their test rotating drum, and the levels of specimen irradiation and moisture saturation tested. The samples were P75-S pitch graphite fiber/CE339, T300 graphite fiber/934, GY70 graphite fiber/X-30, and Kevlar 49 Aramid/5209 composites. O.C.

A83-29754#
BERYLLIUM APPLICATION FOR SPACECRAFT DEPLOYABLE SOLAR ARRAY BOOMS
A. W. SHEFFLER (RCA, Astro Electronics, Princeton, NJ) IN: Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1983, p. 263-268. refs
(AIAA 83-0867)

The design and development of beryllium support booms are presented for the deployed solar arrays on geosynchronous communication satellites. The design requirements and material selection are discussed in terms of volume, constraints, stiffness, strength and weight along with a trade-off of beryllium versus graphite/epoxy. The unique characteristics of high isotrophic stiffness and low weight make beryllium ideally suited to the support of large deployable solar array appendages. The overall stiffness of the deployed array must be sufficient to maintain dynamic stability with the spacecraft attitude control systems while maintaining a minimum weight design. Special consideration is given to the cost and weight trade-off as applied to commercial satellites where the earnings per year of operation are quite high. The flight history is presented for beryllium applications on the RCA Satcom series of communication satellites. A brief description is given of the design and fabrication details as well as the quality assurance acceptance testing of the material and the brazed assembly. Qualification of the beryllium boom assemblies is conducted at spacecraft level sine, acoustic and shock testing at qualification levels. Author

A83-32794#
EVOLUTION OF NEW MATERIALS FOR SPACE APPLICATIONS
D. M. PURDY (General Electric Co., Space Systems Div., Philadelphia, PA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, Lake Tahoe, NV, May 2-4, 1983. 8 p. refs
(AIAA PAPER 83-0792)

The implications of spacecraft design requirements for materials technology are surveyed, with a focus on current trends and future needs. Criteria for materials selection are discussed, including contamination control (low-outgassing materials), electrical and thermal characteristics, structural stiffness, safety requirements, and survivability (under natural space conditions for longer periods and under potential hostile particle-beam or laser attack). The applications and potential of polymer-matrix, metal-matrix and ceramic-matrix composites are discussed and compared. While polymer-matrix-material applications are seen as extendable by using high-stiffness fibers and improving ultraviolet protection, the greatest potential is seen in the development of the metal-matrix and ceramic-matrix composites, as used in the Space Shuttle. A need for cheaper, lighter, more radiation-resistant and less contamination-prone thermal-control coatings than the present optical-solar-reflector tiles, silica fabric, and indium-tin-oxide coating is projected. Methods for the analysis of structural defects in viscoelastic electrical components are presented. The materials requirements of larger and more powerful future spacecraft are evaluated. T.K.

A83-33114
COMPOSITES FOR EXTREME ENVIRONMENTS
N. R. ADSIT, ED. (General Dynamics Corp., Convair Div., San Diego, CA) Philadelphia, PA, American Society for Testing and Materials , 1982, 187 p.

The present conference on the extreme environment properties of graphite fiber-reinforced polymer composites considers composite formulations suitable for high temperature environments, the effects on composites of atmospheric and extroatmospheric environments, and composite behavior in high moisture environments. Among the topics specifically discussed are the characteristics of the V378 polyimide resin as a composite matrix material, the thermophysical and elastic properties and fracture behavior of graphite polyimide materials, filament-wound composite thermal isolator structures for cryogenic dewars and instruments,

the environmental effects of space on graphite/epoxy composites, the dynamic testing of graphite/epoxy composites in hygrothermal environments, and the influence of quality control variables on the failure of graphite/epoxy under extreme moisture conditions.
O.C.

A83-33121
SPACE ENVIRONMENTAL EFFECTS ON GRAPHITE/EPOXY COMPOSITES
C. L. LEUNG (Rockwell International Science Center, Thousand Oaks, CA) IN: Composites for extreme environments. Philadelphia, PA, American Society for Testing and Materials, 1982, p. 110-117. refs

For the case of a T300 graphite fiber/934 epoxy matrix composite from which the skins of the Space Shuttle cargo bay doors are to be fabricated, directional moisture absorption/desorption kinetics, glass transition temperatures, interlaminar shear strength, and damping peaks, are studied as a function of increasing gamma ray exposure dosages. Four dosage levels are considered, of which the highest is equivalent to a three-year orbit life. Directional moisture diffusion studies indicate anomalies in the translaminar, transfibrous, and interlaminar diffusion axes. Although the glass transition temperatures remained constant, the damping peak height measurements showed an initial increase, followed by a decrease, with increasing radiation dosage. O.C.

A83-34909#
ALPHA-S/EPSILON-H MEASUREMENTS OF THERMAL CONTROL COATINGS OVER FOUR YEARS AT GEOSYNCHRONOUS ALTITUDE
D. F. HALL and A. A. FOTE (Aerospace Corp., Chemistry and Physics Laboratory, El Segundo, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 9 p. refs
(Contract F04701-82-C-0083)
(AIAA PAPER 83-1450)

P 78-2 was inserted into a 27,600 x 43,300-km orbit on 2 February 1979 after 3 days in a transfer orbit. The ML12 experiment on board the P78-2 spacecraft includes 16 thermal control coating (TCC) samples, each mounted in a calorimeter. The solar absorptances, alpha-s, of these samples are deduced from on-orbit measurements of temperatures and the prelaunch-measured values of thermal emittances, epsilon-H, and residual heat leaks. The time-dependent alpha-s of each sample is reported for the first 4 years on orbit. With one exception the early orbital values of alpha-s are in good agreement with prelaunch values indicating there was little contamination during prelaunch activities. The very small change in alpha-s for an OSR and other space-stable samples indicates that the SCATHA spacecraft was exceptionally clean. As a result, large alpha-s changes for other TCCs are attributed to the effects of radiation damage. Author

A83-34918#
IMPROVED METHODS FOR CHARACTERIZING MATERIAL-INDUCED CONTAMINATION
A. P. M. GLASSFORD, R. A. OSIECKI, C.-K. LIU (Lockheed Research Laboratories, Palo Alto, CA), and M. HITCHCOCK (USAF, Materials Laboratory, Wright-Patterson AFB, OH) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 12 p. refs
(AIAA PAPER 83-1496)

Contamination of space system surfaces by condensation of outgassing products from materials of construction represents a potential mechanism for degarding lifetime or performance. Procedures have been developed by the industry to control contamination at the design stage. The present investigation has the objective to review the main technical inputs and alternatives involved in selecting new methods for measuring outgassing, condensation, and deposit morphology phenomena. Attention is given to the nature of the basic phenomena involved, the various types of models used to represent these phenomena, the type of property data needed for the models, and the types of measurement apparatuses which can be used to conduct these measurements. The discussed considerations are employed as a basis for the proposal of new apparatus concepts. G.R.

A83-35771#
STANDARD FAILURE CRITERIA NEEDED FOR ADVANCED COMPOSITES
R. C. BURK (McDonnell Douglas Astronautics Co., St. Louis, MO) Astronautics and Aeronautics (ISSN 0004-6213), vol. 21, June 1983, p. 58-62.

In connection with the development and the steadily increasing use of advanced composite materials, aerospace structures undergo currently the most rapid evolution since the introduction of the all-metal aircraft. In addition to being lighter and sometimes less costly than metals, advanced composites can offer low conductance, resistance against corrosion, and a near-zero coefficient of thermal expansion. In connection with the considered characteristics composites are superior to metals for a number of applications. However, because of the greater complexity of their composition, composites demand a much more complex structural evaluation than metals. A strength or fatigue analysis must take into consideration fiber type and material, matrix material, fiber directions, lamina stacking, processing cycle, applied-load combinations, temperature, moisture content, fiber volume, and sensitivity to holes and impact damage. Attention is given to failure definitions, failure criteria, and design allowables. G.R.

A83-40282
MICROSTRUCTURE AND FRACTURE BEHAVIOUR OF UNIDIRECTIONALLY REINFORCED CARBON FIBER/CARBON COMPOSITES
S. KIMURA, E. YASUDA, and Y. TANABE (Tokyo Institute of Technology, Yokohama, Japan) IN: Progress in science and engineering of composites; Proceedings of the Fourth International Conference on Composite Materials, Tokyo, Japan, October 25-28, 1982. Volume 2. Tokyo/Amsterdam, Japan Society for Composite Materials/North-Holland, 1982, p. 1601-1608.

The microstructure and high temperature strength of unidirectionally reinforced carbon fiber/carbon composites were investigated using carbon matrices prepared from the pyrolysis of thermo-setting resin (GC) and CVD carbon (CVD) and fibers composed of high strength and high modulus (HM CF) carbon fibers. The CF/GC composites with heat treatment below 1000 C were found to show a brittle fracture, while when heat treated to above 2000 C these composites exhibited pseudo-plastic fracture. The transition temperature from brittle to pseudo-plastic fracture was found to depend on the fiber used. The fracture pattern was also affected by the contents of the graphite structure. The CF/CVD C composites of isotropic carbon matrix showed a brittle fracture, while the composites of smooth columnar carbon matrix showed pseudo-plastic fracture patterns caused by the presence of annular cracks around the fiber. The fracture behavior at high temperature was similar to that occurring at ambient temperature. The strength at 1400 C was found to be higher by 10-15 percent as compared with that found at ambient temperature, while the Young's modulus of the HM CF/GC composite was 40 percent higher at 1400 C than at ambient temperature. N.B.

A83-40285
DEVELOPMENT OF STRUCTURAL GRAPHITE/EPOXY TUBE FOR SPACE APPLICATION
Y. SAKATANI and Y. YAMAGUCHI (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Nagoya, Japan) IN: Progress in science and engineering of composites; Proceedings of the Fourth International Conference on Composite Materials, Tokyo, Japan, October 25-28, 1982. Volume 2. Tokyo/Amsterdam, Japan Society for Composite Materials/North-Holland, 1982, p. 1633-1638.

