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

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# TABLE OF CONTENTS

## Subject Categories

Abstracts in this bibliography are grouped under the following categories:

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<thead>
<tr>
<th>Category</th>
<th>Page</th>
</tr>
</thead>
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<tr>
<td><strong>01 SYSTEMS</strong></td>
<td>41</td>
</tr>
<tr>
<td>Includes mission requirements, focus missions, conceptual studies, technology planning, and systems integration.</td>
<td></td>
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<tr>
<td><strong>02 INTERACTIVE ANALYSIS AND DESIGN</strong></td>
<td>43</td>
</tr>
<tr>
<td>Includes computerized technology design and development programs, dynamic analysis techniques, thermal modeling, and math modeling.</td>
<td></td>
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<tr>
<td><strong>03 STRUCTURAL CONCEPTS</strong></td>
<td>47</td>
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<td>Includes erectable structures (joints, struts, and columns), deployable platforms and booms, solar sail, deployable reflectors, space fabrication techniques and protrusion processing.</td>
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<tr>
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<td>51</td>
</tr>
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<td></td>
</tr>
<tr>
<td><strong>05 ELECTRONICS</strong></td>
<td>57</td>
</tr>
<tr>
<td>Includes techniques for power and data distribution.</td>
<td></td>
</tr>
<tr>
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<td>59</td>
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<td>Includes matrix composites, polyimide films and thermal control coatings, and space environmental effects on these materials.</td>
<td></td>
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<tr>
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<td>61</td>
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<td>Includes automated manipulator techniques, EVA, robot assembly, teleoperators, and equipment installation.</td>
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<td>63</td>
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<tr>
<td>Includes propulsion designs utilizing solar sailing, solar electric, ion, and low thrust chemical concepts.</td>
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<tr>
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<tr>
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<td>Includes solar power satellite concepts with emphasis upon structures, materials, and controls.</td>
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<td><strong>11 GENERAL</strong></td>
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<td>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.</td>
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**SUBJECT INDEX** ................................................................. A-1
**PERSONAL AUTHOR INDEX** .................................................. B-1
**CORPORATE SOURCE INDEX** .................................................. C-1
**CONTRACT NUMBER INDEX** .................................................. D-1
**REPORT/ACCESSION NUMBER INDEX** ........................................ E-1
Critical technical, market, and policy issues relevant to future large broadband switched satellite networks are summarized. Our market projections for the period 1980 to 2000 are compared. Clusters of switched satellites, in lieu of large platforms, etc., are shown to have significant advantages. Analysis of an optimum terrestrial network architecture suggests the proper densities of ground stations and that link reliabilities > 99.99% may entail less than a 10% cost premium for diversity protection at 20/30 GHz. These analyses suggest that system costs increase as the 0.6 power of traffic. Cost estimates for nominal 20/30 GHz satellite and ground facilities suggest optimum system configurations might employ satellites with 285 beams, multiple TDMA bands each carrying 256 Mbps, and 16 ft ground station antennas. A nominal development program is outlined.

The paper deals with the problem of system identifiability for a linear dynamical system. Two theorems are given relating the sufficient condition of system identifiability for certain linear structures to the total number of inputs and outputs. The principle of least squares, that seeks the minimization of a cost function is employed to carry out the system identification process. To illustrate the concept of the paper, a structural model of a beam with point masses is examined. Parameter identification methods are studied and a random search technique is introduced.

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.


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 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.

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SPACE CONSTRUCTION EXPERIMENTS CONCEPTS Final Report
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 addressed and their construction procedures and requirements are identified.
A.W.H.


SPACE CONSTRUCTION SYSTEM ANALYSIS. PART 2: PLATFORM DEFINITION Final Report
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.

N80-531451*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

LARGE SPACE SYSTEMS TECHNOLOGY PROGRAM

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-rip 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.

N80-24343*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

SPACE OPERATIONS CENTER: A CONCEPT ANALYSIS
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.


SPACE CONSTRUCTION SYSTEM ANALYSIS STUDY: PROJECT SYSTEMS AND MISSIONS DESCRIPTIONS Final Report
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
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 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.
02 INTERACTIVE ANALYSIS AND DESIGN

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


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


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 include mechanical (stiffness), 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)


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)


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/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.


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)


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.


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 the 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)
02 INTERACTIVE ANALYSIS AND DESIGN


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)


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 membrane 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)


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 micro-rotation, 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* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md. INTEGRATED ANALYSIS AND DESIGN

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 No. 185) (NASA-13156). 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


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 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.

N80-31461* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md. INTEGRATED ANALYSIS OF LARGE SPACE SYSTEMS


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


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 was 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
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.

ON THE DESIGN VERIFICATION OF LARGE FLEXIBLE SOLAR ARRAYS: FIRST EXPERIENCES GAINED

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 production. 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.


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)


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)


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)


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.


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.


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. Wallisom, inventors (to NASA)
(Vought Corp., Hampton, Va.) Filed 5 Dec. 1979 17 p
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 groove and a strut joint half with semicircular groove 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

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
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.

The MAGSAT MAGNETOMETER BOOM
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.

N80-23799*# General Dynamics/Convair, San Diego, Calif.
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 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
J. S. Richardson, John Coven, Alan Fenn, and Al Brook Griffiss.
AFB, N.Y. RADC Mar. 1980 329 p refs
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. L.F.M.

N80-29376*# Grumman Aerospace Corp., Bethpage, N.Y.
(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.
(Contract NAS8-32390)
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.
(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.

The feasibility and costs were determined for a 1 m to 30 m diameter ambient temperature, infrared to submillimeter orbiting 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).
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)
04

CONTROL SYSTEMS

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


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)


Mission performance objectives dictate ultrastringent dimension-al 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 synergy 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)


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.)


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)


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.)


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 differentering, statistically optimal nonrecursive 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)


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

51
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.


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)


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 state-variant optimal control problem for the maneuvering of the spacecraft. (Author)


A method for the optimal control of self-adjoint distributed-parameter systems admitting closed-form eigenfunctions 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)


Based on partial differential equations of motion the closed form solution for the optimal estimation of a spatially continuous state variable 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)


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 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.


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 fast motion for closed 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.


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. Farenkopf (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In: Guidance and Control
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.


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)


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.


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.


The use of an annular momentum control device (AMCD) is proposed for enhancing the modal damping of large space structures (LSS’s) during finite 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.


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 horizontal with its major surface perpendicular to the orbit 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


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.


(NASA-CR-159171) Avail: NTIS HC A06/MF A01 CSCL 22A

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.


(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-decay 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


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.


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; (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)


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


Seven classes of large space structures were identified and idealized into simple geometric shapes which could be easily modeled. 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 scales 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.

GRA

ACOSS FOUR (ACTIVE CONTROL OF SPACE STRUCTURES) THEORY, VOLUME 4, PART C: 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

The dynamics and stability of large orbiting flexible beams, 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-degree-of-freedom gimbaled dumbbell are also developed and show 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
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.
Includes techniques for power and data distribution.


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)


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 (up to 120 V from 30 V). Component selection and design considerations are also discussed. (Author)


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)


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 baselines 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.


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 or remote assembly construction. DOE


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 electrical systems and electronic compartments which contain high-voltage, high-power electrical and electronic equipment. The influence of plasma and particulate 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 activities 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.

05 ELECTRONICS

(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 kW 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 payloads needed 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.


Mid to late 1980's power management technology needs to support development of a general purpose space platform, capable of supplying 100 to 250 KW to a variety of users in low Earth orbit are examined. A typical, shuttle assembled and deployed space platform is illustrated, 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 and the parameters used to develop system details which lead to technology goals, including: array and transmission voltages, worst frequency for ac power transmission, and advantages and disadvantages of 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


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. 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.


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.

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


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 -10th 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)


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 Meteorat, Marots, Intelsat V and LST. Advantages and the manufacturing process of the CFRP are presented. N.D.


The use of carbon-fiber composites as an alternative to metals in structural aerospace applications is 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.


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 materials. Methods of preparing (and designing with) resin composites and metal-matrix composites are discussed. V.P.


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 silafluorien links. The investigation was conducted using infrared and ultraviolet spectrosco-py. It is shown that polymethyl silafluorien siloxane is most stable to the radiation. The materials studied may be used as components in spacecraft thermal control coatings. B.J.


The activities of the Division Systemes Ballistiques et Spatiaux de l'Airspatiale 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 offshore oil drilling, flywheels for energy storage and the Syscomoram real-time medical data acquisition and processing system. A.L.W.


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.

A series of tests was performed to determine an optimum resin to be used as a UV rigidizable matrix in expanable 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 to be 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 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 mixture is cast as a thin film onto a surface and cured at approximately 300 C to produce a flexible electrically conductive cyclic palladium containing polyimide. The source of palladium ions is selected from the group of palladium 2 compounds consisting of LiPdC14, Pd[S(CH3)2]2Cl2, Na2PdCl4, and PdC14. NASA


ELECTRICALLY CONDUCTIVE PALLADIUM CONTAINING POLYIMIDE FILMS Patent Application

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 polyamic acid solution is prepared by reacting an aromatic dianhydride with an equimolar quantity of a palladium 2 ion-containing salt or complex. The reactant mixture is cast as a thin film onto a surface and cured at approximately 300 C to produce a flexible electrically conductive cyclic palladium containing polyimide. The source of palladium ions is selected from the group of palladium 2 compounds consisting of LiPdC14, Pd[S(CH3)2]2Cl2, Na2PdCl4, and PdC14. NASA

N80-28395# National Aeronautics and Space Administration. Langley Research Center. Langley Station. Va.

UNIAXIAL AND BIAXIAL TENSIONING EFFECTS ON THIN MEMBRANE MATERIALS

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 uniaxial 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 to 0.000635 cm) to 0.002 in (0.00508 cm). Some of the materials 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
ASSEMBLY CONCEPTS

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


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.


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 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.


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.


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)


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)


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 cargos 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.


