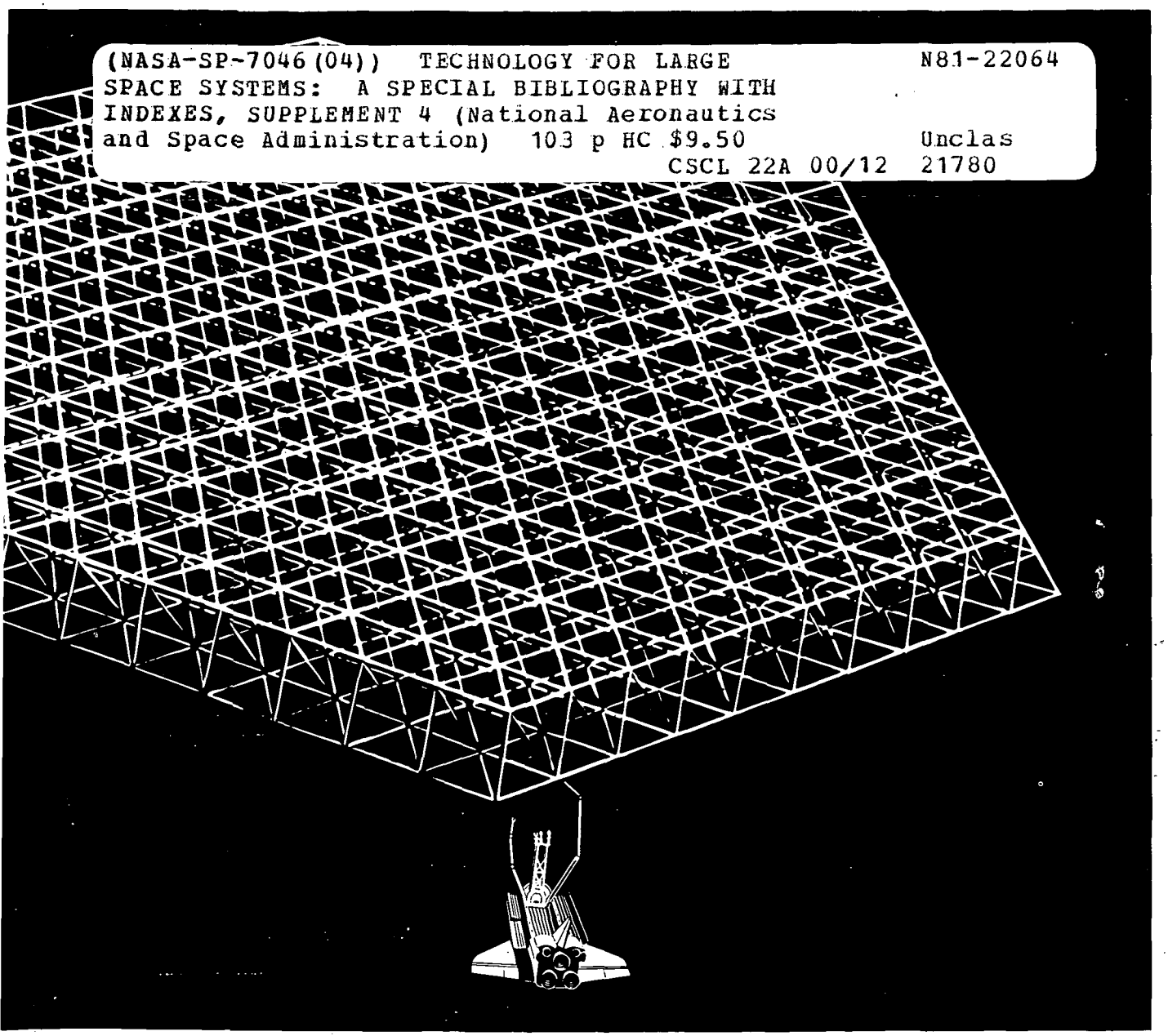
NASA

Technology for Large Space Systems

A Special Bibliography with Indexes

NASA SP-7046(04)
January 1981

National Aeronautics and Space Administration



Page Intentionally Left Blank

INTRODUCTION

This special bibliography is designed to be helpful to the researcher and manager engaged in developing technology within the discipline areas of the Large Space Systems Technology (LSST) Program. 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 259 reports, articles and other documents announced between July 1, 1980 and December 31, 1980 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 Interactive Analysis and Design, Control Systems, Electronics, Advanced Materials, Assembly Concepts, and Propulsion. Electronics is a very limited field in this bibliography, primarily addressing power and data distribution techniques.

This issue of the bibliography will also contain citations to documents dealing primarily with the Solar Power Satellite System (SPS) as will subsequent issues.

The reader will not find references to material that has been designated as "limited" distribution or security classified material. These types of documents will be identified by the LSST Program Office, and a separate listing will be distributed to selected recipients.

A Flight Experiments category and a General category complete the list of subjects addressed by this document.

The selected items are grouped into eleven 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. The citations and abstracts are reproduced exactly as they appeared originally in *STAR* and *IAA* including the original accession numbers from the respective announcement journals. This procedure accounts for the variation in citation appearance.

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

1) *IAA* entries identified by accession number series A80-10,000 in ascending accession number order;
2) *STAR* entries identified by accession number series N80-10,000 in ascending accession number order.

After the abstract section there are five indexes – subject, personal author, corporate source, contract number, and report/accession number

AVAILABILITY OF CITED PUBLICATIONS

IAA ENTRIES (A80-10000 Series)

All publications abstracted in this Section are available from the Technical Information Service, American Institute of Aeronautics and Astronautics, Inc. (AIAA), as follows: Paper copies of accessions are available at $7.00 per document up to a maximum of 40 pages. The charge for each additional page is $0.25. Microfiche[1] of documents announced in *IAA* are available at the rate of $3.00 per microfiche on demand, and at the rate of $1.25 per microfiche for standing orders for all *IAA* microfiche. The price for the *IAA* microfiche by category is available at the rate of $1.50 per microfiche plus a $1.00 service charge per category per issue. Microfiche of all the current AIAA Meeting Papers are available on a standing order basis at the rate of $1.50 per microfiche.

Minimum air-mail postage to foreign countries is $1.00 and all foreign orders are shipped on payment of pro-forma invoices.

All inquiries and requests should be addressed to AIAA Technical Information Service. Please refer to the accession number when requesting publications.

STAR ENTRIES (N80-10000 Series)

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

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

Documents on microfiche are designated by a pound sign (#) following the accession number. The pound sign is used without regard to the source or quality of the microfiche.

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

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

Avail: SOD (or GPO). Sold by the Superintendent of Documents, U.S. Government Printing Office, in hard copy. The current price and order number are given following the availability line. (NTIS will fill microfiche requests, at the standard $3.50 price, for those documents identified by a # symbol.)

(1) A microfiche is a transparent sheet of film, 105 by 148 mm in size, containing as many as 60 to 98 pages of information reduced to micro images (not to exceed 26:1 reduction).

Avail: NASA Public Document Rooms. Documents so indicated may be examined at or purchased from the National Aeronautics and Space Administration, Public Documents Room (Room 126), 600 Independence Ave., S.W., Washington, D.C. 20546, or public document rooms located at each of the NASA research centers, the NASA Space Technology Laboratories, and the NASA Pasadena Office at the Jet Propulsion Laboratory.

Avail: DOE Depository Libraries. Organizations in U.S. cities and abroad that maintain collections of Department of Energy reports, usually in microfiche form, are listed in *Energy Research Abstracts*. Services available from the DOE and its depositories are described in a booklet, *DOE Technical Information Center - Its Functions and Services* (TID-4660), which may be obtained without charge from the DOE Technical Information Center.

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

Avail: USGS. Originals of many reports from the U.S. Geological Survey, which may contain color illustrations, or otherwise may not have the quality of illustrations preserved in the microfiche or facsimile reproduction, may be examined by the public at the libraries of the USGS field offices whose addresses are listed in this introduction. The libraries may be queried concerning the availability of specific documents and the possible utilization of local copying services, such as color reproduction.

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

Avail: BLL (formerly NLL): British Library Lending Division, Boston Spa, Wetherby, Yorkshire, England. Photocopies available from this organization at the price shown. (If none is given, inquiry should be addressed to the BLL.)

Avail: Fachinformationszentrum, Karlsruhe. Sold by the Fachinformationszentrum Energie, Physik, Mathematik GMBH, Eggenstein Leopoldshafen, Federal Republic of Germany, at the price shown in deutschmarks (DM).

Avail: Issuing Activity, or Corporate Author, or no indication of availability. Inquiries as to the availability of these documents should be addressed to the organization shown in the citation as the corporate author of the document.

Avail: U.S. Patent and Trademark Office. Sold by Commissioner of Patents and Trademarks, U.S. Patent and Trademark Office, at the standard price of 50 cents each, postage free.

Other availabilities: If the publication is available from a source other than the above, the publisher and his address will be displayed entirely on the availability line or in combination with the corporate author line.

ADDRESSES OF ORGANIZATIONS

American Institute of Aeronautics
and Astronautics
Technical Information Service
555 West 57th Street, 12th Floor
New York, New York 10019

British Library Lending Division,
Boston Spa, Wetherby, Yorkshire,
England

Commissioner of Patents and
Trademarks
U.S. Patent and Trademark Office
Washington, D.C. 20231

Department of Energy
Technical Information Center
P.O. Box 62
Oak Ridge, Tennessee 37830

ESA-Information Retrieval Service
ESRIN
Via Galileo Galilei
00044 Frascati (Rome) Italy

Fachinformationszentrum Energie, Physik,
Mathematik GMBH
7514 Eggenstein Leopoldshafen
Federal Republic of Germany

Her Majesty's Stationery Office
P.O. Box 569, S.E. 1
London, England

NASA Scientific and Technical Information
Facility
P.O. Box 8757
B. W. I. Airport, Maryland 21240

National Aeronautics and Space
Administration
Scientific and Technical Information
Branch (NST-41)
Washington, D.C. 20546

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

Pendragon House, Inc.
899 Broadway Avenue
Redwood City, California 94063

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

University Microfilms
A Xerox Company
300 North Zeeb Road
Ann Arbor, Michigan 48106

University Microfilms, Ltd.
Tylers Green
London, England

U.S. Geological Survey
1033 General Services Administration
Building
Washington, D.C. 20242

U.S. Geological Survey
601 E. Cedar Avenue
Flagstaff, Arizona 86002

U.S. Geological Survey
345 Middlefield Road
Menlo Park, California 94025

U.S. Geological Survey
Bldg. 25, Denver Federal Center
Denver, Colorado 80225

NTIS PRICE SCHEDULES

Schedule A

STANDARD PAPER COPY PRICE SCHEDULE

(Effective January 1, 1981)

Price Code	Page Range	North American Price	Foreign Price
A01	Microfiche	$ 3.50	$ 7.00
A02	001-025	5.00	10.00
A03	026-050	6.50	13.00
A04	051-075	8.00	16.00
A05	076-100	9.50	19.00
A06	101-125	11.00	22.00
A07	126-150	12.50	25.00
A08	151-175	14.00	28.00
A09	176-200	15.50	31.00
A10	201-225	17.00	34.00
A11	226-250	18.50	37.00
A12	251-275	20.00	40.00
A13	276-300	21.50	43.00
A14	301-325	23.00	46.00
A15	326-350	24.50	49.00
A16	351-375	26.00	52.00
A17	376-400	27.50	55.00
A18	401-425	29.00	58.00
A19	426-450	30.50	61.00
A20	451-475	32.00	64.00
A21	476-500	33.50	67.00
A22	501-525	35.00	70.00
A23	526-550	36.50	73.00
A24	551-575	38.00	76.00
A25	576-600	39.50	79.00
	601-up	-- 1/	-- 2/

A99 - *Write for quote*

1/ Add $1.50 for each additional 25 page increment or portion thereof for 601 pages up.

2/ Add $3.00 for each additional 25 page increment or portion thereof for 601 pages and more.

Schedule E

EXCEPTION PRICE SCHEDULE

Paper Copy & Microfiche

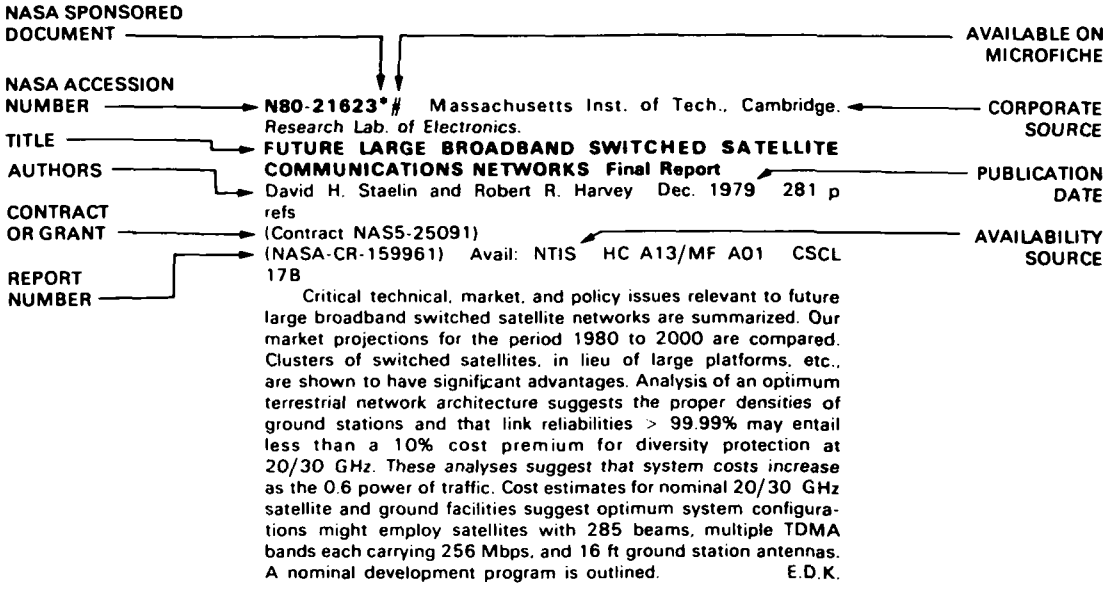
Price Code	North American Price	Foreign Price
E01	$ 5.50	$ 11.50
E02	6.50	13.50
E03	8.50	17.50
E04	10.50	21.50
E05	12.50	25.50
E06	14.50	29.50
E07	16.50	33.50
E08	18.50	37.50
E09	20.50	41.50
E10	22.50	45.50
E11	24.50	49.50
E12	27.50	55.50
E13	30.50	61.50
E14	33.50	67.50
E15	36.50	73.50
E16	39.50	79.50
E17	42.50	85.50
E18	45.50	91.50
E19	50.50	100.50
E20	60.50	121.50
E99 - Write for quote		
N01	28.00	40.00

TABLE OF CONTENTS

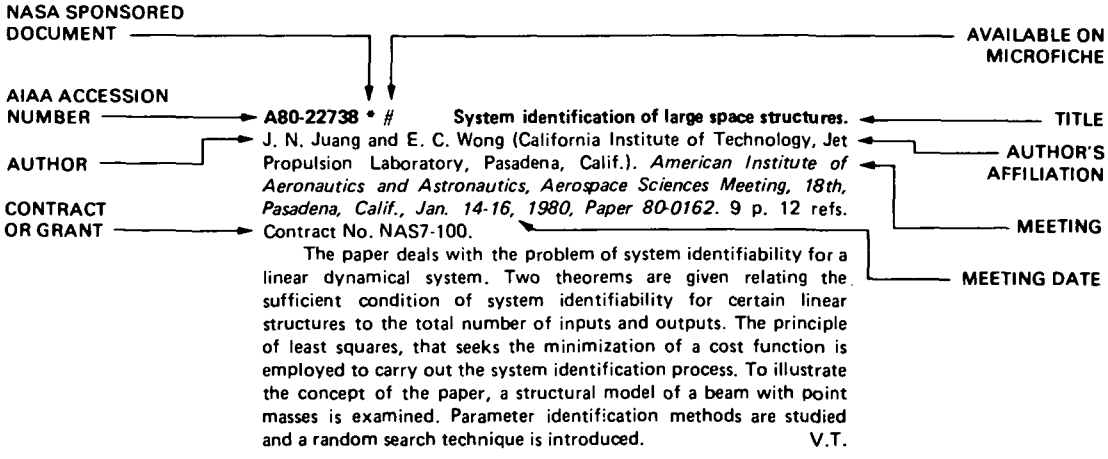
Subject Categories

Abstracts in this bibliography are grouped under the following categories: *page:*

TYPICAL CITATION AND ABSTRACT FROM *STAR*



TYPICAL CITATION AND ABSTRACT FROM *IAA*



TECHNOLOGY FOR LARGE SPACE SYSTEMS *A Special Bibliography (Suppl. 4)*

JANUARY 1981

01 SYSTEMS

Includes mission requirements, focus missions, conceptual studies, technology planning, and systems integration.

A80-38794 # **Large space structures and the remote sensing of soil moisture (Le grandi strutture spaziali ed il telerilevamento dell'umidità del suolo).** F. Graziani (Roma, Università, Rome, Italy). In: Applications of remote sensing and ranging systems from space; International Scientific Conference on Space, 20th, Rome, Italy, March 11-13, 1980, Proceedings. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1980, p. 97-106. 24 refs. In Italian.

Techniques of remote sensing from large space structures for estimating soil moisture are surveyed. The advantages of microwave sensors include greater cloud cover transparency and their apparent maintenance of sensitivity to moisture variations in the presence of a crop canopy. Since spatial resolution for microwave sensors is limited by antenna size, however, the use of large space structures for minimizing the antenna restrictions are considered. Emphasis is placed on terrain roughness, the presence of vegetation and the depth of soil penetration, as well as infrared techniques. J.P.B.

A80-46887 # **Spacecraft charging during eclipse passage.** H. B. Garrett and D. M. Gauntt (USAF, Geophysics Laboratory, Bedford, Mass.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 227-251. 28 refs.

The passage of a space structure through the earth's (or moon's) shadow is attended by a change in the photoelectron flux from the surface of the spacecraft. If, as is often observed in and near geosynchronous orbit, the ambient electron flux is sufficient, spacecraft charging will result. In this paper, the detailed variation of the photoelectron flux will be modeled. Using this and other simple models of the spacecraft charging phenomena, the changing potential on a typical geosynchronous satellite will be estimated. The model will then be extended to encompass the case of a large (10-km diam) passive circular structure (the space-based radar) and of a large (100 sq km) passive square structure (the solar power satellite). Depending on the material, significant potential gradients are possible across such objects. Although little danger is expected from eclipse passage if proper design criteria are followed, the results do indicate the need for caution in the design of any spacecraft expected to spend time in the geosynchronous (or similar) plasma environment. (Author)

A80-52280 * **SOLARES orbiting mirror system.** K. Billman (NASA, Ames Research Center, Moffett Field, Calif.). In: Remember the future - The Apollo legacy; Proceedings of the Meeting, San Francisco, Calif., July 20, 21, 1979. San Diego, Calif., American Astronautical Society, 1980, p. 15-26. (AAS 79-304)

Hardware characteristics and applications opportunities of large orbital mirrors, as determined to date by NASA's 'SOLARES' program are assessed. Assuming Space Shuttle availability, methods and timetables for the deployment of these thin film-covered structures are presented and comparisons are made between electricity-production values of terrestrial solar-energy systems to which SOLARES units deliver high-intensity insolation, on one hand, and on the other the various conventional generation systems. Electrolytic and photochemical production of gaseous and liquid fuels is also compared to synthetic hydrocarbon fuels derived from fossil sources, with considerable attention to project economics and overall process efficiencies. O.C.

N80-22375*# Rockwell International Corp., Downey, Calif. **SPACE CONSTRUCTION SYSTEM ANALYSIS. PART 2: CONSTRUCTION ANALYSIS Final Report**
J. A. Roebuck, P. A. Buck, G. W. Gimlich, H. S. Greenberg, R. J. Hart, J. Indrikis, A. E. LeFever, A. N. Lillenas, C. K. McBaine et al Apr. 1980 776 p
(Contract NAS9-15718)
(NASA-CR-160579; SSD-80-0038-Pt-2) Avail: NTIS HC A99/MF A01 CSCL 22A

The construction methods specific to the end to end construction process for building the ETVP in low Earth orbit, using the space shuttle orbiter as a construction base, are analyzed. The analyses concerned three missions required to build the basic platform. The first mission involved performing the fabrication of beams in space and assembling the beams into a basic structural framework. The second mission was to install the forward support structure and aft support structure, the forward assembly, and a TT&C antenna. The third mission plan was to complete the construction of the platform and activate it to begin operations in low Earth orbit. The integration of the activities for each mission is described along with the construction requirements and construction logic. A.W.H.

N80-22376*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SPACE CONSTRUCTION SYSTEM ANALYSIS. PART 2: COST AND PROGRAMMATICS Final Report
F. W. VonFlue and W. Cooper Apr. 1980 76 p
(Contract NAS9-15718)
(NASA-CR-160580; SSD-80-0039-Pt-2) Avail: NTIS HC A05/MF A01 CSCL 22A

Cost and programmatic elements of the space construction systems analysis study are discussed. The programmatic aspects of the ETVP program define a comprehensive plan for the development of a space platform, the construction system, and the space shuttle operations/logistics requirements. The cost analysis identified significant items of cost on ETVP development, ground, and flight segments, and detailed the items of space construction equipment and operations. A.W.H.

N80-22377*# Rockwell International Corp., Downey, Calif. **SPACE CONSTRUCTION SYSTEM ANALYSIS. PART 2:**

SPACE CONSTRUCTION EXPERIMENTS CONCEPTS Final Report
J. A. Boddy, L. F. Wiley, G. W. Gimlich, H. S. Greenberg, R. J. Hart, A. E. LeFever, A. N. Lillenas, and R. S. Totah Apr. 1980 261 p
(Contract NAS9-15718)
(NASA-CR-160581; SSD-80-0040-Pt-2) Avail: NTIS HC A12/MF A01 CSCL 22A

Technology areas in the orbital assembly of large space structures are addressed. The areas included structures, remotely operated assembly techniques, and control and stabilization. Various large space structure design concepts are reviewed and their construction procedures and requirements are identified. A.W.H.

N80-22392*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems. Div.
SPACE CONSTRUCTION SYSTEM ANALYSIS. PART 2: PLATFORM DEFINITION Final Report
R. J. Hart, H. L. Myers, R. D. Abramson, P. N. DeJong, R. D. Donavan, H. S. Greenberg, J. Indrikis, J. S. Jandrasi, M. Manoff, C. K. McBaine et al Apr. 1980 312 p
(Contract NAS9-15718)
(NASA-CR-160578; SSD-80-0037-Pt-2) Avail: NTIS HC A14/MF A01 CSCL 22B

The top level system requirements are summarized and the accompanying conceptual design for an engineering and technology verification platform (ETVP) system is presented. An encompassing statement of the system objectives which drive the system requirements is presented and the major mission and subsystem requirements are described with emphasis on the advanced communications technology mission payload. The platform design is defined and used as a reference configuration for an end to space construction analyses. The preferred construction methods and processes, the important interactions between the platform design and the construction system design and operation, and the technology development efforts required to support the design and space construction of the ETVP are outlined. A.W.H.

N80-24343*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE OPERATIONS CENTER: A CONCEPT ANALYSIS
Louis E. Livingston 29 Nov. 1979 180 p
(NASA-TM-81062; JSC-16277) Avail: NTIS HC A09/MF A01 CSCL 22B

The Space Operations Center is a concept for a shuttle-service, permanent, manned facility in low Earth orbit. An analysis of this concept was conducted and the results are reported. It is noted that there are no NASA plans at present to implement such a concept. The results are intended for consideration in future planning. J.M.S.

N80-27400*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.
SPACE CONSTRUCTION SYSTEM ANALYSIS STUDY: PROJECT SYSTEMS AND MISSIONS DESCRIPTIONS Final Report
26 Apr. 1979 301 p refs
(Contract NAS9-15718)
(NASA-CR-160748; SSD-79-0077) Avail: NTIS HC A14/MF A01 CSCL 22A

Three project systems are defined and summarized. The systems are: (1) a Solar Power Satellite (SPS) Development Flight Test Vehicle configured for fabrication and compatible with solar electric propulsion orbit transfer; (2) an Advanced Communications Platform configured for space fabrication and compatible with low thrust chemical orbit transfer propulsion; and (3) the same Platform, configured to be space erectable but still compatible with low thrust chemical orbit transfer propulsion. These project systems are intended to serve as configuration models for use in detailed analyses of space construction techniques and processes. They represent feasible concepts for real projects; real in the sense that they are realistic contenders on the list of candidate missions currently projected for the national space program. Thus, they represent reasonable configurations upon which to base early studies of alternative space construction processes. E.D.K.

N80-28406*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
LSST SYSTEM ANALYSIS AND INTEGRATION TASK FOR AN ADVANCED SCIENCE AND APPLICATION SPACE PLATFORM Final Report
Jul. 1980 112 p refs
(Contract NAS8-33592)
(NASA-CR-161528; MDC-G8533) Avail: NTIS HC A06/MF A01 CSCL 22B

To support the development of an advanced science and application space platform (ASASP) requirements of a representative set of payloads requiring large separation distances selected from the Science and Applications Space Platform data base. These payloads were a 100 meter diameter atmospheric gravity wave antenna, a 100 meter by 100 meter particle beam injection experiment, a 2 meter diameter, 18 meter long astrometric telescope, and a 15 meter diameter, 35 meter long large ambient deployable IR telescope. A low earth orbit at 500 km altitude and 56 deg inclination was selected as being the best compromise for meeting payload requirements. Platform subsystems were defined which would support the payload requirements and a physical platform concept was developed. Structural system requirements which included utilities accommodation, interface requirements, and platform strength and stiffness requirements were developed. An attitude control system concept was also described. The resultant ASASP concept was analyzed and technological developments deemed necessary in the area of large space systems were recommended. A.R.H.

N80-31451*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LARGE SPACE SYSTEMS TECHNOLOGY PROGRAM
Robert L. James, Jr. *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 9-22
Avail: NTIS HC A15/MF A01 CSCL 21H

Technical challenges of shuttle-era large space systems include the development of space-configured spacecraft concepts, compatibility with the space transportation system, and cost effectiveness. The objectives and organization of NASA's large space structures program are outlined and program elements are discussed. The technology for the offset wrap-rib and the maypole (hoop/column) antenna concepts are discussed as well as analysis techniques for predicting the electromagnetic performance of a broad class of large reflectors. Deployable systems, assembly methods, and modular control systems for space platforms are described. Assembly equipment and devices, surface sensors and shape control, control and stabilization, and integrated analysis and design are also considered. A.R.H.

N80-31454*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LSS/PROPULSION INTERACTIONS STUDIES
Omer F. Spurlock *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 37-52

Avail: NTIS HC A15/MF A01 CSCL 21H

Interactions between the LSS and the propulsion system are large, significant, interrelated, and complex. Issues and problems in interfacing include the effects on the structure from static, dynamic, and launch loads, control, thrust distribution, throttling, and the environment. Control interaction, the disposal of debris/obsolete spacecraft, and the constraints of launch to low Earth orbit must also be considered. A.R.H.

02
INTERACTIVE ANALYSIS AND DESIGN

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

A80-32858 # **Structural distortions of space systems due to environmental disturbances.** F. Ayer and K. Soosaar (Charles Stark Draper Laboratory, Inc., Cambridge, Mass.). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0854.* 14 p. 21 refs.

The paper presents an overview of the major sources of environmental disturbance that effect structural distortions of space systems. Space system characteristics are discussed along with disturbance identification, structural distortion evaluation, and performance evaluation and improvement. V.T.

A80-35002 * # **Continuum modeling of the mechanical and thermal behavior of discrete large structures.** A. H. Nayfeh and M. S. Hefzy (Cincinnati, University, Cincinnati, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 137-146. 32 refs. Grant No. NsG-1185. (AIAA 80-0679)

In the present paper we introduce a rather straightforward construction procedure in order to derive continuum equivalence of discrete truss-like repetitive structures. Once the actual structure is specified, the construction procedure can be outlined by the following three steps: (a) all sets of parallel members are identified, (b) unidirectional 'effective continuum' properties are derived for each of these sets and (c) orthogonal transformations are finally used to determine the contribution of each set to the 'overall effective continuum' properties of the structure. Here the properties includes mechanical (stiffnesses), thermal (coefficients of thermal expansions) and material densities. Once expanded descriptions of the steps (b) and (c) are done, the construction procedure will be applied to a wide variety of discrete structures and the results will be compared with those of other existing methods. (Author)

A80-35080 # **A general dynamic synthesis for structures with discrete substructures.** L. Meirovitch and A. L. Hale (Virginia Polytechnic Institute and State University, Blacksburg, Va.). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 790-800. 16 refs. Grant No. DAAG29-78-G-0038. (AIAA 80-0798)

This paper presents a substructure synthesis method for the dynamic simulation of complex structures consisting of an assemblage of discrete substructures. The method invokes extensively the analogy between distributed and discrete structures. To simulate the motion of discrete substructures, the concept of 'admissible vectors' is introduced, where admissible vectors represent the discrete counterpart of admissible functions for distributed substructures. The individual substructures are forced to act as a whole structure by imposing certain geometric compatibility on internal boundaries shared by any two substructures. A numerical example illustrating the substructure synthesis method is presented. (Author)

A80-37014 **Heat transfer, thermal control, and heat pipes.** Edited by W. B. Olstad (NASA, Washington, D.C.). New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 70), 1980. 415 p. Members, $22.60; nonmembers, $37.50.

This volume provides information on recent progress in spacecraft thermal control and the supporting disciplines of conduction, thermal radiation, and heat pipe theory and application. Four problem areas are considered: conduction heat transfer, radiation heat transfer, thermal control, and heat pipes. The topics covered include finite-element methodology for transient conduction/forced-convection thermal analysis; effects of surface finish on thermal contact resistance between different materials; mathematical models for wide-band nongray gas radiation in spherical and cylindrical geometries; thermal design, analysis and testing of the Shuttle remote manipulator arm; porous heat pipe; and transient behavior of liquid trap heat-pipe thermal diodes. Also discussed is the thermal design concept for a high-resolution UV spectrometer. S.D.

A80-37474 * **Modal approach for modelling flexible manipulators - Experimental results.** O. Maizza-Neto (São Paulo, Universidade; Conselho Nacional de Desenvolvimento Científico e Tecnológico, Instituto Nacional de Pesquisas Espaciais, São Paulo, Brazil). In: Automatic control in space; Proceedings of the Eighth Symposium, Oxford, England, July 2-6, 1979.
Oxford, Pergamon Press, Ltd., 1980, p. 405-411. 6 refs. Research sponsored by the Fundação de Amparo à Pesquisa do Estado de São Paulo; Contract No. NAS8-28055.