For the purpose of lightening future spacecraft structures, trial manufacturing tests of the tube truss structure made from graphite/epoxy, which is superior in respect of specific strength-modulus and dimensional stability, were performed. This paper presents the establishment of manufacturing and processing methods for graphite/epoxy tubes with lightweight joints, strength tests of the trial manufacturing components, and the trial assembly of the structure from those components. As the result of the trial manufacturing tests, a 30-40 percent weight reduction was attained in the graphite/epoxy tube truss structure compared to one made from aluminium. Also, identified was the use of multi-stepped lap joints which lowered the shear stress concentration at the joints by 30 percent as compared to single-stepped lap joints. Author

A83-46178
SYNTHETIC APERTURE RADAR ANTENNA FROM CFRP
R. WAGNER (Dornier System GmbH, Friedrichshafen, West Germany) and P. INGVARSON (Telefonaktiebolaget LM Ericsson, Molndal, Sweden) IN: 1982 International Geoscience and Remote Sensing Symposium, Munich, West Germany, June 1-4, 1982, Digest. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1982, 6 p. refs

The paper describes the design of a slotted waveguide array antenna presently under development for the SAR to be flown on ERS-1. It also presents results available to-date. The development effort is concentrated in two areas. The first is the electrical design of the large array under stringent requirements, and the development of suitable software for synthesis and analysis. The second area is the mechanical implementation in carbon fiber reinforced plastic (CFRP). This requires special manufacturing and metallization techniques to provide satisfactory electrical properties. One antenna of 2 m x 1 m has been designed, manufactured, and tested, and the performance requirements have been met. Author

A83-47378#
NON DESTRUCTIVE TESTING OF HONEYCOMB STRUCTURES BY COMPUTERIZED THERMOGRAPHIC SYSTEMS
R. MONTI and G. MANNARA (Napoli, Universita, Naples, Italy) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 9 p.
(IAF PAPER 83-419)

Thermography can be used to detect the position of defects (delaminations, noneffective bondings, cracks) in honeycomb space structures, (antennas, solar panels) in those cases where the defects cause a thermal resistance deriving from the low conductivity of the air filling the defect volume. The idea here is to set up a heat flow distribution in the specimen which is altered by the presence of the defect and to detect the resulting surface temperature distribution. A numerical analysis and preliminary experimental tests are carried out. The preliminary results show that for typical honeycomb structures, the experimental equipment built around a computerized thermographic system is able to detect defect sizes occurring at the honeycomb plate bonding with sufficient accuracy. G.R.

A83-47391#
THE MARTENSITIC TRANSFORMATION AND SHAPE MEMORY EFFECT IN A NEW SPACE MATERIAL
J. YANG (Harbin Institute of Technology, Harbin, People's Republic of China) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 6 p. refs
(IAF PAPER 83-ST-16)

Resistance measurements and optical and electron transmission microscopy are used to investigate the effect of Mn content on the transition temperatures, martensitic morphology and substructure of a Cu-Al-Sn-Mn-Ni material designed for use in space. Also investigated in the shape memory effect in this material. It is found that with an increasing Mn content, the transition temperatures are lowered and the temperature range of the thermoelastic transformation becomes wider; another consequence is that the martensitic morphology is improved from separately parallel plates to a self-accommodating configuration. An increased Mn content also causes the substructure of martensite to undergo a transition from twin to stacking fault type. A decrease in the cooling medium temperature has a similar effect and promotes an overgrowth of martensitic variants. C.R.

A83-47424
COMPOSITE INTERPHASE CHARACTERIZATION
L. T. DRZAL (USAF, Materials Laboratory, Wright-Patterson AFB, OH) (Society for the Advancement of Material and Process Engineering, Spring Symposium and Exhibition, Anaheim, CA, Apr. 12-14, 1983) SAMPE Journal (ISSN 0091-1062), vol. 19, Sept.-Oct. 1983, p. 7-13. refs

The employment of composite materials in aerospace applications is increasing. As the operating environments for composites are extended, it becomes necessary to obtain a fundamental understanding of the fiber-matrix interface as well as structure-property relationships for the fiber and matrix. The present investigation is concerned with the experimental techniques available for the characterization of the interphase region. In addition, two examples of fiber-matrix interphases are reviewed to illustrate that different parts of the interphase may be the controlling factor in different fiber-matrix systems. One graphite fiber made from polyacrylonitrile was selected as the representative fiber for a study. An epoxy system was chosen as matrix. Attention is given to surface characterization by means of surface spectroscopy and surface physical-chemical techniques. G.R.

N83-23347*# Pennsylvania State Univ., University Park. Dept. of Physics.
MASS ANALYSIS OF NEUTRAL PARTICLES AND IONS RELEASED DURING ELECTRICAL BREAKDOWNS ON SPACECRAFT SURFACES Semiannual Status Report, 4 Sep. 1982 - 3 Mar. 1983
B. R. F. KENDALL 21 Apr. 1983 18 p refs
(Contract NSG-3301)
(NASA-CR-170299; NAS 1.26:170299; SASR-7) Avail: NTIS HC A02/MF A01 CSCL 22B

A specialized spectrometer was designed and developed to measure the mass and velocity distributions of neutral particles (molecules and molecular clusters) released from metal-backed Teflon and Kapton films. Promising results were obtained with an insulation breakdown initiation system based on a moveable contact touching the insulated surfaces. A variable energy, high voltage pulse is applied to the contact. The resulting surface damage sites can be made similar in size and shape to those produced by a high voltage electron beam system operating at similar discharge energies. The point discharge apparatus was used for final development of several high speed recording systems and for measurements of the composition of the materials given off by the discharge. Results with this apparatus show evolution of large amounts of fluorocarbon fragments from discharge through Teflon FEP, while discharges through Kapton produce mainly very light hydrocarbon fragments at masses below about 80 a.m.u. A.R.H.

N83-23607*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRACTICAL SMALL-SCALE EXPLOSIVE SEAM WELDING
L. J. BEMENT Apr. 1983 21 p refs Presented at the 17th Aerospace Mech. Symp., Pasadena, Calif., 5-6 May 1983 Previously announced in NASA-CP-2273
(NASA-TM-84649; L-15622; NAS 1.15:84649) Avail: NTIS HC A02/MF A01 CSCL 13H

Joining principles and variables, types of joints, capabilities, and current and potential applications are described for an explosive seam welding process developed at NASA Langley Research Center. Variable small quantities of RDX explosive in a ribbon configuration are used to create narrow (less than 0.5 inch), long length, uniform, hermetically sealed joints that exhibit parent metal properties in a wide variety of metals, alloys, and combinations. The first major all application of the process is the repair of four nuclear reactors in Canada. Potential applications include pipelines, sealing of vessels, and assembly of large space structures. A.R.H.

N83-24896*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRACTICAL SMALL-SCALE EXPLOSIVE SEAM WELDING
L. J. BEMENT *In* JPL The 17th Aerospace Mech. Symp. p 227-244 May 1983 refs
Avail: NTIS HC A17/MF A01 CSCL 20K

A small-scale explosive seam welding process has been developed that can significantly contribute to remote metal joining operations under hazardous or inaccessible conditions, such as nuclear reactor repair and assembly of structure in space. This paper describes this explosive seam welding process in terms of joining principles, variables, types of joints created, capabilities, and applications. Very small quantities of explosive in a ribbon configuration are used to create narrow (less than 0.5 inch), long-length, uniform, hermetically sealed joints that exhibit parent metal properties in a wide variety of metals, alloys, and combinations. The practicality of this process has been demonstrated by its current acceptance, as well as its capabilities that are superior in many applications to the universally accepted joining processes, such as mechanical fasteners, fusion and resistance welding, and adhesives. Author

N83-26866*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACECRAFT MATERIALS RESEARCH: A NASA PERSPECTIVE
D. R. TENNY *In its* Large Space Antenna Systems Technol., Pt. 1 p 213-240 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

This paper reviews NASA's spacecraft materials research program. This is a multicenter program and includes research in the following areas: space environmental effects on materials, low expansion composites, fatigue and fracture of composites, thermal control coatings, and contamination. Research to date has concentrated on current graphite-reinforced composites and polymer systems, and developing analytical models to explain observed changes in mechanical, physical, and optical properties. As a result of these research efforts, new experimental facilities have been developed to simulate the space environment and measure the observed property changes. Chemical and microstructural analyses have also been performed to establish damage mechanisms and the limits for accelerated testing. The implications of these results on material selection and system performance are discussed, and additional research needs and opportunities in the area of tougher resin/matrix and metal/matrix composites are identified. Author

N83-26867*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACECRAFT MATERIAL APPLICATIONS: LONG-TERM STABILITY QUESTIONS
F. W. CROSSMAN *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 241-256 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

An examination of the materials concerns for a variety of spacecraft components shows that long-term stability within the space environments is a major issue in the design of large space antenna systems. This survey paper will review some of the more recent work on the effect of space environment on (1) thin films, (2) structural composites, and (3) thermal control materials. Degradation in thermal-mechanical and optical properties associated with atmospheric and trapped particles and ultraviolet light will be highlighted. Finally, the dimensional instability associated with microcracking during thermal cycling will be examined and a methodology for estimating thermal fatigue effects from results of mechanical fatigue tests will be presented. Author

N83-28095*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DIAMONDLIKE FLAKE COMPOSITES Patent Application
B. A. BANKS, inventor (to NASA) 17 May 1983 10 p
(NASA-CASE-LEW-13837-1; US-PATENT-APPL-SN-495381)
Avail: NTIS HC A02/MF A01 CSCL 11D

A carbon coating is vacuum arc deposited on a smooth surface of a target which is simultaneously ion beam sputtered. The bombarding ions have sufficient energy to create diamond bombs. Spalling occurs as the carbon deposit thickens. The resulting diamond like carbon flakes are mixed with a binder or matrix material to form a composite material having improved thermal, electrical, mechanical, and tribological properties when used in aerospace structures and components. NASA

N83-30479# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
ENVIRONMENTAL EFFECTS ON MATERIALS FOR SPACE APPLICATIONS
Loughton, England Specialised Printing Services Ltd. Mar. 1983 221 p refs Conf. held in Toronto, 19-24 Sep. 1982
(AD-A129847; ISBN-92-835-0330-9; AGARD-CP-327) Avail: NTIS HC A10/MF A01

The mechanical, surface, electrical, and thermal properties of spacecraft construction materials are examined as well as the effects of temperature, vacuum, radiation, charged particles, micrometeoroids, contaminants, and the pre-launch environment on these materials. Tests methods are assessed.