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.
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. Loughhead 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-suit equipped subjects in a neutral buoyancy 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 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 space platforms were studied. Emphasis was placed on errectable 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

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.

(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
(Contract NAS9-15290)
(NASA-CR-163968) 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
(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
(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.


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 Gutman, 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)


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 Contaur 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)


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 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. (Author)


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.


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) interorbital 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)


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)


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.


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.


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)


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)


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


Aval: 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


Aval: 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


Aval: 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


Aval: 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.

N80-31459\# Martin Marietta Corp., Bethesda, Md.


Aval: 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 are 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


Aval: 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 inte grated with space systems, and it’s low pollution potential.

M.G.


LOW-THRUST CHEMICAL ROCKET ENGINE STUDY


Aval: 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, 02/H2 and 02/CH4 regen engine systems and 02/H2 film cooled engines were selected for further study in the system analysis. Six engine design concepts are examined.

M.G.


SOLAR ROCKET SYSTEM CONCEPT ANALYSIS Final Report

65
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.
SOLAR POWER SATELLITE SYSTEM

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


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.


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 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 telecommunications 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.


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.


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.


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.


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.


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, structural 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.


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 2W/cm^2, originally proposed as a threshold for nonlinear interactions could be doubled to 40 or 50 mW/sq cm.

J.P.B.


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.


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)


Starting from the hypothesis of a moderate growth for energy demand through the year 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)


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.


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 injections on the atmosphere, and (3) effects of SPS operations on electromagnetic systems and use of the radio spectrum.

A.T.


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 scale and magnitude of the associated environmental impacts. (Author)

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.

The 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)

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.

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.

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. Details of the comparison are presented.
B.J.

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 solar array, including the beaming of laser light after solar radiation is reflected by mirrors into space into a laser, are presented. Attention is given to the computer coding that models the way high-power lasers 'burn holes' in dense plasma as well as to the effects of laser interaction with the atmosphere. Several advantages of employing solar power are discussed such as solars for burning oil slicks, and cleaning snow from mountain-pass roads and fog from runways.
C.F.W.

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)
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 will involve laboratory development and testing of selected system elements to answer key technological and environmental questions. (Author)


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)


Evaluation 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)


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


Avail: NTIS

A solar power satellite transmission system which incorporates automatic beam forming, steering, and phase control is discussed. The phase control concept centers around the notion 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 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.

A80-22779*# Boeing Aerospace Co., Seattle, Wash.


Avail: NTIS

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.


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.

A80-22780*# Boeing Aerospace Co., Seattle, Wash.


Avail: NTIS

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.


Gerald F. Zollars Dec. 1979 88 pg. Sponsored by NASA and NTIS
10 SOLAR POWER SATELLITE SYSTEM

(NASA-CR-162931; PB80-802697) Avail: NTIS HC A05/MF A01 CSL 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 RECEPTCNA


(NASA-CR-161438) Avail: NTIS HC A08/MF A01 CSL 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 the modifications can allowed 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 CSL 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


(NASA-CR-161446) Avail: NTIS HC A05/MF A01 CSL 131

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.


(NASA-CR-161451; HONEYWELL-B05RC8) Avail: NTIS HC A08/MF A01 CSL 10A

The feasibility 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 38 p (Contract NASA-CR-32988)

(NASA-CR-161467) Avail: NTIS HC A05/MF A01 CSL 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.

N80-25380*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex. THE SOLAR POWER SATELLITE CONCEPTS: THE PAST DECADE AND THE NEXT DECADE


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, satellite and launch vehicle 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.

N80-25384*# Battelle Columbus Labs., Ohio. PRELIMINARY MATERIALS ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS)


(Contract W-7405-eng-92) (DOE/ER-0038) Avail: NTIS HC A07/MF A01 CSL 22B

Reference System Report: Concept Development and Evaluation Plan. This listing identified 22 materials used in the SPS. 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

N80-25363# Aerospace Corp., El Segundo, Calif. Space Sciences Lab.

Exhaust emissions 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 emissions when compared with the total mass and energy contents of the inner magnetosphere. The sources of these emissions 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 emissions are likely to be deposited inside the magnetosphere. DOE

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.

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 rectenna 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 cause 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


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.


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

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
10 SOLAR POWER SATELLITE SYSTEM

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
(Contract NAS9-15636)
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 conclusions were reached: antenna mounted solid state transmitters are potentially as cost effective as the klystron approach, although 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.
PHASE 3
(Contract NAS9-15636)
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
(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
(Contract NAS9-15636)
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
(Contract NAS9-15636)
HC A05/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
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)
EUROPEAN TECHNOLOGY APPLICABLE TO SOLAR POWER SATELLITE SYSTEMS (SPS) OF THE INTERNATIONAL ASTRONAUTICAL FEDERATION, Munich, 16 Sep. 1979
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
(Contract W-31-109-eng-38)
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
10 SOLAR POWER SATELLITE SYSTEM


SELECTION OF ALTERNATIVE CENTRAL STATION TECHNOLOGIES FOR THE SOLAR POWER SYSTEM (SPS) COMPARATIVE ASSESSMENT

An important effort is the Satellite Power System (SPS) comparative assessment. This 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


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


The Satellite Power System (SPS) program is 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.


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 preferred design is an antenna array consisting of individually encapsulated dipoles with reflectors or tags 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.


Takes performed to extend the database 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 modeling 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.

N80-30897* ECON, Inc., Princeton, N. J.


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 demonstration 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.


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

L.F.M.
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 configurations are discussed. Mass estimates for the system, the average cost per system unit, and the cost per flight estimates are also given.

M.G.
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.


(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.


(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 analysed 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 constntruction 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 preferable.

J.M.S.

N80-32928# Argonne National Lab., III. 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. SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, VOLUME 2, PART 2: SYSTEM ENGINEERING G. M. Hanley Sep. 1980 422 p


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.


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]
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.


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 NASCAP Charge 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.


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 errectable structures, concepts for earth-fabricated and space-fabricated members have been demonstrated.


Papers are presented on Spacelab science, materials processing in space, future satellite power system concepts, geostationary platforms, and Shuttle-era remote sensing. Consideration is 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.


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.


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


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 Altitude 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)


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.


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.


Recent progress in mass driver and additional 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 achrmonic trajectory for launching lunar materials to L2 or L5 is introduced, and various means for material capture and location are presented. A.L.W.


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 very 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.


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,

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.


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 nonoptimal SPS missions 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)


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 pulsed jet, electric storm atmospheric coupling, MHD-fan pulsed jet, 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.


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 large 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.


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 50-500 km, the major contaminant sources are SPS microwave transmissions and rocket effluents. Although no significant effects have yet been found for microwaves, deposition of rocket effluents causes compositional changes, most of which appear to be associated with the release of large amounts of water. From 50-36,000 km, rocket effluents and ion engine contaminants (primarily Ar(+)i could alter magnetospheric and plasmapheric 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)


This is a review of the effects associated with the propagation of intense microwave beams through the ionosphere. Collisonal 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)


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)


Large-scale operation of argon-ion engines in space may give rise to global-scale modification of the magnetosphere. In this paper, ion injector 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)


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)


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)


The passage of a space structure through the earth’s (or moon’s) shadow is attended by a change in the photogenerated plasma 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 photogenerated electron flux will be modeled. Using this and other simple models of the spacecraft charging phenomena, the charging 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)


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 microcircuity.

(Author)

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 and bias 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)


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 hereetofore 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)


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)


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.


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)


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.


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.


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

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)


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.


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


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


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 1980. 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.


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.


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 involving 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, as well as the choice 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.


**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 ion 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.


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

**N80-30225#** Committee on Science and Technology (U. S. House).

**NASA AUTHORIZATION. 1981. VOLUME 5**


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 conception 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


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**


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**


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.
A COMPUTER MODEL OF SOLAR PANEL-PLASMA INTERACTIONS Final Report

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 consistent space charge calculations. Such models include PANEL predictions for the Child-Langmuir diode problem. S.F.

LARGE SOLAR ARRAYS

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.

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)
Typical Subject Index Listing

**SUBJECT INDEX**

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

JANUARY 1981

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

ACCELERATION (PHYSICS)
Influence of interorbit acceleration on the design of large space antennas

ACCELEROMETERS
ACTUATORS
AT SOLAR REFLECTORS
ACTIMETERS
AT IMPLANTED SCANNERS
AT SOLAR INTERMITTER
ACTIVE CONTROL
Preliminary investigations into the active control of large space structures: Solution of the Timoshenko beam equations by the method of characteristics

ACOSS Four (Active Control of Space Structures) theory, volume 1

ADAPTIVE CONTROL
AT ACTIVATION
AT LEARNING MACHINES
A survey of automatic control techniques for large space structures

Adaptive and learning control of large space structures

Hardware demonstration of flexible beam control

ADAPTIVE CONTROL SYSTEMS
U ADAPTIVE CONTROL
AERONAUTICAL ENGINEERING
NASA authorization for fiscal year 1981, part 2

AERONAUTICS
NASA program plan

AEROSPACE ENGINEERING
AT AEROSPACE ENGINEERING
Structural distortions of space systems due to environmental disturbances

Space structure - To-day and to-morrow: Carbon-fiber composites for aerospace structures

A design procedure for a tension-wire stiffened truss-column

Proceedings of the 14th Aerospace Mechanisms Symposium

ALUMINUM-GALLIUM ARSENIDES
ALLEGIERS
NT NONLINEAR EQUATIONS
NT STATE VECTORS
ALGORITHMS
Large motions of unrestrained space trusses

ALTERNATIVES
SPS salvage and disposal alternatives

ALTITUDE CONTROL
ACOSS Four (Active Control of Space Structures) theory. Volume 2: Appendix