This work presents a mathematical model for flexible appendices via modal technique. The flexible studied was decomposed in two motions: rigid and flexible. The equations of motion were obtained together with the natural frequencies of the first modes. A comparison is presented with experimental results. (Author)

A80-40749 # **Passive dissipation of energy in large space structures.** P. C. Hughes (Toronto, University, Toronto, Canada). *Journal of Guidance and Control,* vol. 3, July-Aug. 1980, p. 380-382. 7 refs.

An accurate, useful approach to the structural analysis of large space structures and flexible spacecraft is proposed in which energy dissipation is modeled in the frequency domain. The structural response to a general input is written as the inverse Fourier transformation of the structural response to a sinusoidal excitation, which is expressed in terms of a frequency-dependent stiffness matrix and damping matrix based on loss factors and the standard system inertia matrix. The stiffness and damping matrices can be calculated from theories applicable to the particular structure, or from analysis of data from frequency response experiments. Corrections to ensure the causality and realness of the impulse response matrix in these experiments are also presented. A.L.W.

A80-45567 # **Super mode rejection technique and complex variable bending mode representation.** E. D. Scott (Lockheed Missiles and Space Co., Inc., Guidance and Control Systems Div., Sunnyvale, Calif.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers.
New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 429-434. (AIAA 80-1793)

Super mode is a term used for a poorly convergent flexibility modal series. The simulated control stability is dramatically affected by the number of modes used. The phenomenon of super modes which arise whenever the dynamics of a many degrees-of-freedom structure is reduced to a few dominant modes is discussed. The reasons behind the fallacies in the reduced model which cause the super modes are presented. A static gain correction technique is presented which allows the use of the simplified dynamics structure of the few dominant modes while maintaining a static gain equal to that of the full unreduced structure. A novel method of computing the damped envelope of bending modes is shown using a simple complex variable dual of the modal dynamics. The complex variable modal model is presented and its simple closed-form equations derived. (Author)

A80-48127 **Large motions of unrestrained space trusses.** T. R. Kane (Stanford University, Stanford, Calif.) and D. A. Levinson (Lockheed Research Laboratories, Palo Alto, Calif.). *Journal of the Astronautical Sciences,* vol. 28, Jan.-Mar. 1980, p. 49-88. 24 refs. Research supported by the Lockheed Missiles and Space Independent Research Program; NSF Grant No. ENG-77-04449.

This paper contains an algorithm that enables one to simulate large motions of unrestrained space trusses having any initial motions and acted upon by external forces applied at joints. An illustrative example is provided, the theory underlying the algorithm is set forth in detail, and the relationship between the present work and earlier efforts to simulate large motions of flexible structures is discussed. (Author)

A80-53838 **Nonlinear dynamic analysis of space trusses.** A. K. Noor and J. M. Peters (George Washington University, Hampton, Va.). *Computer Methods in Applied Mechanics and Engineering,* vol. 21, Feb. 1980, p. 131-151. 18 refs.

A computational procedure is presented for predicting the dynamic response of space trusses with both geometric and material nonlinearities. A mixed formulation is used with the fundamental unknowns consisting of member forces, nodal velocities and nodal displacements. The governing equations consist of a mixed system of algebraic and differential equations. The temporal integration of the differential equations is performed by using an explicit half-station leap-frog method. The advantages of the proposed computational procedure over explicit methods used with the displacement formulation are discussed. The high accuracy of the procedure is demonstrated by means of numerical examples of plane and space trusses. The constitutive relations in these examples are assumed, for convenience, to be represented by the Ramberg-Osgood polynomials. Comparison is also made with solutions obtained by using implicit multistep temporal integration schemes. (Author)

A80-53845 **Micropolar beam models for lattice grids with rigid joints.** A. K. Noor and M. P. Nemeth (George Washington University, Hampton, Va.). *Computer Methods in Applied Mechanics and Engineering,* vol. 21, Feb. 1980, p. 249-263. 10 refs.

A simple, rational approach is presented for developing micropolar beam models for large repetitive beam-like planar lattices with rigid joints. The micropolar beam models have independent microrotation, and displacement fields and are characterized by their strain and kinetic energies, from which the equations of motion and boundary conditions can be derived. The procedure for developing the expression for the strain energy of the micropolar beam involves introducing basic assumptions regarding the variation of the displacement and microrotation components in the plane of the cross-section and obtaining effective elastic coefficients of the continuum in terms of the material properties and geometry of the original lattice structure. The high accuracy of the solutions obtained by the micropolar beam models is demonstrated by means of numerical examples. (Author)

N80-22736*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.
GEOMETRIC MODELING AND ANALYSIS OF LARGE LATTICED SURFACES
Adnan H. Nayfeh and Mohamed S. Hefzy Apr. 1980 65 p refs
(Grant NsG-1185)
(NASA-CR-3156) Avail: NTIS HC A04/MF A01 CSCL 20K

The application of geometrical schemes, similar to geodesic domes, to large spherical antenna reflectors was investigated. The shape and size of flat segmented latticed surfaces which approximate general shells of revolution, and in particular spherical and paraboloidal reflective surfaces, were determined. The extensive mathematical and computational geometric analyses of the reflector resulted in the development of a general purpose computer program capable of generating the complete design parameters of the dish. The program also includes a graphical self contained subroutine for graphic display of the required design. E.D.K.

N80-31460*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF ORBITAL TRANSFER LOADS ON LARGE PLATFORMS
Joseph E. Walz, Harold G. Bush, Walter L. Heard, Jr., and John J. Rehder *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 143-155 refs
Avail: NTIS HC A15/MF A01 CSCL 21H

A preliminary automated structural sizing procedure suitable for conceptual design and early tradeoff studies of large truss platforms configured for shuttle transportation to LEO is discussed as well as some orbital transfer design considerations. Platforms that are sized to withstand orbital transfer loads for the LEO to GEO maneuver are compared to platforms sized only for LEO application. It is concluded that for platforms supporting low mass distributed payloads, platform and strut frequency requirements are strong design drivers for LEO applications. The struts are found to be extremely slender, thinswalled, and of small diameter. If full advantage is to be taken of these minimum mass designs, a manufacturing capability must be developed for long straight struts. For platforms that are to be transferred from LEO to GEO in a deployed state, the orbital transfer loads become design drivers. However, even for an initial thrust-to-weight ratio equal to 0.1, a platform on the order of 100 m diameter appears packageable with its OTV in one shuttle flight, and larger platforms appear possible at lower thrust-to-weight ratios. A.R.H.

N80-31461*# Astro Research Corp., Santa Barbara, Calif.
INFLUENCE OF INTERORBIT ACCELERATION ON THE DESIGN OF LARGE SPACE ANTENNAS
John M. Hedgepeth *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 157-178 refs
Avail: NTIS HC A15/MF A01 CSCL 21H

The characteristics of the acceleration-induced loading in structures consisting of triangular lattices are investigated and some initial quantitative results on the effect on the design mass and stowage volume are presented. The approach used defines the structural design that would be used if no interorbit acceleration were required and then determines what strengthening would be required to accommodate the loads due to acceleration. The basic zero acceleration design can be based on the stringent accuracy requirements placed on the antennas. A.R.H.

N80-31462*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
INTEGRATED ANALYSIS OF LARGE SPACE SYSTEMS
Joseph P. Young *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 179-192
Avail: NTIS HC A15/MF A01 CSCL 12B

Based on the belief that actual flight hardware development of large space systems will necessitate a formalized method of integrating the various engineering discipline analyses, an efficient highly user oriented software system capable of performing interdisciplinary design analyses with tolerable solution turnaround time is planned Specific analysis capability goals were set forth with initial emphasis given to sequential and quasi-static thermal/structural analysis and fully coupled structural/control system analysis. Subsequently, the IAC would be expanded to include a fully coupled thermal/structural/control system, electromagnetic radiation, and optical performance analyses. A.R.H.

N80-31463*# Boeing Aerospace Co., Seattle, Wash.
INTEGRATED ANALYSIS CAPABILITY FOR LARGE SPACE SYSTEMS

Robert G. Vos *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 193-202

(Contract NAS5-25767)
Avail: NTIS HC A15/MF A01 CSCL 12B

The development of an integrated analysis computer program capable of performing the conceptual/preliminary structural system design analysis of large space systems is addressed. The integrated analysis capability (IAC) specifications include thermal/structural/controls integration, an emphasis on existing software and interactive graphics and I/O, a project size capability of 1 to 50 users (1 to 5 users concurrent), and the use of the FORTRAN '77 language. The advantages of the DISCOS and NASTRAN computer programs to the IAC are outlined and recommendations for other programs are made. Barriers to the development of the system arising from the interdisciplinary data flow are defined. M.G.

N80-33897# Aerospace Engineering Office, Zurich (Switzerland).
ON THE DESIGN VERIFICATION OF LARGE FLEXIBLE SOLAR ARRAYS: FIRST EXPERIENCES GAINED
K. J. Zimmermann and L. Zago (Pilatus Aircraft Ltd.) *In* ESA Photovoltaic Generators in Space Jun. 1980 p 187-193 refs

Avail: NTIS HC A12/MF A01; ESA, Paris FF 80

Design verification of large flexible solar arrays requires the adaptation of the mathematical model to well defined ground tests. Design verification itself and on-orbit predictions are then provided by the updated mathematical model. Prestressed flexible solar arrays impose geometric nonlinearities. Thus, empirical correlation of mathematical models may no longer be considered feasible. This verification approach was checked on a Communications Technology Satellite (CTS) solar array Sub-Panel Assembly by Static tests. The update of the mathematical models was performed by differential sensitivity analysis algorithms applied to geometric nonlinearities, executed by a simple correlation algorithms minimizing the error in the analytical prediction. Correlation is possible to any type of measurement parameter. The study yields an updated mathematical model with a mean error of approximately 7% and a computational strategy that reduces computer cost. Further increase in the model's accuracy is possible through iteration. Author (ESA)

03
STRUCTURAL CONCEPTS

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

A80-35000 * # **Large space structures activity at MSFC.** S. J. Denton and E. E. Engler (NASA, Marshall Space Flight Center, Huntsville, Ala.). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 115-123. (AIAA 80-0675)

This paper describes a broad based set of activities which have been undertaken at the Marshall Space Flight Center (MSFC) developing technologies necessary to emplace and operate large structures in space. Progress has been made in the development of processes and equipment needed for the in space fabrication of structural members in both aluminum and graphite composite materials. Designs for member joining attachments have been completed and the evaluation of procedures for structural assembly have been simulated and evaluated utilizing the MSFC Neutral Buoyancy Facility. A concept of a flight test necessary for flight verification of the technologies for space fabrication, assembly, and operation of large space structure is described. Recently initiated is a project to develop design characteristics of a deployable structure required for the Science and Applications Space Platform (SASP). This is being accomplished through the design, fabrication, analysis, and test of a full scale ground test article which reflects the influence of system requirements of the SASP. Development of designs for erectable/deployable structures which are modular and have various applications to large space structures is in progress. (Author)

A80-35003 * # **Structural sizing considerations for large space platforms.** W. L. Heard, Jr., H. G. Bush, J. E. Walz, and J. J. Rehder (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 147-158. 13 refs. (AIAA 80-0680)

Structural optimization studies are made using mathematical programming techniques to examine minimum mass structural proportions of deployable and erectable tetrahedral truss platforms subject to the integrated effects of practical design requirements. Considerations integrated into the optimization process are: 1) lowest natural frequencies of the platform and individual platform components (struts); 2) packaging constraints imposed by the Shuttle cargo bay capacity; 3) initial curvature of the struts; 4) column buckling of the struts due to gravity gradient, orbital transfer, strut length tolerance, or design loads; and 5) practical lower limits for strut diameter and wall thickness. Ultra-low mass designs are shown to be possible with strut proportions much more slender than those conventionally used for earthbound application. (Author)

A80-35004 * # **Buckling of periodic structures.** M. S. Anderson (NASA, Langley Research Center, Structures and Dynamics Div., Hampton, Va.). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 159-166. 8 refs. (AIAA 80-0681)

Equations are developed for the buckling of a general lattice structure that has repetitive geometry. Equilibrium at a typical node is expressed using finite element techniques, and the only assumption is that the response is periodic. By basing the stiffness matrix on the exact solution of the beam column equation, accurate results are obtained for complex buckling behavior that would require a very large system of equations using conventional techniques. The present method requires the eigenvalues of only a 6x6 determinant. The results are used to study the buckling of isogrid cylinders, three-element truss columns and polygonal rings. Details of the analysis including expressions for all terms in the governing stability determinant are given. (Author)

A80-35095 # **Prediction of loads on antenna ribs due to mesh deployment.** D. Bushnell (Lockheed Research Laboratories, Palo Alto, Calif.). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 915-932. 15 refs. (AIAA 80-0814)

The study relates to the optimum design of a very light-weight large-diameter unfurlable antenna for space applications. A model is described which determines the state of the mesh in a typical gore during the final stage of deployment in which the ribs are completely unfurled. The ribs are simply rotating as rigid bodies about attachment points to a hub through an angle of 90 deg from positions tangential to positions normal to the hub circumference. The deployment process is modeled on reverse sequence, with the initial condition being a nonuniform prestrain calculated from the boundary layer theory for the fully deployed mesh; the state of the mesh during deployment is determined incrementally as the ribs rotate through 90 deg from normal to tangential positions. A.T.

A80-35854 * **Collision avoidance in space.** D. J. Kessler, B. G. Cour-Palais, R. E. Taylor (NASA, Johnson Space Center, Houston, Tex.), and P. M. Landry (U.S. Department of Defense, North American Air Defense Command, Washington, D.C.). *IEEE Spectrum*, vol. 17, June 1980, p. 37-41.

Collisions in earth orbital space between operational payloads and various forms of space debris (nonoperational payloads, non-functional mission-related objects and fragments resulting from collisions and explosions) are discussed and possible means of avoiding them are considered. From 10,000 to 15,000 objects are estimated to be in earth orbital space, most of which represent spacecraft fragments and debris too small to be detected and tracked by earth-based sensors, and it is considered likely that some of them will be or have already been involved in direct collisions with the ever increasing number of operational satellites and space stations. Means of protecting proposed large space structures and smaller spacecraft from significant damage by larger space objects, particularly in the 400-4000 km altitude range where most debris occurs, include structural redundancy and the double shielding of sensitive components. Other means of collision avoidance are the collection or relocation of satellites, rocket bodies and other objects by the Space Shuttle, the prevention of explosions and the disposal of spent rocket parts by reentry. Finally, a management structure would be required to administer guidelines for the prevention and elimination of space debris. A.L.W.

A80-48214 * # **Large area flexible solar array design for Space Shuttle application.** C. J. Souza (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1.

New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 410-414. Contract No. NAS9-15595.

A large area flexible solar array has been designed for Shuttle power augmentation. The solar array utilizes large area, low cost, weldable solar cells. The paper addresses how the unique requirements of this system are implemented into the design. Economic and reliability issues relating to the optimization of a large area, foldable solar array concomitant to the Shuttle/Orbiter system are reviewed. (Author)

N80-22704*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
MECHANICAL END JOINT SYSTEM FOR STRUCTURAL COLUMN ELEMENTS Patent Application
Harold G. Bush and Richard E. Wallsom, inventors (to NASA) (Vought Corp., Hampton, Va.) Filed 5 Dec. 1979 17 p
(NASA-Case-LAR-12482-1; US-Patent-Appl-SN-100611) Avail: NTIS HC A02/MF A01 CSCL 13I

A mathematical end joint system, useful for the transverse connection of strut elements to a common mode is described. Included are node joint half with semicircular tongue and groove and a strut joint half with semicircular tongue and groove. The two joint halves were engaged transversely and the connection was made secure by the inherent physical property characteristics of locking latches or by a spring-actioned shaft. A quick release mechanism is also described which provides rapid disengagement of the joint halves. NASA

N80-22735*# Kentron International, Inc., Hampton, Va. Technical Center.
A DESIGN PROCEDURE FOR A TENSION-WIRE STIFFENED TRUSS-COLUMN
William H. Greene Apr. 1980 36 p refs
(Contract NAS1-16000)
(NASA-CR-3273) Avail: NTIS HC A03/MF A01 CSCL 20K

A deployable, tension wire stiffened, truss column configuration was considered for space structure applications. An analytical procedure, developed for design of the truss column and exercised in numerical studies, was based on equivalent beam stiffness coefficients in the classical analysis for an initially imperfect beam column. Failure constraints were formulated to be used in a combined weight/strength and nonlinear mathematical programming automated design procedure to determine the minimum mass column for a particular combination of design load and length. Numerical studies gave the mass characteristics of the truss column for broad ranges of load and length. Comparisons of the truss column with a baseline tubular column used a special structural efficiency parameter for this class of columns. E.D.K.

N80-23516*# Grumman Aerospace Corp., Bethpage, N.Y.
AUTOMATED BEAM BUILDER
Walter K. Muench *In* NASA. Langley Res. Center Proc. of the 14th Aerospace Mech. Symp. May 1980 p 247-265 refs

Avail: NTIS HC A15/MF A01 CSCL 13I

Requirements for the space fabrication of large space structures are considered with emphasis on the design, development, manufacture, and testing of a machine which automatically produces a basic building block aluminum beam. Particular problems discussed include those associated with beam cap forming; brace storage, dispensing, and transporting; beam component fastening; and beam cut-off. Various critical process tests conducted to develop technology for a machine to produce composite beams are also discussed. A.R.H.

N80-23517*# Applied Physics Lab., Johns Hopkins Univ., Laurel, Md.
THE MAGSAT MAGNETOMETER BOOM
James F. Smola, Wade E. Radford, and Marcus H. Reitz *In* NASA. Langley Res. Center Proc. of the 14th Aerospace Mech. Symp. May 1980 p 267-278 ref

Avail: NTIS HC A15/MF A01 CSCL 13I

A lightweight extendable structure that can precisely position magnetically sensitive instruments safe distances from magnetic sources in a spacecraft is described as well as the major areas of concern that played dominant roles in its development. Weight, packaging volume, thermal distortion, mechanical misalignments, dimensional instability, launch environments, and low temperature functioning were areas that presented some formidable obstacles. The ways in which these obstacles were dealt with are examined for those involving the development of similar aerospace mechanisms with equally restrictive requirements. A.R.H.

N80-27399*# General Dynamics/Convair, San Diego, Calif.
SPACE CONSTRUCTION AUTOMATED FABRICATION EXPERIMENT DEFINITION STUDY (SCAFEDS), PART 3. VOLUME 3: REQUIREMENTS Final Report
29 Jun. 1979 115 p refs
(Contract NAS9-15310)
(NASA-CR-160747; CASD-ASP78-016-Pt-3-Vol-3) Avail: NTIS HC A06/MF A01 CSCL 22A

The performance, design and verification requirements for the space Construction Automated Fabrication Experiment (SCAFE) are defined. The SCAFE program defines, develops, and demonstrates the techniques, processes, and equipment required for the automatic fabrication of structural elements in space and for the assembly of such elements into a large, lightweight structure. The program defines a large structural platform to be constructed in orbit using the space shuttle as a launch vehicle and construction base. E.D.K.

N80-27581# Martin Marietta Aerospace, Denver, Colo.
ADAPTIVE TECHNIQUES FOR LARGE SPACE APERTURES Final Technical Report, 6 Nov. 1978 - 5 Nov. 1979
R. J. Richardson, John Coyner, Alan Fenn, and Al Brook Griffiss AFB, N.Y. RADC Mar. 1980 329 p refs
(Contract F30602-79-C-0017; AF Proj. 4506)
(AD-A084631; RADC-TR-80-52) Avail: NTIS HC A15/MF A01 CSCL 17/9

Two missions which utilize large space apertures were considered on the program. These were the space-based radar mission (SBR) and the space-based millimeter-wave radiometer mission (MWR). *The greater part of the effort was spent on the* radar mission. The intent of the program was to investigate reflector-based alternates to the space-fed phased array system that is the current baseline for the space-based radar program. The three major tasks on the program were Task 1, Concept Development/Assessment; Task 2, Performance Analysis, Selected Approach; and Task 3, Specific Mission Designs. The adaptive techniques of interest were those that might be required to compensate for surface irregularities in the large, space-deployable reflectors that would be required for these missions. This and other system requirements were considered in selecting an antenna system for each mission. GRA

N80-29376*# Grumman Aerospace Corp., Bethpage, N.Y.
SYSTEMS DEFINITION STUDY FOR SHUTTLE DEMONSTRATION FLIGHTS OF LARGE SPACE STRUCTURES. VOLUME 1: EXECUTIVE SUMMARY Final Report
Jul. 1979 29 p 3 Vol.
(Contract NAS8-32390)
(NASA-CR-161534; DRD-MA-04-Vol-1) Avail: NTIS HC A03/MF A01 CSCL 22A

The development of large space structure technology is discussed, with emphasis on space fabricated structures which are automatically manufactured in space from sheet-strip materials and assembled on-orbit. Definition of a flight demonstration involving an Automated Beam Builder and the building and assembling of large structures is presented. L.F.M.

N80-29377*# Grumman Aerospace Corp., Bethpage, N.Y.
SYSTEMS DEFINITION STUDY FOR SHUTTLE DEMONSTRATION FLIGHTS OF LARGE SPACE STRUCTURES, VOLUME 2: TECHNICAL REPORT Final Report
Jul. 1979 220 p 3 Vol.
(Contract NAS8-32390)
(NASA-CR-161535; DRD-MA-04-Vol-2) Avail: NTIS HC A10/MF A01 CSCL 22A

The development of large space structure (LSS) technology is discussed, with emphasis on space fabricated structures which are automatically manufactured in space from sheet-strip materials and assembled on-orbit. It is concluded that an LSS flight

demonstration using an Automated Beam Builder and the orbiter as a construction base, could be performed in the 1983-1984 time period. The estimated cost is $24 million exclusive of shuttle launch costs. During the mission, a simple space platform could be constructed in-orbit to accommodate user requirements associated with earth viewing and materials exposure experiments needs. L.F.M.

N80-29378*# Grumman Aerospace Corp., Bethpage, N.Y.
SYSTEMS DEFINITION STUDY FOR SHUTTLE DEMONSTRATION FLIGHTS OF LARGE SPACE STRUCTURES. VOLUME 3: THERMAL ANALYSES Final Report
Jul. 1979 80 p 3 Vol.
(Contract NAS8-32390)
(NASA-CR-161536; DRD-MA-04-Vol-3) Avail: NTIS HC A05/MF A01 CSCL 22A

The development of large space structure technology is discussed. A detailed thermal analysis of a model space fabricated 1 meter beam is presented. Alternative thermal coatings are evaluated, and deflections, stresses, and stiffness variations resulting from flight orientations and solar conditions are predicted. L.F.M.

N80-33319*# Lockheed Missiles and Space Co., Sunnyvale, Calif. Electro-Optics Lab.
LARGE DEPLOYABLE REFLECTOR (LDR) Final Report
W. H. Alff Jul. 1980 124 p refs
(Contract NAS2-10427)
(NASA-CR-152402; LMSC-D766449) Avail: NTIS HC A06/MF A01 CSCL 03A

The feasibility and costs were determined for a 1 m to 30 m diameter ambient temperature, infrared to submillimeter oribiting astronomical telescope which is to be shuttle-deployed, free-flying, and have a 10 year orbital life. Baseline concepts, constraints on delivery and deployment, and the sunshield required are examined. Reflector concepts, the optical configuration, alignment and pointing, and materials are also discussed. Technology studies show that a 10 m to 30 m diameter system which is background and diffraction limited at 30 micron m is feasible within the stated time frame. A 10 m system is feasible with current mirror technology, while a 30 m system requires technology still in development. A.R.H.

N80-33881# British Aerospace Dynamics Group, Bristol (England).
TELESCOPIC MASTS FOR DEPLOYMENT OF FLEXIBLE SOLAR ARRAYS
P. A. Champion *In* ESA Photovoltaic Generators in Space Jun. 1980 p 65-71

Avail: NTIS HC A12/MF A01; ESA, Paris FF 80

Detail design features of a nine element 16 m aluminum mast are given. These masts are driven by stored gas and controlled by an escape mechanism. Test results and their correlation with analytical models are reviewed, and a description of an alternative, mechanical drive system under development for future missions requiring retraction capability is given.
Author (ESA)

Page Intentionally Left Blank

04
CONTROL SYSTEMS

Includes new attitude and control techniques, improved surface accuracy measurement and control techniques.

A80-33284 # **Optimal modal-space control of flexible gyroscopic systems.** H. Oz and L. Meirovitch (Virginia Polytechnic Institute and State University, Blacksburg, Va.) *Journal of Guidance and Control*, vol. 3, May-June 1980, p. 218-226. 15 refs.

A solution for the optimal control of large-order gyroscopic systems using quadratic performance index is presented. The approach is based on independent modal-space control, and it requires the solution of n/2 decoupled 2 x 2 matrix Riccati equations (one for each pair of conjugate modes) instead of a general n x n matrix Riccati equation, where n is the number of modes to be controlled. The solution of the 2 x 2 steady-state matrix Riccati equations can be obtained in closed-form. Moreover, the transient solution is obtained by using augmented matrix formulation for 2 x 2 matrices, and it reduces to the inversion of such matrices, a very simple operation. The solutions obtained via the modal approach exhibit dependence of the control gains on the system natural frequencies, thus providing physical insight into the system behavior. The method is applied to a dual-spin flexible spacecraft. (Author)

A80-35001 # **Passive damping in large precision space structures.** R. W. Trudell, R. C. Curley (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.), and L. C. Rogers (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 124-136. 18 refs. Contract No. F33615-75-C-3016. (AIAA 80-0677)

Mission performance objectives dictate ultrastringent dimensional tolerances for space-based antenna and optical element surfaces. Vibration control is a critical need. The interrelationships of isolation, active control, and passive damping as a combined approach to vibration control are analyzed for a specific system, from which careful generalizations are drawn. It is shown that a combined approach is mandatory, that passive damping technology is essential, and that there is a strong beneficial synergism between active controls and passive damping. Technical system design and material refinement issues are identified and discussed. A program to provide the essential advancement of passive damping technology and its system integration is outlined. (Author)

A80-37426 **Automatic control in space; Proceedings of the Eighth Symposium, Oxford, England, July 2-6, 1979.** Symposium sponsored by the International Federation of Automatic Control. Edited by C. W. Munday. Oxford, Pergamon Press, Ltd., 1980. 498 p. $96.50.

The symposium focused on state-of-the-art methods and equipment for automatic attitude control in space. Papers were presented on an internal image motion compensation system for the Shuttle infrared telescope facility, stochastic algorithms for parameters estimation and their application to space navigation, a simple stability criterion for satellites with flexible appendages, and low-noise control system for a high-pointing-accuracy satellite. Other papers included: analysis and design of special-purpose software for a spaceborne digital computer, a low-cost magnetic bearing reaction wheel, motion control system development for a mobile robot, and a laser rangefinder path selection system for a Martian rover using a logarithmic scanning scheme. V.L.

A80-37453 **Attitude estimation and control of satellites in geosynchronous orbit.** J. S.-C. Yuan (Spar Aerospace, Ltd., Toronto, Canada). In: Automatic control in space; Proceedings of the Eighth Symposium, Oxford, England, July 2-6, 1979. Oxford, Pergamon Press, Ltd., 1980, p. 219-227. 11 refs. Department of Supply and Services Contract No. 15ST-36100-7-4001.

Both roll and yaw information of a spacecraft can be obtained in a single gyroscope with its input axis skewed between the roll and yaw axes. This paper describes a novel approach that combines the skewed gyro concept with a microwave attitude sensing system to estimate all the attitude angles of a geostationary satellite. A compensator is presented which decouples the roll and yaw dynamics and allows independent specification of the closed loop dynamics in all three axes. Analysis and simulation results indicate that the proposed scheme is well capable of meeting the high pointing accuracy requirements for the future generation of communications satellites. (Author)

A80-37460 **A survey of automatic control techniques for large space structures.** S. R. Croopnick, Y. H. Lin, and R. R. Strunce (Charles Stark Draper Laboratory, Inc., Cambridge, Mass.). In: Automatic control in space; Proceedings of the Eighth Symposium, Oxford, England, July 2-6, 1979. Oxford, Pergamon Press, Ltd., 1980, p. 275-284. 70 refs.

Problems associated with the control of large space structures (LSS) are discussed with reference to various techniques used for attitude, vibration, and shape control, and current approaches to the modeling of complex LSSs. It is shown that the currently used structure dynamics computer programs produce errors due to the truncation to finite dimensions. Model parameters also change because of the changes in the structure properties over extended periods, and changes in mass due to depletion of consumables. The following directions in the development of LSS control are indicated: design of a finite dimensional controller which is either insensitive to modeling errors or error compensated, design of an adaptive vibration suppression controller, and applications of state-of-the-art techniques to LSS. V.L.

A80-39104 **Background suppression and tracking with a staring mosaic sensor.** H. E. Rauch, W. I. Futterman, and D. B. Kemmer (Lockheed Research Laboratories, Palo Alto, Calif.). In: Modern utilization of infrared technology V; Proceedings of the Fifth Annual Seminar, San Diego, Calif., August 29, 30, 1979. Bellingham, Wash., Society of Photo-Optical Instrumentation Engineers, 1979, p. 19-29. 5 refs.

This paper presents theoretical analysis for a staring mosaic infrared sensor with representative examples of data processing from a computer simulation. The analysis treats: (1) generation of synthetic two-dimensional scenes with specified cloud geometry and desired statistical characteristics, (2) the processing of frames of data from two-dimensional scenes to represent temporal, spatial, and multispectral filtering, and (3) the thresholding and examination of the processed scenes to implement track association. The temporal filtering includes multiple differencing, statistically optimal non-recursive filtering, and recursive filtering. Methods are presented for reducing the computation load when calculating the optimal coefficients in spatial and multispectral filtering. The track association uses thresholding and examination to eliminate stationary objects with track assembly similar to the 'streak algorithm'. For visual display, the two-dimensional scenes and the processed frames are output with a forty-eight level gray scale. (Author)

A80-40748 * # **Optimal member damper controller design for large space structures.** S. M. Joshi (Old Dominion University Research Foundation, Norfolk, Va.) and N. J. Groom (NASA, Langley Research Center, Hampton, Va.). *Journal of Guidance and Control*, vol. 3, July-Aug. 1980, p. 378-380. 8 refs.

Consideration is given to the selection of velocity feedback gains for individual dampers for the members of a structurally controlled

large flexible space structure. The problem is formulated as an optimal output feedback regulator problem, and necessary conditions are derived for minimizing a quadratic performance function. The diagonal nature of the gain matrix is taken into account, along with knowledge of noise covariances. It is pointed out that the method presented offers a systematic approach to the design of a class of controllers for enhancing structural damping, which have significant potential if used in conjunction with a reduced-order optimal controller for rigid-body modes and selected structural modes. A.L.W.

A80-45041 * # **Control of a large flexible platform in orbit.** A. S. S. R. Reddy, P. M. Bainum, R. Krishna (Howard University, Washington, D.C.), and H. A. Hamer (NASA, Langley Research Center, Hampton, Va.). *American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Danvers, Mass., Aug. 11-13, 1980, AIAA Paper 80-1668.* 13 p. 10 refs. Grant No. NsG-1414.