N83-30483# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DESIGN AND TESTING OF A CARBON-EPOXY TRELLIS STRUCTURE FOR SATELLITES [REALISATION ET ESSAIS D'UNE STRUCTURE TREILLIS CARBONE-EPOXY POUR SATELLITES]
J. F. PATIN and J. L. CECCONI *In* AGARD Environ. Effects on Mater. for Space Appl. 8 p Mar. 1983 In FRENCH
Avail: NTIS HC A10/MF A01

A trellis structure with high dimensional stability was studied and constructed. The bars of the trellis are based on high modulus (GY 70) high resistant (T 300) fibers and have a specific elevated rigidity and an expansion coefficient near zero. The joining elements between the bars are based on high modulus (M 40) fibers. The expansion coefficients of each element were adjusted so as to have an equivalent coefficient of expansion (near zero) between the points where the bars converge. The dimensional stability of the different connections as a function of temperature was verified. Space-type thermal cycling does not affect the mechanical behavior of the structure. Static tests of the trellis show that the high rigidity of the structures conform to the hypothesis of dimensioning. The mechanical strength was confirmed by tests, a first stage needed joint reinforcement. Transl. by A.R.H.

N83-30484# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
THE EFFECT OF SPACE ENVIRONMENT ON THE THERMAL DISTORTION OF POLYMER MATRIX COMPOSITES
R. C. TENNYSON, G. E. MABSON, and S. AHMED (Communication Research Centre) *In* AGARD Environ. Effects on Mater. for Space Appl. 14 p Mar. 1983 refs Sponsored in part by Communication Research Centre of Canada
(Contract AF-AFOSR-3694-78)
Avail: NTIS HC A10/MF A01

The combined effects of vacuum, thermal cycling, and UV radiation on the thermal distortion of selected polymer matrix composites were investigated. Data was obtained for exposure periods exceeding 400 days in hard vacuum and over 180 equivalent sun days of UV radiation. During this time, in situ measurements of the thermal distortion and coefficients of thermal expansion (CTE) were made using strain gauges and laser interferometry. Results were compared to an analytical model to demonstrate the usefulness of the data in predicting the thermal response of arbitrary laminates. Author

N83-30485*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE ENVIRONMENTAL EFFECTS ON MATERIALS
D. R. TENNY, G. F. SYKES, and D. E. BOWLES *In* AGARD Environ. Effects on Mater. for Space Appl. 24 p Mar. 1983 refs Previously announced as A83-14125
Avail: NTIS HC A10/MF A01 CSCL 07B

Research efforts at NASA-Langley to characterize the durability of composite materials which are candidates or use as components on various space hardware systems are reviewed. The material applications include large space structures, antennas, cables, thermal control coatings, solar reflectors, and satellite power systems. Simulation facilities have been built to study radiation effects on polymer matrix composites, and the dimensional stability of the matrix composites and tension stabilized. M.S.K. (IAA)

N83-30487# Royal Aircraft Establishment, Farnborough (England).
ELECTROSTATIC DISCHARGING BEHAVIOUR OF KAPTON AND OTHER DIELECTRIC MATERIALS IN A SIMULATED SPACE ENVIRONMENT
A. A. DOLLERY and D. VERDIN (Atomic Energy Research Estab.) *In* AGARD Environ. Effects on Mater. for Space Appl. 16 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01

The electrostatic charging and discharging of different thicknesses of Kapton when irradiated in vacuum with mono-energetic electrons of 5 to 30 keV energy was studied at different temperatures. The leakage currents and rates of discharging always increased with the incident electron energy and flux, whereas the surface voltage showed a more complex behavior, exhibiting a maximum and then falling at higher energies for the thinner films. The surface voltage, the rate of discharging, the peak current, and the total charge flow during a discharge were enhanced as the temperature was decreased from +70 C to -180 C. The results are discussed in terms of the resistivity of the polymer and the secondary emission of electrons, and they demonstrate that very thin Kapton films are markedly less susceptible to electrostatic charging and discharging. The electrostatic behavior of Kapton when it is incorporated into a laminated material, or when used as an insulator for an electric heater pad, or in the form of a substrate for a flexible solar array is also described. In addition, data are presented which demonstrate the performance of thermal control paints (Chemglaze A276 and L300), aluminized PTFE, and solar cell cover glasses under similar conditions. M.G.

N83-30488# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
CANDIDATE MATERIALS FOR PRETENSIONED MEMBRANES OF FIBRE COMPOSITE MATERIALS FOR SPACE APPLICATION
W. BUCHS *In* AGARD Environ. Effects on Mater. for Space Appl. 6 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01

The properties of pretensioned membranes of fiber composite materials under consideration for use as solar cell substrates, thermal shields, etc., were examined. Various particular areas of investigation arose from loads (launch vibrations) and environmental conditions (vacuum, temperature, irradiation). Glass-, carbon- and aramidfabric composite materials were analyzed with respect to the requirements and the interfaces determined by the tensioning frame. Sections and full-scale samples of some membranes were manufactured and tested with methods, which in several cases had to be specifically developed for these purposes. Special attention was given to the decrease of characteristics of aramid-fiber composites under UV-irradiation. Analysis results are presented as well as test data and manufacturing experience. Author

N83-30489*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EFFECTS OF LONG DURATION EXPOSURE TO SIMULATED SPACE ENVIRONMENT ON NONMETALLIC MATERIALS PROPERTIES
C. L. PEACOCK, JR. and A. F. WHITAKER *In* AGARD Environ. Effects on Mater. for Space Appl. 14 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01 CSCL 11G

Nonmetallic materials specimens from the Viking program were tested in situ invacuo after continuous thermal vacuum exposure from 1971/1972 to the present. Eleven tests were done on appropriate specimens of 30 materials; however, no single material received all the tests. Some specimens also were exposed to 1 or 2.5 MeV electrons at differing fluences before testing. Baseline exposure data is reported for graphite/epoxy specimens that were exposed to vacuum since 1974. These materials were transferred to the thermal vacuum storage facility for future in situ testing and irradiation. Thin G/E specimens were tensile tested after thermal-vacuum cycling exposure. Photomicrographic examinations and SEM analyses were done on the failed specimens. Author

N83-30490# Istituto di Tecnologia Aerospaziale, Rome (Italy).
STRUCTURAL DAMPING OF COMPOSITE MATERIALS FOR SPACE APPLICATIONS
L. BALIS-CREMA, R. BARBONI, and A. CASTELLANI *In* AGARD Environ. Effects on Mater. for Space Appl. 8 p Mar. 1983 refs Sponsored in part by Ministero Pubblica Istruzione
Avail: NTIS HC A10/MF A01

A series of experimental tests carried out on specimens of composite materials is presented. The measured damping ratios were obtained, in a vacuum chamber (10 to the -6 power torr), from the three first bending modes resonance (frequency range between 15 and 1400 Hz). The influence of the following parameters is considered: vibration amplitudes, frequency, air pressure, laminae number and mode shape. The tests were performed with an electromagnetic exciter and a vibration detector; the measurements of the damping coefficient were worked by the frequency sweep and the decay transient method. Author

N83-30492# Toronto Univ. (Ontario). Inst. for Aerospace Studies.
THE EFFECT OF SPACE ENVIRONMENT ON THE DAMPING OF POLYMER MATRIX COMPOSITE
R. C. TENNYSON, W. D. MORISON, and G. E. MABSON *In* AGARD Environ. Effects on Mater. for Space Appl. 15 p Mar. 1983 refs Sponsored in part by Natural Sciences and Engineering Research Council of Canada
(Contract AF-AFOSR-3694-78)
Avail: NTIS HC A10/MF A01

A combined experimental and analytical investigation was undertaken to evaluate material damping of laminated composites. Particular emphasis was given to the effect of thermal-vacuum exposure and U.V. radiation on the change in damping response. A laminate analysis was developed for predicting material damping utilizing experimentaly determined principal damping coefficients. Results are presented based on flexural vibration and creep compliance tests performed on graphite/epoxy laminates at ambient conditions and in a space simulator. Author

N83-30494# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).
THE MBB COMBINED EFFECTS CHAMBER FOR REAL TIME AND ACCELERATED TESTS UNDER SIMULATED SPACE ENVIRONMENT
O. K. HUSMANN *In* AGARD Environ. Effects on Mater. for Space Appl. 8 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01

The MBB Space Division solar radiation simulation test facility is described. This test equipment is fully automated and runs without interruption 24 hours a day, as long as specified, with its radiation sources operating simultaneously or alone. The test chamber provides clean vacuum. The sample temperatures are adjustable between -30 C and +100 C. The UV - radiation exposures may be accelerated up to 6 solar constants. The electron and the proton current densities can be selected from 10 to the -10 power amps/sq cm to 10 to the -8 power amps/sq cm. Their energies may range from 5 KeVolts to 60 KeVolts. Eight samples size 11 x 11 mm are exposed simultaneously, or four samples 20 x 20 mm. For assessment of damages inflicted a spectrometer is mated to the vacuum chamber for in situ measurement of sample spectral reflectances from 240 nm to 2.5 um. Author