ALUMINUM-GALLIUM ARSENIDES
Satellite Power Systems (SPS) cost review

AMIDES
AT POLYMERS
AMPLIFIERS
MT MICROWAVE AMPLIFIERS
MT POWER AMPLIFIERS
Satellite Power Systems (SPS) concept definition study. Volume 6: In-depth element investigation
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
<th>ANALYSIS (MATHEMATICS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA study group, Executive summary</td>
<td>- [NASA-CR-163380]</td>
</tr>
<tr>
<td>ARTIFICIAL SATELLITES</td>
<td>- [NASA-CR-163180]</td>
</tr>
<tr>
<td>SATISFICATIONS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>COMMUNICATION SATELLITES</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>RASAT &amp; SATELLITE</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ORBITAL SPACE STATIONS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ORBITAL WORKSHOPS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>SOLAR POWER SATELLITES</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>SYNCHRONOUS SATELLITES</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>Solar power --- solar energy landing in space</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASPIRATION</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>VACUUM</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASSEMBLING</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ORBITAL ASSEMBLY</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASSESSMENTS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>TECHNOLOGY ASSESSMENTS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASTROBAY MAINTENANCE EQUIPMENT</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>EVA equipment for satellite service</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASTROBAYS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ORBITAL WORKERS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASTROBAY NAVECOCOGICS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>Large Deployable Reflector (LDR)</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ASTROBAY NAVECOCOGICS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ATMOSPHERIC COMPOSITION</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>Tropospheric effects of satellite power systems</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ATMOSPHERIC EFFECTS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>Effects of construction and operation of a satellite power system upon the magnetosphere --- injection of orbit transfer vehicle exhaust</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ATTITUDE CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>SATELLITE ATTITUDE CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>A survey of automatic control techniques for large space structures</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>The dynamics and control of large flexible space structures, 3. Part A: Shape and orientation control of a platform in orbit using point actuators</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ACOS 20 (Active Control of Space Structures) theory, volume 1</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>Auxiliary control of LSS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ATTITUDE STABILITY</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>VIBROACOUSTIC STABILITY</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>AUTOMATA THEORY</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>AUTOMATIC CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ACTIVE CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>ADAPTIVE CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>DYNAMIC CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>FEEDBACK CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>LEARNING MACHINES</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>OPTIMAL CONTROL</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>A survey of automatic control techniques for large space structures</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>Automated beam builder</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>AUTOMATIC BEAM IMPACT PREDICTORS</td>
<td>- [NASA-CR-163597]</td>
</tr>
<tr>
<td>COMPUTERIZED SIMULATION</td>
<td>- [NASA-CR-163597]</td>
</tr>
</tbody>
</table>
SUBJECT INDEX

AUXILIARY POWER SOURCES
Selection of alternative central-station technologies for the Satellite Power System (SPS) comparative assessment [DOE/ER-0052] p0074 880-29807

AVIATION 
U AERONAUTICS
AVOIDANCE
ST COLLISION AVOIDANCE
AXIAL STRESS
Uniaxial and biaxial tensioning effects on thin membrane materials --- large space structures [NASA-TM-81812] p0060 880-26395

BARDENAPPROXIMATION
U ELECTRICAL PROPERTIES
BEAMS (RADIATION)
NT ION BEAMS
BEAMS (SUPPORTS)
NT TORSIONAL BEAMS
Hardware demonstration of flexible beam control [AIAA 80-1794] p0053 880-65568
Micropolar beam models for lattice grids with rigid joints
Automated beam builder
Control-structure interaction in a free beam --- large space structures [NASA-TM-81029] p0053 880-28742

BENDING
Super mode rejection technique and complex variable bending mode representation [AIAA 80-1793] p0043 880-45567

BIBLIOGRAPHIES
Antenna arrays. Citations from the Engineering Index data base [PB80-80975] p0049 880-28462

BODIES OF REVOLUTION
NT CYLINDRICAL BODIES
BENDING
NT METAL BODIES
BOARDS (EQUIPMENT)
The Magnet magnetometer boom
Telescopic masts for deployment of flexible solar arrays

BOOST 
U ACCELERATION (PHYSICS)
BUCKLING
Buckling of periodic structures [AIAA 80-0681] p0047 880-35004
BUILDING MATERIALS 
U CONSTRUCTION MATERIALS

C ALGEBRA

CALCULUS
NT POWER SERIES
CAPE KENNEDY LAUNCH COMPLEX
Space Shuttle cargo processing at the Kennedy Space Center
CAPTIVE TESTS
NT STATIC TESTS
CARBON DIOXIDE LASERS 

CARBON FIBER REINFORCED PLASTICS
Application of composite materials to space structures [AIAA PAPER HT 79-45] p0059 880-36877
CARBON FIBERS
Space structure - to-day and to-morrow --- carbon-fiber composites for aerospace structures [AIAA PAPER HT 79-46] p0059 880-36878
CARBON MONOXIDE LASERS 
CARGO SPACECRAFT
Space Shuttle cargo processing at the Kennedy Space Center p0081 880-51940

CARRIER ROCKETS
U LAUNCH VEHICLES
CASCADE HOST/ST
U FIELD EFFECT TRANSISTORS
CASSUBRAIN OPTICS
CATIONS
NT METAL IONS
CELESTIAL BODIES
NT EARTH (PLANET)

CHEMICAL ELEMENTS
NT PALLADIUM
NT SILICON
CHEMICAL PROPULSION
Propulsion technology in the 1980's to support space missions to the year 2000. [AIAA PAPER HT 80-1216] p0063 880-41197
Leo-to-GEO low thrust chemical propulsion [NASA-CB-160748] p0042 880-30384
Low-thrust vehicles concept studies
Low-thrust chemical rocket engine study [AIAA PAPER 80-1216] p0065 880-31453
Low-thrust chemical rocket engine study [AIAA PAPER 80-1216] p0065 880-31459
CHEMOCORELATION PROPULSION
U CHEMICAL PROPULSION
CLASSICAL MECHANICS
NT SPACE MECHANICS
CLOSURE LOOP SYSTEMS
U FEEDBACK CONTROL
CLOTHING
NT SPACE SUITS
COATINGS 
NT THERMAL CONTROL COATINGS
COLLISION AVOIDANCE
Collision avoidance in space [NASA-CR-160764] p0047 880-35854

COLLISION WARNING DEVICES
U COLLISION AVOIDANCE
COLORS (SUPPORTS)
A design procedure for a tension-wire stiffened truss-boom [NASA-CR-3271] p0048 880-22735
COMMUNICATION SATELLITES
How large is large - Reflections on future large telecommunications satellites
Decentralized control for large communication satellites by model error sensitivity suppression [NASA-CR-160764] p0033 880-47559
Control of large communication satellites
Space construction system analysis study: Project systems and missions descriptions [NASA-CR-160764] p0042 880-27400
COMMUNICATION SYSTEMS 
U TELECOMMUNICATION
COMPARISON
Selection of alternative central-station technologies for the Satellite Power System
COMPUTERIZED DESIGN

A general dynamic synthesis for structures with
discrete substructures

Parameter plane analysis for large scale systems
--- large satellite controller design

COMPLEX VARIABLES

Establishing approximate root loci using power
series expansions --- control system
performance prediction for large space structures

Super node reduction technique and complex
variable bending mode representation

COMPOSITE MATERIALS

NT CARBON FIBER REINFORCED PLASTICS
NT FIBER COMPOSITES
NT GLASSFIBER-REINFORCED COMPOSITE MATERIALS
NT LAMINATES
NT METAL MATRIX COMPOSITES
NT REINFORCED PLASTICS

Composite materials in a simulated space environment

Composite structures for space system

COMPOSITE STRUCTURES

NT LAMINATES

Space structure - To-day and to-morrow ---
carbon-fiber composites for aerospace structures

Composite structures for space systems

The future belongs to composites - From space to the
ground

Development of ultraviolet rigidizable materials
--- expandable space erectable structures

COMPOSITES

U COMPOSITE MATERIALS

COMPOSITION (PROPERTY)
NT ATMOSPHERIC COMPOSITION

COMPUTER METHODS

U COMPUTER PROGRAMS

NASCAP modeling computations on large optics
spacecraft in geosynchronous substorm environments

Geometric modeling and analysis of large latticed
surfaces

The dynamics and control of large flexible space
structures, 3. Part A: Shape and orientation
control of a platform in orbit using point
actuators

Large space structure charging during eclipse

Integrated analysis of large space systems

A computer model of solar panel-plasma interactions

COMPUTER SIMULATION

U COMPUTERIZED SIMULATION

COMPUTER SYSTEMS DESIGN

Advanced development of a programmable power
processor

Integrated analysis capability for large space
systems

COMPUTER TECHNIQUES

Micropolar beam models for lattice grids with
rigid joints

COMPUTERIZED DESIGN

Nonlinear dynamic analysis of space trusses

COMPUTERIZED SIMULATION

Large motions of unrestrained space trusses

SPS phase control system performance via
analytical simulation

COMPUTERS

NT AIRBORNE/SPACEBORNE COMPUTERS

COMPOSING

Outgassing data for spacecraft materials

COMPOSITE HEAT TRANSFER

Heat transfer, thermal control, and heat pipes ---

CONFERENCES

Structures, Structural Dynamics, and Materials
Conference, 21st, Seattle, Wash., May 12-14,
1980, Technical Papers. Parts 1 & 2

Shuttle to the next space age; Proceedings of the
Southeast Seminar for Reporters and Teachers,
Huntsville, Ala., July 18, 19, 1979

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Eighth Symposium, Oxford, England, July 2-6, 1979

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ventures; Proceedings of the Seventeenth Goddard
Memorial Symposium, Washington, D.C., March
28-30, 1979

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August 11-13, 1980, Collection of Technical Papers

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Conference, Princeton University, Princeton,
N.J., May 14-17, 1979

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Symposium

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Effects of Satellite Power System Rectenna
Operation and Related Microwave Transmission
Problems

Workshop on Satellite Power Systems (SPS) Effects
on Optical and Radio Astronomy

Large Space Systems/Low-Thrust Propulsion Technology

Synchronous Energy Technology

CONGRESSOAL REPORTS

NASA authorization for fiscal year 1981, part 2

NASA authorization, 1981, volume 5

CONNECTIONS

U JOINTS (JUNCTIONS)