The dynamics and attitude and shape control of a large thin flexible platform in orbit are studied. Attitude and shape control is assumed to result from actuators placed perpendicular to the main surface and one edge and their effect on the rigid body and elastic modes is modelled to first order. The equations of motion are linearized about nominal orientations where the undeformed plate follows either the local vertical or local horizontal. The stability of the uncontrolled system is investigated analytically. Once controllability is established for a set of actuator locations, control law development is based on pole placement, decoupling, and linear optimal control theory. (Author)

A80-45042 * # **On maneuvering large flexible spacecraft using an annular momentum control device.** H. Oz, L. Meirovitch (Virginia Polytechnic Institute and State University, Blacksburg, Va.), and R. C. Montgomery (NASA, Langley Research Center, Hampton, Va.). *American Institute of Aeronautics and Astronautics and American Astronautical Society, Astrodynamics Conference, Danvers, Mass., Aug. 11-13, 1980, AIAA Paper 80-1669.* 14 p. 8 refs. Grant No. NCC1-4.

A scheme for the control and maneuvering of a large flexible spacecraft by means of two flexible AMCD's using noncontacting magnetic suspension is presented. The system consists of a flexible vehicle, two flexible rings and a magnetic suspension and driving assembly. The necessary skewing of the rings for maneuvering of the vehicle is accomplished by moving the pairs of magnets along tracks distributed around the circumference of the vehicle. The equations of motion for each subsystem are derived by the Lagrangian approach. Attitude motions are described in terms of quasi-coordinates. For small vehicle angular rates and rings attitude motions, an ordering scheme can be used to separate the equations of motion according to the magnitude of the terms. The ordered equations of motion lead to a linear time-variant optimal control problem for the maneuvering of the spacecraft. (Author)

A80-45515 # **Control of self-adjoint distributed-parameter systems.** L. Meirovitch and H. Baruh (Virginia Polytechnic Institute and State University, Blacksburg, Va.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1-10. 22 refs. Contract No. N00014-78-C-0194. (AIAA 80-1707)

A method for the optimal control of self-adjoint distributed-parameter systems admitting closed-form eigensolutions is presented. For such systems, control of the actual distributed-parameter system is possible and no discretization is necessary. The control scheme is based on the concept of independent modal-space control, leading to a set of independent second-order matrix Riccati equations. The method requires as many actuators as the number of controlled modes. The number of sensors depends on the mode participation in the overall response. (Author)

A80-45519 * # **Local distributed estimation.** D. B. Schaechter (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. (A80-45514 19-17) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 33-37. 6 refs. Contract No. NAS7-100.

Based on partial differential equations of motion the closed form solution for the optimal estimation of a spatially continuous state vector is derived, using a continuously distributed sensor. Local control is shown to be the feedback that minimizes a quadratic performance index of sensor and process disturbances. A detailed example of the control of a string in tension is presented. (Author)

A80-45532 # **Extensions of suboptimal output feedback control with application to large space structures.** D. R. Hegg (Charles Stark Draper Laboratory, Inc., Cambridge, Mass.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 147-153. 10 refs. Contract No. F30602-78-C-0268. (AIAA 80-1735)

The paper extends the Kosut method of suboptimal output feedback to be applicable with arbitrary sensor configurations. It was found that the linear algebraic equation for the output feedback gain matrix is algebraically consistent regardless of the rank of the reduced-state observation matrix. When the latter is rank deficient, a family of solutions to the gain equation exists; free parameters generating this family are proportional in number to the rank-deficiency, and their values may be chosen to improve the performance of the full-order system driven by the reduced-order controller. A numerical example with a two-mass oscillator is given to demonstrate the application of extensions and to indicate some of the types of possible performance improvements. A.T.

A80-45533 * # **Adaptive and learning control of large space structures.** R. C. Montgomery (NASA, Langley Research Center, Hampton, Va.) and F. J. Thau (New York, City University, New York, N.Y.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers.

New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 154-162. 9 refs. (AIAA 80-1739)

The paper describes the adaptive learning system for space operations which assumes that structural testing can be conducted during deployment and assembly. Simulation results using the solar electric propulsion array and a novel remote sensor are presented; they involve faster scan television coverage of the motions of the array from four cameras on the corners of the Space Shuttle payload bay. The description of the simulation, the filtering algorithm for processing the TV data, the parameter extraction algorithm, and the simulation results are presented. A.T.

A80-45565 # **Parameter plane analysis for large scale systems.** S. M. Seltzer, B. A. Asner, Jr. (Dallas, University, Irving, Tex.), and R. L. Jackson (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 414-419. 6 refs. Research supported by TRW. (AIAA 80-1790)

A positivity concept is applied to a moderately high order system consisting of a model of a flexible satellite plant, a controller, and an estimator. Concurrently, the extended parameter plane concept is applied to determine the region of stability in terms of two selected parameters. It is shown that the design point resulting from the positivity approach lies robustly within the stable region defined by the parameter plane approach. B.J.

A80-45566 # **Establishing approximate root loci using power series expansions.** R. L. Farrenkopf (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In: Guidance and Control

Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 420-428. (AIAA 80-1791)

An algorithm is presented for calculating a power series that accurately describes the motion in the complex plane of any particular system eigenvalue in the case when a system parameter changes over some limited range. A simple example is presented which illustrates the use of such a power series to predict the value of the damping coefficient that maximizes the damping ratio of a particular system root. This technique is useful in analyzing the impact of the distributed control/sensing of large space structures as it improves on currently available approaches for predicting a root's motion. B.J.

A80-45568 * # **Hardware demonstration of flexible beam control.** D. B. Schaechter (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 435-444. Contract No. NAS7-100. (AIAA 80-1794)

An experiment employing a pinned-free flexible beam has been constructed to demonstrate and verify several facets of the control of flexible structures. The desired features of the experiment are to demonstrate active shape control, active dynamic control, adaptive control, various control law design approaches, and associated hardware requirements and mechanization difficulties. This paper contains the analytical work performed in support of the facility development, the final design specifications, control law synthesis, and some preliminary results. (Author)

A80-47559 **Decentralized control for large communication satellites by model error sensitivity suppression.** J. R. Sesak (General Dynamics Corp., Convair Div., San Diego, Calif.). In: ITC/USA/'79; Proceedings of the International Telemetering Conference, San Diego, Calif., November 19-21, 1979. Pittsburgh, Pa., Instrument Society of America, 1979, p. 117-127. 26 refs.

A decentralized control methodology for large communication satellites is discussed. The design methodology, termed model error sensitivity suppression (MESS), allows noninteracting control with distributed microprocessing. It provides a solution for the problem of rigid body control in the presence of low frequency elastic modes that are in the rigid body controller bandwidth. V.T.

A80-47561 **Control of large communication satellites.** R. Gran, M. Proise, and A. Zislin (Grumman Aerospace Corp., Bethpage, N.Y.). In: ITC/USA/'79; Proceedings of the International Telemetering Conference, San Diego, Calif., November 19-21, 1979. Pittsburgh, Pa., Instrument Society of America, 1979, p. 145-152.

The various approaches proposed for controlling large flexible spacecraft are discussed for the case when structural and control frequencies overlap. It is noted that the control problem is best handled by measuring as many states as possible and by using full state feedback from each of the measurements. V.T.

A80-47725 * # **Modal damping enhancement in large space structures using AMCD's.** S. M. Joshi (ViRA, Inc., Hampton, Va.) and N. J. Groom (NASA, Langley Research Center, Hampton, Va.). *Journal of Guidance and Control*, vol. 3, Sept.-Oct. 1980, p. 477-479.

The use of an annular momentum control device (AMCD) is proposed for enhancing the modal damping of large space structures (LSS's) during fine pointing missions. Theoretical and experimental studies proved that an AMCD cannot destabilize the LSS and that the system is asymptotically stable under certain conditions. S.S.

N80-27419*# Howard Univ., Washington, D. C. School of Engineering.

THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES, 3. PART A: SHAPE AND ORIENTATION CONTROL OF A PLATFORM IN ORBIT USING POINT ACTUATORS Final Report

Peter M. Bainum, A. S. S. R. Reddy, R. Krishna, and Paul K. James Jun. 1980 179 p refs
(Grant NsG-1414)
(NASA-CR-163253) Avail: NTIS HC A09/MF A01 CSCL 22B

The dynamics, attitude, and shape control of a large thin flexible square platform in orbit are studied. Attitude and shape control are assumed to result from actuators placed perpendicular to the main surface and one edge and their effect on the rigid body and elastic modes is modelled to first order. The equations of motion are linearized about three different nominal orientations: (1) the platform following the local vertical with its major surface perpendicular to the orbital plane; (2) the platform following the local horizontal with its major surface normal to the local vertical; and (3) the platform following the local vertical with its major surface perpendicular to the orbit normal. The stability of the uncontrolled system is investigated analytically. Once controllability is established for a set of actuator locations, control law development is based on decoupling, pole placement, and linear optimal control theory. Frequencies and elastic modal shape functions are obtained using a finite element computer algorithm, two different approximate analytical methods, and the results of the three methods compared. Author

N80-28398*# Virginia Polytechnic Inst. and State Univ., Blacksburg.

OPTIMAL LARGE ANGLE MANEUVERS WITH SIMULTANEOUS SHAPE CONTROL/VIBRATION ARREST

James D. Turner and John L. Junkins *In* NASA. Goddard Space Flight Center Flight Mech./Estimation Theory Symp. 1980 p 201-214 refs
Avail: NTIS HC A12/MF A01 CSCL 22A

A relaxation method is demonstrated which reliably solves the nonlinear two point boundary value problem which arises when optimal control theory is applied to determination of large angle maneuvers of flexible spacecraft. The basic ideas are summarized and several idealized maneuvers are determined. The emphasis is upon demonstrating the basic ideas and practical aspects of the methodology. J.M.S.

N80-28417*# Lockheed Aircraft Corp., Palo Alto, Calif.

GYRODAMPERS FOR LARGE SPACE STRUCTURES

J. N. Aubrun and G. Margulies Feb. 1979 107 p refs
(Contract NAS1-14887)
(NASA-CR-159171) Avail: NTIS HC A06/MF A01 CSCL 22B

The problem of controlling the vibrations of a large space structures by the use of actively augmented damping devices distributed throughout the structure is addressed. The gyrodamper which consists of a set of single gimbal control moment gyros which are actively controlled to extract the structural vibratory energy through the local rotational deformations of the structure, is described and analyzed. Various linear and nonlinear dynamic simulations of gyrodamped beams are shown, including results on self-induced vibrations due to sensor noise and rotor imbalance. The complete nonlinear dynamic equations are included. The problem of designing and sizing a system of gyrodampers for a given structure, or extrapolating results for one gyrodamped structure to another is solved in terms of scaling laws. Novel scaling laws for gyro systems are derived, based upon fundamental physical principles, and various examples are given. A.R.H.

N80-28742*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

CONTROL-STRUCTURE INTERACTION IN A FREE BEAM

S. K. Shrivastava and R. C. Ried May 1980 17 p refs
(NASA-TM-81029; JSC-16699) Avail: NTIS HC A02/MF A01 CSCL 20K

A simple energy approach to study the problem of control structure interactions in large space structures is presented. For the illustrative case of a free-free beam, the vibrational energy imparted during operation of constant, step, and pulsed thrusters is found in a nondimensional closed form. Then based on a parametric study, suggestions are made on the choice of parameters to minimize the control structure interactions. The study of this simple system provides physical insight and understanding for more complex systems. Author

N80-29418*# Old Dominion Univ., Norfolk, Va. Dept. of Mathematical Sciences.
PRELIMINARY INVESTIGATIONS INTO THE ACTIVE CONTROL OF LARGE SPACE STRUCTURES: SOLUTION OF THE TIMOSHENKO BEAM EQUATIONS BY THE METHOD OF CHARACTERISTICS Final Report, 15 Feb. 1976 - 15 Aug. 1980
John Tweed Aug. 1980 197 p refs
(Grant NsG-1279)
(NASA-CR-163408) Avail: NTIS HC A09/MF A01 CSCL 22B

An algorithm was developed and incorporated into a computer program for solving the damped, Timoshenko beam equations with free-free boundary conditions and prescribed initial data. A number of special cases are considered and, where appropriate, comparisons are made with known results. A.R.H.

N80-29421# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS FOUR (ACTIVE CONTROL OF SPACE STRUCTURES) THEORY, VOLUME 1 Final Technical Report, 24 Jul. 1978 - 31 Dec. 1979
Robert R. Strunce, Daniel R. Hegg, Jiguan G. Lin, and Timothy C. Henderson Griffiss AFB, N.Y. RADC Apr. 1980 68 p refs 2 Vol.
(Contract F30602-78-C-0268; ARPA Order 3654)
(AD-A085654; R-1338-Vol-1; RADC-TR-80-78-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 22/2

The objective of the research reported here was to develop the theoretical and analytical tools to support the successful implementation of active vibration control of large flexible spacecraft. Parallel efforts in theory and applications were initiated. For the theoretical effort, several representative design methods were selected for careful study focusing on an examination of the theoretical basis for each method and potential difficulties associated with their use in reduced-order large space structure controller design. The methods initially selected are characterized by constant-gain output feedback, the simplest form of active multivariable control: (1) modal decoupling, (2) pole assignment, (3) optimal output feedback, (4) subbptimal output feedback, and (5) stochastic optimal output feedback. A performance comparison of specific designs with these methods was made. Extensions to the published Kosut methods of suboptimal output feedback are developed, as well as the details of an algorithm necessary for a numerical solution. GRA

N80-29422# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS FOUR (ACTIVE CONTROL OF SPACE STRUCTURES) THEORY. VOLUME 2: APPENDIX Final Technical Report, 24 Jul. 1978 - 31 Dec. 1979
Robert R. Strunce, Daniel R. Hegg, Jiguan G. Lin, and Timothy C. Henderson Griffiss AFB, N.Y. RADC Apr. 1980 64 p 2 Vol.
(Contract F30602-78-C-0268; ARPA Order 3654)
(AD-A085816; R-1338-Vol-2-App; RADC-TR-80-78-Vol-2) Avail: NTIS HC A04/MF A01 CSCL 22/2

This is the Charles Stark Draper Laboratory, Inc., final technical report on its Actively Controlled Structures Theory Study. The objective of the research reported here was to develop the theoretical and analytical tools to support the successful implementation of active vibration control of large flexible spacecraft. Parallel efforts in theory and applications were initiated. For the theoretical effort, several representative design methods were selected for careful study focusing on an examination of the theoretical basis for each method and potential difficulties associated with their use in reduced-order large space structure controller design. The methods initially selected are characterized by constant-gain output feedback, the simplest form of active multivariable control: (1) Modal Decoupling, (2) Pole Assignment, (3) Optimal Output Feedback, (4) Suboptimal Output Feedback, and (5) Stochastic Optimal Output Feedback. A performance comparison of specific designs with these methods was made. Extensions to the published Kosut methods of suboptimal output feedback are developed, as well as the details of an algorithm necessary for a numerical solution. Techniques and conditions are developed for reduction of control (observation) spillover by placement of actuators (sensors), by synthesis of the actuator (sensor) influences, and by compensation of actuators (sensors): GRA

N80-31459*# Boeing Aerospace Co., Seattle, Wash.
AUXILIARY CONTROL OF LSS Progress Report, 28 Aug. 1979 - 27 Nov. 1980
William Smith *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 129-141

(Contract NAS3-21952)
Avail: NTIS HC A15/MF A01 CSCL 21H

Seven classes of large space structures were identified and idealized into simple geometric shapes which could be easily modelled. Scaling laws were generated which allowed the seven ideal structures to be continuously scaled as to size and mass properties over their respective size ranges. Relevant sources of disturbances were determined and their effects on LSS were compared. These disturbances were applied over the range of scaling parameters to generate control force and torque requirements. Important auxiliary propulsion system (APS) characteristics were identified and an APS characteristic sensitivity matrix was established. A.R.H.

N80-31464*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CONTROLS FOR LSS
Fernando Tolivar *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 203-217
Avail: NTIS HC A15/MF A01 CSCL 21H

An overiew of control development for large space structures (LSS) is presented addressing the activities of LSS modeling for control synthesis, technology identification and development, and performance evaluation. Specifically discussed are a 100 meter wrap rib antenna, a multiple payload science application platform, and a solar power satellite. In addition, the static shape control of flexible space structures by utilizing the Green's function is described. M.G.

N80-33449*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
THE DYNAMICS AND CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES. VOLUME 3, PART B: THE MODELLING, DYNAMICS, AND STABILITY OF LARGE EARTH POINTING ORBITING STRUCTURES Final Report
Peter M. Bainum and V. K. Kumar Sep. 1980 71 p refs
(Contract NsG-1414)
(NASA-CR-163612) Avail: NTIS HC A04/MF A01 CSCL 22B

The dynamics and stability of large orbiting flexible beams, and platforms and dish type structures oriented along the local horizontal are treated both analytically and numerically. It is assumed that such structures could be gravitationally stabilized by attaching a rigid light-weight dumbbell at the center of mass by a spring loaded hinge which also could provide viscous damping. For the beam, the small amplitude inplane pitch motion, dumbbell librational motion, and the anti-symmetric elastic modes are all coupled. The three dimensional equations of motion for a circular flat plate and shallow spherical shell in orbit with a two-deqree-of freedom gimballed dumbbell are also developed and snow that only those elastic modes described by a single nodal diameter line are influenced by the dumbbell motion. Stability criteria are developed for all the examples and a sensitivity study of the

system response characteristics to the key system parameters is carried out. A.R.H.

N80-33461# Lockheed Missiles and Space Co., Palo Alto, Calif.
ACROSS THREE (ACTIVE CONTROL OF SPACE STRUCTURES), PHASE 1 Final Technical Report, 2 Jan. - 30 Sep. 1979
Michall G. Lyons, Jean N. Auburn, Gabriel Margulies, and Narenda K. Gupta May 1980 235 p refs
(Contract F30602-79-C-0087; AF Proj. C654)
(AD-A089142; RADC-TR-80-131) Avail: NTIS HC A11/MF A01 CSCL 22/2

The theory of stability augmentation (active control of vehicle dynamics) for large space structures is developed and tested analytically on a number of strawman configurations including large surveillance and HEL weapons plateforms. It is shown that active control is potentially feasible for micro-vibration stabilization of precision large structures; performance of several experimental breadboards is illustrated to enhance the theory. GRA

05
ELECTRONICS

Includes techniques for power and data distribution.

A80-48173 * # **Progress in space power technology.** J. P. Mullin, L. P. Randolph, and W. R. Hudson (NASA, Washington, D.C.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 83-88.

The National Aeronautics and Space Administration's Space Power Research and Technology Program has the objective of providing the technology base for future space power systems. The current technology program which consists of photovoltaic energy conversion, chemical energy conversion and storage, thermal-to-electric conversion, power systems management and distribution, and advanced energetics is discussed. In each area highlights, current programs, and near-term directions will be presented. (Author)

A80-48264 * # **Advanced development of a programmable power processor.** F. E. Lukens (Martin Marietta Aerospace, Denver, Colo.), J. R. Lanier, Jr., R. E. Kapustka, and J. Graves (NASA, Marshall Space Flight Center, Huntsville, Ala.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 777-781.

The need for the development of a multipurpose flexible programmable power processor (PPP) has increased significantly in recent years to reduce ever rising development costs. One of the program requirements the PPP specification will cover is the 25 kW power module power conversion needs. The 25 kW power module could support the Space Shuttle program during the 1980s and 1990s and could be the stepping stone to future large space programs. Trades that led to selection of a microprocessor controlled power processor are briefly discussed. Emphasis is given to the power processing equipment that uses a microprocessor to provide versatility that allows multiple use and to provide for future growth by reprogramming output voltage to a higher level (to 120 V from 30 V). Component selection and design considerations are also discussed. (Author)

A80-48357 * # **Power management for multi-100 KWe space systems.** J. W. Mildice (General Dynamics Corp., Convair Div., San Diego, Calif.) and M. E. Valgora (NASA, Lewis Research Center, Cleveland, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1401-1405. Contract No. NAS3-21757.

This paper examines mid to late 1980s power management technology needs to support development of a general-purpose space platform, capable of supplying 100 to 250 KWe to a variety of users in LEO. To that end, a typical Shuttle-assembled and supplied space platform is described, along with a group of payloads which might reasonably be expected to use such a facility. Examination of platform and user power needs yields a set of power system requirements used to evaluate power management options for life cycle cost effectiveness. The most cost-effective AC/DC and DC systems are evaluated, specifically to develop system details which lead to technology goals including array and transmission voltage, best frequency for AC power transmission, and advantages and disadvantages of AC and DC systems for this application. Finally, system and component requirements are compared with the state of the art to identify areas where technology development is required. (Author)

N80-26365*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM UTILITIES DISTRIBUTION STUDY
A. E. LeFever Jul. 1980 84 p refs
(Contract NAS1-15322)
(NASA-CR-159272) Avail: NTIS HC A05/MF A01 CSCL 22A

Generic concepts for the installation of power data and thermal fluid distribution lines on large space platforms were discussed. Connections with central utility subsystem modules and pallet interfaces were also considered. Three system concept study platforms were used as basepoints for the detail development. The tradeoff of high voltage low voltage power distribution and the impact of fiber optics as a data distribution mechanism were analyzed. Thermal expansion and temperature control of utility lines and ducts were considered. Technology developments required for implementation of the generic distribution concepts were identified. B.D.

N80-26604*# Boeing Aerospace Co., Seattle, Wash.
GROUND/BONDING FOR LARGE SPACE SYSTEM TECHNOLOGY (LSST) Final Report
W. G. Dunbar Apr. 1980 93 p refs
(Contract NAS8-33432)
(NASA-CR-161486) Avail: NTIS HC A05/MF A01 CSCL 09C

The influence of the environment and extravehicular activity remote assembly operations on the grounding and bonding of metallic and nonmetallic structures is discussed. Grounding and bonding philosophy is outlined for the electrical systems and electronic compartments which contain high voltage, high power electrical and electronic equipment. The influence of plasma and particulate on the system was analyzed and the effects of static buildup on the spacecraft electrical system discussed. Conceptual grounding bonding designs are assessed for capability to withstand high current arcs to ground from a high voltage conductor and electromagnetic interference. Also shown were the extravehicular activities required of the space station and or supply spacecraft crew members to join and inspect the ground system using manual on remote assembly construction. DOE

N80-28713*# Boeing Aerospace Co., Seattle, Wash.
CABLES AND CONNECTORS FOR LARGE SPACE SYSTEM TECHNOLOGY (LSST) Final Report
W. G. Dunbar Apr. 1980 104 p refs
(Contract NAS8-33432)
(NASA-CR-161423) Avail: NTIS HC A06/MF A01 CSCL 13E

The effect of the environment and extravehicular activity/remote assembly operations on the cables and connectors for spacecraft with metallic and/or nonmetallic structures was examined. Cable and connector philosophy was outlined for the elctrical systems and electronic compartments which contain high-voltage, high-power electrical and electronic equipment. The influence of plasma and particulates on the system is analyzed and the effect of static buildup on the spacecraft electrical system discussed. Conceptual cable and connector designs are assessed for capability to withstand high current and high voltage without danger of arcs and electromagnetic interference. The extravehicular activites required of the space station and/or supply spacecraft crew members to join and inspect the electrical system, using manual or remote assembly construction are also considered. A.R.H.

N80-28862*# General Dynamics/Convair, San Diego, Calif.
STUDY OF POWER MANAGEMENT TECHNOLOGY FOR ORBITAL MULTI-100KWe APPLICATIONS. VOLUME 2: STUDY RESULTS Final Report
J. W. Mildice 15 Jul. 1980 293 p 3 Vol.
(Contract NAS3-21757)

(NASA-CR-159834-Vol-2; GDC-ASP-80-015) Avail: NTIS HC A13/MF A01 CSCL 10B

The preliminary requirements and technology advances required for cost effective space power management systems for multi-100 kilowatt requirements were identified. System requirements were defined by establishing a baseline space platform in the 250 KE KWe range and examining typical user loads and interfaces. The most critical design parameters identified for detailed analysis include: increased distribution voltages and space plasma losses, the choice between ac and dc distribution systems, shuttle servicing effects on reliability, life cycle costs, and frequency impacts to power management system and payload systems for AC transmission. The first choice for a power management system for this kind of application and size range is a hybrid ac/dc combination with the following major features: modular design and construction-sized minimum weight/life cycle cost; high voltage transmission (100 Vac RMS); medium voltage array < or = 440 Vdc); resonant inversion; transformer rotary joint; high frequency power transmission line > or = 20 KHz); energy storage on array side or rotary joint; fully redundant; and 10 year life with minimal replacement and repair. J.M.S.

N80-29845*# General Dynamics/Convair, San Diego, Calif.
STUDY OF POWER MANAGEMENT TECHNOLOGY FOR ORBITAL MULTI-100KWe APPLICATIONS. VOLUME 3: REQUIREMENTS
J. W. Mildice 15 Jul. 1980 37 p refs 3 Vol.
(Contract NAS3-21757)
(NASA-CR-159834; GDC-ASP-80-015) Avail: NTIS HC A03/MF A01 CSCL 10B

Mid to late 1980's power management technology needs to support development of a general purpose space platform, capable of suplying 100 to 250 KWe to a variety of users in low Earth orbit are examined. A typical, shuttle assembled and supplied space platform is illustred, along with a group of payloads which might reasonably be expected to use such a facility. Examination of platform and user power needs yields a set of power requirements used to evaluate power management options for life cycle cost effectivness. The most cost effective ac/dc and dc systems are evaluated, specifically to develop system details which lead to technology goals, including: array and transmission voltages, best frequency for ac power transmission, and advantages and disadvantages of ac and dc systems for this application. System and component requirements are compared with the state-of-the-art to identify areas where technological development is required. Author

N80-33465*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNCHRONOUS ENERGY TECHNOLOGY
Sep. 1980 144 p Symp. held in Cleveland, 29-30 Apr. 1980
(NASA-CP-2154; E-469) Avail: NTIS HC A07/MF A01 CSCL 21H

The synchronous technology requirements for large space power systems are summarized. A variety of technology areas including photovoltaics, thermal management, and energy storage, and power management are addressed.

N80-33466*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SYNCHRONOUS ENERGY TECHNOLOGY PROGRAM
Robert C. Finke *In its* Synchronous Energy Technol. Sep. 1980 p 1-7
Avail: NTIS HC A07/MF A01 CSCL 10B

The power program in NASA and DOD are discussed with emphasis on the technology for future large space power systems. The structure of the synchronous energy technology program is described and the technologies required for future geosynchronous power stations are defined. The output of the program is to be a series of design data documents to provide design information and to transfer the technology to the involved community. R.C.T.

N80-33469*# National Aeronautics and Space Administration, Washington, D. C.
SPACECRAFT SYSTEM OVERVIEW OF SPACE POWER AT GEOSTATIONARY EARTH ORBIT
Richard F. Carlisle *In* NASA. Lewis Space Flight Center Synchronous Energy Technol. Sep. 1980 p 29-45

Avail: NTIS HC A07/MF A01 CSCL 10B

The power requirements at geostationary Earth orbit are discussed. Special design considerations are introduced and power system elements and opportunities for technological improvements are described. R.C.T.

N80-33475*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
POWER MANAGEMENT
J. Graves *In* NASA. Lewis Space Flight Center Synchronous Energy Technol. Sep. 1980 p 107-114

Avail: NTIS HC A07/MF A01 CSCL 21H

The multihundred kW power system management and a distribution program aims to develop critical components, circuits, and subsystems required to manage the generation, storage, and distribution of energy in large, orbital space systems. To accomplish this objective, a reference system including subsystems for the generation and storage of energy and management of electrical and thermal energy was designed and is being used to assess at the system level the impact of changing various subsystem parameters. A power management subsystem will then be designed. The subsystem is autonomous and based on ground utility systems concepts to the maximum extent possible. An agency power system breadboard is under development for characterizing and verifying the various component and subsystem technology developments. A.R.H.

06
ADVANCED MATERIALS

Includes matrix composites, polyimide films and thermal control coatings, and space environmental effects on these materials.

A80-35104 # **Composite materials in a simulated space environment.** R. C. Tennyson (Toronto, University, Toronto, Canada). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1009-1018. National Research Council of Canada Grant No. A-2783. Grant No. AF-AFOSR-78-3694-A. (AIAA 80-0678)

A review of the space simulation facilities that are currently being utilized to investigate polymer matrix composites is presented. Based on in-situ measurements, experimental results are given for the coefficients of thermal expansion (CTE) and flexural damping values for several laminate configurations. CTE data have been obtained for thermal-vacuum cycling at pressures of 10 to the -6th to 10 to the -8th torr over temperatures ranging from 75 to approximately 200 F, with exposure times in some instances exceeding 9 months. The materials studied include graphite/epoxy, Kevlar/epoxy and boron/epoxy. (Author)

A80-36877 # **Application of composite materials to space structures (Application des matériaux composites aux structures spatiales).** J. N. Giraudbit (Centre National d'Etudes Spatiales, Toulouse, France). *Association Aéronautique et Astronautique de France, Congrès International Aéronautique, 14th, Paris, France, June 6-8, 1979, Paper NT 79-45.* 49 p. In French.

The need for high dimensional stability of antenna systems and telescope structures to thermal deformations, together with their critical dynamic behavior has forced the use of carbon fiber reinforced plastics in communication and earth resources satellites. Boron and organic (Kevlar) fibers present good mechanical performances (rigidity, dilation coefficient, and humidity) and low manufacturing costs, and have been used in Meteosat, Marots, Intelsat V and LST. Advantages and the manufacturing process of the CFRP are presented. N.D.

A80-36878 # **Space structure - To-day and to-morrow.** K. Brunsch (Messerschmitt-Bölkow-Blohm ,GmbH, Ottobrunn, West Germany). *Association Aéronautique et Astronautique de France, Congrès International Aéronautique, 14th, Paris, France, June 6-8, 1979, Paper NT 79-46.* 11 p.

The use of carbon-fiber composites as an alternative to metals in structural aerospace applications in discussed with regard to the mechanical properties of the composites and their cost effectiveness. The composites are shown to have favorable strength and stiffness/density ratios, low coefficient of thermal expansion and high environmental resistance. Ratios of mass of finished components to raw material mass are 0.9 to 0.75 for composites as compared with ratios of 0.4 and lower for metals. The increasing cost effectiveness of composite structures and growing energy costs will contribute to increased use of light carbon-fiber composites in space structures. V.L.

A80-36949 **Composite structures for space systems.** J. S. Archer and W. E. Winters (TRW Defense and Space Systems Group, Redondo Beach, Calif.). *Quest*, vol. 4, Spring 1980, p. 43-65. 9 refs.