N83-30495# Toronto Univ., Downsview (Ontario). Inst. for Aerospace Studies.
THE EFFECT OF COMBINED U.V. RADIATION AND HIGH ENERGY ELECTRONS ON THE BEHAVIOUR OF POLYMER MATRIX COMPOSITES IN HARD VACUUM
R. C. TENNYSON, B. A. W. SMITH, and L. P. HEBERT *In* AGARD Environ. Effects on Mater. for Space Appl. 12 p Mar. 1983 refs Sponsored in part by Natural Sciences and Engineering Research Council of Canada
(Contract AF-AFOSR-3694-78)
Avail: NTIS HC A10/MF A01

A description of a space simulator capable of thermal-vacuum testing of samples subject to combined UV and high energy electron radiation is presented. Particular attention is given to the use a natural beta emitting Sr90 source to simulate space conditions. In-situ thermal and mechanical loading capabilities are also described together with test results obtained on selected polymer matrix composites. Specifically, graphite/epoxy and Kevlar/epoxy laminates have been employed to assess the combined effects of hard vacuum, thermal cycling and radiation on the change in stiffness, creep compliance and coefficient of thermal expansion. Author

N83-30496# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
THERMAL CYCLING TESTS ON MATERIALS AND COMPONENTS FOR SPACE APPLICATIONS
H. HAMACHER, W. LEY, and K. V. REHMANN *In* AGARD Environ. Effects on Mater. for Space Appl. 9 p Mar. 1983 refs
Avail: NTIS HC A10/MF A01

Thermal cycling tests were performed on materials and components under high vacuum conditions. The purpose of these tests was to investigate changes in properties by thermal fatigue due to microcracking, delamination, etc. The test facility used was developed with respect to the need of true simulation of the strong temperature gradients to be expected in space flight. Tests were performed on carbon fiber composite materials which are candidates for large space structures use and on solar cell panel samples. The description of the facility, a presentation and discussion of the results is given. Author

N83-31637# European Space Agency, Paris (France).
MATERIALS SCIENCES UNDER MICROGRAVITY
T. D. GUYENNE, ed. and J. HUNT, ed. Jun. 1983 448 p refs Proc. of 4th European Symp. on Mater. Sci. under Microgravity, Madrid, 5-8 Apr. 1983; sponsored by ESA, Universidad Politecnica de Madrid, ELGRA and COSPAR
(ESA-SP-191) Avail: NTIS HC A19/MF A01; ESA, Paris FF 140

The ESA, NASA, Soviet and other microgravity research programs; composites and heterogeneous phases; experimental facilities; transport phenomena; combustion; gas-liquid interfaces; liquid-solid interfaces; and critical point phenomena were discussed.

N83-31733*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
FABRICATION OF SLENDER STRUTS FOR DEPLOYABLE ANTENNAS Final Report
R. M. BLUCK and R. R. JOHNSON Apr. 1983 17 p
(Contract NAS1-14887)
(NASA-CR-172164; NAS 1.26:172164; LMSC-D889763) Avail: NTIS HC A02/MF A01 CSCL 11D

A procedure for manufacturing long slender graphite tubing is desired. Such tubing has considerable application in truss supported spacecraft applications. The motivation for the selection of the tubing size developed in this program is for use as struts in a NASA, Langley Research Center truss supported antenna concept. The manufacturing procedure uses the LMSC vertical winding machine. A procedure for fabricating graphite epoxy tubing with an aluminum foil inner and outer wrap was also developed. The aluminum foil provides a vapor barrier, significantly improves the thermal conductivity, and provides an excellent thermal control surface. Author

08

ASSEMBLY CONCEPTS

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

A83-36981* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROL OF ROBOT MANIPULATORS FOR HANDLING AND ASSEMBLY IN SPACE
E. HEER and A. K. BEJCZY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) Mechanism and Machine Theory (ISSN 0094-114X), vol. 18, no. 1, 1983, p. 23-35. refs
(Contract NAS7-100)

Long-range NASA planning includes construction and erection of large systems in space requiring automatic handling equipment, teleoperators, or robots under supervisory control. This paper investigates and explores some of the requirements for the control of teleoperated and autonomous space manipulators. The critical technology development areas are identified and discussed in the context of the developments at the Jet Propulsion Laboratory (JPL), and other places. Author

A83-37481
IN-SPACE ASSEMBLY AND MAINTENANCE OF UNMANNED SPACECRAFT
J. L. LACOMBE and G. BERGER (Matra, S.A., Velizy-Villacoublay, Yvelines, France) IN: Automatic control in space 1982; Proceedings of the Ninth Symposium, Noordwijkerhout, Netherlands, July 5-9, 1982 . Oxford, Pergamon Press, 1983, p. 477-488. Sponsorship: European Space Agency. refs
(Contract ESA-4267/80/F/DD(SC))

The feasibility of automated assembly, repair, and maintenance in geostationary orbit is investigated. Present technology is seen as limiting these operations to modules specifically adapted to the purpose, and as favoring satellite-life extension by in-orbit maintenance (using an 'add-a-spare-on-failure' approach) and refueling (using direct fluid transfer). Key areas in developing these capabilities are rendezvous and docking, where a combination of teleoperation beyond a range of 3-10 km and 'go/no-go'-monitored autonomous short-range operation involving advanced sensors and/or an expandable docking probe is considered best. Maintenance and repair operations can be most practically performed by an autonomous or semiautonomous robot rather than a master-slave telemanipulator. These technically realizable techniques are predicted to be economically feasible if judged on the scale of families of missions. T.K.

A83-43031
SPACE ROBOTICS AT CNES - PROBLEMS PROJECTED AND WORKING PROGRAMS IN THE MIDTERM [LA ROBOTIQUE AU CNES - PROBLEMES POSES ET PROGRAMMES DE TRAVAIL AMOYEN TERME]
J.-M. GUILBERT and M. MAURETTE (Centre National d'Etudes Spatiales, Toulouse, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 100, 1983, p. 29-34. In French.

Possible missions and technology requirements for robotics in European spatial applications are discussed. Studies performed regarding the Ariane as the prime launch vehicle have identified two modes of robot usage: intervention and deployment. The intervention robot will be orbited to repair and maintain satellites, while the deployment robot will be used to construct large space structures and modular structures. The repair satellite will have orbit-changing capability, as well as a manipulator arm for grappling the target spacecraft. Developmental work is necessary to produce a servo-controlled arm and satisfy performance requirements in a laboratory setting. Attention will be paid to characterizing the difference between industrial and spatial manipulators. Preliminary results indicate a configuration with five degrees of freedom and two movement modes, one in approach and a second with more precise maneuverability and dexterity for close-in interactive tasks. Other work is defining the manipulator controls, simulating the space-based workplace, and developing sensors. M.S.K.

A83-44602
CANADARM AND THE SPACE SHUTTLE
B. A. AIKENHEAD (National Aeronautical Establishment, Ottawa, Canada), R. G. DANIELL, and F. M. DAVIS (SPAR Aerospace, Ltd., Toronto, Canada) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 1, Apr.-June 1983, pt. 1, p. 126-132. Research supported by the National Research Council of Canada.

The remote manipulator system designed for the Space Shuttle is discussed. The system requirements and environment are summarized, and the manipulator arm assembly and its installation in the Orbiter, the joint assemblies, the end effector, and the wrist roll joint are discussed. The system uses brushless dc servomotors to drive the six joints and the end effector in a variety of control modes which provide both manual and automatic control of the arm functions. Allowances made for the vacuum environment are addressed, and proof of compliance with requirements is considered. C.D.

A83-46422* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRACTICAL SMALL-SCALE EXPLOSIVE SEAM WELDING
L. J. BEMENT (NASA, Langley Research Center, Hampton, VA) (California Institute of Technology, Jet Propulsion Laboratory, Aerospace Mechanisms Symposium, 17th, Pasadena, CA, May 1983). Mechanical Engineering (ISSN 0025-6501), vol. 105, Sept. 1983, p. 53-59. refs

A small-scale explosive seam welding process has been developed that can significantly contribute to remote metal joining operations under hazardous or inaccessible conditions, such as nuclear reactor repair and assembly of structure in space. This paper describes this explosive seam welding process in terms of joining principles, variables, types of joints created, capabilities, and applications. Very small quantities of explosive in a ribbon configuration are used to create narrow (less than 0.5 inch), long-length, uniform, hermetically sealed joints that exhibit parent metal properties in a wide variety of metals, alloys, and combinations. The practicality of this process has been demonstrated by its current acceptance, as well as its capabilities that are superior in many applications to the universally accepted joining processes, such as mechanical fasteners, fusion and resistance welding, and adhesives. Previously announced in STAR as N83-24896 Author

A83-47244#
A SPACE STATION EXPERIMENT ON LARGE ANTENNA ASSEMBLY AND MEASUREMENT
T. IIDA, K. OKAMOTO (Ministry of Posts and Telecommunications, Radio Research Laboratories, Koganei, Tokyo, Japan), Y. OHKAMI, S. KIBE, H. KOSHIISHI, M. NAKA, and H. YAMAMOTO (National Aerospace Laboratory, Chofu, Tokyo, Japan) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 9 p. refs
(IAF PAPER 83-50)

An experimental antenna assembly task for a Space Station crew is described. The 10-m antenna would be assembled in three phases: assembly of test articles using manipulators, evaluation of the mechanical and electrical performance of the antenna, assessment of the performance of the pointing control system, and operation of the weather radar and large aperture microwave radiometer equipment. The antenna would have 10 segments and be carried aloft by the Shuttle. Once in orbit the parts, held in a container, would be extracted and assembled with a manipulator. The test equipment is specified, together with the test procedures for the initial antenna and a weather radar unit. The antennas would be disassembled and returned to the container after the trials were complete. Areas of further development needed before the construction, configuration of the connectors, wiring procedures, and use of manipulators could be attempted are identified. M.S.K.