CONNECTORS

NT ELECTRIC CONNECTORS

CONNECTORS (ELECTRIC)

U ELECTRIC CONNECTORS

CONSTRUCTION

Space construction system analysis. Part 2:
Construction analysis

Space construction system analysis. Part 2:
Space construction experiments concepts

CONSTRUCTION IN SPACE

U ORBITAL ASSEMBLY

CONSTRUCTION MATERIALS

Structures, Structural Dynamics, and Materials
Conference, 21st, Seattle, Wash., May 12-14,
1980, Technical Papers. Parts 1 & 2

CONTRIBUTION

NT SPACECRAFT CONTAMINATION

Argon-ion contamination of the plasmasphere

CONTROL CONFIGURED VEHICLES

Across three (active control of space structures),
phase 1

CONTROL EQUIPMENT

ST TELEOPERATORS
CONTROL ROBERT: GYROSCOPES
Gyrodampers for large space structures
NASA-CB-150971 p0053 A80-28047

CONTROL SIMULATION
Adaptive and learning control of large space structures
AIAA 80-1739 p0052 A80-45533
Super node rejection technique and complex variable bending mode representation
AIAA 80-1793 p0043 A80-45567

CONTROL STABILITY
Establishing approximate root loci using power series expansions --- in control system performance prediction for large space structures
AIAA 80-1791 p0052 A80-45566
Super node rejection technique and complex variable bending mode representation
AIAA 80-1793 p0043 A80-45567
Modal damping enhancement in large space structures using AMCD's --- Angular Momentum Control Device
AIAA 80-1792 p0053 A80-47725

CONTROL VALVES
Maintainable maintenance disconnect valve /MSDV/ for on-orbit component replacement
ASME PAPER 80-ENAS-42 p0061 A80-43216

COSMIC DUST
Environmental effects of particulate debris on spacecraft systems
AIAA 80-1793 p0043 A80-45567

COSMIC PLASMA
Dynamics of a rigid body in the space plasma
AIAA 80-1791 p0052 A80-45566

COSMOGONY
Shuttle to the next space age; Proceedings of the Southeast Seminar for Reporters and Teachers, Huntsville, Ala., July 18, 19, 1979
AIAA 80-1791 p0052 A80-45566

COST ANALYSIS
NASA-CB-150971 p0076 A80-33869

COST EFFECTIVENESS
UAR/NASA Workshop on Space Science Platform
AIAA 80-1793 p0043 A80-45567

COST ESTIMATES
Start up considerations for a space manufacturing enterprise
AIAA 80-1791 p0052 A80-45566

CROW STATIONS
MT CROW WORK STATIONS
Crew Work Stations
MSLV remote work station - A flexible tool for Shuttle operations
ASME PAPER 80-88824 p0061 A80-43216

Crews
MT SPACECRAFT
CEREBRA
MT STRUCTURAL DESIGN CRITERIA
CURRENT DENSITY
Prediction of spacecraft potentials at geosynchronous orbit
AIAA 80-1794 p0082 A80-28047

CURRENTS
MT EXTERNAL SURFACE CURRENTS
CURVED SURFACES
Cylindrical Afterbodies
Cylindrical Bodies
Buckling of periodic structures
AIAA 80-06681 p0047 A80-35004
Cylindricals
Cylindrical Bodies

DARLING
VT VIBRATION DAMPING
DATA MANAGEMENT
Integrated analysis of large space systems
AIAA 80-1791 p0052 A80-45566

DATA PROCESSING
VT SIGNAL PROCESSING
DATA PROCESSING EQUIPMENT
MT AIRBORNE/SPACEBORNE COMPUTERS
MT MICRCOPROCESSORS

DEBRIS
MT SPACE DEBRIS
DECAT
MT PHOTOCURRENT EFFECT

DEFENSE PROGRAM
DOD low-thrust mission studies
AIAA 80-1791 p0052 A80-45566

DELIVERY
MT PAYLOAD DELIVERY (STS)

DENSITY (NUCLEAR/NUCLEAR)
MT MAGNETIC FIELD DENSITY
MT PLASMA DENSITY

DEPLOYMENT
Prediction of loads on antenna ribs due to mesh deployment
AIAA 80-0814 p0047 A80-37460

Large space systems technology program
AIAA 80-1791 p0052 A80-45566

Effect of orbital transfer loads on large platforms
AIAA 80-1791 p0052 A80-45566

DESIGN ANALYSIS
Large area flexible solar array design for Space Shuttle application
AIAA 80-1791 p0052 A80-45566

Space construction system analysis. Part 2: Construction analysis
NASA-CB-150971 p0076 A80-33869

Preliminary materials assessment for the Satellite Power System (SPS)
DOE/ER-0038 p0071 A80-25364

DIFFERENTIAL EQUATIONS
MT HYPERBOLIC DIFFERENTIAL EQUATIONS
MT PARTIAL DIFFERENTIAL EQUATIONS

DIMENSIONAL STABILITY
MT STRUCTURAL STABILITY
DIODES
MT THERMIOTIC DIODES
DIRECT POWER GENERATORS
MT SOLAR CELLS

DIRECTIONAL ANTENNAS
MT PARABOLIC ANTENNAS
MT RADAR ANTENNAS
MT SLOT ANTENNAS

DIRECTIONAL STABILITY
MT GYROSCOPIC STABILITY

DISCONNECT DEVICES
Maintainable maintenance disconnect valve /MSDV/ for on-orbit component replacement
ASME PAPER 80-88824 p0061 A80-43216

DISCONNECTORS
MT DISCONNECT DEVICES

DISHES
MT PARABOLIC REFLECTORS

DISPOSAL
MT SPS salvage and disposal alternatives
NASA-CB-161548 p0078 A80-33869

DISSIPATION
MT ENERGY DISSIPATION

DISTRIBUTED PARAMETER SYSTEMS
A survey of automatic control techniques for large space structures
AIAA 80-1794 p0082 A80-28047

Control of self-adjoint distributed-parameter systems
AIAA 80-1794 p0082 A80-28047

DISTRIBUTION
MT THRESHOLD DISTRIBUTION

DISTRIBUTION (PROBABILITY)
MT ANTENNA RADIATION PATTERNS
MT LOAD DISTRIBUTION (FORCES)

DISTURBANCE THEORY
MT RANDOMIZATION THEORY

DOCUMENTS
MT BIBLIOGRAPHIES

DRAG
MT SATELLITE DRAG
DUAL SPIN SPACECRAFT

DUAL SPIN SPACECRAFT
Optimal nodal-space control of flexible gyrosopic systems --- with application to dual spin large spacecraft
p0051 A80-332804

DUST

ST COSMIC DUST

DYNAMIC CHARACTERISTICS

NT CONTROL STABILITY
NT GEYROSCOPIC STABILITY
NT SATELLITE DYNAMICS
NT SPACECRAFT STABILITY
NT TRANSIENT RESPONSE

DYNAMIC CONTROL

Dynamics and control of a continuous model for a solar power system
p0068 A80-45534
Hardware demonstration of flexible beam control
[AIAA 80-1794] p0053 A80-45568
Large motions of unrestrained space trusses
p0046 A80-48127
The dynamics and control of large flexible space structures, 3. Part A: Shape and orientation control of a platform in orbit using joint actuators
[NASA-CR-163253] p0053 B80-27419
Access three (active control of space structures), phase 1
[AD-A089142] p0055 B80-33461

DYNAMIC LOADS

NT THrust LOADS

DYNAMIC RESPONSE

NT TRANSIENT RESPONSE

DYNAMIC STABILITY

NT CONTROL STABILITY
NT GEYROSCOPIC STABILITY
NT SPACECRAFT STABILITY

DYNAMIC STRUCTURAL ANALYSIS

p0077 A80-34993
A general dynamic synthesis for structures with discrete substructures
[NASA-CR-163408] p0054 B80-29418
Modal approach for modeling flexible manipulators -- Experimental results
p0043 A80-37474
Passive dissipation of energy in large space structures
p0043 A80-40749
Nonlinear dynamic analysis of space trusses
p0044 A80-53838
Control-structure interaction in a free beam --- large space structures
[NASA-TM-81029] p0053 B80-28742
Preliminary investigations into the active control of large space structures: Solution of the Timoshenko beam equations by the method of characteristics
[NASA-CR-163408] p0054 B80-29418
Primary propulsion/large space system interactions
p0065 B80-31458
The dynamics and control of large flexible space structures, Volume 3, part B: The modeling, dynamics, and stability of large earth pointing orbiting structures
[NASA-CR-163612] p0054 B80-33449

E

EARTH ORBITS
Space Operations Center: A concept analysis

EARTH RESOURCES
Fabrication and products, and economic considerations --- space processing
p0078 A80-46380

EARTH SATellites

NT COMMUNICATION SATELLITES
NT MAGSAT A SATELLITE
NT SOLAR POWER SATELLITES
NT SYNCHRONOUS SATELLITES

ECLIPsES
Spacecraft charging during eclipse passage
p0090 A80-46887
Large space structure charging during eclipse passage
[p¬A-16048101] p0083 B80-28022

ECONOMIC ANALYSIS
Fabrication and products, and economic considerations --- space processing
p0078 A80-46380
Potential economics of large space based solar power stations
p0069 A80-48354

ECONOMIC FACTORS
Solar energy economics - Orbiting reflectors for world energy
p0067 A80-41324

EFFECTIVENESS
NT COST EFFECTIVENESS

EFFICIENCY
NT ENERGY CONVERSION EFFICIENCY
NT POWER EFFICIENCY
NT PROPULSIVE EFFICIENCY

ELECTRIC CHARGE
Large space structure charging during eclipse passage
[p¬A-16048101] p0083 B80-28022

ELECTRIC CONNECTORS
Cables and connectors for Large Space System Technology (LSS) Technology
[NASA-CR-161423] p0057 B80-28713