The present paper is a historical review of composite materials, starting with adobes made of straw and mud via reinforced concrete to modern filamentary materials which, combined with an appropriate matrix, possess mechanical properties that are competitive with steel but weigh considerably less. The fibers in modern composites are few in number, but diversified in their properties. A graphical comparison of the strength and stiffness characteristics of high-strength graphite and high-modulus graphite fibers and boron, glass, Kevlar, and aluminum-oxide fibers is given, along with a comparison of composites with conventional structural materals. Methods of preparing (and designing with) resin composites and metal-matrix composites are discussed. V.P.

A80-38754 # **Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links (Izuchenie deistviia izluchenii na poliorganosiloksany, soderzhashchie silafluorenil'nye zven'ia).** L. N. Pankratova, A. N. Goriachev, M. V. Zheliznikova, V. V. Severnyi, N. V. Varlamova, and T. I. Sunekants. In: Materials and processes for use in space technology. Moscow, Izdatel'stvo Nauka, 1980, p. 177-179. In Russian.

Consideration is given to the effects of protons at an energy of 500 keV and ultraviolet radiation on polymethyl, polyphenyl, and polymethyl phenyl siloxanes containing silafluorenil links. The investigation was conducted using infrared and ultraviolet spectroscopy. It is shown that polymethyl silafluorenil siloxane is most stable to the radiation. The materials studied may be used as components in spacecraft thermal control coatings. B.J.

A80-39850 # **The future belongs to composites - From space to the ground (L'avenir appartient aux composites - Du spatial au terrestre).** J. Moréchal. *Plastiques Renforcés, Fibres de Verre Textile,* vol. 19, Apr. 1980, p. 22-24, 27, 29, 30. In French.

The activities of the Division Systèmes Ballistiques et Spatiaux of Aérospatiale in the application of advanced composite technologies in aerospace and terrestrial industries are reviewed. Attention is given to the use of fiber composites in the Sylda Ariane double launch system, structures fabricated by filament winding and the materials employed, plasma generators for the testing of composite thermal protection materials for missiles, the mechanical testing of composites for missiles and industrial applications, multidirectional composites, and filament-wound pressure vessels with metallic shells. Activities of the division in collaboration with users in other fields include the development of composite structures for off-shore oil drilling, flywheels for energy storage and the Syscomoram real-time medical data acquisition and processing system. A.L.W.

A80-46814 # **A study of the effect of proton bombardment on the mechanical properties of polymers (Izuchenie vliianiia protonnoi bombardirovki na mekhanicheskie svoistva nekotorykh polimernykh materialov).** A. M. Markus, V. F. Udovenko, N. I. Velichko, V. A. Vinokurov, B. S. Romanov, and V. G. Turov. *Kosmicheskie Issledovaniia na Ukraine,* no. 12, 1978, p. 63-65. 5 refs. In Russian.

Several polymeric materials, including teflon, low-density polyethylene, and rubber, have been tested mechanically after an exposure to incident protons with energies of up to 200 keV in high vacuum. Results indicate that irradiation dosages of 10 to the 16th proton/sq cm result in a 40-50% strength decrease. Even when the proton path is small in relation to the total specimen thickness, the mechanical properties may change significantly due to surface layer damage. V.L.

N80-22491*# Hughes Aircraft Co., Culver City, Calif. Advanced Technology Lab.
DEVELOPMENT OF ULTRAVIOLET RIGIDIZABLE MATERIALS Final Report
D. P. Salisbury Oct. 1979 42 p
(Contract NAS8-32895)
(NASA-CR-161426; FR-79-76-1290; HAC-F2545) Avail: NTIS HC A03/MF A01 CSCL 11G

A series of tests was performed to determine an optimum resin to be used as a UV rigidizable matrix in expandable rigidizable space structures. Commercially available resins including several types of polyesters, epoxies, epoxy-acrylics, an acrylic and a urethane were used as well as a polyester, produced by 3M Company's Solar Laboratory facility, which was found the best from the standpoint of physical properties and ability to be 'B' staged. Two other synthesized materials were also tested, but were not found to be superior to the Solar resin. An optimum fabric for use with the preferred resin was not found; however, the 15 ounce fabric from Solar Laboratories has the best combination of physical properties with respect to handling and processing characteristics. Expansion techniques for tubular structures, 'B' staging of the solar resin, and stowage techniques for up to 5 months were developed. A one meter high tetrahedron preprototype structure was prepared to evaluate and demonstrate stowage, deployment, and rigidization techniques. A.R.H.

N80-24549*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

ELECTRICALLY CONDUCTIVE PALLADIUM CONTAINING POLYIMIDE FILMS Patent Application

Larry T. Taylor (Virginia Polytech. Inst. and State Univ.), Anne K. StClair (Virginia Polytech. Inst. and State Univ.), Vicki C. Carver (Virginia Polytech. Inst. and State Univ.), and Thomas A. Furtsch, inventors (to NASA) (Virginia Polytech. Inst. and State Univ.) Filed 28 Mar. 1980 16 p Sponsored by NASA

(NASA-Case-LAR-12705-1; US-Patent-Appl-SN-135058) Avail: NTIS HC A02/MF A01 CSCL 09A

A method is described for preparing lightweight, high temperature resistant, electrically conductive, palladium containing, polyimide films for use on aerodynamic and space applications. A palladium (2) ion-containing polymamic acid solution is prepared by reacting an aromatic dianhydride with an equimolar quantity of a palladium 2 ion-containing salt or complex. The reactant product is cast as a thin film onto a surface and cured at approximately 300 C to produce a flexible electrically conductive cyclic palladium containing polyimide. The source of palladium ions is selected from the gruop of palladium 2 compounds consisting of LiPdC14, Pd[S(CH3)2]2Cl2, Na2PdC14, and PdC14. NASA

N80-26395*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

UNIAXIAL AND BIAXIAL TENSIONING EFFECTS ON THIN MEMBRANE MATERIALS

W. F. Hinson and J. W. Goslee Jun. 1980 25 p refs

(NASA-TM-81812) Avail: NTIS HC A02/MF A01 CSCL 11D

Thin laminated membranes are being considered for various surface applications on future large space structural systems. Some of the thin membranes would be stretched across or between structural members with the requirement that the membrane be maintained within specified limits of smoothness which would be dictated by the particular applications such as antenna reflector requirements. The multiaxial tensile force required to maintain the smoothness in the membrane needs to be determined for use in the structure design. Therefore, several types of thicknesses of thin membrane materials have been subjected to varied levels of uniaxial and biaxial tensile loads. During the biaxial tests, deviations of the material surface smoothness were measured by a noncontacting capacitance probe. Basic materials consisted of composites of vacuum deposited aluminum on Mylar and Kapton ranging in thickness from 0.00025 in (0.000635 cm) to 0.002 in (0.00508 cm). Some of the material was reinforced with Kevlar and Nomex scrim. The uniaxial tests determined the material elongation and tensile forces up to ultimate conditions. Biaxial tests indicated that a relatively smooth material surface could be achieved with tensile force of approximately 1 to 15 Newtons per centimeter, depending upon the material thickness and/or reinforcement. Author

N80-30441*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

OUTGASSING DATA FOR SPACECRAFT MATERIALS

William A. Campbell, Jr., Richard S. Marriott, and John J. Park Aug. 1980 259 p refs

(NASA-RP-1061; Rept-80-F-7000) Avail: NTIS HC A12/MF A01 CSCL 11D

A system for determining the mass loss in vacuum and for collecting the outgassed compounds was developed. Outgassing data, derived from tests at 398 K (125 degrees C) for 24 hours in vacuum as per ASTM E 59577, are compiled for numerous materials for spacecraft use. The data presented are the total mass loss (TML) and the collected volatile condensable materials (CVCM). The various materials are compiled by likely usage and alphabetically. R.K.G.

N80-33479*# Martin Marietta Corp., Denver, Colo.

EVALUATION AND PREDICTION OF LONG TERM SPACE ENVIRONMENTAL EFFECTS ON NON-METALLIC MATERIALS Quarterly Progress Report

John A. Shepic 8 Oct. 1980 12 p

(Contract NAS8-33578)

(NASA-CR-161585; MCR-80-509-Issue-4; QPR-4) Avail: NTIS HC A02/MF A01 CSCL 11G

The effects of prolonged spacecraft materials were determined and the results compared with predicted behavior. The adhesion and dielectric properties of poly-thermaleze and therm-amid magnet wire insulation were studied. The tensile properties of Lexan, polyurethane, polyethelyne, lucite, and nylon were studied well as the flexure and tensile characteristic of Adlock 851, a phenolic laminate. The volume resistivity of Cho-seal, a conductive elastomer was also a examined. Tables showethe time exposed at thermal vacuum, and the high, low, and average MPA and KSI. A.R.H.

07
ASSEMBLY CONCEPTS

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

A80-41757 # **The Shuttle's remote manipulator system - Status and operation.** C. M. Hinds (Spar Aerospace, Ltd., Toronto, Canada). *Deutsche Gesellschaft für Luft- und Raumfahrt and American Astronautical Society, Symposium on Shuttle/Spacelab - The New Transportation System and its Utilization, 3rd, Hanover, West Germany, Apr. 28-30, 1980, DGLR Paper 80-075.* 14 p.

The design and operation of the Shuttle remote manipulator system (RMS) is described, and its uses in conjunction with Spacelab experiments are reviewed along with free flying payloads. Attention is given to modes of control and RMS performance. Special facilities including system testing and simulation are outlined, and current status is discussed. V.T.

A80-41762 # **Manned remote work station - A flexible tool for Shuttle operations.** R. L. Kline and C. A. Nathan (Grumman Aerospace Corp., Bethpage, N.Y.). *Deutsche Gesellschaft für Luft- und Raumfahrt and American Astronautical Society, Symposium on Shuttle/Spacelab - The New Transportation System and its Utilization, 3rd, Hanover, West Germany, Apr. 28-30, 1980, DGLR Paper 80-082.* 24 p.

The manned remote work station in the open cherry picker (OCP) configuration is discussed with emphasis on its potential application to Spacelab missions. Attention is given to the OCP's potential for enhancing Spacelab sortie mission operations by providing a convenient means of deploying and retracting pallet-mounted experiments, and to its possible use for in-orbit servicing of automated payloads such as the Space Telescope. Also considered is the use of an OCP for the support of construction R&D activities; fabrication and ground simulation are also discussed. J.P.B.

A80-41766 # **Space operations - Future requirements and systems.** W. E. Dean (Rockwell International Corp., Satellite Systems Div., Downey, Calif.). *Deutsche Gesellschaft für Luft- und Raumfahrt and American Astronautical Society, Symposium on Shuttle/Spacelab - The New Transportation System and its Utilization, 3rd, Hanover, West Germany, Apr. 28-30, 1980, DGLR Paper 80-093.* 8 p.

Tools for space operations, such as remotely operated vehicles, remote manipulator systems, and advanced vehicles, are described. Advanced manned operations are considered along with industrial systems in space, including Spacelab, space platforms, material processing R & D, and public service capabilities. Asteroids and lunar prospects are also discussed. V.T.

A80-43216 # **Maintainable maintenance disconnect valve /MMDV/ for on-orbit component replacement.** T. E. Burr, C. K. Boynton, and A. O. Brouillet (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). *American Society of Mechanical Engineers, Intersociety Environmental Systems Conference, San Diego, Calif., July 14-17, 1980, Paper 80-ENAs-42.* 5 p. Members, $1.50; nonmembers, $3.00.

Future long duration space missions will require maintenance disconnect valves to support on-orbit removal and replacement of fluid line components. The Maintainable Maintenance Disconnect Valve (MMDV), a lightweight disconnect valve developed specifically to simplify EVA and IVA zero 'g' fluid component replacement is described. A probe version of the MMDV is examined which simplifies the replacement of small components, such as instruments, in liquid lines. The MMDV is a rugged, compact, positive isolation valve that permits component attachment to fixed plumbing and provides component replacement without liquid spillage or air inclusion. Thus, servicing operations on liquid loops on-orbit can be accomplished without the need for evacuation and backfilling. Applications described include the 25 Kw power system, space operations center, orbital transfer vehicle, and permanent space-based vehicle liquid loops. (Author)

A80-43222 # **EVA equipment for satellite service.** H. R. Griswold and R. C. Wilde (United Technologies Corp., Hamilton Standard Div., Windsor Locks, Conn.). *American Society of Mechanical Engineers, Intersociety Environmental Systems Conference, San Diego, Calif., July 14-17, 1980, Paper 80-ENAs-48.* 10 p. 10 refs. Members, $1.50; nonmembers, $3.00.

Requirements are projected for performing orbital satellite service. Emphasis is on defining the role of Extravehicular Activity (EVA) required to support this future space activity. Specific EVA service techniques and equipment are concepted, building on initial baseline service capability supported by the Shuttle Orbiter, Remote Manipulator System, Extravehicular Mobility Unit, and Manned Maneuvering Unit. New EVA concepts discussed are compatible with current and near-term satellites, projected evolution of the Space Transportation System, and anticipated future space construction requirements. (Author)

A80-46078 **The Remote Manipulator System.** G. L. Borrowman. *Spaceflight,* vol. 21, Dec. 1979, p. 495, 496.

The Remote Manipulator System (RMS) contributed by Canada as a mission-critical element of the Space Shuttle is presented. The manipulator, which is an analog of the human arm, will be used to maneuver cargoes such as astronauts and satellites in its position attached to the Shuttle. The RMS will be controlled from a work station on the Orbiter flight deck. The program is currently on schedule in the final phase of hardware construction, and was due to be delivered to NASA in July 1979 for flight on the third Shuttle test flight. In addition, it has been suggested that manipulator arms be added to the Teleoperator Retrieval System to further complement Shuttle Orbiter capabilities in the field of payload inspection and retrieval. A.L.W.

A80-52466 **The birth of the mechanical spaceman - The Teleoperator Retrieval System.** G. L. Borrowman. *Spaceflight,* vol. 22, Mar. 1980, p. 130, 131, 144.

The Teleoperator Retrieval System (TRS) to be used in conjunction with the Space Shuttle and its applications is discussed. The TRS includes a guidance, navigation and control system, a communications and data management system, a propellant tank, a docking system with two TV cameras, and its own propulsion system. Guidance and control maneuvers could be directed either through pre-programmed computer instruction, or manually by a Shuttle crew member. Transmitting commands to the TRS, receiving and processing telemetry and receiving TV pictures from the TRS would take place in the command station aboard the Orbiter. A.C.W.

N80-23515*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.

A MECHANICAL ADAPTER FOR INSTALLING MISSION EQUIPMENT ON LARGE SPACE STRUCTURES

A. LeFever and R. S. Totah *In* NASA. *Langley Res. Center* Proc. of the 14th Aerospace Mech. Symp. May 1980 p 237-245 refs

Avail: NTIS HC A15/MF A01 CSCL 13I

A mechanical attachment adapter was designed, constructed, and tested. The adapter was was included in a simulation program that investigated techniques for assembling erectable structures under simulated zero-g conditions by pressure-suited subjects in a simulated EVA mode. The adapter was utilized as

an interface attachment between a simulated equipment module and one node point of a tetrahedral structural cell. The mating performance of the adapter, a self-energized mechanism, was easily and quickly demonstrated and required little effort on the part of the test subjects. R.C.T.

N80-23988*# Essex Corp., Huntsville, Ala.
EVA MANIPULATION AND ASSEMBLY OF SPACE STRUCTURE COLUMNS
Tomas E. Loughead and Edwin C. Pruett May 1980 58 p
(Contract NAS8-32989)
(NASA-CR-3285; M-299) Avail: NTIS HC A04/MF A01 CSCL 05H

Assembly techniques and hardware configurations used in assembly of the basic tetrahedral cell by A7LB pressure-suited subjects in a neutral bouyancy simulator were studied. Eleven subjects participated in assembly procedures which investigated two types of structural members and two configurations of attachment hardware. The assembly was accomplished through extra-vehicular activity (EVA) only, EVA with simulated manned maneuvering unit (MMU), and EVA with simulated MMU and simulated remote manipulator system (RMS). Assembly times as low as 10.20 minutes per tetrahedron were achieved. Task element data, as well as assembly procedures, are included. R.E.S.

N80-26366*# Rockwell International Corp., Downey, Calif. Space Operations and Satellite Systems Div.
SPACE ASSEMBLY FIXTURES AND AIDS Final Report
K. A. Bloom and A. N. Lillenas Jul. 1980 198 p refs
(Contract NAS1-15322)
(NASA-CR-159285; SSD-80-0021) Avail: NTIS HC A09/MF A01 CSCL 22A

Concepts and requirements for assembly fixtures and aids necessary for the assembly and maintenance of spare platforms were studied. Emphasis was placed on erectable and deployable type structures with the shuttle orbiter as the assembly base. Both single and multiple orbiter flight cases for the platform assembly were considered. Applicable space platform assembly studies were reviewed to provide a data base for establishing the assembly fixture and aids design requirements, assembly constraints, and the development of representative design concepts. Conclusions indicated that fixture requirements will vary with platform size. Larger platforms will require translation relative to the orbiter RMS working volume. The installation of platform payloads and subsystems (e.g., utility distribution) must also be considered in the specification of assembly fixtures and aids. Author

N80-30086*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MACHINE INTELLIGENCE AND ROBOTICS: REPORT OF THE NASA STUDY GROUP. EXECUTIVE SUMMARY
Sep. 1979 23 p
(NASA-CR-163380; JPL-730-51) Avail: NTIS HC A02/MF A01 CSCL 09B

A brief overview of applications of machine intelligence and robotics in the space program is given. These space exploration robots, global service robots to collect data for public service use on soil conditions, sea states, global crop conditions, weather, geology, disasters, etc., from Earth orbit, space industrialization and processing technologies, and construction of large structures in space. Program options for research, advanced development, and implementation of machine intelligence and robot technology for use in program planning are discussed. A vigorous and long-range program to incorporate and keep pace with state of the art developments in computer technology, both in spaceborne and ground-based computer systems is recommended. J.M.S.

N80-34101*# Hamilton Standard, Windsor Locks, Conn.
EXTRAVEHICULAR CREWMAN WORK SYSTEM (ECWS) STUDY PROGRAM. VOLUME 1: EXECUTIVE SUMMARY Final Report
R. C. Wilde Jul. 1980 58 p 4 Vol.
(Contract NAS9-15290)
(NASA-CR-163597) Avail: NTIS HC A04/MF A01 CSCL 05H

The Extravehicular Crewman Work System (ECWS) requirements for manned support of space construction and satellite service are defined. Characteristics of structures and satellites are described. Requirements for extravehicular tasks and support equipment are defined. Equipment concepts are presented and evaluated for extravehicular life support, spacesuit, and work aids. Preliminary design of recommended ECWS equipment concepts and new technology developments required for their implementation are discussed. S.F.

N80-34102*# Hamilton Standard, Windsor Locks, Conn.
EXTRAVEHICULAR CREWMAN WORK SYSTEM (ECWS) STUDY PROGRAM. VOLUME 2: CONSTRUCTION Final Report
R. C. Wilde Jul. 1980 392 p refs 4 Vol.
(Contract NAS9-15290)
(NASA-CR-163698) Avail: NTIS HC A17/MF A01 CSCL 05H

The construction portion of the Extravehicular Crewman Work System Study defines the requirements and selects the concepts for the crewman work system required to support the construction of large structures in space. S.F.

N80-34103*# Hamilton Standard, Windsor Locks, Conn.
EXTRAVEHICULAR CREWMAN WORK SYSTEM (ECWS) STUDY PROGRAM. VOLUME 3: SATELLITE SERVICE Final Report
R. C. Wilde Jul. 1980 102 p refs 4 Vol.
(Contract NAS9-15290)
(NASA-CR-163599) Avail: NTIS HC A06/MF A01 CSCL 05H

The satellite service portion of the Extravehicular Crewman Work System Study defines requirements and service equipment concepts for performing satellite service from the space shuttle orbiter. Both normal and contingency orbital satellite service is required. Service oriented satellite design practices are required to provide on orbit satellite service capability for the wide variety of satellites at the subsystem level. Development of additional satellite service equipment is required. The existing space transportation system provides a limited capability for performing satellite service tasks in the shuttle payload bay area. S.F.

N80-34104*# Hamilton Standard, Windsor Locks, Conn.
EXTRAVEHICULAR CREWMAN WORK SYSTEM (ECWS) STUDY PROGRAM. VOLUME 4: PROGRAM EVOLUTION Final Report
R. C. Wilde Jul. 1980 141 p refs 4 Vol.
(Contract NAS9-15290)
(NASA-CR-163600) Avail: NTIS HC A07/MF A01 CSCL 05H

The program evaluation portion of the Extravehicular Crewman Work System Study defines the new technology requirements for equipment to support space construction and satellite service in orbit. S.F.

08
PROPULSION

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

A80-32702 * # **Energetic ion beam magnetosphere injection and solar power satellite transport.** S. A. Curtis and J. M. Grebowsky (NASA, Goddard Space Flight Center, Laboratory for Planetary Atmospheres, Greenbelt, Md.). *Journal of Geophysical Research*, vol. 85, Apr. 1, 1980, p. 1729-1735. 21 refs.

The effects of ion beam injection in the magnetosphere are considered. The beam's parameters are those characteristic of the ion propulsion engines envisioned for use in solar power satellite placement (Hanley and Guttman, 1978). Specifically, from a detailed analysis of the beam's propagation through the magnetosphere it is shown that the bulk of the ion beam is not stopped in the magnetosphere. However, the relatively small fraction of the beam which is deposited via the beam's sheath loss may give rise to a large distortion in the magnetospheric plasma population. Possible loss mechanisms from the magnetosphere for this artificial energetic ion component are evaluated. Electron Coulomb scattering yields the shortest lifetime throughout most of the plasmasphere provided that plasmasphere heating by beam ions is not too intense. Charge exchange dominates beyond the plasmasphere. The effects of pitch angle scattering due to beam ion turbulence may appreciably shorten beam ion lifetimes throughout the magnetosphere. (Author)

A80-38972 # **OTV evolution to the 1990s.** D. A. Heald (General Dynamics Corp., Convair Div., San Diego, Calif.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1212.* 5 p.

The broad range of Orbital Transfer Vehicle (OTV) missions includes transfer of very large systems such as Geostationary Platform at low acceleration and manned sortie. Integrating the existing Centaur with STS offers high performance and proven reliability at low development cost for initial missions. An optimized new configuration to satisfy the full range of missions has nearly twice the hydrogen-oxygen propellant capacity. It uses a toroidal oxygen tank to allow payloads up to 30 feet long. An RL10-derivative engine with pumped idle mode is adequate for the current mission model, although a new, higher performance engine would benefit round-trip manned missions. An aerodynamic brake is very advantageous for return missions in that it allows reduction of vehicle size and therefore minimizes STS launches. This single OTV concept satisfies the entire mission model without depending on development of a 100K STS. (Author)

A80-38975 * # **Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures.** T. H. Silva (Aerospace Corp., El Segundo, Calif.) and D. C. Byers (NASA, Lewis Research Center, Cleveland, Ohio). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1223.* 13 p. 17 refs.

The paper discusses a potential application of electric propulsion to perform orbit transfer of a large spacecraft structure to geosynchronous orbit (GEO) from LEO, utilizing a nuclear reactor space power source in the spacecraft on a shared basis. The discussions include spacecraft, thrust system, and nuclear reactor space power system concepts. Emphasis is placed on orbiter payload arrangements, spacecraft launch constraints, and spacecraft LEO assembly and deployment sequences. V.T.

A80-41197 # **Propulsion technology in the 1980's to support space missions to the year 2000.** W. E. Pipes (Martin Marietta Aerospace, Denver, Colo.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1216.* 9 p. 16 refs.

The study presents an assessment of liquid chemical and electric propulsion technology necessary to support the area of large space systems. Liquid chemical propulsion vehicles are discussed along with electric propulsion ones. Comparing electric propulsion to chemical propulsion shows that economic advantages can be obtained when electric propulsion is utilized on very large delivery weight systems. V.T.

A80-41201 * # **Applications of an MPD propulsion system.** R. M. Jones (California Institute of Technology, Jet Propulsion Laboratory, Electrical Power and Propulsion Section, Pasadena, Calif.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1225.* 11 p. 27 refs. Contract No. NAS7-100.

Recent studies of the self-field magnetoplasmadynamic (MPD) thruster indicate that the attainable value of thrust efficiency can be over 50% with argon propellant at 5000 sec. Projections for hydrogen propellant show that the specific impulse may exceed 10,000 sec. Improving performance projections such as these create a need for systems and applications studies to be updated. This paper reviews the configurations for an MPD propulsion system and those missions on which such a system might find application. An MPD propulsion system could be used for: (1) attitude control and stationkeeping of large space structures, (2) interorbit transportation, and (3) interplanetary propulsion. A trajectory analysis of a Saturn Orbiter using a nuclear power supply and an MPD propulsion system is presented. A LEO to GEO MPD-OTV concept is presented that uses a remote source transmitting power to the OTV in the form of microwaves. Trajectory analysis of this latter concept indicates that a payload of 20,000 kg can be delivered to GEO in about 20 days if the MPD propulsion system receives 20 MW of input power. (Author)

A80-41202 * # **Ion thruster plume effects on spacecraft surfaces.** M. R. Carruth, Jr. and Y. S. Kuo (California Institute of Technology, Jet Propulsion Laboratory, Electric Propulsion and Advanced Concepts Group, Pasadena, Calif.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1228.* 12 p. 26 refs. Contract No. NAS7-100.

A charge-exchange plasma, generated by an ion thruster, is capable of flowing upstream from the ion thruster and therefore represents a source of contamination to a spacecraft. An analytical model of the charge-exchange plasma density around a spacecraft is used to estimate the contamination which various spacecraft materials may be exposed to. Measurements of plasma density around an ion thruster are compared to this model. Results of experimental studies regarding the effects on various spacecraft materials' properties due to exposure to expected mercury contamination levels are presented. (Author)

A80-41520 * # **Low thrust transfer of Large Space Systems.** W. J. Ketchum (General Dynamics Corp., Convair Div., San Diego, Calif.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 16th, Hartford, Conn., June 30-July 2, 1980, AIAA Paper 80-1265.* 6 p. Contract No. NAS8-33527.

A study which defined an optimized low-thrust orbit transfer vehicle (OTV) is presented. The objectives of this NASA study were to (1) characterize missions which require or benefit from low-orbit transfer; (2) evaluate and compare candidate low-thrust liquid propulsion orbit transfer vehicle concepts; (3) determine propulsion/system characteristics which have the greatest influence on system suitability/capability; and (4) identify and describe propulsion technology requirements. A computerized optimization procedure was developed to determine the effect of thrust level and transients, number of burns, and payload structure material; a baseline hydrogen/oxygen low thrust OTV configured specifically for orbit

transfer of large space systems was defined. Finally, the requirements for the engine for an optimized low thrust stage and the optimum vehicle for low acceleration missions were specified. A.T.

A80-41767 * # **Solar electric propulsion - A versatile stage for earth orbiting missions.** D. D. Smith and E. D. Webb (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). *Deutsche Gesellschaft für Luft- und Raumfahrt and American Astronautical Society, Symposium on Shuttle/Spacelab - The New Transportation System and its Utilization, 3rd, Hanover, West Germany, Apr. 28-30, 1980, DGLR Paper 80-095.* 15 p. Contract No. NAS8-33754. (LMSC-D758135)

The paper examines recent developments in solar array and ion propulsion systems which make possible the utilization of readily available solar energy for spacecraft propulsion and operation. The Solar Electric Propulsion System (SEPS) stage represents a substantial increase in capability to perform interplanetary and earth orbiting missions due to the combination of high performance and low thrust. SEPS is an important augmentation to the Space Transportation System (STS) for numerous earth orbit missions because it can deliver a greatly increased total satellite mass to a geosynchronous orbit or greatly increase the on-orbit delta V capability. A.T.

A80-41897 * # **Orbital transfer of large space structures with nuclear electric rockets.** T. H. Silva (Aerospace Corp., El Segundo, Calif.) and D. C. Byers (NASA, Lewis Research Center, Electric Thruster Section, Cleveland, Ohio). *American Astronautical Society, Goddard Memorial Symposium, 18th, Washington, D.C., Mar. 27, 28, 1980, Paper 80-083.* 13 p. 17 refs.

This paper discusses the potential application of electric propulsion for orbit transfer of a large spacecraft structure from low earth orbit to geosynchronous altitude in a deployed configuration. The electric power was provided by the spacecraft nuclear reactor space power system on a shared basis during transfer operations. Factors considered with respect to system effectiveness included nuclear power source sizing, electric propulsion thruster concept, spacecraft deployment constraints, and orbital operations and safety. It is shown that the favorable total impulse capability inherent in electric propulsion provides a potential economic advantage over chemical propulsion orbit transfer vehicles by reducing the number of Space Shuttle flights in ground-to-orbit transportation requirements. (Author)

A80-41973 # **Station keeping of geostationary satellites by electric propulsion (Positionshaltung geostationärer Satelliten mit elektrischen Triebwerken).** M. C. Eckstein (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany). *Deutsche Gesellschaft für Luft- und Raumfahrt, Walter-Hohmann-Symposium über Raumflugmechanik, Cologne, West Germany, Mar. 12, 13, 1980, Paper 80-009.* 43 p. 9 refs. In German.

As various types of perturbations tend to drive a geostationary satellite away from its prescribed position, occasional orbit corrections have to be carried out by means of a suitable propulsion system. In future geostationary missions, low thrust electric propulsion is likely to be applied for station keeping because of considerable mass savings. In this paper a station keeping strategy for electric propulsion systems is developed. Both the unconstrained case and the case where thrust operation constraints are present are considered and tested by computer simulation of a realistic example. (Author)

N80-26376*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DISCUSSION MEETING ON GOSSAMER SPACECRAFT (ULTRALIGHTWEIGHT SPACECRAFT) Final Report
Roy G. Brereton, ed. 15 May 1980 186 p refs Meeting held at Pasadena, Calif., 19-20 Dec. 1979

(Contract NAS7-100)
(NASA-CR-163275; JPL-Pub-80-26) Avail: NTIS HC A09/MF A01 CSCL 22B

Concepts, technology, and application of ultralightweight structures in space are examined. Gossamer spacecraft represented a generic class of space vehicles or structures characterized by a low mass per unit area (approximately 50g/sq m). Gossamer concepts include the solar sail, the space tether, and various two and three dimensional large lightweight structures that were deployed or assembled in space. The Gossamer Spacecraft had a high potential for use as a transportation device (solar sail), as a science instrument (reflecting or occulting antenna), or as a large structural component for an enclosure, manned platform, or other human habitats. Inflatable structures were one possible building element for large ultralightweight structures in space. B.D.

N80-30384* Rocketdyne, Canoga Park, Calif.
LEO-TO-GEO LOW THRUST CHEMICAL PROPULSION
J. M. Shoji *In* APL The 1980 JANNAF Propulsion Meeting, Vol. 5 Mar. 1980 p 35-51 refs

(Contract NAS3-21941)
Avail: Issuing Activity CSCL 21H

One approach being considered for transporting large space structures from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) is the use of low thrust chemical propulsion systems. A variety of chemical rocket engine cycles evaluated for this application for oxygen/hydrogen and oxygen/hydrocarbon propellants (oxygen/methane and oxygen/RF-1) are discussed. These cycles include conventional propellant turbine drives, turboalternator/electric motor pump drive, and fuel cell/electric motor pump drive as well as pressure fed engines. Thrust chamber cooling analysis results are presented for regenerative/radiation and film/radiation cooling. J.M.S.