A83-47390#
REMOTE WORK STATION CONCEPT STUDY
J. SIFNER (Observator a Planetarium, Prague, Czechoslovakia) International Astronautical Federation, International Astronautical Congress, 34th, Budapest, Hungary, Oct. 10-15, 1983. 10 p.
(IAF PAPER 83-ST-14)

The design, operation, and equipment of a remote work station (RWS) to assemble and service future orbital systems are discussed. The envisaged demands on the RWS are considered in the light of four main types of operation: searching for an object, manipulating an object, testing an object, and working with an object. Variants of manned, unmanned, and remotely operated RWS's called classical cherry picker, spider, railer, mobile cherry picker, small RWS, and big RWS are considered and evaluated. Three possible RWS design types are examined: RWS with fixed structure, pallet structure, and a newly developed unified structure. Universal joints and manipulators to be used for a small RWS are discussed, and the design of a small RWS is addressed in terms of modules, electronics, stabilization, thermoregulation, flight regime, and combinations of modules. C.D.

N83-26869*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
MANNED ASSEMBLY OF SPACE STRUCTURES
D. AKIN, M. BOWDEN, and J. MAR *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 285-300 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

This presentation will describe some results which have been obtained and the experiments which have been conducted in the Marshall Space Flight Center's Neutral Buoyancy Facility (MSFC NBF). The MSFC NBF is a tank of water 40 feet deep and 70 feet in diameter. Presently there is a mockup of the Orbiter payload bay at the bottom. There also is a Remote Manipulator System at the edge of the tank. B.W.

N83-31895* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
BEAM CONNECTOR APPARATUS AND ASSEMBLY Patent
G. F. VONTIESENHAUSEN, inventor (to NASA) 3 May 1983 6 p Filed 8 Oct. 1980 Supersedes A81-12283 (19 - 03, p 0332)
(NASA-CASE-MFS-25134-1; US-PATENT-4,381,583; US-PATENT-APPL-SN-195226; US-PATENT-CLASS-24-214; US-PATENT-CLASS-244-159) Avail: US Patent and Trademark Office CSCL 13I

An apparatus and assembly for connecting beams and like structural members is disclosed which is particularly advantageous for connecting two members which are moved laterally into place. The connector apparatus requires no relative longitudinal movement between the ends of the beams or members being connected to make a connection joint. The apparatus includes a receptacle member and a connector housing carried by opposed ends of the structural member being connected. A spring-loaded connector member is carried by the connector housing which may be released for extension and engagement into the receptacle member.

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

09

PROPULSION

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

A83-32714#

SOLAR POWERED, SELF-REFUELING, MICROWAVE PROPELLED INTERORBITAL TRANSPORTATION SYSTEM

M. A. MINOVITCH (Phaser Telepropulsion, Inc., Los Angeles, CA) American Institute of Aeronautics and Astronautics, Thermophysics Conference, 18th, Montreal, Canada, June 1-3, 1983. 25 p. refs

(AIAA PAPER 83-1446)

This paper introduces an economical and comprehensive interorbital transportation system for transporting high mass payloads between low initial orbits and geosynchronous orbits. The system comprises a fleet of space-based, microwave propelled orbiting transfer vehicles, an earth-based microwave transmitter, an orbiting microwave relay satellite and an orbiting air-scooping vehicle which periodically dips into, collects, and liquefies portions of the earth's atmosphere. The microwave transmitter consists of a large multiple dish, beam focusing phased array antenna operating at X - band and fed by several thousand high power microwave generators with a total radiated power exceeding 10 GWs. A relatively low mass, 600 m diameter steerable antenna, mounted onboard the transfer vehicles collects and reflectively concentrates the microwave radiation into a pair of cyclotron resonance plasma accelerators. These accelerators ionize low density nitrogen gas and accelerate it to very high exhaust velocities. The nitrogen working fluid is manufactured in orbit by the air-scooping vehicle. The microwave antenna is utilized as a large solar electric generating plant during the day, and as a large SETI antenna at night when it is not used for propelling transfer vehicles. The electric power generation is sufficiently large such that the entire system can pay for itself within 20 years. Author

A83-36047#

AVOIDING THE VAN ALLEN BELT IN LOW-THRUST TRANSFER TO GEOSYNCHRONOUS ORBIT

D. C. REDDING American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 21st, Reno, NV, Jan. 10-13, 1983. 16 p. refs

(AIAA PAPER 83-0195)

Several strategies for low-thrust transfer to geosynchronous orbit are compared on the basis of fuel efficiency and radiation exposure. An approximate analysis is done to characterize the problem of choosing transfer type, for a range of fuel efficiency and radiation dosage limits. Exact minimum-fuel optimal transfer results are also presented. It is shown that three-burn or four-burn transfers may be more fuel-efficient than standard two-burn transfer while incurring only slightly more radiation dose, for thrust-accelerations below a certain level. Author

A83-36306*# Martin Marietta Aerospace, Denver, Colo.

BENEFITS AND COSTS OF LOW THRUST PROPULSION SYSTEMS

R. I. ROBERTSON, L. J. ROSE (Martin Marietta Aerospace, Denver, CO), and J. E. MALOY (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 11 p.

(Contract NAS3-23246)

(AIAA PAPER 83-1248)

The results of costs/benefits analyses of three chemical propulsion systems that are candidates for transferring high density, low volume STS payloads from LEO to GEO are reported. Separate algorithms were developed for benefits and costs of primary propulsion systems (PPS) as functions of the required thrust levels. The life cycle costs of each system were computed based on the developmental, production, and deployment costs. A weighted criteria rating approach was taken for the benefits, with each benefit assigned a value commensurate to its relative worth to the overall system. Support costs were included in the costs modeling. Reference missions from NASA, commercial, and DoD catalog payloads were examined. The program was concluded reliable and flexible for evaluating benefits and costs of launch and orbit transfer for any catalog mission, with the most beneficial PPS being a dedicated low thrust configuration using the RL-10 system. M.S.K.

A83-36331#

PERFORMANCE POTENTIAL OF ADVANCED SOLAR THERMAL PROPULSION

J. M. SHOJI (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 12 p.

(Contract F04611-79-C-0007; F04611-80-C-0039)

(AIAA PAPER 83-1307)

Design features, component test results, and performance levels of a solar thermal propulsion system for transferring payloads from LEO to GEO are detailed. Solar radiation is collected by two inflated paraboloidal reflectors which funnel the light into a radiant cavity through which propellant is flowing. The propellant, preferably H2 due to its high specific impulse at low temperatures, is then directed through a nozzle to provide 200 lb of thrust. Attention has been given to turbine, rotating bed, and seeded absorber configurations. Testing concentrated on directly heated concepts because of a potential 20 pct increase in thrust using 24.7 kWt concentrated on a 6 cm diameter spot. An open-ended-absorber reached a 76.9 pct thermal efficiency and delivered a specific impulse of 808 lbft-sec/lbm. Rhenium tubes were used in the final test design, which included a quartz window with an IR protective coating. Further component testing is recommended, together with investigations of advanced concepts, in order to assay the ultimate performance capabilities of the propulsion system. M.S.K.

A83-36373*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.

TEST PROGRAM TO DEMONSTRATE THE STABILITY OF HYDRAZINE IN PROPELLANT TANKS

C. M. MORAN (California Institute of Technology, Jet Propulsion Laboratory, Propulsion Systems Section, Pasadena, CA) and D. SUTTON (Propellants, Explosives and Rocket Motor Establishment, Aylesbury, Bucks., England) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 10 p. Research sponsored by the Treasury and Supply Delegation of England, Propellants, Explosives and Rocket Motor Establishment, and NASA.

(AIAA PAPER 83-1382)

The suitability of stainless steels and Inconel for long-term hydrazine propellant-storage tanks is investigated. Rectangular coupon samples cut from propellent tanks were sealed with a measured amount of hydrazine in glass capsules, stored at 43 or 60 C, and removed after 6 to 24 months, when corrosion of the coupon and decomposition of the hydrazine was determined, and SEM and electron spectroscopy were performed on some coupons. Corrosion was found to be unmeasurably low for all the coupons, and hydrazine decomposition produced less than 1.0 cu cm of gas per sq cm of wetted surface per year, except in those few cases when catalysis or contamination were detected. Especially good stability was observed for type 304L stainless steel. The decomposition rates determined in the coupon tests are confirmed by preliminary results of actual tank storage trials. T.K.

A83-36381#

A COMPARISON BETWEEN ADVANCED CHEMICAL AND MPD PROPULSION FOR GEOCENTRIC MISSIONS

L. K. RUDOLPH and K. M. HAMLYN (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 11 p. refs

(Contract F04611-82-C-0049)

(AIAA PAPER 83-1391)

The high performance and potential system simplicity of the self-field MPD thruster has stimulated an increasing activity toward developing a flight system for application on future space missions. To assess the potential benefits of such a system, a comparison of projected MPD and advanced chemical system capabilities has been completed for missions in the 1990-2000 time period. Geocentric orbit transfers with impulsive delta V requirements from 100 to 70,000 m/s were examined for a payload mass range from 1,000 to 50,000 kg. Using estimated MPD thruster system characteristics and a range of power source specific masses from 5 to 25 kg/kWe, the thruster specific impulse required to minimize orbit transfer time was found to be 1000 s for all the missions considered. At this specific impulse, the minimum system power required to balance transfer time penalties with launch mass benefits is 50 kWe. The maximum allowable power is determined by the maximum allowable system mass relative to alternative chemical systems and is no higher than 3-5 MWe. Author

A83-36382#

PROCEDURES TO INTEGRATE ELECTRIC SECONDARY PROPULSION SYSTEMS TO LARGE DEPLOYABLE SPACE SYSTEMS

G. M. OGG (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 10 p.
(AIAA PAPER 83-1392)

Various aspects of the inclusion of electric secondary propulsion systems on large deployable space systems (LDSS) are discussed. Consideration is given to the shape and structural materials of the LDSS in order to determine the thruster positions and allowable acceleration levels for the spacecraft. The numbers of thrusters will be limited by the interior volumes of the LDSS and the requirement that the operation of the thrusters does not degrade the structural integrity of the LDSS. Electric thrusters can be used for pointing and positioning, will need to operate for the duration of the LDSS mission, and must be tailored to avoid interfering with EM signals necessary for the mission. Analytical concerns for employment of the thrusters, to be accounted for in the control logic, comprise the external forces and torques, the thruster positions and firing sequences, the number of thrusters, the lifetime and reliability of the propulsion system, and integration of all the factors. M.S.K.