ELECTRIC CURRENT
NT PLASMA CURRENTS

ELECTRIC FIELDS
NT INTERNAL SURFACE CURRENTS

ELECTRIC GENERATORS
NT SOLAR CELLS
NT SOLAR GENERATORS

ELECTRIC POTENTIAL
Study of power management technology for orbital multi-100kW applications. Volume 3: Requirements
[NASA-CR-159834] p0058 B80-29845

ELECTRIC POWER
Implications for the use of solar-power satellites --- from 100kW as an energy source
p0068 A80-43836
Satellite power systems for Western Europe -- Problems and solution proposals
p0069 A80-50633
Status of the satellite power system concept development and evaluation program
p0070 A80-50952
Rockwell Satellite Power System /SPS/ concept definition studies
p0070 A80-50953
The first realistic solar energy project
p0070 A80-50994
Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems
[DOE/ER-0056] p0075 B80-30916

ELECTRIC POWER PLANTS

NT NUCLEAR POWER PLANTS
The SPS concept -- an overview of status and outlook --- Satellite Power System
[p¬A-16048101] p0069 A80-48353
Preliminary comparative assessment of land use for the Satellite Power System (SPS) and alternative electric energy technologies
[NASA-CR-163327] p0073 B80-29866
Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems
[DOE/ER-0056] p0075 B80-30916

ELECTRIC POWER SUPPLIES
NT SPACECRAFT POWER SUPPLIES

EARTH ATMOSPHERE

NT P REGION
NT LOWER IONOSPHERE
NT MAGNETOSPHERE
NT THERMOSPHERE
NT UPPER ATMOSPHERE

EARTH ENVIRONMENT
Space systems and their interactions with earth's space environment --- Book
p0079 A80-46879

EARTH OBSERVATIONS (FROM SPACE)
Background suppression and tracking with a staring mosaic sensor --- for space platforms
p0051 A80-39104

EARTH PLANETS
The benefits of solar power satellites
p0068 A80-46387

EARTH SPACECRAFT

ELECTROSTATIC SUPPLIES

ELECTRICAL SUPPLIES
Progress in space power technology

Ground/bonding for Large Space System Technology (LSST) --- of metallic and nonmetallic structures

[NASA-CR-15606] p0057 880-26604

ELECTRIC POWER TRANSMISSION

Space platform utilities distribution study


Microwave beamed power technology improvement --- magnetrons and slotted waveguide arrays

[NASA-CR-163043] p0072 880-26785

Cables and connectors for Large Space System Technology (LSST)


Study of power management technology for orbital multi-100kWe applications. Volume 3: Requirements

[NASA-CR-159834] p0058 880-29945

Satellite power systems (SPS) concept definition study. Volume 1: Executive summary

p0076 880-30901

ELECTRIC PROPULSION

ELECTRIC ION PROPULSION

ELECTRIC LASER PROPULSION

ELECTRIC SOLAR ELECTRIC PROPULSION

SPS emissions and comparison with ambient loadings --- effects of Satellite Power System exhaust on atmosphere

[AAAPAPER 80-0868] p0067 880-32869

Propulsion technology in the 1980's to support space missions to the year 2000

[AAAPAPER 80-1216] p0063 880-41197

Station keeping of geostationary satellites by electric propulsion

[UCLAPAPER 80-009] p0064 880-41973

Electric propulsion technology

p0064 880-31452

Auxiliary control of LSS

p0054 880-31459

Electric propulsion and power

p0065 880-31465

Electric propulsion for SPS

p0075 880-31466

ELECTRIC ROCKET ENGINES

ELECTRIC ION ENGINES

ELECTRIC MERCURY ION ENGINES

ELECTRIC PLASMA ENGINES

Orbital transfer of large space structures with nuclear electric rockets

[AAAPAPER 80-0853] p0064 880-41897

ELECTRICAL CONDUCTIVITY

U ELECTRICAL RESISTIVITY

ELECTRICAL ENERGY

U ELECTRIC POWER

ELECTRICAL GROUNDING

Ground/bonding for Large Space System Technology (LSST) --- of metallic and nonmetallic structures


ELECTRICAL PROPERTIES

ELECTRICAL RESISTIVITY

Evaluation and prediction of long term space environmental effects on non-metallic materials

[NASA-CR-161505] p0060 880-33479

ELECTRICAL UNSTABILITY

Electrically conductive palladium containing polyimide films

[NASA-CAS-114-12705-1] p0060 880-24549

ELECTROMAGNETIC CONTROL

U REMOTE CONTROL

ELECTROMAGNETIC FIELDS

U FAR FIELDS

ELECTROMAGNETIC INTERACTIONS

U PLASMA-ELECTROMAGNETIC INTERACTION

ELECTROMAGNETIC PROPERTIES

U ELECTRICAL PROPERTIES

U PHOTOELECTRIC EFFECT

ELECTROMAGNETIC PROPULSION

U MASS DRIVERS (PAYLOAD DELIVERY)

ELECTROMAGNETIC RADIATION

U MICROWAVES

U ULTRAVIOLET RADIATION

ELECTROMAGNETIC WAVE TRANSMISSION

U THERMOABSORPTION PROPAGATION

U MICROWAVE TRANSMISSION

ELECTRON DENSITY (CONCENTRATION)

U MAGNETOSPHERIC ELECTRON DENSITY

ELECTRON TUBES

U MAGNETRONS

U THERMIONIC DIODES

ELECTRONIC AMPLIFIERS

U AMPLIFIERS

ELECTRONIC EQUIPMENT

U FIELD EFFECT TRANSISTORS

U PHOTOVOLTAIC CELLS

U SOLID STATE DEVICES

U SOLID STATE LASERS

U SPACECRAFT ELECTRONIC EQUIPMENT

ELECTROMAGNETIC PROPULSION

U ION PROPULSION

ELECTROMAGNETIC SHIELDING

ELECTROMAGNETIC PROTECTION OF THE SOLAR POWER SATellite and rectenna


ELECTROHERAL ENGINES

U FLASH ENGINES

ECLIPTICAL ORBITS

U TRANSFER ORBITS

EMISSION

U EXHAUST EMISSION

U PHOTOELECTRIC EFFECT

ENERGY CONVERSION

U SATELLITE SOLAR ENERGY CONVERSION

U SOLAR ENERGY CONVERSION

ENERGY DISSIPATION

Passive dissipation of energy in large space structures

p0043 880-40749

ENERGY LOSSES

U ENERGY DISSIPATION

ENERGY METHODS

U STORAGE ENERGY METHODS

ENERGY POLICY

The SPS concept - An overview of status and outlook

--- Satellite Power System

Potential economics of large space based solar power stations

p0069 880-42535

Satellite Power Systems (SPS): Concept development and evaluation program, preliminary assessment

[DOE/ER-0041] p0072 880-27404

Solar power satellite system definition study. Volume 1: Executive summary, phase 3

[NASA-CR-160742] p0073 880-27609

Solar power satellite system definition study. Volume 3: Laser SPS analysis, phase 3

[NASA-CR-160744] p0073 880-27611

Solar power satellite system definition study. Volume 4: Solid State SPS Analysis, Phase 3

[NASA-CR-160745] p0073 880-27812

Solar power satellite system definition study. Volume 5: Space transportation analysis, phase 3

[NASA-CR-160746] p0073 880-27813

Satellite Power Systems (SPS): Concept development and evaluation program: Preliminary assessment

[NASA-TM-81162] p0073 880-29842

Selection of alternative central-station space technologies for the Satellite Power System (SPS) competitive assessment

[DOE/ER-0052] p0074 880-29897

Some questions and answers about the Satellite Power System (SPS)

[NASA-CR-16329] p0074 880-29997

Satellite Power Systems (SPS) FY 79 program summary

[NASA-CR-163479] p0074 880-29990

Satellite power systems (SPS) concept definition study. Volume 2, part 1: System engineering

[NASA-CR-3318] p0075 880-31890

Satellite power systems: Status and planned activities

p0076 880-33904

ENERGY REQUIREMENTS

The potential global market in 2025 for Satellite Solar Power Stations

p0068 880-46382
FLYING PERSONNEL

FLYING PERSONNEL
NT ORBITAL WORKERS
NT SPACECRAFTS
FOLDING STRUCTURES
The Sagittar magnetometer boom
Design and technology of solar arrays for shuttle launched missions
p0048 N80-23517
p0084 N80-33883
FORCASTING
NT PERFORMANCE PREDICTION
NT PREDICTION ANALYSIS TECHNIQUES
NT TECHNOLOGICAL FORCASTING
FOREIGN POLICY
NT INTERNATIONAL COOPERATION
FORM
U SHAPES
FRANKHOFER REGION
U FAR FIELDS
FIRST ELECTRON LASERS
G FORCE
U ACCELERATION (PHYSICS)
GALLIUM ABSENIDES
NT ALUMINUM GALLIUM ABSENIDES
Preliminary materials assessment for the Satellite Power System (SPS) [DOE/ER-0038] p0071 N80-25364
GALLIUM COMPOUNDS
NT ALUMINUM GALLIUM ABSENIDES
NT GALLIUM ABSENIDES
GAS LASES
NT CARBON DIOXIDE LASES
NT CARBON MONOXIDE LASES
GAS LIQUEFACTION
U CONDENSING
GASES
U EXHAUST GASES
GASSTHERMETERS
U MAGNETOMETERS
GEODRIS LIMITS
Geometric modeling and analysis of large latticed surfaces [NASA-CR-3156] p0044 N80-22736
GEOGRAPHIC STORMS
U MAGNETIC STORMS
GEOGRAPHIC HYDROESEISMICS
U MAGNETIC HYDROESEISMICS
GEOMETRY
NT ANALYTIC GEOMETRY
NT GEODESIC LIMITS
GEOHYDROESEISMICS SATELLITES
U SYNCHRONOUS SATELLITES
GEOSYNCHRONOUS ORBITS
#5CAP modelling computations on large optics spacecraft in geosynchronous substorm environments [NASA-CR-160747] p0077 A80-32829
Attitude estimation and control of satellites in geosynchronous orbit p0051 A80-37453
A seminumerical procedure for the calculation of geostationary orbit perturbations caused by the Sun and the Moon [NASA-TT-455-BEV] p0081 N80-22389
Prediction of spacecraft potentials at geosynchronous orbit p0082 N80-24684
Synchronous Energy Technology [NASA-CP-2154] p0058 N80-33465
Synchronous energy technology program p0058 N80-33466
Spacecraft system overview of space power at geostationary Earth Orbit p0058 N80-33469
Large solar arrays p0084 N80-33471
U MAGNETOMETERS
GEODRIS LIMITS
U MAGNETIC STORMS
GRAPHITE-EPoxy COMPOSITE MATERIALS
Manufacturing methods for graphite/polyimide composite reentry vehicle substructures
SUBJECT INDEX