N80-31450*# National Aeronautics and Space Administration, Washington, D. C.
INTRODUCTION: THE CHALLENGE OF OPTIMUM INTEGRATION OF PROPULSION SYSTEMS AND LARGE SPACE STRUCTURES
Richard F. Carlisle *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 1-8

Avail: NTIS HC A15/MF A01 CSCL 21H

A functional matrix of possible propulsion system characteristics for a spacecraft for deployable and assembled spacecraft structures shows that either electric propulsion or low thrust chemical propulsion systems could provide the propulsion required. The trade-off considerations of a single propulsion engine or multiengines are outlined and it is shown that a single point engine is bounded by some upper limit of thrust for assembled spacecraft. The matrix also shows several additional functions that can be provided to the spacecraft if a propulsion system is an integral part of the spacecraft. A review of all of the functions that can be provided for a spacecraft by an integral propulsion system may result in the inclusion of the propulsion for several functions even if no single function were mandatory. Propulsion interface issues for each combination of engines are identified. A.R.H.

N80-31452*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRIC PROPULSION TECHNOLOGY
Robert C. Finke *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 23-30

Avail: NTIS HC A15/MF A01 CSCL 21H

The advanced electric propulsion program is directed towards lowering the specific impulse and increasing the thrust per unit of ion thruster systems. In addition, electrothermal and electromagnetic propulsion technologies are being developed to attempt to fill the gap between the conventional ion thruster and chemical rocket systems. Most of these new concepts are exagenous and are represented by rail accelerators, ablative Teflon thrusters,

MPD arcs, Free Radicals, etc. Endogenous systems such as metallic hydrogen offer great promise and are also being pursued. A.R.H.

N80-31453*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
CHEMICAL PROPULSION TECHNOLOGY
Richard J. Priem *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 31-36

Avail: NTIS HC A15/MF A01 CSCL 21H
An overview of NASA's low thrust liquid chemical propulsion program is presented with particular emphasis on thrust system technology in the ten to one thousand pound thrust range. Key technology issues include high performance of cooled low thrust engines; small cryogenic pumps; multiple starts-shutdowns (10) with slow ramps (approximately 10 seconds); thrust variation - 4/1 in flight and 20/1 between flights; long life (100 hours); improved system weight and size; and propellant selection. A.R.H.

N80-31455*# Martin Marietta Corp., Bethesda, Md.
DOD LOW-THRUST MISSION STUDIES
William E. Pipes *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 53-71
(Contract F04611-79-C-0032)
Avail: NTIS HC A15/MF A01 CSCL 21H
The space transportation system (STS) will be the principal means of launching USAF spacecraft beginning in the 1980's. Since it is manned and reusable it provides new opportunities for unique approaches for cost effective utilization of its capabilities. The STS also places additional requirements and constraints on advanced spacecraft deployment systems that did not previously exist for expandable launch vehicles. To fully utilize these new capabilities designers must be prepared by having cost effective technologies available. Advanced propulsion technology that would provide flexibility, performance, and economic benefits to future Air Force missions was identified. Both electric and chemical propulsion systems are discussed. An LO2/LH2 stage with a torus LO2 tank and 500 lbf pump fed engine is high on the list of propulsion technology. A.R.H.

N80-31456*# General Dynamics Corp., San Diego, Calif.
LOW-THRUST VEHICLES CONCEPT STUDIES
William J. Ketchum *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 73-96
Avail: NTIS HC A15/MF A01 CSCL 21H
Low thrust chemical (hydrogen-oxygen) propulsion systems configured specifically for low acceleration orbit transfer of large space systems were studied in order to provide the required additional data to better compare new, low thrust chemical propulsion systems with other propulsion approaches such as advanced electric systems. Study results indicate that it is cost-effective and least risk to combine the low thrust OTV and stowed spacecraft in a single 65 K shuttle. Mission analysis indicates that there are 25 such missions, starting in 1987. Multiple shuttles (LSS in one, OTV in another) result in a 20% increase in LSS (SBR) diameter over single shuttle launches. Synthesis and optimization of the LSS characteristics and OTV capability resulted in determination of the optimum thrust-to-weight and thrust level. For the space based radar with radial truss arms (center thrust application), the optimum thrust-to-weight (maximum) is 0.1, giving a thrust of 2000 lb. For the annular truss (edge-on thrust application) the structure is not as sensitive, and thrust of 1000 lb appears optimum. For the geoplatform, optimum T/W is .15 (3000 lb thrust). The effects of LSS structure material, weight distribution, and unit area density were evaluated, as were the OTV engine thrust transient and number of burns. A.R.H.

N80-31457*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LOW-THRUST VEHICLE CONCEPT STUDIES
George R. Smolak *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 97-106

Avail: NTIS HC A15/MF A01 CSCL 21H
Part of NASA's orbit transfer vehicle propulsion program is devoted to the development of analytical tools to define propulsion system performance, weight, size, and other parameters, and to develop packing concepts for LSS mission propulsion and payload systems. Packing studies discussed relate to shuttle cargo bay constraints; low thrust engine profile and performance; large space frame concept and weight; low thrust vehicles stowed in shuttle. LSS payload capability, and weight distribution. Further study is needed to determine interactions among propulsion system, payload structures, and shuttle. Low thrust-to-weight ratios are desirable to maximize payload weights and deployed areas. A.R.H.

N80-31458*# Martin Marietta Corp., Bethesda, Md.
PRIMARY PROPULSION/LARGE SPACE SYSTEM INTERACTIONS Progress Report, 20 Sep. 1979 - 20 Sep. 1980
Ralph H. Dergance *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 107-128
(Contract NAS3-21955)
Avail: NTIS HC A15/MF A01 CSCL 21H
Three generic types of structural concepts and nonstructural surface densities were selected and combined to represent potential LSS applications. The design characteristics of various classes of large space systems that are impacted by primary propulsion thrust required to effect orbit transfer were identified. The effects of propulsion system thrust-to-mass ratio, thrust transients, and performance on the mass, area, and orbit transfer characteristics of large space systems were determined. A.R.H.

N80-31465*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRIC PROPULSION AND POWER
David C. Byers *In its* Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 219-228

Avail: NTIS HC A15/MF A01 CSCL 21H
The development of electric propulsion systems is discussed and the benefits of these systems to various space mission requirements are outlined. The characteristics and development status of 8 and 30 cm mercury ion thrusters and solar electric propulsion systems are reported. In addition the advantages of an inert gas thruster for Earth orbital missions are examined and include its capability for operation at higher values of specific impulse, the ease at which it can be integrated with space systems, and it's low pollution potential. M.G.

N80-31467*# Aerojet Liquid Rocket Co., Sacramento, Calif.
LOW-THRUST CHEMICAL ROCKET ENGINE STUDY
Joseph A. Mellish *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 237-261
(Contract NAS3-21940)
Avail: NTIS HC A15/MF A01 CSCL 21H
Parametric data and preliminary designs on liquid rocket engines for low thrust cargo orbit-transfer-vehicles are described and those items where technology is required to enhance the designs are identified. The results of film cooling studies to establish the upper chamber pressure limit are given. The study showed that regen cooling with RP-1 was not feasible over the entire thrust and chamber pressure ranges. The thermal data showed that the RP-1 bulk temperature exceeded the study coking temperature limit of 1010 R. Based upon the results presented, O2/H2 and O2/CH4 regen engine systems and O2/H2 film cooled engines were selected for further study in the system analysis. Six engine design concepts are examined. M.G.

N80-31470*# Rockwell International Corp., Pittsburgh, Pa.
SOLAR ROCKET SYSTEM CONCEPT ANALYSIS Final Report

Jack A. Boddy *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 311-336
(Contract F04611-79-C-0007)
Avail: NTIS HC A15/MF A01 CSCL 21H

The use of solar energy to heat propellant for application to Earth orbital/planetary propulsion systems is of interest because of its performance capabilities. The achievable specific impulse values are approximately double those delivered by a chemical rocket system, and the thrust is at least an order of magnitude greater than that produced by a mercury bombardment ion propulsion thruster. The primary advantage the solar heater thruster has over a mercury ion bombardment system is that its significantly higher thrust permits a marked reduction in mission trip time. The development of the space transportation system, offers the opportunity to utilize the full performance potential of the solar rocket. The requirements for transfer from low Earth orbit (LEO) to geosynchronous equatorial orbit (GEO) was examined as the return trip, GEO to LEO, both with and without payload. Payload weights considered ranged from 2000 to 100,000 pounds. The performance of the solar rocket was compared with that provided by LO2-LH2, N2O4-MMH, and mercury ion bombardment systems. A.R.H.

10
SOLAR POWER SATELLITE SYSTEM

Includes solar power satellite concepts with emphasis upon structures, materials, and controls.

A80-32869 # **SPS emissions and comparison with ambient loadings.** E. Bauer (Institute for Defense Analyses, Arlington, Va.) and K. L. Brubaker (Argonne National Laboratory, Argonne, Ill.). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0883.* 8 p. 10 refs. U.S. Department of Energy Contracts No. 31-109-38-5033; No. 31-109-ENG-38.

This paper provides an overview of propulsion injections into the atmosphere due to Satellite Power System (SPS) transportation vehicles, and relates the magnitudes of these injections to the ambient burdens of the different chemical species. The significance of the different injections is discussed in terms of a dimensionless 'perturbation factor', the magnitude of which is a measure of the expected concentration change relative to the existing ambient concentration. (Author)

A80-32870 # **Tropospheric effects of satellite power systems.** K. L. Brubaker and J. Lee (Argonne National Laboratory, Argonne, Ill.). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0884.* 10 p. 25 refs.

The effects of the launching of large rockets and the existence and operation of ground-based rectennas for satellite solar power systems on the troposphere are discussed. Consideration is given to the effects of the ground cloud produced by the heavy lift launch vehicles and personnel launch vehicles on the atmospheric content and deposition of gaseous air pollutants, the possible meteorological effects of the presence of a rectenna covering approximately 100 sq km on air temperature, local and mesoscale circulation patterns and cloud population, and to inadvertent weather modification caused by the proposed high level of space flight activity. Although environmentally significant ground-level concentrations of nitrogen dioxide, a possible enhancement of convective activity and small weather and climatic effects comparable to other land use changes are expected, no clearly unacceptable environmental effects of satellite solar power stations on the troposphere are identified. A.L.W.

A80-32873 # **SPS-related ionospheric heating.** C. M. Rush (U.S. Department of Commerce, Institute for Telecommunication Sciences, Boulder, Colo.) and L. Duncan (California, University, Los Alamos, N. Mex.). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0890.* 8 p. 7 refs.

A detailed technological program is being undertaken to assess the potential impact of the operation of the Satellite Power System (SPS) on the ionosphere and ionosphere-dependent telecommunication systems. The program revolved around ground-based heating facilities in order to simulate the ionospheric heating expected from SPS operation. The status of this assessment is described, and recent results are presented. Emphasis is on ground-based simulation of SPS ionospheric effects, experimental studies on ionosphere/microwave interactions, and telecommunication studies of SPS impact. S.D.

A80-32875 # **Magnetospheric effects of solar power satellite.** J. B. Cladis, G. T. Davidson (Lockheed Research Laboratories, Palo Alto, Calif.), and H. I. West, Jr. (California, University, Livermore, Calif.). *American Institute of Aeronautics and Astronautics, International Meeting and Technical Display on Global Technology 2000, Baltimore, Md., May 6-8, 1980, Paper 80-0892.* 7 p. 20 refs. Contract No. W-7405-eng-48; Grant No. AF-AFOSR-ISSA-77-12.

During the construction phase of the SPS, large quantities of Ar(+) ions and neutral gases will be injected into the magnetosphere by propulsion devices. The increased plasma density resulting from ion injection will inflate the plasmasphere and the magnetosphere and reduce the size of the statistical auroral oval. Prevailing theories do not account for the dynamical behavior of such electrons during magnetic storms. Recent observational results are discussed. The results indicate that the peak of the relativistic electron distribution may move outward, appreciably increasing the flux in the region of the synchronous orbit. (Author)

A80-32942 **Increasing power input to a single solar power satellite rectenna by using a pair of satellites.** R. V. Gelsthorpe (ERA Technology, Ltd., Leatherhead, Surrey, England) and P. Q. Collins (Imperial College of Science and Technology, London, England). *Electronics Letters,* vol. 16, Apr. 24, 1980, p. 311-313.

An outline of the solar power satellite concept is given, and some remarks are made regarding the desirability of increasing the power handling capability of the receiving site. Three arrangements, each based on the use of a pair of satellites, are described by means of which the power handled by a single site may be doubled. (Author)

A80-36963 # **New directions for future satellite power system /SPS/ concepts.** G. M. Hanley (Rockwell International Corp., Pittsburgh, Pa.). In: Shuttle to the next space age; Proceedings of the Southeast Seminar for Reporters and Teachers, Huntsville, Ala., July 18, 19, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 49-54. (AIAA 79-3069)

Evolution of SPS concepts since initiation of DOE/NASA system studies is described, and directions these concepts may take are discussed. Early SPS studies considered a large matrix of concepts, including several variations of solar thermal and solar photovoltaic concepts as well as nuclear concepts. These studies narrowed down to two solar photovoltaic satellite concepts that are currently the DOE/NASA reference concepts. Recent technology improvements in solid-state transistors and solar cells appear to have a potentially significant impact on future SPS satellite concepts. These impacts are discussed. (Author)

A80-41324 **Solar energy economics - Orbiting reflectors for world energy.** K. W. Billman, W. P. Gilbreath, and S. W. Bowen. In: How big and still beautiful. Macro-engineering revisited. Boulder, Colo., Westview Press, Inc. (AAAS Selected Symposia Series, No. 40), 1980, p. 293-342. 19 refs.

The paper outlines a recent study made on a space-terrestrial solar energy system (SOLARES) consisting of a set of orbiting mirrors that provide nearly continuous reflected sunlight to a world-distributed set of solar conversion sites. This solar concept is examined under the four criteria which any candidate energy system must satisfy: (1) technical feasibility, (2) significant and renewable energy impact, (3) economic feasibility, and (4) social/political acceptability. V.T.

A80-41898 * # **Satellite Power Systems /SPS/ - Overview of system studies and critical technology.** S. V. Manson (NASA, Washington, D.C.). *American Astronautical Society, Goddard Memorial Symposium, 18th, Washington, D.C., Mar. 27, 28, 1980, Paper 80-084.* 20 p. 11 refs.

Systems studies and critical technology issues for the development and evaluation of Satellite Power Systems (SPS) for the photovoltaic generation of electrical energy and its transmission to earth are reviewed. Initial concept studies completed in 1976 and system definition studies initiated in the same year have indicated the technical feasibility of SPS and identified challenging issues to be

addressed as part of the SPS Concept Development and Evaluation Program. Systems considered in the study include photovoltaic and solar thermal power conversion configurations employing klystron or solid state microwave generators or lasers for power transmission, and power transmission options, system constructability and in-orbit and ground operations. Technology investigations are being performed in the areas of microwave power transmission, structure/controls interactions and the behavior of key materials in the space/SPS environment. Favorable results have been obtained in the areas of microwave phase distribution and phase control, dc-RF conversion, antenna radiating element, and no insurmountable problems have been discovered in any of the investigations to date. A.L.W.

A80-41924 # **SPS impacts on the upper atmosphere.** W. E. Gordon (Rice University, Houston, Tex.) and L. M. Duncan (California, University, Los Alamos, N. Mex.). *Astronautics and Aeronautics,* vol. 18, July-Aug. 1980, p. 46-48, 52. 11 refs.

The physical aspects of using a solar power satellite to beam microwaves to a receiving antenna as a source of base load power are addressed. Emphasis is placed on microwave beam interaction with the ionized upper atmosphere and effects on the atmosphere of emissions from heavy-lift launch vehicles needed to carry into space the materials to be assembled into the satellite. Also considered are ohmic heating, wave self-focusing, collisional heating and cooling processes of the ionospheric plasma and possible telecommunication problems. It is found that the beam power density of 23 mW/sq cm originally proposed as a threshold for nonlinear interactions could be doubled to 40 or 50 mW/sq cm. J.P.B.

A80-43836 * **Implications for the UK of solar-power satellites /s.p.s/ as an energy source.** R. M. Shelton (British Aerospace, Dynamics Group, Filton, Glos., England). *IEE Proceedings, Part A - Physical Science, Measurement and Instrumentation, Management and Education, Reviews,* vol. 127, pt. A, no. 5, June 1980, p. 336-343. 13 refs. Research supported by the U.S. Department of Energy and NASA.

The solar power satellite concept which would make the sun's radiation available on earth as a source of energy, is discussed. Attention is given to the concept currently under evaluation in the USA, and also in Europe, though to a lesser extent. The advantages and problems associated with its adoption by the UK as a major source of electrical energy are discussed. The discussion covers topics such as sizing, reference system, and construction, costs, and problem areas. M.E.P.

A80-45534 * # **Dynamics and control of a continuum model for a solar power system.** J. N. Juang (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 163-173. 11 refs. Contract No. NAS7-100. (AIAA 80-1740)

An approach for modeling dynamic equations of motion of a plate attached with rigid bodies is presented. The equations of motion are developed using the principle of virtual work. Lagrange multipliers are used as interaction forces and/or moments to maintain prescribed constraints which is the basis of the interconnection between the plate and rigid bodies. The overall approach is unique in the sense that a continuous model described by a family of partial differential equations is established. An approximate formulation by using variational method is established yielding a solution compatible with the assumed degree of approximation. The formulation is useful particularly when parametric study of dynamic response for a satellite power system is desired. As an example, an approximate governing equation of algebraic eigenvalue problem is given for a dual microwave power transmission system. Controller design is discussed. (Author)

A80-46382 # **The potential global market in 2025 for Satellite Solar Power Stations.** A. Dupas and M. Claverie (CNRS, Paris, France). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 71-76. 25 refs.

Starting from the hypothesis of moderate growth for energy demand through 2000/2025, the market of Large Electrical Power Plants (LEPP) in the range 24-40 TWh/yr suited for base-load electrical needs was computed. A numerical model predicting the future demands for centralized and decentralized electrical energy according to geographical position was developed. The inputs to this model are: the geographical distribution of population at the present time, the energy demand growth in the different world regions, the part of energy consumption used for electricity generation in each world region. The model leads to a world market for LEPP in 2020/2025 of 752/942 plants, which could be provided alternatively by conventional thermal plants, breeder nuclear reactors, fusion reactors or SSPS (Satellite Solar Power Station) among the centralized concepts. (Author)

A80-46387 # **The benefits of solar power satellites.** P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 235-242; Discussion, p. 241, 243. 20 refs.

The development of solar power satellites (SPS) is discussed in light of the benefits the conversion of solar power in space for use on earth would have for terrestrial energy supplies. The SPS reference system adopted for the purposes of economic and environmental assessment studies is outlined, and technological options available for system components are examined. The economics and organizational aspects of SPS are considered, with attention given to cost estimates, financing, and political and social consequences. Results of studies indicating minimal environmental impact of SPS are indicated, although it is noted that especially as regards the biological effects of microwave exposure much work remains to be done. A.L.W.

A80-46396 # **An environmental assessment of the satellite power system reference design.** N. F. Barr (U.S. Department of Energy, Satellite Power Systems Office, Washington, D.C.). In: Space Manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 441-445; Discussion, p. 446.

The paper describes an environmental assessment program which will identify and define environmental issues associated with the installation and operation of Satellite Power Systems (SPS). A joint Concept Development and Evaluation Program (CDEP) of NASA and DOE will provide a plan for ground based R&D work which will also reduce uncertainties regarding environmental impacts. Environmental problems will include: (1) microwave exposure effects on human health and ecosystems, (2) impacts of SPS launch and heat insertions on the atmosphere, and (3) effects of SPS operations on electromagnetic systems and use of the radio spectrum. A.T.

A80-46397 # **Solar power satellites - The ionospheric connection.** L. M. Duncan and J. Zinn (California, University, Los Alamos, N. Mex.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 447-454. 21 refs.

This paper reviews the ionospheric effects and associated environmental impacts which may be produced during the construction and operation of a solar power satellite system. Propellant emissions from heavy lift launch vehicles are predicted to cause wide-spread ionospheric depletions in electron and ion densities. Collisional damping of the microwave power beam in the lower

ionosphere will significantly enhance the local free electron temperatures. Thermal self-focusing of the power beam in the ionosphere will excite variations in the beam power flux density and create large-scale field-aligned electron density irregularities. These large-scale irregularities may also trigger the formation of small-scale plasma striations. Ionospheric modifications can lead to the development of potentially serious telecommunications and climate impacts. A comprehensive research program is being conducted to understand the physical interactions driving these ionospheric effects and to determine the scope and magnitude of the associated environmental impacts. (Author)

A80-46735 **Photovoltaic power generators in space.** K. K. Reinhartz (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands). In: Photovoltaic Solar Energy Conference, 2nd, Berlin, West Germany, April 23-26, 1979, Proceedings. Dordrecht, D. Reidel Publishing Co., 1979, p. 456-468. 19 refs.

A review of the requirements, current technology, and development trends of solar space generators is presented. Requirements for solar generators in space including efficiency, corrosion resistance of solar panels, and resistance to thermal cycling are discussed; the increased efficiencies through the use of lower ohmic base material, shallow junctions to increase blue sensitivity, and nonreflective surfaces to reduce optical losses are described. The reliability of a photovoltaic space solar generator can be affected by failures of interconnections, and 'hot spot' and/or reverse breakdown failures. Solar satellite power systems are considered, noting that compared to conventional terrestrial applications, solar systems must be very light to minimize the transport cost into space and their sensitivity to radiation must be very low. A.T.

A80-46899 * # **Environmental protection of the solar power satellite.** P. H. Reiff, J. W. Freeman (Rice University, Houston, Tex.), and D. L. Cooke. In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 554-576. 26 refs. Research supported by the Brown Foundation; Contract No. NAS8-33023.

This paper examines theoretically several features of the interactions of the Solar Power Satellite (SPS) with its space environment. The leakage currents through the kapton and sapphire solar cell blankets are calculated. At geosynchronous orbit, this parasitic power loss is only 0.7%, and is easily compensated by oversizing. At low-earth orbit, the power loss is potentially much larger (3%), and anomalous arcing is expected for the high-voltage negative surfaces. Preliminary results of a three-dimensional self-consistent plasma and electric field computer program are presented, confirming the validity of the predictions made from the one-dimensional models. Lastly, the paper proposes magnetic shielding of the satellite, to reduce the power drain and to protect the solar cells from energetic electron and plasma ion bombardment. It is concluded that minor modifications from the baseline SPS design can allow the SPS to operate safely and efficiently in its space environment. (Author)

A80-47562 * **Solar power satellites - The present and the future.** G. D. Arndt (NASA, Johnson Space Center, Houston, Tex.). In: ITC/USA/'79; Proceedings of the International Telemetering Conference, San Diego, Calif., November 19-21, 1979. Pittsburgh, Pa., Instrument Society of America, 1979, p. 165-181.

The present reference solar power satellite (SPS) configuration is discussed with emphasis on the microwave subsystems and possible alternatives. Other considerations, including study guidelines, system sizing tradeoffs, mass and cost projections, and environmental factors, are outlined. V.T.

A80-48353 * # **The SPS concept - An overview of status and outlook.** F. C. Schwenk (NASA, Washington, D.C.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1375-1381. 10 refs.

The satellite power system (SPS) concept has been reviewed and assessed in a concept development and evaluation program. This paper presents the results of the assessment in systems definition, environmental factors, social impacts, and comparison of future energy systems. Although no insurmountable objections to SPS have been identified, there remain issues that can be resolved only through further research. B.J.

A80-48354 # **Potential economics of large space based solar power stations.** O. E. Johnson (Boeing Aerospace Co., Seattle, Wash.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 2. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 1384-1389.

The predicted economics of a solar power satellite are compared to those of future conventional power plants (coal fired or nuclear). It is found that transmission of solar power from space is potentially an economic energy alternative for the United States. The details of the comparison are presented. B.J.

A80-50627 **Solaser power.** M. M. Michaelis and P. T. Rumsby (Science Research Council, Rutherford and Appleton Laboratories, Didcot, Berks., England). *Sunworld,* vol. 4, no. 1, 1980, p. 28, 29. 6 refs.

The paper discusses a method of obtaining a 24-hour, all season source of energy: the conversion of solar energy into laser power through an orbiting station. Several diagrams that show the function and process of solaser scheme, including the beaming of laser light after solar radiation is reflected by mirrors in space into a laser, are presented. Attention is given to the computer coding that models the way high-power lasers 'burn holes' in dense plasmas as well as to the effects of solaser interaction with the atmosphere. Several advantages of employing solaser power are discussed such as solasers for burning oil slicks, and cleaning snow from mountain-pass roads and fog from runways. C.F.W.

A80-50633 **Satellite power systems for Western Europe - Problems and solution proposals (Energiesatelliten für Westeuropa - Probleme und Lösungsansätze).** J. Ruth and W. Westphal (Berlin, Technische Universität, Berlin, West Germany). *Zeitschrift für Flugwissenschaften und Weltraumforschung,* vol. 4, July-Aug. 1980, p. 224-230. 12 refs. In German.

This paper deals with the potential utilization of solar satellite power systems (SPS) as baseload powerplants for Western European countries. There are significant differences compared with the U.S.A. for geographical, political, organizational, orbital, and industrial reasons. These differences have been analyzed and critically examined, but no unsurmountable problems have been found. There exist, however, a lot of challenging problems to be solved prior to a full scale SPS development. In this paper some of the most important problems are presented and some potential solutions are discussed. Finally, a research program is proposed, which could help to answer the following question: Is it possible to develop, construct and operate an SPS system which is (1) economically viable, (2) technically feasible, (3) environmentally compatible, and (4) politically acceptable. (Author)

A80-50951 * **The solar power satellite concept - The past decade and the next decade.** C. C. Kraft, Jr. and R. O. Piland (NASA, Johnson Space Center, Houston, Tex.). *Space Solar Power Review,* vol. 1, no. 1-2, 1980, p. 39-65. 20 refs.

10 SOLAR POWER SATELLITE SYSTEM

The concept of using space satellites to collect solar energy for earth use was first proposed in 1968. The present paper summarizes the results of various studies conducted since that time. The concept is now being evaluated by DOE and NASA. This evaluation will result in a recommendation as to whether the concept should be pursued further. A possible plan for the continued exploration of the concept is presented. The initial thrust of this plan would involve laboratory development and testing of selected system elements to answer key technological and environmental questions. (Author)

A80-50952 **Status of the satellite power system concept development and evaluation program.** F. A. Koomanoff (U.S. Department of Energy, Satellite Power System Projects Office, Washington, D.C.) and C. A. Sandahl (Argonne National Laboratory, Washington, D.C.). *Space Solar Power Review*, vol. 1, no. 1-2, 1980, p. 67-77. 22 refs.

This article presents the status of the joint Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA) Satellite Power System (SPS) Concept Development and Evaluation Project (CDEP) as of October 1979. The evaluation procedure is described including the definition of the Reference System for which the assessments (environmental, societal, and comparative) are being made. The provisions for public involvement and information organization and dissemination are described. Some preliminary findings are presented. (Author)

A80-50953 **Rockwell Satellite Power System /SPS/ concept definition studies.** G. M. Hanley (Rockwell International Corp., Pittsburgh, Pa.). *Space Solar Power Review*, vol. 1, no. 1-2, 1980, p. 79-95.

Evolution of SPS concepts since initiation of the DOE/NASA system studies is described. Early studies included solar thermal, solar photovoltaic, and nuclear concepts, all of which had microwave transmission systems. As a result of these earlier studies, three concepts were considered to be viable SPS candidates: (1) a Rankine solar thermal concept, (2) a silicon solar array photovoltaic concept, and (3) a gallium arsenide (GaAs) solar array photovoltaic concept. The Rockwell effort has since been concentrated on the GaAs photovoltaic concept. The major characteristics of this system are described. Alternatives to this system considered during the past year also are described. A summary is presented of ground and space construction, the space transportation system elements, and the SPS program. (Author)

A80-50955 **Feasibility of siting SPS rectennas over the sea.** P. Q. Collins (Imperial College of Science and Technology, London, England). *Space Solar Power Review*, vol. 1, no. 1-2, 1980, p. 133-144. 26 refs.

The feasibility of constructing sea-based rectennas for the reception of satellite power station energy intended to supply western Europe is examined. Three different approaches to the design of such structures are considered, including a rigid piled support structure, an artificial island, and a flexible, floating structure, and the costs of these approaches are estimated. It is shown that cost minimization in a system employing a marine rectenna would require a larger satellite transmitting antenna and a different illumination function across the microwave beam, which would result in energy costs only 10-15% higher than the baseline land-based design. Recommendations are presented concerning further work on the siting of marine rectennas. A.L.W.

A80-50994 # **The first realistic solar energy project (Das erst realistische Sonnenenergie-Projekt).** K. Kaindl and W. Lothaller. *Berichte und Informationen*, vol. 35, no. 4, 1980, p. 16-18. In German.

A proposed solar power satellite uses solar cells to produce electric energy which is sent to the earth as microwaves. An antenna receives the microwaves which can be converted into electric current. The satellite weighs between 35,000 and 50,000 metric tons, and the solar cells consist of silicon or gallium arsenides. The cost for development of the project is discussed, with emphasis on the share of the cost of Europe and particularly for Austria. R.C.

N80-22378*# LinCom Corp., Pasadena, Calif.
SPS PHASE CONTROL SYSTEM PERFORMANCE VIA ANALYTICAL SIMULATION
W. C. Lindsey, A. V. Kantak, C. M. Chie, and R. W. D. Booth
Mar. 1979 222 p refs
(Contract NAS9-15725)
(NASA-CR-160582; TR-7903-0977) Avail: NTIS HC A10/MF A01 CSCL 22A

A solar power satellite transmission system which incorporates automatic beam forming, steering, and phase control is discussed. The phase control concept centers around the notation of an active retrodirective phased array as a means of pointing the beam to the appropriate spot on Earth. The transmitting antenna (spacetenna) directs the high power beam so that it focuses on the ground-based receiving antenna (rectenna). A combination of analysis and computerized simulation was conducted to determine the far field performance of the reference distribution system, and the beam forming and microwave power generating systems. A.R.H.