A83-36383#

COMPARISON OF ELECTRIC AND CHEMICAL THRUSTER SYSTEMS FOR SECONDARY PROPULSION ON A LARGE SPACE SYSTEM

L. R. REDD and G. M. OGG (Martin Marietta Aerospace, Denver, CO) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 7 p.
(AIAA PAPER 83-1393)

Electric and liquid chemical propulsion systems were sized to accommodate secondary propulsion requirements of a typical large space system (LSS). The LSS configuration considered here is a large radiometer intended for deployment in a low earth orbit. The selected thruster for the electric system was a one millipound pulsed plasma thruster (PPT) and a 0.5 lb(f) bipropellant engine was chosen for the liquid chemical system. Thruster systems are to be packaged into the available volumes within the LSS while stowed in the Shuttle payload bay. Both thruster systems were found to meet the 10-year secondary propulsion requirements with the exception of the chemical thruster cycle life being exceeded. In a total system comparison the chemical system considered was found to be about twice as massive as the electric system. Author

A83-45512*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AUXILIARY PROPULSION REQUIREMENTS FOR LARGE SPACE SYSTEMS

J. E. MALOY (NASA, Lewis Research Center, Cleveland, OH), W. W. SMITH, and G. W. MACHLES (Boeing Aerospace Co., Seattle, WA) AIAA, SAE, and ASME, Joint Propulsion Conference, 19th, Seattle, WA, June 27-29, 1983. 23 p.
(AIAA PAPER 83-1217)

An insight into auxiliary propulsion systems (APS) requirements for large space systems (LSS) launchable by a single shuttle is presented. In an effort to scope the APS requirements for LSS, a set of generic LSSs were defined. For each generic LSS class a specific structural configuration, representative of that most likely to serve the needs of the 1980's and 1990's was defined. The environmental disturbance forces and torques which would be acting on each specific structural configuration in LEO and GEO orbits were then determined. Auxiliary propulsion requirements were determined as a function of: generic class specific configuration, size and openness of structure, orbit, angle of orientation, correction frequency, duty cycle, number and location of thrusters and direction of thrusters and APS/LSS interactions. The results of this analysis were used to define the APS characteristics of: (1) number and distribution of thrusters, (2) thruster modulation, (3) thrust level, (4) mission energy requirements, (5) total APS mass component breakdown, and (6) state of the art adequacy/deficiency. Previously announced in STAR as N83-26922 S.L.

N83-26864*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE SPACE SYSTEMS AUXILIARY PROPULSION REQUIREMENTS

J. E. MALOY and W. W. SMITH (Boeing Aerospace Co., Seattle, Wash.) *In* NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 1 p 175-200 May 1983 refs
Avail: NTIS HC A25/MF A01 CSCL 22B

To meet the needs of a variety of civilian and military missions objectives large space systems (LSS) will become a greater percentage of our orbiting hardware. These LSS's will be transported to low Earth orbit (LEO) by the space transportation system (STS Shuttle). Concurrently, for LSS missions to orbit higher than LEO, the predominant mission scenario is that the LSS will be deployed or assembled in LEO and then transferred to a higher orbit. In support of the LSS concepts, the Office of Aeronautics and Space Technology (OAST) has sponsored studies to determine LSS mission propulsion requirements. Since the fall of 1979, the Boeing Aerospace Company, under contract to NASA and Lewis Research Center, has been studying the disturbance forces and torques that will be experienced by LSS, and they have identified some of the associated auxiliary propulsion systems (APS) requirements. This presentation provides an insight into the results of some of the APS studies, focusing primarily on the APS requirements of single Shuttle launchable LSS's. Author

N83-26922*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

AUXILIARY PROPULSION REQUIREMENTS FOR LARGE SPACE SYSTEMS

J. E. MALOY, W. W. SMITH (Boeing Aerospace, Seattle, Wash.), and G. W. MACHLES (Boeing Aerospace, Seattle, Wash.) 1983 23 p refs Presented at the 19th Joint Propulsion Conf. and Tech. Display, Seattle, 27-29 Jun. 1983; sponsored by the AIAA, SAE and ASME
(NASA-TM-83388; E-1666; NAS 1.15:83388; AIAA-83-1217)
Avail: NTIS HC A02/MF A01 CSCL 21H

An insight into auxiliary propulsion systems (APS) requirements for large space systems (LSS) launchable by a single shuttle is presented. In an effort to scope the APS requirements for LSS, a set of generic LSSs were defined. For each generic LSS class a specific structural configuration, representative of that most likely to serve the needs of the 1980's and 1990's was defined. The environmental disturbance forces and torques which would be acting on each specific structural configuration in LEO and GEO orbits were then determined. Auxiliary propulsion requirements were determined as a function of: generic class specific configuration, size and openness of structure, orbit, angle of orientation, correction frequency, duty cycle, number and location of thrusters and direction of thrusters and APS/LSS interactions. The results of this analysis were used to define the APS characteristics of: (1) number and distribution of thrusters, (2) thruster modulation, (3) thrust level, (4) mission energy requirements, (5) total APS mass component breakdown, and (6) state of the art adequacy/deficiency. S.L.

N83-28070 Royal Aircraft Establishment, Farnborough (England).
ELECTRIC PROPULSION OF SPACECRAFT
D. G. FEARN 28 Oct. 1981 32 p refs
(RAE-TR-81131; RAE-SPACE-608; BR83019) Avail: Issuing Activity

The merits of electric propulsion technology are discussed explaining that the very high exhaust velocities attainable allow the propellant masses required for most missions to be drastically reduced. The various types of electric thruster are described. The most highly developed and potentially useful thurster, the Kaufman electron bombardment ion thruster, is covered in greater detail, with particular reference to the T5 device. Candidate missions are discussed, ranging from attitude and orbit control functions to the application of ion propulsion to the deployment of solar power satellites. Important terrestrial applications of electric propulsion technology are also mentioned. Author (ESA)

N83-29436# Giessen Univ. (West Germany). Inst. fuer Physik.
STUDIES ABOUT ALTERNATIVE PROPELLANTS FOR ION PROPULSION SYSTEMS Final Report
K. GROH Bonn Bundesministerium fuer Forschung und Technologie Jan. 1982 36 p refs In GERMAN; ENGLISH summary Sponsored by Bundesministerium fuer Forschung und Technologie
Avail: NTIS HC A03/MF A01

The use of inert gases as alternative propellants for electric propulsion was investigated. The largest electric propulsion system (RIT engine) is evaluated from the physical point of view. By means of the scaling laws, the thruster performance data can be extrapolated. The RF ionization mechanism can be applied up to any diameter. Author (ESA)

N83-32842*# Hughes Research Labs., Malibu, Calif.
EVALUATION OF THE USE OF ON-BOARD SPACECRAFT ENERGY STORAGE FOR ELECTRIC PROPULSION MISSIONS
R. L. POESCHEL and F. M. PALMER Aug. 1983 42 p
(Contract NAS3-23258)
(NASA-CR-168209; NAS 1.26:168209) Avail: NTIS HC A03/MF A01 CSCL 21C

On-board spacecraft energy storage represents an under utilized resource for some types of missions that also benefit from using relatively high specific impulse capability of electric propulsion. This resource can provide an appreciable fraction of the power required for operating the electric propulsion subsystem in some missions. The most probable mission requirement for utilization of this energy is that of geostationary satellites which have secondary batteries for operating at high power levels during eclipse. The study summarized in this report selected four examples of missions that could benefit from use of electric propulsion and on-board energy storage. Engineering analyses were performed to evaluate the mass saved and economic benefit expected when electric propulsion and on-board batteries perform some propulsion maneuvers that would conventionally be provided by chemical propulsion. For a given payload mass in geosynchronous orbit, use of electric propulsion in this manner typically provides a 10% reduction in spacecraft mass. Author

N83-33917# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
SPACE ENERGETICS
A. YEFUSIJI 7 Apr. 1983 11 p Transl. into ENGLISH from Hangkong Zhishi (China), 1982 p 4-5
(AD-A128238; FTD-ID(RS)T-0206-83) Avail: NTIS HC A02/MF A01 CSCL 22B

Advantages and disadvantages of a space power plant, a new concept of space power engineering, and laser carrier rocket propulsion, are discussed. N.W.