Some questions and answers about the Satellite Power System (SPS) [NASA-CR-163329] p0074 A80-29897

HYDRODYNAMICS
[ NASA-MAGNETOHYDRODYNAMICS

MAGNETOHYDRODYNAMICS

HYDROMAGNETICS

U MAGNETOHYDRODYNAMICS

HYDROMAGNETICS

MAGNETOHYDRODYNAMICS

HYDROSCHEMICS

MAGNETOHYDRODYNAMICS

HYPERBOLIC DIFFERENTIAL EQUATIONS

Preliminary investigations into the active control of large space structures; Solution of the Timoshenko beam equations by the method of characteristics [NASA-CR-163400] p0054 A80-29418

IDENTIFYING
[ NT PARAMETER IDENTIFICATION

NT SYSTEM IDENTIFICATION

IMAGE PROCESSING

Background suppression and tracking with a staring sensor --- for space platforms p0051 A80-39104

INDICATING INSTRUMENTS
[ NT MICROWAVE SENSORS

INELASTIC BODIES

U RIGID STRUCTURES

INFRARED HORIZON SCANNERS

U INFRARED SCANNERS

INFRARED INSTRUMENTS

U INFRARED SCANNERS

INFRARED SCANNERS

Background suppression and tracking with a staring sensor --- for space platforms p0051 A80-39104

INJECTION
[ NT ION INJECTION

INJECTOR PACKAGES

The Magnum magnetometer boom p0048 A80-23517

INTELLIGENCE
[ NT ARTIFICIAL INTELLIGENCE

INTERFACES

LSS/propulsion interactions studies p0042 A80-31454

INTERNATIONAL COOPERATION


Possibilities of participating in the American Space Operations Center /SOC/ [DGRL PAPER 80-039] p0078 A80-46290

INTERNATIONAL RELATIONS

NT INTERNATIONAL COOPERATION

INTERPLANETARY TRAJECTORIES

Optimization of space manufacturing systems p0079 A80-46389

INTERPLANETARY FLIGHT

NT LONG DURATION SPACE FLIGHT

Solar electric propulsion - A versatile stage for earth orbiting missions [DGRL PAPER 80-095] p0064 A80-41767

INTERPLANETARY PROPULSION

U INTERPLANETARY SPACECRAFT

U ROCKET ENGINES

INTERPLANETARY SPACECRAFT

Applications of an MHD propulsion system [AIAA PAPER 80-1225] p0063 A80-41201

ION BEAMS

Energetic ion beam magnetosphere injection and solar power satellite transport p0063 A80-32702

ION CURRENTS

NT ION BEAMS

ION SOURCES

NT MERCURY ION ENGINES

ION SOURCES

Argon-ion contamination of the plasmasphere p0080 A80-46884

ION INJECTION

Magnetospheric effects of solar power satellite [AIAA PAPER 80-0092] p0067 A80-32875

ION IRRADIATION

NT PHOTON IRRADIATION
optimal modal-space control of flexible gyroscopic systems --- with application to dual spin large spacecraft

Large space structures — Fantasies and facts

[ AIAA 80-0674 ] p0077 A80-34999

Large space structures activity at NSFC

[ AIAA 80-0670 ] p0077 A80-35000

Passive damping in large precision space structures

[ AIAA 80-0677 ] p0077 A80-35001

Continuum modeling of the mechanical and thermal behavior of discrete large structures

[ AIAA 80-0679 ] p0077 A80-35002

Structural sizing considerations for large space platforms

[ AIAA 80-0680 ] p0077 A80-35003

Buckling of periodic structures

[ AIAA 80-0681 ] p0077 A80-35004

A survey of automatic control techniques for large space structures

[ AIAA 80-37690 ] p0077 A80-37690

Large space structures and the remote sensing of soil moisture

[ AIAA 80-38794 ] p0077 A80-38795

Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures

[ AIAA PAPER 80-1223 ] p0077 A80-1223

Optimal maneuvering controller design for large space structures

[ AIAA 80-40751 ] p0077 A80-40751

Passive dissipation of energy in large space structures

[ AIAA 80-40743 ] p0077 A80-40743

Solar energy economics — Orbiting reflectors for world energy

[ AIAA 80-40753 ] p0077 A80-40753

Low thrust transfer of Large Space Systems

[ AIAA 80-1265 ] p0077 A80-1265

Orbital transfer of large space structures with nuclear electric rockets

[ AIAA PAPER 80-083 ] p0077 A80-083

Control of a large flexible platform in orbit

[ AIAA PAPER 80-1668 ] p0077 A80-1668

On maneuvering large flexible spacecraft using an annular momentum control device

[ AIAA PAPER 80-1669 ] p0077 A80-1669

Extensions of suboptimal output feedback control with application to large space structures

[ AIAA 80-1735 ] p0077 A80-1735

Adaptive and learning control of large space structures

[ AIAA 80-1739 ] p0077 A80-1739

Earth space demonstration of flexible beam control

[ AIAA 80-1794 ] p0077 A80-1794

Possibilities of participating in the American Space Operations Center /SOC/

[ DGLR PAPER 80-039 ] p0077 A80-039

Space systems and their interactions with earth's space environment — Book

[ AIAA 80-46880 ] p0077 A80-46880

Environmental effects of space systems — A review

[ AIAA 80-46880 ] p0077 A80-46880

Modification of the ionosphere by large space vehicles

[ AIAA 80-46893 ] p0077 A80-46893

Argon-ion contamination of the plasmasphere

[ AIAA 80-46893 ] p0077 A80-46893

Magnetospheric modification by gas releases from large space structures

[ AIAA 80-46880 ] p0077 A80-46880

Spacecraft charging during eclipse passage

[ AIAA 80-46885 ] p0077 A80-46885

Space environmental interactions with biased spacecraft surfaces

[ AIAA 80-46887 ] p0077 A80-46887

Plasmashade — Photons for large high-voltage space structures

[ AIAA 80-46889 ] p0077 A80-46889

Dynamics of a rigid body in the space plasma

[ AIAA 80-46900 ] p0077 A80-46900

Decentralized control for large communication satellites by model error sensitivity suppression

[ AIAA 80-47559 ] p0077 A80-47559

Control of large communication satellites

[ AIAA 80-47561 ] p0077 A80-47561

Modal damping enhancement in large space structures using AMCD’s — Angular Momentum Control Device

[ AIAA 80-47561 ] p0077 A80-47561

Potential economics of large space based solar power stations

[ AIAA 80-47725 ] p0077 A80-47725

The solar power satellite concept — The past decade and the next decade

[ AIAA 80-48354 ] p0077 A80-48354

Rockwell Satellite Power System/SPS/ concept definition studies

[ AIAA 80-50951 ] p0077 A80-50951

Men or machines to build in space

[ AIAA 80-51564 ] p0077 A80-51564

SOLARES orbiting mirror system

[ AIAA 80-52280 ] p0077 A80-52280

Nonlinear dynamic analysis of space trusses

[ AIAA 80-53838 ] p0077 A80-53838

Space construction system analysis. Part 2:

[ NASA-CB-160578 ] p0077 A80-160578

A mechanical adapter for installing precision equipment on large space structures

[ NASA-CB-162392 ] p0077 A80-162392

Automated beam builder

[ AIAA 80-23515 ] p0077 A80-23515

EVA manipulation and assembly of space structure columns

[ NASA-CB-3285 ] p0077 A80-3285

Spectrophotovoltaic orbital power generation

[ NASA-CB-161466 ] p0077 A80-161466

Study of multi-KW solar arrays for Earth orbit applications: Midterm performance review

[ NASA-CB-161467 ] p0077 A80-161467

Relax and bianular tensioning effects on thin membrane materials — large space structures

[ NASA-TE-81812 ] p0077 A80-26395

Ground/landing for Large Space System Technology (L5ST) --- of metallic and nonmetallic structures

[ NASA-CB-161468 ] p0077 A80-161468

LSST system analysis and integration task for an advanced science and application space platform

[ NASA-CB-161528 ] p0077 A80-161528

Cables and connectors for Large Space System Technology (L5ST)

[ NASA-CB-161423 ] p0077 A80-161423

Control-structure interaction in a free beam — large space structures

[ NASA-TP-81405 ] p0077 A80-28713

The dynamics of rigid body in the space plasma

[ AD-A084806 ] p0077 A80-28420

Large space structure charging during eclipse passage

[ AD-A084810 ] p0077 A80-28420

Systems definition study for shuttle demonstration flights of large space structures, Volume 2:

[ NASA-CB-161535 ] p0077 A80-28396

Systems definition study for shuttle demonstration flights of large space structures, Volume 3:

[ NASA-CB-161535 ] p0077 A80-28396

Preliminary investigations into the active control of large space structures: Solution of the Tsiolkovski beam equations by the method of characteristics

[ NASA-CB-163408 ] p0077 A80-29418

ACSOS Four (Active Control of Space Structures) theory, Volume 1

[ AD-A056544 ] p0077 A80-29421

Large Space Systems/Low-Thrust Propulsion Technology

[ NASA-CB-21404 ] p0077 A80-31449

Introduction: The challenge of optimal integration of propulsion systems and large space structures