N80-22779*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE (SPS) SOLID-STATE ANTENNA POWER COMBINER Final Report, 13 Jun. 1979 - 31 Jan. 1980
29 Feb. 1980 108 p ref
(Contract NAS9-15636)
(NASA-CR-160574; D180-25895-1) Avail: NTIS HC A06/MF A01 CSCL 10A

A low loss power-combining microstrip antenna suitable for solid state solar power satellite (SPS) application was developed. A unique approach for performing both the combining and radiating function in a single cavity-type circuit was verified, representing substantial refinements over previous demonstration models in terms of detailed geometry to obtain good matching and adequate bandwidth at the design frequency. The combiner circuit was designed, built, and tested and the overall results support the view that the solid state power-combining antenna approach is a viable candidate for a solid state SPS antenna building block. R.E.S.

N80-22780*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE (SPS) FIBER OPTIC LINK ASSESSMENT Final Report
31 Jan. 1980 102 p refs
(Contract NAS9-15636)
(NASA-CR-160575; D180-25888-1) Avail: NTIS HC A06/MF A01 CSCL 10A

A feasibility demonstration of a 980 MHz fiber optic link for the Solar Power Satellite (SPS) phase reference distribution system was accomplished. A dual fiber-optic link suitable for a phase distribution frequency of 980 MHz was built and tested. The major link components include single mode injection laser diodes, avalanche photodiodes, and multimode high bandwidth fibers. Signal throughput was demonstrated to be stable and of high quality in all cases. For a typical SPS link length of 200 meters, the transmitted phase at 980 MHz varies approximately 2.5 degrees for every deg C of fiber temperature change. This rate is acceptable because of the link length compensation feature of the phase control design. R.E.S.

N80-22861*# New Mexico Univ., Albuquerque. Technology Application Center.
SOLAR POWER SATELLITES. CITATIONS FROM THE INTERNATIONAL AEROSPACE ABSTRACTS DATA BASE Progress Report, 1973 - Nov. 1979
Gerald F. Zollars Dec. 1979 88 p Sponsored by NASA and NTIS

(NASA-CR-162931; PB80-802697) Avail: NTIS HC A05/MF A01 CSCL 10B

This bibliography of 320 citations to the international literature concerns the development of solar power satellites. The design and construction of the satellite solar arrays and the technology of satellite solar energy conversion and transmission to Earth are the major topics covered. Feasibility analyses of the solar power satellite concept are also included. GRA

N80-23348*# Rice Univ., Houston, Tex.
ELECTROSTATIC PROTECTION OF THE SOLAR POWER SATELLITE AND RECTENNA
John W. Freeman, Arthur A. Few, Jr., Patricia H. Reiff, David Cooke, Jerry Bohannon, and Bob Haymes May 1979 157 p
(Contract NAS8-33023)
(NASA-CR-161438) Avail: NTIS HC A08/MF A01 CSCL 22B

Several features of the interactions of the solar power satellite (SPS) with its space environment were examined theoretically. The voltages produced at various surfaces due to space plasmas and the plasma leakage currents through the kapton and sapphire solar cell blankets were calculated. At geosynchronous orbit, this parasitic power loss is only 0.7%, and is easily compensated by oversizing. At low-Earth orbit, the power loss is potentially much larger (3%), and anomalous arcing is expected for the EOTV high voltage negative surfaces. Preliminary results of a three dimensional self-consistent plasma and electric field computer program are presented, confirming the validity of the predictions made from the one dimensional models. Magnetic shielding of the satellite, to reduce the power drain and to protect the solar cells from energetic electron and plasma ion bombardment is considered. It is concluded that minor modifications can allow the SPS to operate safely and efficiently in its space environment. The SPS design employed in this study is the 1978 MSFC baseline design utilizing GaAs solar cells at CR-2 and an aluminum structure. A.R.H.

N80-24344*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
STUDY OF MULTI-kW SOLAR ARRAYS FOR EARTH ORBIT APPLICATION
30 Apr. 1980 334 p
(Contract NAS8-32981)
(NASA-CR-161453; LMSC-D715841) Avail: NTIS HC A14/MF A01 CSCL 22B

Low cost low Earth orbit (LOW) and geosynchronous Earth orbit (GEO) Solar Array concepts in the 300 to 1000 kW range which could be reduced to hardware in the mid 1980's, are identified. Size scaling factors and longer life demands are recognized as the prime drivers for the designs if low life cycle costs for energy are to be achieved. Technology is identified which requires further development in order to assure component readiness and availability. Use of the low concentration ratio (CR) concentrator, which uses gallium arsenide solar cells for both LEO and GEO applications, is recommended. E.D.K.

N80-24515*# Tennessee Univ., Knoxville. Systems and Radar Lab.
SPS ANTENNA POINTING CONTROL
James C. Hung 29 Feb. 1980 84 p refs
(Contract NAS8-33604)
(NASA-CR-161446) Avail: NTIS HC A05/MF A01 CSCL 13I

The pointing control of a microwave antenna of the Satellite Power System was investigated emphasizing: (1) the SPS antenna pointing error sensing method; (2) a rigid body pointing control design; and (3) approaches for modeling the flexible body characteristics of the solar collector. Accuracy requirements for the antenna pointing control consist of a mechanical pointing control accuracy of three arc-minutes and an electronic phased array pointing accuracy of three arc-seconds. Results based on the factors considered in current analysis, show that the three arc-minute overall pointing control accuracy can be achieved in practice. J.M.S.

N80-24757*# Honeywell, Inc., Minneapolis, Minn.
SPECTROPHOTOVOLTAIC ORBITAL POWER GENERATION
Final Report, Aug. 1979 - Feb. 1980
Joan R. Onffroy Feb. 1980 195 p refs
(Contract NAS8-33511)
(NASA-CR-161451; HONEYWELL-80SRC8) Avail: NTIS HC A09/MF A01 CSCL 10A

The feasibilty of a spectrophotovoltaic orbital power generation system that optically concentrates solar energy is demonstrated. A dichroic beam-splitting mirror is used to divide the solar spectrum into two wavebands. Absorption of these wavebands by GaAs and Si solar cell arrays with matched energy bandgaps increases the cell efficiency while decreasing the amount of heat that must be rejected. The projected cost per peak watt if this system is $2.50/W sub p. R.E.S.

N80-24798*# Rockwell International Corp., Huntsville, Ala.
STUDY OF MULTI-kW SOLAR ARRAYS FOR EARTH ORBIT APPLICATIONS: MIDTERM PERFORMANCE REVIEW
26 Jul. 1979 98 p
(Contract NAS8-32988)
(NASA-CR-161467) Avail: NTIS HC A05/MF A01 CSCL 10A

Planar and concentrator solar array concepts capable of providing 300 kW to 1000 kW in low Earth orbit applications in the 1987 time period at an array recurring cost less than or equal to thirty dollars per watt are examined. Silicon and gallium arsenide solar cell applicability are evaluated. On-orbit maintenance by space shuttle is also investigated. Design configurations for the solar arrays and solar cells are recommended. R.E.S.

N80-25360*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THE SOLAR POWER SATELLITE CONCEPTS: THE PAST DECADE AND THE NEXT DECADE
Christopher C. Kraft, Jr. Jul. 1979 22 p Presented at the 15th AIAA Ann. Meeting and Tech. Display, Washington, D.C., 6-8 Feb. 1979 Original contains color illustrations
(NASA-TM-81000; JSC-14898) Avail: NTIS HC A02/MF A01 CSCL 22B

Results of studies on the solar power satellite concept are summarized. The basic advantages are near continuous access to sunlight and freedom from atmospheric effects and cloud cover. The systems definition studies consider photovoltaic and thermal energy conversion systems and find both to be technically feasible, with the photovoltaic approach preferred. A microwave test program is under way which will provide quantitative data on critical parameters, including beam forming and steering accuracy. Ballistic and winged launch vehicles are defined for the transportation of construction materials, with the shuttle expected to provide low cost transportation to and from space. A reference system is outlined for evaluating the concept in terms of environmental and other considerations. Preliminary estimates of natural resource requirements and energy payback intervals are encouraging. E.D.K.

N80-25364# Battelle Columbus Labs., Ohio.
PRELIMINARY MATERIALS ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS)
R. R. Teeter and W. M. Jamieson Jan. 1980 131 p refs
(Contract W-7405-eng-92)
(DOE/ER-0038) Avail: NTIS HC A07/MF A01

Presently, there are two SPS reference design concepts (one using silicon solar cells, the other using gallium arsenide solar cells). A materials assessment of both systems was performed based on the materials lists set forth in the DOE/NASA SPS Reference System Report: Concept Development and Evaluation Program. This listing identified 22 materials used in the SPS. Tracing the production processes for these 22 materials, a total demand for over 20 different bulk materials and nearly 30 raw materials was revealed. Assessment of these SPS material requirements produced a number of potential material supply problems. The more serious problems are those associated with the solar cell materials, and the graphite fiber required for the

satellite structure and space construction facilities. In general, the gallium arsenide SPS option exhibits more serious problems than the silicon option, possibly because gallium arsenide technology is not as well developed as that for silicon. DOE

N80-25365# Aerospace Corp., El Segundo, Calif. Space Sciences Lab.
EFFECTS OF CONSTRUCTION AND OPERATION OF A SATELLITE POWER SYSTEM UPON THE MAGNETOSPHERE Final Report
Y. T. Chiu, J. G. Luhmann, M. Schulz, and J. M. Cornwall (California Univ., Los Angeles) 1 Dec. 1979 80 p refs Prepared for Argonne National Lab., Ill.
(Contract W-31-109-eng-38)
(ATR-80(7824)-1) Avail: NTIS HC A05/MF A01

Exhaust emisions from propulsion and stationkeeping activities of SPS spacecraft induce substantial modifications of magnetospheric processes on both the local and the global scale. This is primarily because of the relatively large mass and energy contents of these emmisions when compared with the total mass and energy contents of the inner magnetosphere. The sources of these emmisions are the argon plasma jet from the solar electric propulsion modules of the cargo orbit transfer vehicle and the H2O neutral exhaust for LO2/LH main engines of the personnel orbit transfer vehicles. Assessment of the SPS scenario, based on presently known physical mechanisms operative in plasma and neutral injection in the magnetosphere, indicates that the major part of the exhaust emmissions are likely to be deposited inside the magnetosphere. DOE

N80-25874# Department of Energy, Washington, D. C. Office of Energy Research.
PRELIMINARY ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS), REVISION 1. VOLUME 1: EXECUTIVE SUMMARY
Jan. 1980 64 p refs
(DOE/ER-0036/1) Avail: NTIS HC A04/MF A01

A preliminary assessment of the environmental impacts of the proposed satellite power system (SPS) is summarized. In this system, satellites would collect solar energy in space, convert it to microwaves, and transmit the microwaves to receiving antennas (rectennas) on Earth. At the rectennas, the microwaves would be converted to electricity. The assessment considers microwave and nonmicrowave effects on the terrestrial environment and human health, atmospheric effects, and disruption of communications and other electromagnetic systems. DOE

N80-26004# Argonne National Lab., Ill.
PROCEEDINGS OF THE WORKSHOP ON METEOROLOGICAL EFFECTS OF SATELLITE POWER SYSTEM RECTENNA OPERATION AND RELATED MICROWAVE TRANSMISSION PROBLEMS
Dec. 1979 58 p refs Workshop held at Rosemont, Ill., 23 Aug. 1978 Sponsored by DOE
(CONF-7808114) Avail: NTIS HC A04/MF A01

From Workshop on Meteorological Effects of Satellite Power Systems Rectenna Operation and Related Microwave Transmission Problems: Rosemont, IL, USA (23 Aug. 1978). Discussion at the workshop concentrated on the effects of the Satellite Power System (SPS) on the atmosphere and the effects of the atmosphere on the SPS microwave beam propagation. The three main concerns were the effects on the atmosphere of the estimated 750 MW excess heat released at the SPS rectanna site, the microwave interactions with the atmosphere, possibly causing loss of beam control and scattering of beam energy, and the possible effects of the beam on atmospheric electrification processes. Construction of a rectenna will modify the thermal and radiative properties of the ground, and operations will introduce a heat source at the surface. It was generally agreed that the direct effects of any single causes due to an SPS in the lower atmosphere will be small but detectable in some instances, and that their combined effects need better definition. Variations in the refractive index of the atmosphere and the presence of hydrometeors in the atmosphere cause refraction, scattering, and adsorption of electromagnetic waves. Refractive-index anomalies in the atmosphere may impact on power beam control. The effect of the rectenna waste heat may be studied on two scales: the mesoscale (regional and city sizes, 10 to 100 km) and the cloud scale (10 km and less). At 2.45 GHz the refractive index of air at fixed pressure depends mostly on water vapor and temperature. In the presence of convective or turbulent air motions a spectrum of atmospheric refractivity develops. These variations can lead to beam wandering and spreading. Direct interactions with the atmospheric electricity fields are not thought to be crucial at the 2.45 GHz frequency. However, the mere physical presence of the rectenna might have some modifying influence on the occurrence and electrical behavior of thunderstorms over and around the rectenna. DOE

N80-26785*# Raytheon Co., Waltham, Mass. Microwave and Power Tube Div.
MICROWAVE BEAMED POWER TECHNOLOGY IMPROVEMENT Final Report
W. C. Brown 15 May 1980 48 p
(Contracts NAS7-100)
(NASA-CR-163043; JPL-9950-373; PT-5613) Avail: NTIS HC A03/MF A01

The magnetron directional amplifier was tested for (1) phase shift and power output as a function of gain, anode current, and anode voltage, (2) background noise and harmonics in the output, (3) long life potential of the magnetron cathode, and (4) high operational efficiency. Examples of results were an adequate range of current and voltage over which 20 dB of amplification could be obtained, spectral noise density 155 dB below the carrier, 81.7% overall efficiency, and potential cathode life of 50 years in a design for solar power satellite use. A fabrication method was used to fabricate a 64 slot, 30 in square slotted waveguide array module from 0.020 in thick aluminum sheet. The test results on the array are discussed. J.M.S.

N80-26836# Department of Energy, Washington, D. C. Office of Energy Research.
PRELIMINARY ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS), REVISION 1. VOLUME 2: DETAILED ASSESSMENT
Jan. 1980 205 p refs
(DOE/ER-00362-Vol-2) Avail: NTIS HC A10/MF A01

The satellite power system (SPS) collects solar energy through a system of satellites in space and transfers this energy to Earth. A reference system is described that converts the energy to microwaves and transmit the microwave energy via directive antennas to large receiving/rectifying antennas (rectennas) located on the Earth. At the rectennas, the microwave energy is converted into electricity. The key environmental issues associated with the SPS which concern human health and safety, ecosystems, climate, and electromagnetic systems interactions are addressed. Microwave-radiation health and ecological effects; nonmicrowave health and ecological effects; atmospheric effects; effects on communication systems due to ionospheric disturbance, and electromagnetic compatibility are among the factors discussed. DOE

N80-27404# Department of Energy, Washington, D. C. Office of Energy Research.
SATELLITE POWER SYSTEMS (SPS): CONCEPT DEVELOPMENT AND EVALUATION PROGRAM, PRELIMINARY ASSESSMENT
Sep. 1979 21 p refs
(DOE/ER-0041) Avail: NTIS HC A02/MF A01

Preliminary results of a DOE-NASA 3-year study of satellite solar energy conversion and microwave transmission to Earth are presented. The assessment includes technical and economic feasibility; the effects of the microwave power transmission beam on biological, ecological, and electromagnetic systems; the impact of SPS construction, deployment and operations on the biosphere and on society; and the merits of SPS compared to other future energy alternatives. DOE

N80-27809*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY. VOLUME 1: EXECUTIVE SUMMARY, PHASE 3 Final Report, Dec. 1979 - May 1980
Jun. 1980 69 p refs 5 Vol.
(Contract NAS9-15636)
(NASA-CR-160742; D180-25969-1-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 10A

Results of a three phase study of the Solar Power Satellite System are summarized. Various options and alternate systems were considered and the following conslusions were reached: antenna mounted solid state transmitters are potentially as cost effective as the klystron approach, althrough limited to 2500 megawatts net output; the free electron laser and optical diode laser appear most promising for laser power transmission; ground antenna siting need not be restricted to below 35 degrees of latitude; and nonrecurring cost reductions attainable by using a smaller Heavy Lift Launch Vehicle are highly attractive. L.F.M.

N80-27810*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY. VOLUME 2, PART 3: FINAL BRIEFING, 16 MAY 1980, PHASE 3
Jun. 1980 410 p 5 Vol.
(Contract NAS9-15636)
(NASA-CR-160743; D180-25969-2-Vol-2) Avail: NTIS HC A18/MF A01 CSCL 10A

Alternatives to the microwave transmission system previously defined Solar Power Satellite Systems were investigated. These were the laser power transmission, transportation systems, and an analysis or solid state power transmission. The advantages of each system are presented. F.O.S.

N80-27811*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY. VOLUME 3: LASER SPS ANALYSIS, PHASE 3 Final Report, Dec. 1979 - May 1980
Jun. 1980 99 p refs 5 Vol.
(Contract NAS9-15636)
(NASA-CR-160744; D180-25969-3-Vol-3) Avail: NTIS HC A05/MF A01 CSCL 10A

The potential use of lasers for transmitting power to Earth from Solar Power Satellites was examined. Free electron lasers appear most promising and would have some benefits over microwave power transmission. Further research in laser technology is needed. L.F.M.

N80-27812*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY. VOLUME 4: SOLID STATE SPS ANALYSIS, PHASE 3 Final Report, Dec. 1979 - May 1980
Jun. 1980 79 p 5 Vol.
(Contract NAS9-15636)
(NASA-CR-160745; D180-25969-4-Vol-4) Avail: NTIS HC A05/MF A01 CSCL 10A

A 2500 megawatt solid ground output Solar Power Satellite (SPS) of conventional configuration was designed and analyzed. Because the power per receiving antenna is halved, as compared with the klystron reference, twice the number of receiving antennas are needed to deliver the same total power. The solid state approach appears feasible with a slightly greater specific mass and slightly higher cost than the klystron SPS design. L.F.M.

N80-27813*# Boeing Aerospace Co., Seattle, Wash.
SOLAR POWER SATELLITE SYSTEM DEFINITION STUDY. VOLUME 5: SPACE TRANSPORTATION ANALYSIS, PHASE 3 Final Report, Dec. 1979 - May 1980
Jun. 1980 153 p refs 5 Vol.
(Contract NAS9-15636)
(NASA-CR-160746; D180-25969-5-Vol-5) Avail: NTIS HC A08/MF A01 CSCL 10A

A small Heavy Lift Launch Vehicle (HLLV) for the Solar Power Satellites (SPS) System was analyzed. It is recommended that the small HLLV with a payload of 120 metric tons be adopted as the SPS launch vehicle. The reference HLLV, a shuttle-derived option with a payload of 400 metric tons, should serve as a backup and be examined further after initial flight experience. The electric orbit transfer vehicle should be retained as the reference orbit-to-orbit cargo system. L.F.M.

N80-29842*# National Aeronautics and Space Administration, Washington, D. C.
SATELLITE POWER SYSTEMS (SPS): CONCEPT DEVELOPMENT AND EVALUATION PROGRAM: PRELIMINARY ASSESSMENT
DOE Sep. 1979 19 p refs Sponsored by DOE
(NASA-TM-81142; DOE/ER-0041) Avail: NTIS HC A02/MF A01 CSCL 10A

A preliminary assessment of a potential Satellite Power System (SPS) is provided. The assessment includes discussion of technical and economic feasibility; the effects of microwave power transmission beams on biological, ecological, and electromagnetic systems; the impact of SPS construction, deployment, and operations on the biosphere and on society; and the merits of SPS compared to other future energy alternatives. L.F.M.

N80-29878# European Space Research and Technology Center, Noordwijk (Netherlands).
EUROPEAN TECHNOLOGY APPLICABLE TO SOLAR POWER SATELLITE SYSTEMS (SPS)
H. Stoewer 1979 24 p refs Presented at the 30th Congr. of the Intern. Astronautical Federation, Munich, 16 Sep. 1979 (INKA-Conf-79-378-046; CONF-7909124-1; IAF-79-174) Avail: NTIS (US Sales Only) HC A02/MF A01; DOE Depository Libraries

The Solar Power Satellite System (SPS) stands for a concept which is intended to collect energy in Earth orbit, transmit it to the Earth and convert it on the ground into electric energy. This paper summarizes European space technology activities that might have potential for application in a possible future Solar Power Satellite System (SPS) program. Before a decision in favor of or against an SPS development program can be made, several critical technology areas must be investigated in order to assess with a reasonable degree of confidence the potential benefits, cost and development risks associated with an SPS. Existing and developing European space technologies are compared with the expected requirements of a study assessment and early key technology verification investigations for SPS concept. It is shown that a number of existing European space technologies and the results of current development efforts apply well to this. However, very substantial advances in almost all technological areas will be necessary before a prudent decision for implementation of an SPS can be made. DOE

N80-29886*# Argonne National Lab., Ill. Integrated Assessments and Policy Evaluations Group.
PRELIMINARY COMPARATIVE ASSESSMENT OF LAND USE FOR THE SATELLITE POWER SYSTEM (SPS) AND ALTERNATIVE ELECTRIC ENERGY TECHNOLOGIES
D. E. Newsom and T. D. Wolsko Apr. 1980 26 p refs Sponsored by NASA
(Contract W-31-109-eng-38)
(NASA-CR-163327; DOE/ER-0054) Avail: NTIS HC A03/MF A01 CSCL 10A

A preliminary comparative assessment of land use for the satellite power system (SPS), other solar technologies, and alternative electric energy technologies was conducted. The alternative technologies are coal gasification/combined-cycle, coal fluidized-bed combustion (FBC), light water reactor (LWR), liquid metal fast breeder reactor (LMFBR), terrestrial photovoltaics (TPV), solar thermal electric (STE), and ocean thermal energy conversion (OTEC). The major issues of a land use assessment are the quantity, purpose, duration, location, and costs of the required land use. The phased methodology described treats the first four issues, but not the costs. Several past efforts are comparative or single technology assessment are reviewed briefly. The current state of knowledge about land use is described for each technology. Conclusions are drawn regarding deficiencies in the data on comparative land use and needs for further research. DOE

N80-29887*# Argonne National Lab., Ill. Integrated Assessment and Policy Evaluation Group.
SELECTION OF ALTERNATIVE CENTRAL-STATION TECHNOLOGIES FOR THE SATELLITE POWER SYSTEM (SPS) COMPARATIVE ASSESSMENT
Michael E. Samsa Apr. 1980 19 p Sponsored by NASA
(Contract W-31-109-eng-38)
(NASA-CR-163328; DOE/ER-0052) Avail: NTIS HC A02/MF A01 CSCL 10A

An important effort is the Satellite Power System (SPS) comparative Assessment is the selection and characterization of alternative technologies to be compared with the SPS concept. The ground rules, criteria, and screening procedure applied in the selection of those alternative technologies are summarized. The final set of central station alternatives selected for comparison with the SPS concept includes: (1) light water reactor with improved fuel utilization, (2) conventional coal combustion with improved environmental controls, (3) open cycle gas turbine with integral low Btu gasifier, (4) terrestrial photovoltaic, (5) liquid metal fast breeder reactor, and (6) magnetic confinement fusion. DOE

N80-29897*# PRC Energy Analysis Co., McLean, Va.
SOME QUESTIONS AND ANSWERS ABOUT THE SATELLITE POWER SYSTEM (SPS)
Jan. 1980 46 p refs Sponsored by NASA
(Contract DE-AC01-79ER-10041)
(NASA-CR-163329; DOE/ER-0049/1) Avail: NTIS HC A03/MF A01 CSCL 10A

Progress in the evaluation of the concept of obtaining significant amount of electrical energy from space through the Satellite Power System is reported. The Concept Development and Evaluation Program plan is described including: systems definition, environmental assessment, societal assessment, and comparative assessment. DOE

N80-29900*# Department of Energy, Washington, D. C. Office of Energy Research.
SATELLITE POWER SYSTEM (SPS) FY 79 PROGRAM SUMMARY
Jan. 1980 200 p refs
(NASA-CR-163479; DOE/ER-0037) Avail: NTIS HC A09/MF A01 CSCL 10A

The Satellite Power System (SPS) program a joint effort to develop an initial understanding of the technical feasibility, the economic practicality, and the social and environmental acceptability of the SPS concept is discussed. This is being accomplished through implementation of the Concept Development and Evaluation Program Plan which is scheduled for completion by the end of FY 1980. This Program Summary not only covers FY 1979 but includes work completed in FY 1977 and FY 1978 in order to give a comprehensive picture of the DOE involvement in the SPS concept development and evaluation process. DOE

N80-30891*# Rice Univ., Houston, Tex.
SOLAR POWER SATELLITE OFFSHORE RECTENNA STUDY Final Report
May 1980 284 p refs Prepared in cooperation with Brown and Root Development, Inc., Houston, Tex. and Little (Arthur D.), Inc., Cambridge, Mass.
(Contract NAS8-33023)
(NASA-CR-161543) Avail: NTIS HC A13/MF A01 CSCL 10A

Offshore rectennas are feasible and cost competitive with land rectennas but the type of rectenna suitable for offshore use is quite different from that specified in the present reference system. A nonground plane design minimizes the weight and greatly reduces the number of costly support towers. This perferred design is an antenna array consisting of individually encapsulated dipoles with reflectors or tagis supported on feed wires. Such a 5 GW rectenna could be built at a 50 m water depth site to withstand hurricane, winter storm, and icing conditions for a one time cost of $5.7 billion. Subsequent units would be about 1.3 less expensive. More benign and more shallow water sites would result in substantially lower costs. The major advantage of an offshore rectenna is the removal of microwave radiation from populated areas. L.F.M.

N80-30897*# Raytheon Co., Waltham, Mass. Microwave and Power Tube Div.
SATELLITE POWER SYSTEM (SPS) MAGNETRON TUBE ASSESSMENT STUDY Final Performance Review
12 Aug. 1980 99 p refs
(Contract NAS8-33157)
(NASA-CR-161547; MA03) Avail: NTIS HC A05/MF A01 CSCL 10A

Taks performed to extend the data base and to define a technology development program for the magnetron directional amplifier for the SPS are reviewed. These include: (1) demonstrating the tracking of phase and amplitude of the microwave output to phase and amplitude references; (2) expanding the range of power over which the directional amplifier will operate; (3) recognizing the importance of amplitude control in overall system design and in simplifying power conditioning; (4) developing a preliminary design for the overall architecture of the power module; (5) demonstrating magnetron starting using the amplitude control system; (6) mathematically modelling and performing a computerized study of the pyrolytic graphite radiating fin; (7) defining the mass of the magnetic circuit for the SPS tube; (8) noise measurement; (9) achieving harmonic suppression by notch reflection filters; (10) estimating the mass of the transmitting antenna; (11) developing a magnetron package with power generation, phase control, and power condition functions; and (12) projecting magnetron package characteristics. A.R.H.

N80-30898*# ECON, Inc., Princeton, N. J.
SPS SALVAGE AND DISPOSAL ALTERNATIVES Final Report
30 Jun. 1980 90 p refs
(Contract NAS8-33783)
(NASA-CR-161548; Rept-80-1489) Avail: NTIS HC A05/MF A01 CSCL 10A

A wide range of salvage options exist for the satellite power system (SPS) satellite, ranging from use in and beyond geosynchronous orbit to use in low Earth orbit to return and use on Earth. The satellite might be used intact to provide for various purposes, it might be cannibalized, or it might be melted down to supply materials for space- or ground-based products. The use of SPS beyond its nominal lifetime provides value that can be deducted from the SPS capital investment cost. It is shown that the present value of the salvage value of the SPS satellites, referenced to the system initial operation data, is likely to be on the order of five to ten percent of its on-orbit capital cost. (Given a 30 year satellite lifetime and a four percent discount rate, the theoretical maximum salvage value is 30.8 percent of the initial capital cost). The SPS demonstration satellite is available some 30 years earlier than the first full-scale SPS satellite and has a likely salvage value on the order of 80 percent of its on site capital cost. In the event that it becomes desirable to dispose of either the demomstration or full-scale SPS satellite, a number of disposal options appear to exist for which intact disposal costs are less than one percent of capital costs. L.F.M.

N80-30900*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 7: SYSTEM/SUBSYSTEM REQUIREMENTS DATA BOOK Final Report
G. M. Hanley Sep. 1980 120 p
(Contract NAS8-32475)
(NASA-CR-3324; SSD-79-0010-7-Vol-7) Avail: NTIS HC A06/MF A01 CSCL 10A

The identified subsystem/systems requirements are defined for the solar power satellites. Recommendations for alternate approaches which may represent improved design features are presented. T.M.

N80-30901*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report

G. M. Hanley Washington NASA Sep. 1980 67 p refs 7 Vol.
(Contract NAS8-32475)
(NASA-CR-3317; SSD-79-0010-1-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 10A

System definition studies resulted in a further definition of the reference system using gallium arsenide solar arrays, analysis of alternative subsystem options for the reference concept, preliminary solid state microwave concept studies, and an environmental analysis of laser transmission systems. The special emphasis studies concentrated on satellite construction, satellite construction base definition, satellite construction base construction, and rectenna construction. Major emphasis in the transportation studies was put on definition of a two stage parallel burn, vertical takeoff/horizontal landing concept. The electric orbit transfer vehicle was defined in greater detail. Program definition included cost analyses and schedule definition. T.M.

N80-30916# Argonne National Lab., Ill. Energy and Environmental Systems Div.
COMPARATIVE ANALYSIS OF NET ENERGY BALANCE FOR SATELLITE POWER SYSTEMS (SPS) AND OTHER ENERGY SYSTEMS
R. R. Cirillo, B. S. Cho, M. R. Monarch, and E. P. Levine Apr. 1980 143 p refs
(Contract W-31-109-eng-38)
(DOE/ER-0056) Avail: NTIS HC A07/MF A01

The net energy balance of seven electric energy systems is assessed: two coal-based, one nuclear, two terrestrial solar, and two solar power satellites, with principal emphasis on the latter two systems. Solar energy systems require much less operating energy per unit of electrical output. However, on the basis of the analysis used here, coal and nuclear systems are two to five times more efficient at extracting useful energy from the primary resource base than are the solar energy systems. The payback period for all systems is less than 1.5 years, except for the terrestrial photovoltaic (19.8 yr) and the solar power satellite system (6.4 yr), both of which rely on energy-intensive silicon cells. DOE

N80-31435# Battelle Pacific Northwest Labs., Richland, Wash.
WORKSHOP ON SATELLITE POWER SYSTEMS (SPS) EFFECTS ON OPTICAL AND RADIO ASTRONOMY
G. M. Stokes and P. A. Ekstrom Apr. 1980 273 p refs Conf. held at Seattle, May 1979
(Contract EY-76-C-06-1830)
(CONF-7905143) Avail: NTIS HC A12/MF A01

The impacts of the satellite solar power system on astronomy are concluded to be: increased sky brightness, reducing the effective aperture of terrestrial telescopes; microwave leakage radiation causing erroneous radioastronomical signals; direct overload of radioastronomical receivers at centimeter wavelengths; and unintentional radio emissions associated with massive amounts of microwave power or with the presence of large, warm structures in orbit causing the satellites to appear as individual stationary radio sources; finally, the fixed location of the geostationary satellite orbits would result in fixed regions of the sky being unusable for observations. DOE

N80-31466*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ELECTRIC PROPULSION FOR SPS
Earle M. Crum *In* NASA. Lewis Research Center Large Space Systems/Low-Thrust Propulsion Technol. Jul. 1980 p 229-236

Avail: NTIS HC A15/MF A01 CSCL 21C

The design and characteristics of the solar power satellite electric propulsion system are described. Both the payload powered orbital transfer vehicle and the independent powered transfer vehicle configuations are discussed. Mass estimates for the system, the average cost per system unit, and the cost per flight estimates are also given. M.G.