N83-35017# Rocketdyne, Canoga Park, Calif.
SOLAR THERMAL ROCKET CONCEPT EVALUATION AND TEST HARDWARE DESIGN
J. M. SHOJI *In* APL The 1983 JANNAF Propulsion Meeting, Vol. 1 p 67-75 Feb. 1983 refs
(Contract F04611-80-C-0039)
Avail: NTIS HC A15/MF A01 CSCL 21H

One potentially attractive propulsion approach for geosynchronous and low Earth orbit missions is solar thermal propulsion. Solar thermal propulsion offers payload gains of greater than 50 percent over conventional chemical propulsion for these missions and is capable of delivering specific impulses from 800 lbf-sec/lbm to values approaching 1200 lbf-sec/lbm depending on the concept employed. A number of candidate concepts were evaluated considering engine performance, thrust capability, durability, complexity, cost, and technical risk. These concepts were compared and a concept selected for design, analysis, and fabrication of a ground test unit. The unique nature of solar thermal propulsion and the design of the ground test unit led to a design philosophy quite different from that of conventional chemical rocket engines. This design philosophy involved a close interrelationship of heat transfer, materials, and the design configuration itself. The selected concept was analyzed and designed to provide a high performance (exceeding 800 lbf-sec/lbm) solar absorber/thruster that is fabricable and satisfactorily cooled. Materials and fabrication processer were defined along with hardware thermal and performance characteristics. R.J.F.

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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.

A83-31188#
THERMAL CONTROL TESTING FOR LOW COST PROGRAMS
J. L. VANIMAN and J. W. OWEN IN: Aerospace Testing Seminar, 6th, Los Angeles, CA, March 11-13, 1981, Proceedings . Mount Prospect, IL, Institute of Environmental Sciences, 1982, p. 109-118; Discussion, p. 119-122.

The possibility that the operational capabilities of the Shuttle will permit a lowering of satellite testing and hardware reliability requirements, and thereby costs, are discussed. The Shuttle offers the possibility of either repairing spacecraft on station or retrieving them for a return to earth and refurbishment. It is suggested that the main implication is a reduction in system level testing to verification of functional acceptance only, which requires vibration and thermal cycling trials. Citing the thermal control system as an example of the potential benefits, it is noted that a complete characterization must be made of the system components and performance before reduced testing becomes acceptable. Breadboard models can then be examined, as well as the presence of leaks. The highest cost advantages are offered by a reduction in thermal vacuum testing. The production of the materials experiment assembly for flight on the Shuttle after breadboard tests only is outlined. M.S.K.

A83-35951

SPACE 2000; INTERNATIONAL ASTRONAUTICAL CONGRESS, 33RD, PARIS, FRANCE, SEPTEMBER 27-OCTOBER 2, 1982, SELECTION OF PAPERS

L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) Congress sponsored by the International Astronautical Federation. New York, American Institute of Aeronautics and Astronautics, 1983, 722 p.

Progress in space systems and technologies is discussed. Facilities, support systems, payloads, and scientific activities applicable to space transportation systems and space stations are addressed. Earth-oriented applications of satellite systems are considered, including communications systems, observations of the ecosphere, safety-related issues, and space medicine. Scientific satellites and space exploration are treated, including the International Solar Polar Mission, the Japanese Halley project, the Galileo Jupiter mission, and others. A number of support technologies are discussed, including propulsion technologies and composite materials. Other subjects covered include a study of a large multiuse platform and a solar sail concept study. C.D.

A83-37076

AMERICAN CONTROL CONFERENCE, 1ST, ARLINGTON, VA, JUNE 14-16, 1982, PROCEEDINGS. VOLUMES 1, 2 & 3

Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1982, p. Vol. 1, 475 p.; vol. 2, 416 p.; vol. 3, 413 p.

The present conference on control system topics covers large space structures, analytical methods for nonlinear dynamic systems, digital control, advances in the dynamic analysis and control of chemical reaction and distillation systems, industrial control, dynamic multiperson optimization problems and applications, parameter identification, control system analysis and design software, distributed and centralized control methods, methods for nonlinear control system design, human information processing and decision making in complex systems, linear systems, on-line process control methodology, analytical approaches and techniques for industrial control, and forecasting identification of complex systems. Also discussed are autonomous spacecraft control, nonlinear systems, analytical methods in stochastic control, control theory in biological processes, multivariable and adaptive methods in process control, automated control of vehicles and traffic, integrated control systems, estimation, fluid control interface technology, decentralized and interconnected systems, failure event detection and identification, distributed estimation for multisensor and multiobject tracking, adaptive control, the humanization of military control systems, applications of process control techniques, instrumentation for measurement of artillery projectile dynamics, linear quadratic control, air transportation systems control, robustness in multivariable control systems, reduced order systems, the synthesis of process control systems, energy management, missile control, and robotics and locomotion. O.C.

A83-37432

AUTOMATIC CONTROL IN SPACE 1982; PROCEEDINGS OF THE NINTH SYMPOSIUM, NOORDWIJKERHOUT, NETHERLANDS, JULY 5-9, 1982

P. T. L. M. VAN WOERKOM, ED. (National Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands) Symposium sponsored by the International Federation of Automatic Control and European Space Agency. Oxford, Pergamon Press, 1983, 602 p.

The present conference on automatic spacecraft control technology discusses Space Telescope pointing control, the L-SAT attitude and orbit control subsystem, sampled control stability of the ESA instrument pointing system, digital control loops for the Telecom 1 AOCS, lumped parameter dynamic models for large space structures with flexible and rigid parts, a novel method of dynamic flight control, attitude measurement and estimation of solar observation satellites, novel control schemes for a magnetic attitude control system, and a delayed pulse roll/yaw controller for a momentum-biased spacecraft. Also considered are a multipurpose sun sensor employing a CCD detector, IR sensors for three-axis stabilized satellites, ion attitude control circuit operational experience, advances in the control of large flexible spacecraft, dynamic tests on active bearing momentum wheels, in-space assembly and maintenance of unmanned spacecraft, the closed loop control of experiments on the GEOS spacecraft, a spin-free analytic platform-type guidance and control system, the reconfiguration of onboard control algorithms, and automatic controls for planetary probe. O.C.

A83-41659

GUIDANCE AND CONTROL CONFERENCE, GATLINBURG, TN, AUGUST 15-17, 1983, COLLECTION OF TECHNICAL PAPERS

Conference sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, 1983, 937 p.

Various topics in guidance and control are addressed. Among the subjects discussed are: integrated airframe/propulsion control system architectures, comparative evaluation of maneuvering target tracking algorithms, line of sight reconstruction for faster homing guidance, simulator applications and technology, flight test results using nonlinear control with the F-8C digital fly-by-wire aircraft, dynamic isolation via momentum compensation for precision instrument pointing, and a reference for sub-arcmin attitude sensing on flexible space structures. C.D.

A83-42526

ANNUAL MINI-SYMPOSIUM ON AEROSPACE SCIENCE AND TECHNOLOGY, 9TH, USAF, INSTITUTE OF TECHNOLOGY, WRIGHT-PATTERSON AFB, OH, MARCH 22, 1983, PROCEEDINGS

Symposium sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, 1983, 310 p.

Topics in aerospace science and technology are discussed. The subjects considered include: computational aero and fluid dynamics, flight operations and environments, flight control and space, structures and structural dynamics, composite materials, experimental facilities, applied mathematics, and bioengineering. Also addressed are: aerodynamics in alpine and nordic skiing competition, propulsion, systems engineering, vibrations, fatigue and fracture, avionics, and chemistry and physics. C.D.

A83-44001

ENGINEERING SCIENCE AND MECHANICS; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, TAINAN, REPUBLIC OF CHINA, DECEMBER 29-31, 1981. PARTS 1 & 2

H.-M. HSIA, ED., Y.-L. CHOU, ED. (National Cheng Kung University, Tainan, Republic of China), and R. W. LONGMAN (Columbia University, New York, NY) Symposium sponsored by the National Cheng Kung University and American Astronautical Society. San Diego, American Astronautical Society , 1983, Pt. 1, 687 p.; pt. 2, 881 p.

The topics considered are related to measurements and controls in physical systems, the control of large scale and distributed parameter systems, chemical engineering systems, aerospace science and technology, thermodynamics and fluid mechanics, and computer applications. Subjects in structural dynamics are discussed, taking into account finite element approximations in transient analysis, buckling finite element analysis of flat plates, dynamic analysis of viscoelastic structures, the transient analysis of large frame structures by simple models, large amplitude vibration of an initially stressed thick plate, nonlinear aeroelasticity, a sensitivity analysis of a combined beam-spring-mass structure, and the optimal design and aeroelastic investigation of segmented windmill rotor blades. Attention is also given to dynamics and control of mechanical and civil engineering systems, composites, and topics in materials. G.R.

A83-44160
GUIDANCE AND CONTROL 1983; PROCEEDINGS OF THE ANNUAL ROCKY MOUNTAIN CONFERENCE, KEYSTONE, CO, FEBRUARY 5-9, 1983
E.J. BAUMAN, ED. (Colorado, University, Colorado Springs, CO) and Z. W. EMSLEY (Ball Corp., Ball Aerospace Systems, Boulder, CO) Conference sponsored by the American Astronautical Society. San Diego, CA, Univelt, Inc. , 1983, 494 p.
Topics related to precision pointing and tracking are considered, taking into account the military space system technology model, the nonlinear feedback control of spacecraft slew maneuvers, aspects of digital control system design for a precision pointing system, the solar optical telescope control system, questions of image motion compensation for the OSS-3/7 telescopes, and the simulation of hot spot tracking loops. Aspects of technical story board display are also discussed along with subjects concerning the stabilization of the space station, trends in autonomous systems, and recent experiences. Attention is given to launch vehicle systems from the private sector, a space shuttle entry flight control overview, the application of identification techniques to remote manipulator system flight data, the first flight performance of the control system of the inertial upper stage, and the stabilization and control of spacecraft. G.R.