[ NASA-CB-31450 ] p0077 A80-31450

Electric propulsion technology

[ AIAA 80-31451 ] p0077 A80-31451

Chemical propulsion technology

[ AIAA 80-31453 ] p0077 A80-31453

Potential economics of large space based solar power stations

[ AIAA 80-47725 ] p0077 A80-47725
The solar power satellite concept – The past decade and the next decade
Status of the solar power system concept development and evaluation program
The birth of the mechanical spaceplane – The Teleoperator Retrieval System
NASA authorization for fiscal year 1981, part 2
NASA authorization, 1981, volume 5
NASA program plan [NASA-TR-81136]

HBBVA (ESGBE)

OPERATIONAL PROBLEMS
Openings
Offshore Platforms
SDBJECTS

THEME

UNIVERSAL ELECTRIC POWER GENERATION

HCBIV ELECTRIC POWER PLANTS

NUCLEAR POWER PLANTS

Comparative analysis of energy efficiency for
Satellite Power Systems (SPS) and other energy
systems

NUCLEAR ELECTRIC PROPULSION

Zeus electric propulsion system utilization for
earth orbit transfer of large spacecraft
structures
Orbital transfer of large space structures with
nuclear electric rockets

NUCLEAR ENGINE FOR ROCKET VEHICLES

Orbital transfer of large space structures with
nuclear electric rockets

NUCLEAR POWER GENERATION

U NUCLEAR ELECTRIC POWER GENERATION

NUCLEAR POWER PLANTS

Space nuclear reactor power plants

NUCLEAR POWER REACTORS

Space nuclear reactor power plants

NUCLEAR PROPULSION

NUCLEAR ELECTRIC PROPULSION

NUCLEAR REACTORS

NUMERICAL ANALYSIS

NE THEORETICAL DIFFERENCE THEORY

A semi-numerical procedure for the calculation of
geostationary orbit perturbations caused by the
Sun and the Moon

OPTIMIZATION

OPTIMAL CONTROL

OPTIMUM CONTROL

OPTIONS

SDBJECTS

SATELLITE POWER SYSTEMS (SPS) AND OTHER ENERGY SYSTEMS

SPS emissions and comparison with ambient loadings
--- effects of Satellite Power System exhaust on
atmosphere

ORBIT TRANSFER VEHICLES

Orbit evolution to the 1990s --- Orbital Transfer
Vehicles for SPS

Nuclear electric propulsion system utilization for
earth orbit transfer of large spacecraft
structures

Low thrust transfer of Large Space Systems
Orbital transfer of large space structures with
nuclear electric rockets

Effects of construction and operation of a
satellite power system upon the magnetosphere
--- injection of orbit transfer vehicle exhaust
--- injection of orbit transfer vehicle exhaust

Technology requirements for future
Earth-to-geosynchronous orbit transportation
systems. Volume 2: Technical results

Low-thrust vehicles concept studies

Low-thrust vehicle concept studies

Electric propulsion for SPS

SPACE OPERATIONS CENTER: A concept analysis

Orbital transfer of Large Space Systems with
application to dual spin large spacecraft

Optimal member damper controller design for large
spacecraft 

Optimal large angle maneuvers with simultaneous
shape control/vibration arrest

Observation

Earth Observations (From Space)

Ocean Surface

Feasibility of siting SPS rectennas over the sea

OFFSHORE PLATFORMS

Solar power satellite offshore rectenna study

OPT

U SPACE TRANSPORTATION SYSTEM FLIGHTS

ONBOARD COMPUTERS

U AIRBORNE/SPACEBORNE COMPUTERS

ONBOARD EQUIPMENT

U AIRBORNE/SPACEBORNE COMPUTERS

ONBOARD ELECTRONIC EQUIPMENT

OPENINGS

U APERTURES

OPERATIONAL PROBLEMS

An environmental assessment of the Satellite Power
system reference design

Space Operations Center – Next goal for manned
space flight

A-16
RECOVERABLE SATELLITES

U RECOVERABLE SPACECRAFT

REVOLUTIONARY SPACECRAFT

NT SPACE SHUTTLES

SPS salvage and disposal alternatives
[ NASA-CR-161548 ] p0074 A80-30898

RECTENNAS

Increasing solar input to a single solar power satellite rectenna by using a pair of satellites p0067 A80-32942

Feasibility of siting SPS rectennas over the sea p0070 A80-59955

Electrostatic protection of the Solar Power Satellite and rectenna
[ NASA-CR-161543 ] p0071 A80-30891

Solar power satellite offshore rectenna study
[ NASA-CR-161543 ] p0074 A80-30899

Satellite Power Systems (SPS) concept definition study. Volume 5: Special emphasis studies -- rectenna and solar power satellite design studies

[ NASA-CR-3319 ] p0076 A80-33869

RECTIFIER ANTENNAS

U RECTENNAS

REENTRY BODIES

U REENTRY VEHICLES

REENTRY VEHICLES

NT RECOVERABLE SPACECRAFT

Manufacturing methods for graphite/polyimide composite reentry vehicle substructures
p0077 A80-34752

REFLECTORS

NT PARABOLIC REFLECTORS

NT SOLAR REFLECTORS

NT SOLETTAS

Large Deployable Reflector (LDR)
[ NASA-CR-152402 ] p0049 A80-33319

REGIONS

NT P REGION

REINFORCED MATERIALS

U COMPOSITE MATERIALS

REINFORCED PLASTICS

Composite structures for space systems
p0059 A80-36949

REINFORCEMENT (STRUCTURES)

A design procedure for a tension-wire stiffened trans-column
[ NASA-CR-3273 ] p0048 A80-22735

REINFORCING FIBERS

NT CARBON FIBERS

RELATIVISTIC PARTICLES

Magnetospheric effects of solar power satellite
[ AIAA PAPER 80-0892 ] p0067 A80-32875

RELIABILITY

NT SPACECRAFT RELIABILITY

RESCOPE CONTROL

The Remote Manipulator System -- for Space Shuttle astronaut and satellites
p0061 A80-46078

RESCOPE MANIPULATOR SYSTEM

The shuttle's remote manipulator system - Status and operations
[ DGLE PAPER 80-075 ] p0061 A80-41757

Space operations - Future requirements and systems
[ DGLE PAPER 80-093 ] p0061 A80-41766

RESCOPE SENSORS

Background suppression and tracking with a staring mosaic sensor -- for space platforms
p0051 A80-39104

REPORTS

NT CONGRESSIONAL REPORTS

RESEARCH

NT MARKET RESEARCH

NT OPERATIONS RESEARCH

RESEARCH AND DEVELOPMENT

The Remote Manipulator System -- for Space Shuttle astronaut and satellites
p0061 A80-46078

Start up considerations for a space manufacturing enterprise
p0078 A80-66388

How large is large -- Reflections on future large telecommunications satellites
p0041 A80-46687

Potential economics of large space based solar power stations
p0041 A80-46687

SUBJECT INDEX

Feasibility of siting SPS rectennas over the sea p0069 A80-48354

RESINS

NT POLYIMIDE RESINS

NT THERMOSETTING RESINS

RESISTIVITY

NT ELECTRICAL RESISTIVITY

RESOURCES

NT EARTH RESOURCES

NT EXTRATERRESTRIAL RESOURCES

RESPONSES

NT MODAL RESPONSE

NT TRANSIENT RESPONSE

RETRACTABLE EQUIPMENT

Design and technology of solar arrays for shuttle launched missions p0049 A80-33883

RETRACTABLE LANDING GEAR

U RETRACTABLE EQUIPMENT

RETRIEVAL

Large space systems technology program p0042 A80-31451

REUSABLE LAUNCH VEHICLES

NT SINGLE STAGE TO ORBIT VEHICLES

REUSABLE SPACECRAFT

NT SINGLE STAGE TO ORBIT VEHICLES

NT SPACE SHUTTLES

RIGID BODIES

NT RIGID STRUCTURES

RIGID STRUCTURES

Dynamics and control of a continuum model for a solar power system [ AIAA 80-1740 ] p0068 A80-45534

Dynamics of a rigid body in the space plasma p0061 A80-48900

Development of ultraviolet rigidizable materials
--- expandable space erectable structures
[ NASA-CR-161426 ] p0059 A80-22491

The dynamics of rigid body in the space plasma
[ AD-A084806 ] p0082 A80-28240

ROBOTS

Machine intelligence and robotics: Report of the NASA study group. Executive summary

ROCKET ENGINE DESIGN

Applications of an HFD propulsion system
[ AIAA PAPER 80-1225 ] p0063 A80-14201

100-to-600 low thrust chemical propulsion
p0064 A80-30304

ROCKET ENGINES

NT ELECTRIC ROCKET ENGINES

NT ION ENGINES

NT RECURT ION ENGINES

NT NUCLEAR ENGINES FOR ROCKET VEHICLES

Low-thrust chemical rocket engine study
p0065 A80-31467

Solar rocket system concept analysis
p0065 A80-31470

ROCKET EXHAUST

Emissions and comparison with ambient loadings
--- emissions of Satellite Power System exhaust on atmosphere
[ AIAA PAPER 80-0893 ] p0067 A80-32868

Magnetospheric effects of solar power satellite
[ AIAA PAPER 80-0892 ] p0067 A80-32875

Environmental effects of space systems - A review
p0079 A80-46880

Modification of the ionosphere by large space vehicles
p0080 A80-46883

Magnetospheric modification by gas releases from large space structures
p0080 A80-46885