N80-31890*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 2, PART 1: SYSTEM ENGINEERING Final Report
G. M. Hanley Washington Sep. 1980 258 p 7 Vol.
(Contract NAS8-32475)
(NASA-CR-3318; SSD-79-0010-2-1) Avail: NTIS HC A12/MF A01 CSCL 10A

Top level trade studies are presented, including comparison of solid state and klystron concepts, higher concentration on the solar cells, composite and aluminum structure, and several variations to the reference concept. Detailed trade studies are presented in each of the subsystem areas (solar array, power distribution, structures, thermal control, attitude control and stationkeeping, microwave transmission, and ground receiving station). A description of the selected point design is also presented. Author

N80-31891*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 4: TRANSPORTATION ANALYSIS Final Report
G. M. Hanley Washington NASA Sep. 1980 270 p refs
(Contract NAS8-32475)
(NASA-CR-3321; SSD-79-0010-4-Vol-4) Avail: NTIS HC A12/MF A01 CSCL 10A

Transportation system elements were synthesized and evaluated on the basis of their potential to satisfy overall satellite (SPS) transportation requirements and of their sensitivities, interfaces, and impact on the SPS. Additional analyses and investigations were conducted to further define transportation system concepts that will be needed for the developmental and operational phases of an SPS program. To accomplish these objectives, transportation systems such as shuttle and its derivatives have been identified; new heavy lift launch vehicle concepts, cargo and personnel orbital transfer vehicles and intra-orbit transfer vehicle concepts have been evaluated. To a limited degree, the program implications of their operations and costs were assessed. The results of these analyses have been integrated into other elements of the overall SPS concept definition studies. T.M.

N80-31951*# Argonne National Lab., Ill. Integrated Assessments and Policy Evaluations Group.
METHODOLOGY FOR THE COMPARATIVE ASSESSMENT OF THE SATELLITE POWER SYSTEM (SPS) AND ALTERNATIVE TECHNOLOGIES
T. Wolsko, W. Buehring, R. Cirillo, J. Gasper, L. Habegger, K. Hub, D. Newsom, M. Samsa, E. Stenehjem, and R. Whitfield Jan. 1980 79 p refs Sponsored by NASA
(Contract W-31-109-eng-38)
(NASA-CR-163049; DOE/ER-0051) Avail: NTIS HC A05/MF A01

The energy systems concerned are the satellite power system, several coal technologies, geothermal energy, fission, fusion, terrestrial solar systems, and ocean thermal energy conversion. Guidelines are suggested for the characterization of these systems, side-by-side analysis, alternative futures analysis, and integration and aggregation of data. A description of the methods for assessing the technical, economic, environmental, societal, and institutional issues surrounding the development of the selected energy technologies is presented. DOE

N80-32859*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 6: IN-DEPTH ELEMENT INVESTIGATION Final Contractor Report
G. M. Hanley Sep. 1980 97 p refs
(Contract NAS8-32475)
(NASA-CR-3323; SSD-79-0010-6) Avail: NTIS HC A05/MF A01 CSCL 10A

The fabrication parameters of GaAs MESFET solid-state amplifiers considering a power added conversion efficiency of at least 80% and power gains of at least 10dB were determined. Operating frequency was 2.45 GHz although 914 MHz was also

considered. Basic circuit to be considered was either Class C or Class E amplification. Two modeling programs were utilized. The results of several computer calculations considering differing loads, temperatures, and efficiencies are presented. Parametric data in both tabular and plotted form are presented. T.M.

N80-32860*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEM (SPS) CONCEPT DEFINITION STUDY. VOLUME 3: EXPERIMENTAL VERIFICATION DEFINITION Final Contractor Report
G. M. Hanley Sep. 1980 145 p
(Contract NAS8-32475)
(NASA-CR-3320; SSD-79-0010-3) Avail: NTIS HC A07/MF A01 CSCL 10A

An evolutionary Satellite Power Systems development plan was prepared. Planning analysis was directed toward the evolution of a scenario that met the stated objectives, was technically possible and economically attractive, and took into account constraining considerations, such as requirements for very large scale end-to-end demonstration in a compressed time frame, the relative cost/technical merits of ground testing versus space testing, and the need for large mass flow capability to low Earth orbit and geosynchronous orbit at reasonable cost per pound. T.M.

N80-32861*# Rockwell International Corp., Downey, Calif.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 5: SPECIAL EMPHASIS STUDIES Final Report
G. M. Hanley Sep. 1980 265 p refs
(Contract NAS8-32475)
(NASA-CR-3322; SSD-79-0010-5) Avail: NTIS HC A12/MF A01 CSCL 10A

Satellite configurations based on the Satellite Power System baseline requirements were analyzed and a preferred concept selected. A satellite construction base was defined, precursor operations incident to establishment of orbital support facilities identified, and the satellite construction sequence and procedures developed. Rectenna construction requirement were also addressed. Mass flow to orbit requirements were revised and traffic models established based on consutrcution of 60 instead of 120 satellites. Analyses were conducted to determine satellite control, resources, manufacturing, and propellant requirements. The impact of the laser beam used for space-to-Earth power transmission upon the intervening atmosphere was examined as well as the inverse effect. The significant space environments and their effects on spacecraft components were investigated to define the design and operational limits imposed by the environments on an orbit transfer vehicle. The results show that LEO altitude <300 nmi and transfer orbit duration <6 months are preferrable. J.M.S.

N80-32928# Argonne National Lab., Ill.
SATELLITE POWER SYSTEMS (SPS) COST REVIEW
J. H. Crowley and E. J. Ziegler May 1980 89 p refs
(Contract W-31-109-eng-38)
(DOE/TIC-11190) Avail: NTIS HC A05/MF A01

Estimated costs for three selected SPS designs were determined. One SPS concept uses silicon solar cells with a concentration ratio of one; the second uses gallium arsenide solar cells with a concentration ratio of two; and the third (reference) design incorporates features of the first two. The systems within the SPS designs chosen include: rectenna construction; graphite fiber reinforced thermoplastic structures; solar cells, satellite electrical slip rings; satellite electrical systems; and ground rectenna electrical systems. DOE

N80-33869*# Rockwell International Corp., Downey, Calif. Space Systems Group.
SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY. VOLUME 2, PART 2: SYSTEM ENGINEERING
G. M. Hanley Sep. 1980 422 p
(Contract NAS8-32475)
(NASA-CR-3319; SSD-79-0010-2-2) Avail: NTIS HC A18/MF A01 CSCL 10A

The latest technical and programmatic developments are considered as well as expansions of the Rockwell SPS cost model covering each phase of the program through the year 2030. Comparative cost/economic analyses cover elements of the satellite, construction system, space transportation vehicles and operations, and the ground receiving station. System plans to define time phased costs and planning requirements that support major milestones through the year 2000. A special analysis is included on natural resources required to build the SPS reference configuration. An appendix contains the SPS Work Breakdown Structure and dictionary along with detail cost data sheet on each system and main element of the program. Over 200 line items address DDT&E, theoretical first unit, investment cost per satellite, and operations charges for replacement capital and normal operations and maintenance costs. A.R.H.

N80-33904# European Space Technology Center, Noordwijk (Netherlands). Systems Engineering Dept.
SATELLITE POWER SYSTEMS: STATUS AND PLANNED ACTIVITIES
D. Kassing *In* ESA Photovoltaic Generators in Space Jun. 1980 p 239-244 refs

Avail: NTIS HC A12/MF A01; ESA, Paris FF 80

The general progress in satellite power system (SPS) system definition and assessment activities to date is summarized, and selected technical issues identified as being crucial for the photovoltaic solar energy conversion subsystem of the reference concept are reviewed. The requirements of the photovoltaic subsystem are discussed with respect to the alternative power transmission options studied by NASA since October 1978, particularly solid state microwave devices and laser. A summary is given of the system impact assessment and European SPS Activities. Author (ESA)

11
GENERAL

Includes either state-of-the-art or advanced technology which may apply to Large Space Systems and does not fit within the previous nine categories. Shuttle payload requirements, on-board requirements, data rates, and shuttle interfaces, and publications of conferences, seminars, and workshops will be covered in this area.

A80-32829 * # NASCAP modelling computations on large optics spacecraft in geosynchronous substorm environments. N. J. Stevens and C. K. Purvis (NASA, Lewis Research Center, Cleveland, Ohio). *Society of Photo-Optical Instrumentation Engineers, Los Angeles Technical Symposium, North Hollywood, Calif., Feb. 4-7, 1980, Paper.* 18 p. 20 refs.

Satellites in geosynchronous orbits have been found to be charged to significant negative voltages during encounters with geomagnetic substorms. When satellite surfaces are charged, there is a probability of enhanced contamination from charged particles attracted back to the satellite by electrostatic forces. This could be particularly disturbing to large satellites using sensitive optical systems. In this study the NASA Charging Analyzer Program (NASCAP) is used to evaluate qualitatively the possibility of such enhanced contamination on a conceptual version of a large satellite. The evaluation is made by computing surface voltages on the satellite due to encounters with substorm environments and then computing charged-particle trajectories in the electric fields around the satellite. Particular attention is paid to the possibility of contaminants reaching a mirror surface inside a dielectric tube because this mirror represents a shielded optical surface in the satellite model used. Deposition of low energy charged particles from other parts of the spacecraft onto the mirror was found to be possible in the assumed moderate substorm environment condition. In the assumed severe substorm environment condition, however, voltage build up on the inside and edges of the dielectric tube in which the mirror is located prevents contaminants from reaching the mirror surface. (Author)

A80-34752 **Manufacturing methods for graphite/polyimide composite reentry vehicle substructures.** P. W. Harruff and P. R. Scherer (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). In: New horizons - Materials and processes for the eighties; Proceedings of the Eleventh National Conference, Boston, Mass., November 13-15, 1979. Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1979, p. 1-17. Contract No. F33615-76-C-5013.

Methods have been developed for fabrication of shell configurations typical of reentry vehicle substructures, using graphite fiber composites of addition-type polyimide resins. Techniques for layup, debulking and autoclave curing have been established. Effects of processing conditions upon composite properties, including microcracking, were determined. Characterization of the F178 resin by means of chromatography techniques has been made. (Author)

A80-34993 **Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Parts 1 & 2.** Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, Inc., 1980. Pt. 1, 535 p.; pt. 2, 523 p. Members, $75.; nonmembers, $100.

Papers are presented on recent developments in structural design, dynamics and materials. Specific topics include, multi-cyclic helicopter rotor control, structural sizing in large space platforms, composite panel instability, the free and forced vibrations of closely coupled turbomachinery blades, the pulse response of nonlinear nonstationary vibrational systems, the compression fatigue of fiber composites and the analysis of stress in angle-ply laminates with holes. Attention is also given to computer-aided design in the production of aircraft drawings, the unsteady aerodynamics of conventional and supercritical airfoils, crack propagation analysis in in-service aircraft, graphite composites with advanced resin matrices, active flutter suppression and gust alleviation using state-space aeroelastic modeling, the repair of advanced composite structures, load transfer in composite bolted joints, the synthesis of structures with discrete substructures, the structural design loads of future airplanes and effects of engine environment on composite behavior. A.L.W.

A80-34999 * # **Large space structures - Fantasies and facts.** M. F. Card and W. J. Boyer (NASA, Langley Research Center, Hampton, Va.). In: Structures, Structural Dynamics, and Materials Conference, 21st, Seattle, Wash., May 12-14, 1980, Technical Papers. Part 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 101-114. 37 refs. (AIAA 80-0674)

A review of large space structures activities from 1973 to 1979 is presented. Long-range studies of space colonies, gigantic solar power stations and projected earth applications revived interest in space activities. Studies suggest opportunities for advanced antenna and platform applications. Matching low-thrust propulsion to large flexible vehicles will be a key technology. Current structures technology investigations include deployable and erectable structures and assembly techniques. Based on orbited structures experience, deployment reliability is a critical issue for deployable structures. For erectable structures, concepts for earth-fabricated and space-fabricated members have been demonstrated. (Author)

A80-36958 **Shuttle to the next space age; Proceedings of the Southeast Seminar for Reporters and Teachers, Huntsville, Ala., July 18, 19, 1979.** Seminar sponsored by the American Institute of Aeronautics and Astronautics. Edited by D. Dooling. New York, American Institute of Aeronautics and Astronautics, Inc., 1979. 135 p. $18.

Papers are presented on Spacelab science, materials processing in space, future satellite power system concepts, geostationary platforms, and Shuttle-era remote sensing. Consideration is also given to the Space Telescope, X-ray astronomy, planetary exploration, life sciences in space, solar-terrestrial research in the Shuttle age, and the role of DOD in the Shuttle age. The Soviet manned space flight program, European space plans, and the new economics of ballistic missile defense are also examined. B.J.

A80-42856 **Space - New opportunities for international ventures; Proceedings of the Seventeenth Goddard Memorial Symposium, Washington, D.C., March 28-30, 1979.** Symposium sponsored by AAS, ESA, DGLR, et al. Edited by W. C. Hayes, Jr. (NASA, Washington, D.C.). San Diego, Calif., American Astronautical Society (Science and Technology Series. Volume 49); Univelt, Inc., 1980. 300 p. $35.

Consideration is given to such topics as new opportunities for international ventures in space, the Tracking and Data Relay Satellite System, the commercial potential for the Space Shuttle, and approaches to the financing of space ventures. Also considered are Japanese space activities and the European role in the Space Transportation System. B.J.

A80-45514 **Guidance and Control Conference, Danvers, Mass., August 11-13, 1980, Collection of Technical Papers.** Conference sponsored by the American Institute of Aeronautics and Astronautics. New York, American Institute of Aeronautics and Astronautics, Inc., 1980. 458 p. Members, $65.; nonmembers, $75.

Papers are presented on the control of self-adjoint distributed-parameter systems, suppressed mode damping for model error

sensitivity suppression flexible aircraft controllers, adaptive and learning control of large space structures, and active flutter suppression using linear quadratic Gaussian theory. Other papers include the reliability/safety analysis of a fly-by-wire system, the optimal platform skewing for Space Shuttle inertial measurement unit redundancy management, fast geodetic coordinate transformations, and a new approach to active control of rotorcraft vibration. V.L.

A80-45609 * First results of material charging in the space environment. P. F. Mizera, H. C. Koons, E. R. Schnauss, D. R. Croley, Jr., H. K. A. Kan, M. S. Leung (Aerospace Corp., El Segundo, Calif.), N. J. Stevens, F. Berkopec, J. Staskus (NASA, Lewis Research Center, Cleveland, Ohio), and W. L. Lehn (USAF, Materials Laboratory, Wright-Patterson AFB, Ohio). *Applied Physics Letters*, vol. 37, Aug. 1, 1980, p. 276-279. 5 refs. Contract No. F04701-79-C-0080.

A satellite experiment, designed to measure potential charging of typical thermal-control materials at near-geosynchronous altitude, was flown as part of the Spacecraft Charging at High Altitudes program. Direct observations of charging of typical satellite materials in a natural charging event (greater than or equal to 5 keV) are presented. The results show some features which differ significantly from previous laboratory simulations of the environment. (Author)

A80-46290 # Possibilities of participating in the American Space Operations Center /SOC/ (Beteiligungsmöglichkeiten am amerikanischen Space Operations Center /SOC/). W. Wienss (ERNO Raumfahrttechnik GmbH, Bremen, West Germany). *Deutsche Gesellschaft für Luft- und Raumfahrt, Jahrestagung, 13th, Braunschweig, West Germany, May 28-30, 1980, Paper 80-039.* 42 p. In German.

The concept of a Space Operation Center, its requirements, and operational capabilities are outlined, and features which will make the SOC independent of ground stations are noted. Tasks and technologies are described by means of which large space platforms can be established. It is shown that the hardware and software required for developing foldable and modular structures are currently available both in the United States and Europe, so that new technologies need not be developed. V.P.

A80-46376 * Space manufacturing III; Proceedings of the Fourth Conference, Princeton University, Princeton, N.J., May 14-17, 1979. Conference sponsored by the American Institute of Aeronautics and Astronautics, Princeton University, NASA, and U.S. Department of Energy. Edited by J. Grey (American Institute of Aeronautics and Astronautics, Inc., New York, N.Y.) and C. Krop. New York, American Institute of Aeronautics and Astronautics, Inc., 1979. 581 p. Members, $30.; nonmembers, $37.50.

Papers are presented on the various technological, political, economic, environmental and social aspects of large manufacturing facilities in space. Specific topics include the potential global market for satellite solar power stations in 2025, the electrostatic separation of lunar soil, methods for extraterrestrial materials processing, the socio-political status of efforts toward the development of space manufacturing facilities, the financing of space industrialization, the optimization of space manufacturing systems, the design and project status of Mass Driver Two, and the use of laser-boosted lighter-than-air-vehicles as heavy-lift launch vehicles. Attention is also given to systems integration in the development of controlled ecological life support systems, the design of a space manufacturing facility to use lunar materials, high performance solar sails, the environmental effects of the satellite power system reference design, the guidance, trajectory and capture of lunar materials ejected from the moon by mass driver, the relative design merits of zero-gravity and one-gravity space environments, consciousness alteration in space and the prospecting and retrieval of asteroids. A.L.W.

A80-46379 # Mass drivers, novel technical concepts, environmental effects, and lunar material trajectories. H. H. Kolm (MIT, Cambridge, Mass.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 31-36.

Recent progress in mass driver and alternative propulsion research, the environmental effects of solar power satellites and the launch of massive payloads, and the trajectories of lunar material launched by a mass driver is reviewed. Consideration is given to Mass Driver Two, which operates in a vacuum and is intended to achieve accelerations of 500 to 1000 g, and problems involved in maintaining mass driver alignment. Alternatives to the mass driver including homopolar generators, compensated alternators and hydromagnetic capacitors used to supply energy for such devices as rail guns and a momentum transformer, are discussed, together with proposals for laser launching and propulsion, electromagnetic propulsion, the recovery of expended shuttle propellant tanks for reuse and the replacement of chemical boosters by air-breathing devices. The environmental effects of microwave power transmission from solar power satellites, space operations and launch recovery impacts are considered, along with the possibility and possible prevention of large asteroid impacts on the earth. Finally, the principle of the achromatic trajectory for launching lunar materials to L2 or L5 is introduced, and various means for material capture and location are presented. A.L.W.

A80-46380 # Fabrication and products, and economic considerations. J. P. Vajk (Science Applications, Inc., Pleasanton, Calif.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 37-44.

The processing of materials in space is discussed together with the economic aspects of space manufacturing and industrialization based on earth and extraterrestrial raw materials. Papers examining the possibility of building the greater part of solar power satellites and other products from materials derived from lunar resources are indicated which conclude that the use of lunar materials can be more cost effective in the fabrication of vary large structures in space. Estimates of the costs and market potentials of materials manufactured in space from terrestrial or lunar raw materials are presented, and a proposal for using solar sails manufactured in space for the retrieval of asteroid materials is pointed out. Finally, consideration is given to methods of financing space industrialization. A.L.W.

A80-46386 * # Scaling and the start-up phase of space industrialization. D. R. Criswell (Lunar and Planetary Institute, Houston, Tex.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979
New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 223-233. 30 refs. Contract No. NSR-09-051-001.

By terrestrial standards very little mass is needed to construct the space portion of a 10,000 megawatt (10 GW) power system. Use of lunar materials makes it reasonable to consider alternatives to silicon solar cells for conversion of sunlight to electricity and thereby avoid present major problems associated with solar cell production. Machinery needed on the moon to excavate lunar materials and deliver them to a transport system, to beneficiate lunar materials, to produce glasses and ceramics from lunar materials and to chemically process lunar materials into their major oxides and elements are minor mass fractions of the total mass of equipment needed in space to produce an SPS. In addition the processing equipment can throughput several hundred times their own mass each year with very little requirement for makeup mass from earth. (Author)

A80-46388 # Start up considerations for a space manufacturing enterprise. J. H. Engel (Illinois, University, Chicago, Ill.) and J. P. Vajk (Science Application, Inc., Pleasanton, Calif.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton,

N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 245-255. 15 refs.

Costing considerations in the planning of a space manufacturing enterprise are discussed. For an operation consisting of facilities in low earth orbit, on the surface of the moon and in an orbit readily accessible from the moon and low earth orbit, placed into orbit by the Space Shuttle and utilizing lunar raw materials delivered by a mass driver, estimates are obtained for costs in the areas of research, development, testing and evaluation, procurement, lift from earth to low earth orbit, depreciation, personnel, mission control, administration, interest, inflation, and taxes. Incomes and other benefits to be provided by the enterprise are examined, and a hypothetical financial forecast for the space manufacturing enterprise is produced. It is found that the enterprise can be supported by a present value subsidy of between $44.6 and $101.6 billion in 1980, resulting in the production of 4 solar power satellites between 1980 and 1992 and 2.4 per year thereafter, for a total of 82.5 GW years delivered by 1993, with a recovery of initial investment by 1994 and an average rate of return before taxes of 7.4% per year by the year 2000. A.L.W.

A80-46389 * # Optimization of space manufacturing systems. D. L. Akin (MIT, Cambridge, Mass.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 257-266. 8 refs. Research supported by the H. N. Slater Flight Transportation Development Fund; Contract No. NAS8-32935.

Four separate analyses are detailed: transportation to low earth orbit, orbit-to-orbit optimization, parametric analysis of SPS logistics based on earth and lunar source locations, and an overall program option optimization implemented with linear programming. It is found that smaller vehicles are favored for earth launch, with the current Space Shuttle being right at optimum payload size. Fully reusable launch vehicles represent a savings of 50% over the Space Shuttle; increased reliability with less maintenance could further double the savings. An optimization of orbit-to-orbit propulsion systems using lunar oxygen for propellants shows that ion propulsion is preferable by a 3:1 cost margin over a mass driver reaction engine at optimum values; however, ion engines cannot yet operate in the lower exhaust velocity range where the optimum lies, and total program costs between the two systems are ambiguous. Heavier payloads favor the use of a MDRE. A parametric model of a space manufacturing facility is proposed, and used to analyze recurring costs, total costs, and net present value discounted cash flows. Parameters studied include productivity, effects of discounting, materials source tradeoffs, economic viability of closed-cycle habitats, and effects of varying degrees of nonterrestrial SPS materials needed from earth. Finally, candidate optimal scenarios are chosen, and implemented in a linear program with external constraints in order to arrive at an optimum blend of SPS production strategies in order to maximize returns. (Author)

A80-46391 # Laser-boosted advanced LTAV as a heavy lift launch vehicle. L. N. Myrabo (W. J. Schafer Associates, Inc., Wakefield, Mass.). In: Space manufacturing III; Proceedings of the Fourth Conference, Princeton, N.J., May 14-17, 1979. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 317-351. 63 refs.

The concept of a laser-propelled lighter-than-air-vehicle (LTAV) is introduced as a promising version of a heavy lift launch vehicle (HLLV) for the large-scale transport of materials into orbit for space industrialization and colonization. The HLLV would be propelled by unique variable cycle laser propulsion engines using beamed energy from satellite solar power stations, and would contain a center section designed to function as a structural building module. Consideration is given to the details of the airframe structure, optics and possible propulsion modes of the rigid airship launch vehicle, including aerostatic and aerodynamic hull lift, vortex lift augmentation, laser pulsejet, electrical storm atmospheric coupling, MHD-fan pulsejet, MHD-pumped vortex induced lift, electromagnetic propulsion as proposed by Way (1958, 1963, 1967, 1968, 1969) and a large-amplitude Alfven wave thruster. Methodology for airframe/optics/propulsion systems integration into a unified HLLV is suggested, and component weight breakdowns for vehicles of various sizes are presented. Finally, the power requirements of the proposed system as a function of lifting capacity are discussed. Advantages of the proposed concept in the reduction of the number and cost of Shuttle launches and an enhanced configuration for building large space structures are noted. A.L.W.

A80-46879 Space systems and their interactions with earth's space environment. Edited by H. B. Garrett and C. P. Pike (USAF, Geophysics Laboratory, Bedford, Mass.). New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 71), 1980. 764 p. Members, $30.; nonmembers, $55.

Aspects of the interaction of space systems with the space environment of the earth believed to be critical to the design and development of space systems in the era of the Space Shuttle are discussed. Consideration is given to the effects of space operations on the earth's space environment, including the effects of microwave beams on the ionosphere, upper atmosphere modifications due to launch vehicle discharges of water vapor, and argon ion contamination of the plasmasphere, and to the interactions involved in spacecraft charging, including charging during eclipse passage, surface discharging and the active control of spacecraft charging. The effects of radiation on space systems are then examined, with attention given to cosmic ray effects on VLSI, radiation effects on solar cells and dielectric charging, and interactions of large space systems with the space environment in the areas of biased spacecraft surfaces, current leakage and the environmental protection of solar power satellites are considered. Finally, attention is given to the effects of the space environment on spacecraft structures, including the dynamics of a rigid body in the space plasma, the deformation of a solar sail, spacecraft contamination, and the creation of a debris belt as a result of artificial satellite collisions. A.L.W.

A80-46880 # Environmental effects of space systems - A review. D. M. Rote (Argonne National Laboratory, Argonne, Ill.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 3-53. 58 refs. Research supported by the U.S. Department of Energy.

This review and the papers in this section focus on the effects of large space systems, primarily the Satellite Power System (SPS), on the upper atmosphere. From 56-500 km, the major contaminant sources are SPS microwave transmissions and rocket effluents. Although no significant effects have yet been found for microwave transmissions, deposition of rocket effluents causes compositional changes, most of which appear to be associated with the release of large amounts of water. From 500-36,000 km, rocket effluents and ion engine contaminants (primarily Ar(+)) could alter magnetospheric and plasmaspheric structure and dynamics. One of the major impacts of these alterations could be perturbation of Van Allen radiation belt stability, leading to changed radiation hazards to materials and personnel and to modification of high energy particle precipitation events. The ambient density falls rapidly and the potential for significant environmental alteration increases as one goes outwards from the earth's surface. And, the further from the earth's surface, the less certain our knowledge of environmental change processes is. (Author)

A80-46881 # Effects of microwave beams on the ionosphere. L. M. Duncan (California, University, Los Alamos, N. Mex.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 54-77. 20 refs. Research supported by the U.S. Department of Energy.

This is a review of the effects associated with the propagation of intense microwave beams through the ionosphere. Collisional damp-

ing of the microwave beam in the lower ionosphere will significantly enhance the local free electron temperatures. Experimental observations of this enhanced electron heating are in general agreement with the theoretical models. In addition, thermal self-focusing of electromagnetic waves in the ionosphere can produce variations in the beam power flux density and create large-scale electron density irregularities. These large-scale irregularities also may trigger the formation of small-scale plasma striations. Again, experimental results support theoretical models of this phenomenon. These investigations of the dominant physical processes involved in microwave propagation through the ionosphere are applicable to the environmental impacts assessment of the proposed solar-power satellite microwave power-transmission system. Ionospheric modifications can lead to the potentially enhanced telecommunications and climate impacts. (Author)

A80-46883 # **Modification of the ionosphere by large space vehicles.** M. Mendillo (Boston University, Boston, Mass.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 99-117. 27 refs.

A brief history of rocket-induced perturbations upon the upper atmosphere is presented. The theory of 'ionospheric hole' formation is described, stressing the role of a rapidly diffusing cloud of highly reactive rocket exhaust molecules interacting with the ionospheric plasma. Computer simulation results of this F-region modification problem show that carefully planned modification experiments can lead to significant advances in our understanding of the near-earth plasma environment. These modification studies are of particular value in attempts to understand large-scale plasma dynamics, the thermal energy balance of a plasma, and the various modes by which plasma instabilities may be generated on a geophysical scale. The results also demonstrate that the F-region ionosphere will experience significant modification effects with virtually every in-orbit engine burn of the Space Shuttle and the proposed Heavy Lift Vehicles needed to construct Solar Power Satellites. Finally, a method of determining how to maximize (or minimize) ionospheric hole formation is detailed. (Author)

A80-46884 # **Argon-ion contamination of the plasmasphere.** Y. T. Chiu, J. G. Luhmann, M. Schulz (Aerospace Corp., Space Sciences Laboratory, El Segundo, Calif.), and J. M. Cornwall (Aerospace Corp., El Segundo; California, University, Los Angeles, Calif.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 118-147. 31 refs. U.S. Department of Energy Contract No. 31-109-38-5075.

Large-scale operation of argon-ion engines in space may give rise to global-scale modification of the magnetosphere. In this paper, ion injectant effects of solar-powered orbit transfer operations of large payloads (approximately 10 to the 7th kg) similar to that of the projected Satellite Power System are considered. It is likely that the ion beam would interact and deposit its energy and mass in the magnetosphere. Magnetospheric heating may change the compositional distribution of thermal ions, thus causing enhancement of relativistic Van Allen radiation belt electrons. Effects upon the ring-current (auroral processes) also are discussed. (Author)

A80-46885 # **Magnetospheric modification by gas releases from large space structures.** R. R. Vondrak (SRI International, Radio Physics Laboratory, Menlo Park, Calif.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 148-163. 29 refs.

The deployment and operation of large structures in space will be accompanied by the release of gases into the earth's space environment. For example, the launch of a spacecraft into low earth orbit is accompanied by the deposition of large amounts of rocket exhaust into the atmosphere and ionosphere. Transfer to a higher orbit requires the release into the magnetosphere of rocket combustion products (or of energetic heavy ions if an electric propulsion engine is used). Even when the spacecraft is in final orbit, both the spacecraft itself and its attitude control system are potential sources of released gases. In the inner magnetosphere, gas releases from large space systems may alter the composition and thermal structure of the plasmasphere and the stability of the Van Allen radiation belts. Neutral gases released at even higher altitudes in the outer magnetosphere initially form a toroidal cloud around the earth. After ionization, these gases may modify the plasma sheet, the magnetospheric current systems, and the magnetopause location. (Author)

A80-46886 # **Spacecraft charging - A review.** H. B. Garrett (USAF, Geophysics Laboratory, Bedford, Mass.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 167-226. 112 refs.

The process of charge buildup on satellite surfaces is reviewed. In particular, the types of charging processes, the different charging models, and the effects of charging are described in a simplified manner in order to prepare the reader for the more detailed studies presented in other sections of this volume. Special emphasis is placed on fundamental concepts and on the space environment. (Author)

A80-46887 # **Spacecraft charging during eclipse passage.** H. B. Garrett and D. M. Gauntt (USAF, Geophysics Laboratory, Bedford, Mass.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 227-251. 28 refs.