A83-45101
DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACECRAFT; PROCEEDINGS OF THE THIRD SYMPOSIUM, BLACKSBURG, VA, JUNE 15-17, 1981
L. MEIROVITCH, ED. Symposium sponsored by the Virginia Polytechnic Institute and State University and American Institute of Aeronautics and Astronautics. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1981, 723 p.
The control of a flexible satellite via elimination of observable spillover is considered along with a definition of the degree of controllability for fuel-optimal systems, spillover and model error bounding techniques for large scale systems, the computation of a degree of controllability via system discretization, and the numerical implementation of suboptimal output feedback control for large space structures. Attention is given to a minimum information approach to regulator design, the application of classical techniques to the control of continuous systems, the modeling and control of flexible space structures, the graph theory approach to the eigenvalue problem of large space structures, optimal positive real controllers for large space structures, and experimental research on structural dynamics and control. Other topics explored are related to a variational perturbation method for problems in nonlinear structural dynamics, the uniqueness of the independent modal-space control method, and exact pole assignment using direct or dynamic output feedback. G.R.

A83-45610
THE FUTURE OF SPACE - LOOKING AHEAD IN SPACE
G. A. KEYWORTH, II (Executive Office of the President, Washington, DC) IEEE Spectrum (ISSN 0018-9235), vol. 20, Sept. 1983, p. 80-84.
The space capabilities that the U.S. has developed are reviewed and some indication is presented of future directions. The most expansive era of U.S. space activities, i.e., the Apollo era, drew on national characteristics such as a pioneer attitude and technological innovation. Exploratory capabilities will be enhanced by the launch of the Space Telescope, the Gamma Ray Observatory, the Galileo probe, and the Venus Radar Mapper. Near-earth experiments and tests will be performed on the Shuttle-Spacelab, which is noted to have greater capabilities than the Salyut-Soyuz combination. Commercialization of launch services is being encouraged through applications of Atlas-Thor, Delta, and Titan technologies as a counterpart to foreign launch services. The decision to build a space station is dependent on formation of a national commitment which would include the purposes of the space station, such as a base to deliver materials for construction of a lunar base and as a stepping point for a Mars mission. M.S.K.

N83-23743# European Space Agency, Paris (France).
SOLAR ENERGY 1982: RESOURCES, TECHNOLOGIES, POTENTIAL
W. R. BURKE, comp. Nov. 1982 256 p refs Proc. of Summer School, Igls, Austria, 28 Jul. - 6 Aug. 1982; sponsored by ESA, CNES and DFVLR
(ESA-SP-181; ISSN-0379-6566) Avail: NTIS HC A12/MF A01
The principles of solar energy conversion are reviewed. The feasibility of applying various solar technologies for the provision of heat and the generation of electricity is discussed. The advantages and disadvantages of various solar technologies are also discussed.

N83-24881*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE 17TH AEROSPACE MECHANISMS SYMPOSIUM
May 1983 390 p refs Symp. held in Pasadena, Calif., 5-6 May 1983; sponsored by NASA, California Inst. of Tech., and LMSC
(NASA-CP-2273; NAS 1.55:2273) Avail: NTIS HC A17/MF A01 CSCL 20K
The proceedings of the Aerospace Mechanisms Symposium are reported. Technological areas covered include space lubrication, aerodynamic devices, spacecraft/Shuttle latches, deployment, positioning, and pointing. Devices for spacecraft tether, magnetic bearing suspension, explosive welding, and a deployable/retractable mast are also described.

N83-26853*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNA SYSTEMS TECHNOLOGY, PART 1
E. B. LIGHTNER, comp. May 1983 596 p refs Conf. held in Hampton, Va., 30 Nov. - 3 Dec. 1982 2 Vol.
(NASA-CP-2269-PT-1; L-15614-PT-1; NAS 1.55:2269-PT-1)
Avail: NTIS HC A25/MF A01 CSCL 22B
A compilation of the unclassified papers presented at the NASA Conference on Large Space Antenna Systems Technology covers the following areas: systems, structures technology, control technology, electromagnetics, and space flight test and evaluation.

N83-26879*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE ANTENNA SYSTEMS TECHNOLOGY, PART 2
E. B. LIGHTNER, comp. May 1983 469 p refs Conf. held in Hampton, Va., 30 Nov. - 3 Dec. 1982 2 Vol.
(NASA-CP-2269-PT-2; L-15614-PT-2; NAS 1.55:2269-PT-2)
Avail: NTIS HC A20/MF A01 CSCL 22B
Control technology, electromagnetics, and space flight test and evaluation are addressed.

N83-30512# MATRA Espace, Paris-Velizy (France).
EFFECTS OF LONG LIFE REQUIREMENTS ON SPACECRAFT DESIGN AND TECHNOLOGY Final Report
C. COUGNET, C. FLOCH, J. F. ARNOULT, G. BERGER, Y. DUBOIS, M. HORBLIN, B. SCHIETECATTE, and C. VIALET Paris ESA Nov. 1982 467 p refs
(Contract ESA-4847/81/NL-PP(SC))
(DM-51/C/CC/FL/0138-82; ESA-CR(P)-1725) Avail: NTIS HC A20/MF A01
The impact on spacecraft design and technology of service life requirements of 15 yr in geostationary and 10 yr in low Earth orbit are summarized. Factors which limit service life are reviewed. The effects of improved technology, onboard computers and in space servicing are discussed. Control of the exposed area of spacecraft radiators to meet instantaneous requirements is suggested. Analysis of parameters which affect battery performance, annealing of solar arrays, and management of thermal control and other subsystems are considered. Author (ESA)

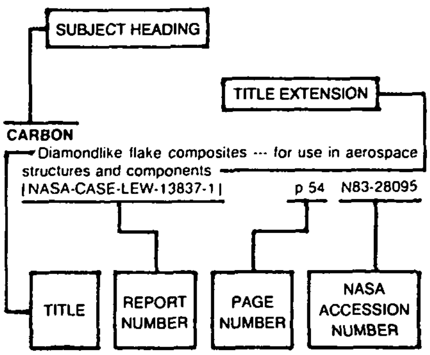
N83-32095*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURES AND DYNAMICS DIVISION: RESEARCH AND TECHNOLOGY PLANS FOR FY 1983 AND ACCOMPLISHMENTS FOR FY 1982
K. S. BALES Jun. 1983 112 p refs
(NASA-TM-85661; NAS 1.15:85661) Avail: NTIS HC A06/MF A01 CSCL 20K

The objectives, expected results, approach, and milestones for research projects of the IPAD Project Office and the impact dynamics, structural mechanics, and structural dynamics branches of the Structures and Dynamics Division are presented. Research facilities are described. Topics covered include computer aided design; general aviation/transport crash dynamics; aircraft ground performance; composite structures; failure analysis, space vehicle dynamics; and large space structures. A.R.H.

N83-36061*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE WORKSHOP ON APPLICATIONS OF DISTRIBUTED SYSTEM THEORY TO THE CONTROL OF LARGE SPACE STRUCTURES
G. RODRIGUEZ, ed. 1 Jul. 1983 635 p refs Workshop held in Pasadena, Calif., 14-16 Jul. 1982; sponsored by JPL and NASA. Langley Research Center
(Contract NAS7-100)
(NASA-CR-173119; JPL-PUB-83-46; NAS 1.26:173119) Avail: NTIS HC A99/MF A01 CSCL 22B

Two general themes in the control of large space structures are addressed: control theory for distributed parameter systems and distributed control for systems requiring spatially-distributed multipoint sensing and actuation. Topics include modeling and control, stabilization, and estimation and identification.

Typical Subject Index Listing



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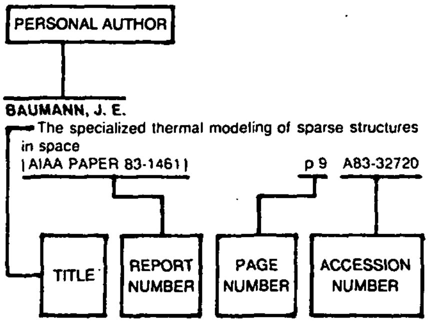
PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing



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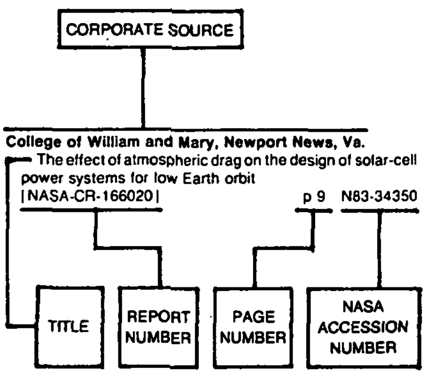
CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing



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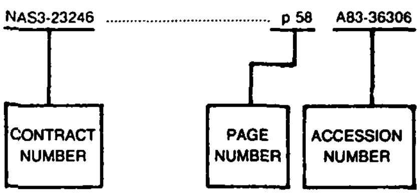
CONTRACT NUMBER INDEX

Typical Contract Number Index Listing



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CONTRACT

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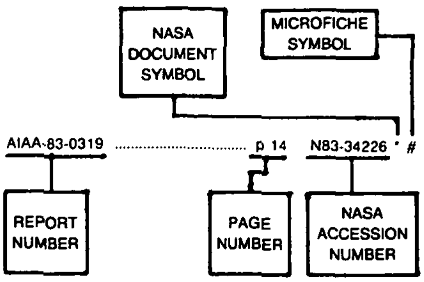

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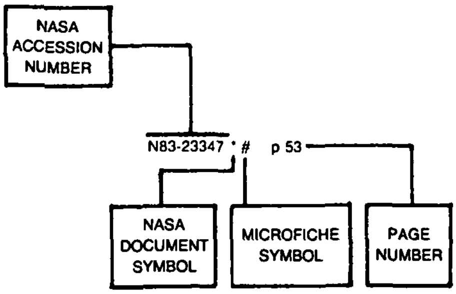

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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7046(10)		

4. Title and Subtitle	5. Report Date
TECHNOLOGY FOR LARGE SPACE SYSTEMS A Bibliography with Indexes	January 1984
	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 408 reports, articles and other documents introduced into the NASA scientific and technical information system between July 1, 1983 and December 31, 1983. 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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