The passage of a space structure through the earth's (or moon's) shadow is attended by a change in the photoelectron flux from the surface of the spacecraft. If, as is often observed in and near geosynchronous orbit, the ambient electron flux is sufficient, spacecraft charging will result. In this paper, the detailed variation of the photoelectron flux will be modeled. Using this and other simple models of the spacecraft charging phenomena, the changing potential on a typical geosynchronous satellite will be estimated. The model will then be extended to encompass the case of a large (10-km diam) passive circular structure (the space-based radar) and of a large (100 sq km) passive square structure (the solar power satellite). Depending on the material, significant potential gradients are possible across such objects. Although little danger is expected from eclipse passage if proper design criteria are followed, the results do indicate the need for caution in the design of any spacecraft expected to spend time in the geosynchronous (or similar) plasma environment. (Author)

A80-46892 # **Radiation effects on space systems and their modeling.** A. L. Vampola (Aerospace Corp., Los Angeles, Calif.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 339-348. 16 refs.

Space systems are subject to degradation of performance and damage by the charged particle populations trapped within the earth's magnetic field. Spacecraft encounter electrons, protons, and ions with energies from a few eV to many MeV in various regions of the magnetosphere. As a result, components suffer radiation damage, logic upsets occur, sensors experience elevated background levels, and, near synchronous altitudes where hot tenuous plasmas occur, differential charging with subsequent arcing may be experienced. Past efforts have produced satisfactory models of the trapped energetic charged particle population in most regions of the magnetosphere. Efforts are continuing in such diverse areas as the interaction of spacecraft with hot plasmas and damage mechanisms in microcircuitry. (Author)

A80-46897 * # **Space environmental interactions with biased spacecraft surfaces.** N. J. Stevens (NASA, Lewis Research Center, Spacecraft Environment Section, Cleveland, Ohio). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 455-476. 31 refs.

Large, high-voltage space power systems are being proposed for future space missions. These systems must operate in the charged-particle environment of space, and interactions between this environment and the high-voltage surfaces are possible. Ground simulation testing has indicated that dielectric surfaces that usually surround biased conductors can influence these interactions. For positive voltages greater than 100 V, it has been found that the dielectrics contribute to discharges. Using these experimental results a large, high-voltage power system operating in geosynchronous orbit was analyzed with the NASCAP code. Results of this analysis indicated that very strong electric fields exist in these power systems. A technology investigation is required to understand the interactions and develop techniques to alleviate any impact on power system performance. (Author)

A80-46898 # **Plasmasheath-photosheath theory for large high-voltage space structures.** L. W. Parker (Lee W. Parker, Inc., Concord, Mass.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 477-522. 39 refs.

This work presents a new method for rigorously computing sheath structures of large spherical bodies with high-voltage surfaces and with photoelectric/secondary emission. This method, using the author's Turning-Point Formulation, is transparently simple and results in a compact computer program. Self-consistency of the Poisson and Vlasov solutions is achieved through iteration. The power and flexibility of the method is illustrated through four sample sheath solutions, including (1) the sheath of a large body (radius 100 Debye lengths) with voltage 400,000 kT/e, the most extreme combination of size and voltage solved rigorously to date, and (2) the 'presheath' of an extremely large body, a nontrivial and heretofore unsolved problem in a warm plasma. In addition, two approximate models are considered: (a) a linearized space charge model (leading to the Debye potential for spheres) and (b) the Langmuir-Blodgett spherical diode. Both approximate models tend to underestimate current collection. (Author)

A80-46900 # **Dynamics of a rigid body in the space plasma.** P. J. L. Wildman (USAF, Geophysics Laboratory, Bedford, Mass.). In: Space systems and their interactions with earth's space environment. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 633-661. 28 refs.

The drag and torque forces acting on a large conducting body passing through a partially ionized plasma are calculated over the altitude range 250 km to 36,000 km (geosynchronous altitude) for a nonrotating body 2 km long and 10 m wide with mass 2 kg. Drag forces resulting from solar radiation pressure, collisions with neutral particles, collisions and interactions with charged particles, and interactions with the earth's magnetic field are relatively unimportant. Torques resulting from these same processes are more important. The torque induced by the earth's gravitational field is the most important of all and dominates all others even at geosynchronous altitudes. The additional forces resulting when the body also has rotational motion are negligible. (Author)

A80-48174 # **Future space power - The D.O.D. perspective.** T. Mahefkey (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, Ohio). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 89-94. 6 refs.

The paper presents DOD space power studies which show a trend towards higher power levels in future missions. Military power systems in the 100 kW electrical capacity will be built by the year 2000 for new types of missions, while maintaining current technology in the 1-10 kW range. While NASA and COMSAT projects will provide high power capabilities, military requirements will be fulfilled by the development of new high-level, high-power density survivable space energy technology. Solar systems in the 100-250 kW range, with 25 W/lb densities, and nuclear reactors with energy densities in the 50 W/lb range or greater will be used in future missions. A.T.

A80-48263 # **Environmental effects of particulate debris on spacecraft systems.** N. N. Youssef and W. G. Dunbar (Boeing Aerospace Co., Seattle, Wash.). In: Energy to the 21st century; Proceedings of the Fifteenth Intersociety Energy Conversion Engineering Conference, Seattle, Wash., August 18-22, 1980. Volume 1. New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 773-776. 15 refs.

Sources for particulate debris that impact a spacecraft are briefly reviewed. It is shown that even though the amount of cosmic dust flux is very small in geosynchronous orbit, the effects of cosmic dust on large spacecraft are significant enough to produce problems with high-voltage systems. (Author)

A80-48797 * # **Space Operations Center - Next goal for manned space flight.** C. Covington and R. O. Piland (NASA, Johnson Space Center, Houston, Tex.). *Astronautics and Aeronautics*, vol. 18, Sept. 1980, p. 30-37.

The paper discusses the concept of the Space Operations Center, a Shuttle-serviced permanent manned LEO space station. The SOC has the mission-oriented role of construction, assembly, and servicing of space systems and spacecraft. Previous space-station concepts are reviewed; future space goals are compared; and objectives for the future Space Operations Center and its initial analysis are described. B.J.

A80-51564 # **Men or machines to build in space.** R. H. Miller, D. B. S. Smith, D. L. Akin, and M. L. Bowden (MIT, Cambridge, Mass.). *Astronautics and Aeronautics*, vol. 18, Oct. 1980, p. 52-59, 63. 9 refs.

The paper outlines some of the factors influencing the economics of exploiting space, with the satellite power system considered as an example. Emphasis is placed on the cost of transportation to low earth orbit and productivity of people in space. It is noted that space workers could be cost-competitive with automated systems, and should be considered a promising option in large-scale space operations. B.J.

A80-51940 * **Space Shuttle cargo processing at the Kennedy Space Center.** W. H. Rock (NASA, Kennedy Space Center, Cargo Projects Office, Cocoa Beach, Fla.). In: A new era in technology; Proceedings of the Seventeenth Space Congress, Cocoa Beach, Fla., April 30-May 2, 1980. Cocoa Beach, Fla., Canaveral Council of Technical Societies, 1980, p. 3-67 to 3-87.

This paper discusses the various activities involved in processing the two basic types of cargo being prepared for launch by the Space Transportation System. An overview will be presented describing the independent processing systems used to ready the Spacelabs and other horizontal cargo as well as upper stages and other vertical cargo. The interrelationship of these two types of preparations with the main line Space Shuttle test and checkout operations will be shown. In the explanation of each process, the ground support equipment and facilities of the Kennedy Space Center are described. (Author)

N80-22389# European Space Agency, Paris (France).
A SEMINUMERICAL PROCEDURE FOR THE CALCULATION OF GEOSTATIONARY ORBIT PERTURBATIONS CAUSED BY THE SUN AND THE MOON
M. C. Eckstein Aug. 1978 28 p refs Transl. into ENGLISH of "Ein Halbnumerisches Verfahren zur Berechnung der Stoerungen einer Geostationaeren Bahn durch Sonne und Mond", Rept. DLR-IB-552-77/23 DFVLR Oberpfaffenhofen, Sep. 1977 Original report in GERMAN previously announced as X79-73159

(ESA-TT-485-Rev; DLR-IB-552-77/23) Avail: NTIS HC A03/MF A01

A simplified semi-numerical perturbation method was developed for the special case of nearly geostationary satellites for orbits perturbed by the Sun and Moon. Whereas the analytical form of the perturbation terms can be derived from geometrical considerations, the coefficients are determined by multiple Fourier analysis of the perturbation equations. The perturbations are expressed in terms of equinoctial elements to avoid singularities for zero eccentricity and inclination. The expressions generated by the computer program are presented in the form of subprograms. Author (ESA)

N80-23495*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.

PROCEEDINGS OF THE 14TH AEROSPACE MECHANISMS SYMPOSIUM

May 1980 327 p refs Symp. held at Hampton, Va., 1-2 May 1980; sponsored in part by Calif. Inst. of Tech. and Lockheed Missiles and Space Co.

(NASA-CP-2127; L-13610) Avail: NTIS HC A15/MF A01 CSCL 20K

Technological areas covered include aviation propulsion, aerodynamic devices, and crew safety; space vehicle propulsion, guidance and control; spacecraft deployment, positioning, and pointing; spacecraft bearings, gimbals, and lubricants; and large space structures. Devices for payload deployment, payload retention, and crew extravehicular activity on the space shuttle orbiter are also described.

N80-24684*# Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div.

PREDICTION OF SPACECRAFT POTENTIALS AT GEOSYNCHRONOUS ORBIT

H. B. Garrett, A. G. Rubin, and C. P. Pike *In* NASA. Marshall Space Flight Center Solar-Terrest. Predictions Proc., Vol. 2 Dec. 1979 p 104-118 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

Two relatively straightforward techniques are outlined for determining spacecraft potentials in the limit of a 'thick sheath' surrounding the spacecraft. A statistical model of the various features of the geosynchronous environment based on ATS-5 and ATS-6 data and an analytic model capable of detailed simulation of the low energy geosynchronous environment are also discussed. The results from these two environmental models are then combined with the charging models in order to provide estimates of the relationships between the geomagnetic index and spacecraft potential. The results are compared with actual potential measurements from ATS-5 and ATS-6. Author

N80-25353*# New Mexico Univ., Albuquerque. Technology Applications Center.

SPACE COLONIES. CITATIONS FROM THE INTERNATIONAL AEROSPACE ABSTRACTS DATA BASE Progress Report, 1973 - Nov. 1979

Gerald F. Zollars Dec. 1979 55 p Sponsored by NASA and NTIS

(NASA-CR-163204; PB80-802960) Avail: NTIS HC $30.00/ MF $30.00 CSCL 22A

Approximately 204 citations to the international literature concerning various aspects of space colonies are presented. Topics include the design and construction of space colonies, the effects on humans of long term life in a variety of spaceborne environments, and the potential uses of orbital space stations and lunar bases. GRA

N80-26374*# Boeing Commercial Airplane Co., Seattle, Wash.

TECHNOLOGY REQUIREMENTS FOR FUTURE EARTH-TO-GEOSYNCHRONOUS ORBIT TRANSPORTATION SYSTEMS. VOLUME 2: TECHNICAL RESULTS Final Report

Vincent A. Caluori Jun. 1980 247 p refs

(Contract NAS1-15301)

(NASA-CR-3266) Avail: NTIS HC A11/MF A01 CSCL 22A

Technologies either critical to performance of offering cost advantages compared to the investment required to bring them to usable confidence levels are identified. A total transportation system is used as an evaluation yardstick. Vehicles included in the system are a single stage to orbit launch vehicle used in a priority cargo role, a matching orbit transfer vehicle, a heavy lift launch vehicle with a low Earth orbit delivery capability of 226, 575 kg, and a matching solar electric cargo orbit transfer vehicle. The system and its reference technology level are consistent with an initial operational capability in 1990. The 15 year mission scenario is based on early space industrialization leading to the deployment of large systems such as power satellites. Life cycle cost benefits in discounted and undiscounted dollars for each vehicle, technology advancement, and the integrated transportation system are calculated. A preliminary functional analysis was made of the operational support requirements for ground based and space based chemical propulsion orbit transfer vehicles: E.D.K.

N80-27177# Los Alamos Scientific Lab., N. Mex.

SPACE NUCLEAR REACTOR POWER PLANTS

D. Buden, W. A. Ranken, and D. R. Koenig Jan. 1980 33 p refs

(Contract W-7405-eng-36)

(LA-8223-MS) Avail: NTIS HC A03/MF A01

Nuclear power is probably the only source for some deep space missions and a major competitor for many orbital missions, especially those at geosynchronous orbit. Because of the potential requirements, a technology program on space nuclear power plant components was initiated. The missions that are foreseen, the current power plant concept, the technology program plan, and early key results are described. DOE

N80-27216# Committee on Commerce, Science, and Transportation (U. S. Senate).

NASA AUTHORIZATION FOR FISCAL YEAR 1981, PART 2

Washington GPO 1980 509 p Hearings on S. 2238 and S. 2240 before the Subcomm. on Sci., Technol., and Space of the Comm. on Com., Sci., and Transportation, 96th Congr., 2nd Sess., 6-7 and 20 Feb. 1980

(GPO-58-741) Avail: Subcomm. on Sci., Technol. and Space

Funding requests to support research and development, construction and of facilities and program management are justified in testimony delivered and responses to questions asked during a 6 day hearing period. Particular emphasis is given to the supplemental funds needed to support development and evaluation of space shuttle components, as well as to plans for the Galileo Project and Spacelab experiments. Accomplishments and plans are reviewed for the following areas: space science, space transportation system, astronaut program, energy programs, technology utilization, space and terrestrial applications, international affairs, aeronautics, space research and technology, and tracking and data systems. Employment policies are also examined. A.R.H.

N80-28420# Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div.

THE DYNAMICS OF RIGID BODY IN THE SPACE PLASMA Environmental Research Papers

Peter J. L. Wildman 28 Aug. 1979 36 p refs Submitted for publication

(AF Proj. 2311; AF Proj. 7661)

(AD-A084806; AFGL-TR-79-0201; AFGL-ERP-673) Avail: NTIS HC A03/MF A01 CSCL 22/3

A time-dependent technique, in conjunction with the boundary-fitted coordinates system, is applied to solve a gas-only one-phase flow and a fully-coupled, gas-particle two-phase flow inside nozzles with small throat radii of curvature, steep wall gradients, and submerged configurations. The emphasis of the study has been placed on one- and two-phase flow in the transonic region. Various particle size and particle mass fractions have been investigated in the two-phase flow. The salient features associated with the two-phase nozzle flow compared with those of the one-phase flow are illustrated through the calculations for a JPL nozzle configuration, for the Titan III solid rocket motor

nozzle, and for the submerged nozzle configuration utilized in the Inertial Upper Stage (IUS) solid rocket motor. GRA

N80-28422# Air Force Geophysics Lab., Hanscom AFB, Mass. Space Physics Div.
LARGE SPACE STRUCTURE CHARGING DURING ECLIPSE PASSAGE Air Force Surveys in Geophysics
David M. Gauntt 15 Jan. 1980 39 p refs
(AF Proj. 7661)
(AD-A084810; AFGL-TR-80-0022; AFGL-AFSG-420) Avail: NTIS HC A03/MF A01 CSCL 22/3

Much work has been developed to the study of the differential charging of geosynchronous spacecraft, primarily that charging caused by injection events and uneven illumination of isolated surfaces. However, as the lack of illumination in the penumbra eliminates the latter problem, little attention has been paid to charging during eclipse passage. For a sufficiently large structure (length greater than 1 km), the gradient of illumination in the penumbra is large enough to contribute significantly to differential charging. In this paper, three main subjects will be discussed: (1) the causes of charging at geosynchronous altitudes; (2) a simple model of the plasma from which the differential charging equations can be derived; and (3) the results of a computer program based on these equations, together with several theoretically fit sets of equations to approximate the results. GRA

N80-28626# National Technical Information Service, Springfield, Va.
ANTENNA ARRAYS. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, 1970 - Mar. 1980
William E. Reed Apr. 1980 261 p Supersedes NTIS/PS-79/0319; NTIS/PS-78/0311
(PB80-809759; NTIS/PS-79/0319; NTIS/PS-79/0311) Avail: NTIS HC $30.00/MF $30.00 CSCL 09E

A bibliography containing 254 abstracts concerning antenna arrays is given. Topics include design, propagation, antenna radiation patterns, mathematical analysis, signal processing, and interference rejection. GRA

N80-30225# Committee on Science and Technology (U. S. House).
NASA AUTHORIZATION, 1981, VOLUME 5
Washington GPO 1980 1164 p Hearings on H.R. 6413 before the Subcomm. on Space Sci. and Appl. of the Comm. on Sci. and Technol., 96th Congr., 2nd Sess., no. 18, 20, 21, 26 Feb., 7-10, 31 Mar. 1980
(GPO-61-213-Vol-5) Avail: Subcommittee on Space Science and Applications

Testimony given on the cooperative energy programs being conducted by NASA for the Department of Energy is presented in light of the budget request for fiscal year 1981. Solar energy activities including small dispersed solar system applications and bioenergy as well as ocean thermal energy conversion, solar augmented desalination systems, and solar ranking applications are discussed. Coal preparation and conversion technologies are also considered. These technology options include coal gasification and liquefaction processes, coal gasifier congeneration systems, and coal fired energy conversion systems. Concepts that would extend the use of advanced systems based in space are examined, including the satellite power systems, orbiting reflectors, and lunar based power plants. The NASA support to the DOE in the solar programs areas of solar heating and cooling, wind energy, solar cells-photovoltaic conversion systems, and high temperature thermal conversion systems is highlighted. J.M.S.

N80-30367*# National Aeronautics and Space Administration, Washington, D. C.
THE SPACE SHUTTLE AT WORK
Howard Allaway 1979 83 p Original contains color illustrations
(NASA-SP-432; NASA-EP-156) Avail: NTIS HC $3.75/MF $3.75 CSCL 22B

The concept of the orbital flight of the space shuttle and the development of the space transportation system are addressed. How the system came to be, why it is designed the way it is, what is expected of it, and how it may grow are among the questions considered. Emphasis is placed on the effect of the space transportation system on U.S. space exploration in the next decade, including plans to make space an extension of life on the Earth's surface. J.M.S.

N80-31269*# National Aeronautics and Space Administration, Washington, D. C.
NASA PROGRAM PLAN Fiscal Years, 1981 - 1985
Jan. 1980 233 p
Avail: NTIS HC A11/MF A01 CSCL 05A

Major facts are given for NASA'S planned FY-1981 through FY-1985 programs in aeronautics, space science, space and terrestrial applications, energy technology, space technology, space transportation systems, space tracking and data systems, and construction of facilities. Competition and cooperation, reimbursable launchings, schedules and milestones, supporting research and technology, mission coverage, and required funding are considered. Tables and graphs summarize new initiatives, significant events, estimates of space shuttle flights, and major missions in astrophysics, planetary exploration, life sciences, environmental and resources observation, and solar terrestrial investigations. The growth in tracking and data systems capabilities is also depicted. A.R.H.

N80-31449*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
LARGE SPACE SYSTEMS/LOW-THRUST PROPULSION TECHNOLOGY
Jul. 1980 347 p refs Meeting held at Cleveland, 20-21 May 1980
(NASA-CP-2144; E-510) Avail: NTIS HC A15/MF A01 CSCL 21H

The potentially critical interactions that occur between propulsion, structures and materials, and controls for large spacecraft are considered, the technology impacts within these fields are defined and the net effect on large systems and the resulting missions is determined. Topical areas are systems/mission analysis, LSS static and dynamic characterization, and propulsion systems characterization.

N80-32414*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.
UAH/NASA WORKSHOP ON SPACE SCIENCE PLATFORM
S. T. Wu, ed. (Alabama Univ., Huntsville) and Samuel Morgan, ed. Dec. 1978 205 p refs Workshop held at Joe Wheeler State Park Resort, Ala., 21-25 Aug. 1978
(NASA-TM-82204) Avail: NTIS HC A10/MF A01 CSCL 22B

The scientific user requirements for a space science platform were defined. The potential user benefits, technological implications and cost of space platforms were examined. Cost effectiveness of the platforms' capabilities were also examined. T.M.

N80-32853*# Rice Univ., Houston, Tex. Dept. of Space Physics and Astronomy.

A COMPUTER MODEL OF SOLAR PANEL-PLASMA INTERACTIONS Final Report

David L. Cooke and John W. Freeman [1980] 59 p refs (Contract NAS9-15796)

(NASA-CR-160796) Avail: NTIS HC A04/MF A01 CSCL 10A

High power solar arrays for satellite power systems are presently being planned with dimensions of kilometers, and with tens of kilovolts distributed over their surface. Such systems face many plasma interaction problems, such as power leakage to the plasma, particle focusing, and anomalous arcing. These effects cannot be adequately modeled without detailed knowledge of the plasma sheath structure and space charge effects. Laboratory studies of 1 by 10 meter solar array in a simulated low Earth orbit plasma are discussed. The plasma screening process is discussed, program theory is outlined, and a series of calibration models is presented. These models are designed to demonstrate that PANEL is capable of accurate self consistant space charge calculations. Such models include PANEL predictions for the Child-Langmuir diode problem. S.F.

N80-33471*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

LARGE SOLAR ARRAYS

William L. Crabtree *In* NASA. Lewis Space Flight Center Synchronous Energy Technol. Sep. 1980 p 57-68

Avail: NTIS HC A07/MF A01 CSCL 10A

A spectrophotovoltaic converter, a thermophotovoltaic converter, a cassegrainian concentrator, a large silicon cell blanket, and a high flux approach are among the concepts being investigated as part of the multihundred kW solar array program for reducing the cost of photovoltaic energy in space. These concepts involve a range of technology risks, the highest risk being represented by the thermophotovoltaics and spectrophotovoltaics approaches which involve manipulation to of the incoming spectrum to enhance system efficiency. The planar array (solar blanket) has no technology risk and a moderate payback. The primary characteristics, components, and technology concerns of each of these concepts are summarized. An orbital power platform mission in the late 1980's is being used to allow a coherent technology advancement program in order to achieve a ten year life with maintenance at a capital recurring cost of $30/watt based on 1978 dollars. A.R.H.

N80-33883# European Space Technology Center, Noordwijk (Netherlands).

DESIGN AND TECHNOLOGY OF SOLAR ARRAYS FOR SHUTTLE LAUNCHED MISSIONS

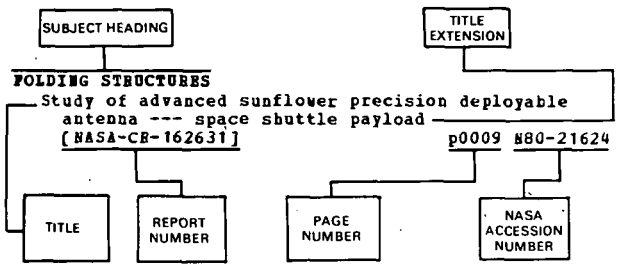
K. Bogus, M. Cathala (SNIAS, Cannes, France), B. Goergens (AEG-Telefunken, Wedel, West Germany), and J. Kerstens (Royal Netherlands Aircraft Factory Fokker, Schiphol-Oost) *In* ESA Photovoltaic Generators in Space Jun. 1980 p 79-91 refs

Avail: NTIS HC A12/MF A01; ESA, Paris FF 80

Very large solar arrays in the 15 to 20 kW power range will be needed for enhancing the low Earth orbit (LEO) operational capabilities for missions utilizing the space transportation system (STS) and Spacelab. A conceptual solar array design study was performed in order to identify the resulting solar array technology requirements. Advantages and disadvantages are listed for both nonplanar and rectangular flat array designs, including both structural considerations and blanket design. Thermal aspects of stowage box design are mentioned. The most promising concept is a modular split blanket array with retractable fold out blankets and a collapsible truss mast. Author (ESA)

SUBJECT INDEX

Typical Subject Index Listing



The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, a title extension is added, separated from the title by three hyphens. The *STAR* or *IAA* accession number is included in each entry to assist the user in locating the abstract in the abstract section of this issue. If applicable a report number is also included as an aid in identifying the document. The page and accession numbers are located beneath and to the right of the title. Under any one subject heading the accession numbers are arranged in sequence with the *IAA* accession numbers appearing first.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

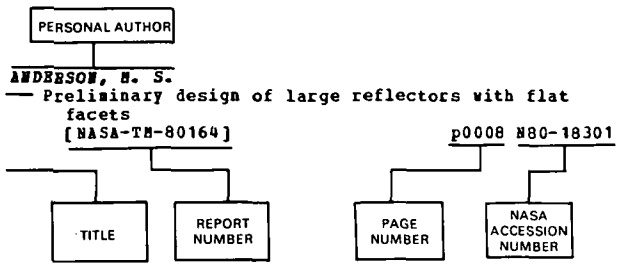
U

V

W

PERSONAL AUTHOR INDEX

Typical Personal Author Index Listing



Listings in this index are arranged alphabetically by personal author. The title of the document provides the user with a brief description of the subject matter. The report number helps to indicate the type of document listed (e.g. NASA report, translation, NASA contractor report). The page and accession numbers are located beneath and to the right of the title, e.g., p0008 N80-18301. Under any one author's name the accession numbers are arranged in sequence with the *IAA* accession numbers appearing first.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

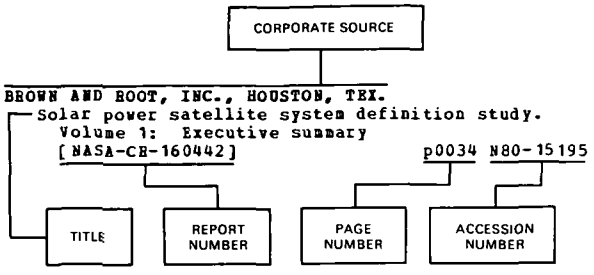
W

Y

Z

CORPORATE SOURCE INDEX

Typical Corporate Source Index Listing



The title of the document is used to provide a brief description of the subject matter. The page number and NASA accession number are included in each entry to assist the user in locating the abstract.

A

B

C

D

E

G

H

J

K

L

M

N

O

P

R

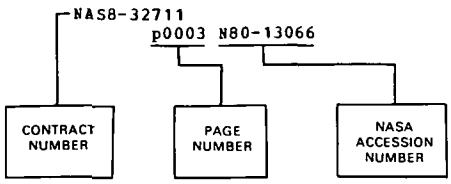
S

T

V

CONTRACT NUMBER INDEX

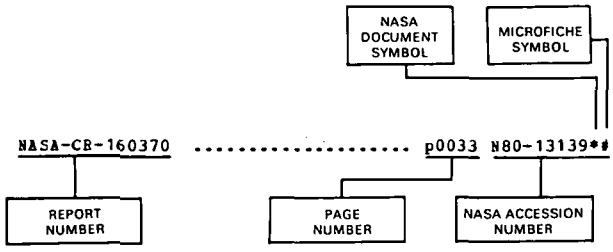
Typical Contract Number Index Listing



Listings in this index are arranged alphanumerically by contract number. Under each contract number, the accession numbers denoting documents that have been produced as a result of research done under that contract are arranged in ascending order with the *IAA* accession numbers appearing first. Preceding the accession number is the page number where the citation may be found.

REPORT/ACCESSION NUMBER INDEX

Typical Report/Accession Number Index Listing



Listings in this index are arranged alphanumerically by report number. The page number indicates the page on which the citation may be located. The accession number denotes the number by which the citation is identified. An asterisk (*) indicates that the item is a NASA report. A pound sign (#) indicates that the item is available on microfiche.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7046(04)		

4. Title and Subtitle	5. Report Date
TECHNOLOGY FOR LARGE SPACE SYSTEMS A Special Bibliography	January 1981
	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 the LSST Program Office, Langley Research Center, Hampton, Virginia.

16. Abstract

This bibliography lists 259 reports, articles, and other documents introduced into the NASA scientific and technical information system between July 1, 1980 and December 31, 1980. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design in the area of the Large Space Systems Technology (LSST) Program. Subject matter is grouped according to systems, interactive analysis and design, structural concepts, control systems, electronics, advanced materials, assembly concepts, propulsion, solar power satellite systems, and flight experiments.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Folding Structures Orbital Space Stations Space Erectable Structures Spacecraft Structures	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	108	$9.50 HC

*For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1981

PUBLIC COLLECTIONS OF NASA DOCUMENTS

DOMESTIC

NASA distributes its technical documents and bibliographic tools to eleven special libraries located in the organizations listed below. Each library is prepared to furnish the public such services as reference assistance, interlibrary loans, photocopy service, and assistance in obtaining copies of NASA documents for retention.

CALIFORNIA
University of California, Berkeley
COLORADO
University of Colorado, Boulder
DISTRICT OF COLUMBIA
Library of Congress
GEORGIA
Georgia Institute of Technology, Atlanta
ILLINOIS
The John Crerar Library, Chicago
MASSACHUSETTS
Massachusetts Institute of Technology, Cambridge
MISSOURI
Linda Hall Library, Kansas City
NEW YORK
Columbia University, New York
OKLAHOMA
University of Oklahoma, Bizzell Library
PENNSYLVANIA
Carnegie Library of Pittsburgh
WASHINGTON
University of Washington, Seattle

NASA publications (those indicated by an "*" following the accession number) are also received by the following public and free libraries:

CALIFORNIA
Los Angeles Public Library
San Diego Public Library
COLORADO
Denver Public Library
CONNECTICUT
Hartford Public Library
MARYLAND
Enoch Pratt Free Library, Baltimore
MASSACHUSETTS
Boston Public Library
MICHIGAN
Detroit Public Library
MINNESOTA
Minneapolis Public Library
MISSOURI
Kansas City Public Library
St. Louis Public Library
NEW JERSEY
Trenton Public Library
NEW YORK
Brooklyn Public Library
Buffalo and Erie County Public Library
Rochester Public Library
New York Public Library
OHIO
Akron Public Library
Cincinnati Public Library
Cleveland Public Library
Dayton Public Library
Toledo Public Library
TENNESSEE
Memphis Public Library
TEXAS
Dallas Public Library
Fort Worth Public Library
WASHINGTON
Seattle Public Library
WISCONSIN
Milwaukee Public Library

An extensive collection of NASA and NASA-sponsored documents and aerospace publications available to the public for reference purposes is maintained by the American Institute of Aeronautics and Astronautics, Technical Information Service, 555 West 57th Street, 12th Floor, New York, New York 10019.

EUROPEAN

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

National Aeronautics and
Space Administration

Washington, D.C.
20546

Official Business
Penalty for Private Use, $300

THIRD-CLASS BULK RATE

Postage and Fees Paid
National Aeronautics and
Space Administration
NASA-451

U.S.MAIL

8 1 1U,B, 032381 S90569AU
NASA
SCIEN & TECH INFO FACILITY
ATTN: ACCESSIONING DEPT
P O BOX 8757 BWI ARPRT
BALTIMORE MD 21240

NASA

POSTMASTER: If Undeliverable (Section 158 Postal Manual) Do Not Return