ROCKET LAUNCHING

NT ORBITAL LAUNCHING

BOGALLO KINGS

U FOLDING STRUCTURES

BOLOFF SOLAR ARRAYS

U SOLAR ARRAYS

ROTARY STABILITY

NT CYCLOSOPIC STABILITY

ROUGHNESS

NT SURFACE ROUGHNESS

SAFETY DEVICES

NT SPACE SUITS
SATELLITE HABITAT

SATELLITE BEHAVIOUR

SATELLITE LAYOUT

SATELLITE GOOD SPOTTING

SATELLITE 1111110 COSMOS

SATELLITE DBAG

SATELLITE DESIRE

SATELLITE ATTITUDE DISTURBANCE

SATELLITE STABILITY

SATELLITE CONFIGURATIONS

The Magsat magnetometer boom

SATELLITE CONTROL

SATELLITE ATTITUDE CONTROL

SATELLITE DESIGN

New directions for future satellite power system

/SPS/ concepts

Parameter plane analysis for large scale systems

--- large satellite controller design

[IAA 80-1750]

How large is large — Reflections on future large telecommunication satellites

[IAA 80-4556]

Environmental protection of the solar satellite

[IAA 80-46687]

Satellite Power Systems (SPS) concept definition study. Volume 5: Special emphasis studies --- rectenna and solar power satellite design studies

[IAA 80-32861]

SATELLITE DRAG

Dynamics of a rigid body in the space plasma

[IAA 80-46900]

SATELLITE GROUND SUPPORT

SATELLITE Power Systems (SPS) concept definition study. Volume 5: Special emphasis studies --- rectenna and solar power satellite design studies

[IAA 80-3322]

SATELLITE LAUNCHING

U SPACECRAFT STABILITY

SATELLITE MANOEUVRES

U SPACECRAFT MANOEUVRES

SATELLITE NETWORKS

Increasing power input to a single solar power rectenna by using a pair of satellites

[IAA 80-32942]

SATELLITE ORBITS

SATELLITE Power Systems (SPS) concept definition study. Volume 5: Special emphasis studies --- rectenna and solar power satellite design studies

[IAA 80-3322]

SATELLITE POWER TRANSMISSION (TO EARTH)

Increasing power input to a single solar power rectenna by using a pair of satellites

[IAA 80-32942]

Satellite Power Systems /SPS/ - Overview of system studies and critical technology

[AAS PAPER 80-084]

Effects of microwave beams on the ionosphere

[IAA 80-46881]

Solar power satellites — The present and the future

[IAA 80-47562]

The first realistic solar energy project

[IAA 80-50994]

SPS phase control system performance via analytical simulation

[IAA 80-47562]

Solar power satellites. Citations from the International Aerospace Abstracts data base

[IAA 80-22378]

Study of multi-kW solar arrays for Earth orbit application

[IAA 80-22861]

The solar power satellite concepts: The past and the next decade

[IAA 80-25360]

Preliminary materials assessment for the Satellite Power System (SPS)

SATELLITE SOLAR POWER STATIONS

Large area flexible solar array design for Space Shuttle application

[IAA 80-28124]

The solar power satellite concepts: The past decade and the next decade

[IAA 80-25360]


[IAA 80-30900]

Satellite power systems (SPS) concept definition study. Volume 5: Special emphasis studies --- rectenna and solar power satellite design studies

[IAA 80-3322]

Satellite power systems: Status and planned activities

[IAA 80-32942]

SATELLITE SOLAR ENERGY CONVERSION

Progress in space power technology

[IAA 80-46173]

Large area flexible solar array design for Space Shuttle application

[IAA 80-48173]

The solar power satellite concepts: The past decade and the next decade

[IAA 80-25360]


[IAA 80-30900]

Satellite power systems (SPS) concept definition study. Volume 5: Special emphasis studies --- rectenna and solar power satellite design studies

[IAA 80-3322]

Satellite power systems: Status and planned activities

[IAA 80-32942]
The SPS concept - an overview of status and outlook

Satellite power systems for Western Europe - Problems and solution proposals

Feasibility of siting SPS rectennas over the sea

Study of multi-kW solar arrays for Earth orbit application

The solar power satellite concepts: The past decade and the next decade

Satellite Power System (SPS): Concept development and evaluation program: Preliminary assessment

Selection of alternative central-station technologies for the Satellite Power System (SPS) comparative assessment

Satellite power systems (SPS) concept definition study. Volume 1: Executive summary

Satellite Power System (SPS) FY 79 program summary

Solar power satellite offshore rectenna study

SPS salvage and disposal alternatives

Satellite Power System (SPS) concept definition study. Volume 7: System/Subsystem requirements data book

Satellite power systems (SPS) concept definition study. Volume 1: Executive summary

Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems

Workshop on Satellite Power Systems (SPS) Effects on Optical and Radio Astronomy

Satellite power systems (SPS) concept definition study. Volume 2, part 1: System engineering

Methodology for the comparative assessment of the Satellite Power System (SPS) and alternative technologies

Solar power satellites - the ionospheric connection

Background suppression and tracking with a staring mosaic sensor — for space platforms

Scanners

Scheduling

Scientific Satellites

Secular Perturbation

Long Term Effects

Selection

Satellite Deployment Satellites

Satellite Erection Devices

Space Construction Automated Fabrication

Experience Definition Study (SCAFEDS), part 3.

Volume 3: Requirements
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
<th>SOLAR POWER SATELLITES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microwave beamed power technology improvement -- magnetrons and slotted waveguide arrays</td>
<td>![Image]</td>
</tr>
<tr>
<td>Satellite power systems (SPS) magnetron tube assessment study</td>
<td>![Image]</td>
</tr>
<tr>
<td>SOLAR ARRAYS</td>
<td>SOLAR ENERGY</td>
</tr>
<tr>
<td>NT SOLAR BLANKETS</td>
<td>Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems</td>
</tr>
<tr>
<td>Adaptive and learning control of large space structures</td>
<td>![Image]</td>
</tr>
<tr>
<td>Large area flexible solar array design for Space Shuttle application</td>
<td>![Image]</td>
</tr>
<tr>
<td>Study of multi-kW solar arrays for Earth orbit application</td>
<td>![Image]</td>
</tr>
<tr>
<td>Study of multi-kW solar arrays for Earth orbit applications: Midteria performance review</td>
<td>![Image]</td>
</tr>
<tr>
<td>Satellite Power Systems (SPS) concept definition study. Volume 6: In-depth element investigation</td>
<td>![Image]</td>
</tr>
<tr>
<td>Satellite power system (SPS) concept definition study. Volume 3: Experimental verification</td>
<td>![Image]</td>
</tr>
<tr>
<td>Large solar arrays</td>
<td>![Image]</td>
</tr>
<tr>
<td>Telescopic mast for deployment of flexible solar arrays</td>
<td>![Image]</td>
</tr>
<tr>
<td>Design and technology of solar arrays for shuttle launched missions</td>
<td>![Image]</td>
</tr>
<tr>
<td>On the design verification of large flexible solar arrays: First experiences gained</td>
<td>![Image]</td>
</tr>
<tr>
<td>SOLAR BLANKETS</td>
<td>SOLAR POWER SATELLITES</td>
</tr>
<tr>
<td>Design and technology of solar arrays for shuttle launched missions</td>
<td>![Image]</td>
</tr>
<tr>
<td>On the design verification of large flexible solar arrays: First experiences gained</td>
<td>![Image]</td>
</tr>
<tr>
<td>SOLAR CELLS</td>
<td>New directions for future satellite power system SPS/ concepts</td>
</tr>
<tr>
<td>New directions for future satellite power system /SPS/ concepts</td>
<td>![Image]</td>
</tr>
<tr>
<td>Photovoltaic power generators in space</td>
<td>![Image]</td>
</tr>
<tr>
<td>Environmental protection of the solar power satellite</td>
<td>![Image]</td>
</tr>
<tr>
<td>Large area flexible solar array design for Space Shuttle application</td>
<td>![Image]</td>
</tr>
<tr>
<td>Preliminary materials assessment for the Satellite Power System (SPS)</td>
<td>![Image]</td>
</tr>
<tr>
<td>Satellite power systems (SPS) concept definition study. Volume 2, part 1: System engineering</td>
<td>![Image]</td>
</tr>
<tr>
<td>SOLAR COLLECTIONS</td>
<td>SOLAR GENERATORS</td>
</tr>
<tr>
<td>NT SOLAR REFLECTORS</td>
<td>NT SOLAR SATELLITES</td>
</tr>
<tr>
<td>SOLAR CONVERTERS</td>
<td>SOLAR GENERATORS</td>
</tr>
<tr>
<td>SOLAR ELECTRIC PROPULSION</td>
<td>SOLAR ENGNERGY</td>
</tr>
<tr>
<td>Solar electric propulsion - A versatile stage for earth orbiting missions</td>
<td>![Image]</td>
</tr>
<tr>
<td>Adaptive and learning control of large space structures</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

A-23
Discussion meeting on Gossamer spacecraft (ultralightweight spacecraft) [NASA-CR-162730] p0064 N80-26376


Effect of orbital transfer loads on large platforms [NASA-CR-160402] p0044 N80-31660

Large Deployable Reflector (LDB) [NASA-CR-165420] p0049 N80-33319

Space Exploration


The space shuttle at work [NASA-SP-432] p0083 N80-30867


Fabrication, products, and economic considerations -- space processing [NASA-CR-163698] p0062 N80-34101

Scaling and the start-up phase of space industrialization [NASA-CR-163698] p0062 N80-34103

Laser-boosted advanced LTV as a heavy lift launch vehicle [NASA-CR-163698] p0062 N80-34104

Space Laboratories

U2 Manned Orbital Laboratories

Space Maintenance

Maintainable maintenance disconnect valve (MMDV) for co-orbit component replacement [AIAA PAPER 80-2629] p0061 A80-42316


Space Manufacturing


Fabrication products, and economic considerations -- space processing [NASA-CR-163597] p0078 N80-46380

Start up considerations for a space manufacturing enterprise [NASA-CR-163597] p0078 N80-46383


Men or machines to build in space [NASA-CR-163597] p0081 N80-51564


Space Mechanics

Space platform utilities distribution study [NASA-CR-165272] p0057 N80-26365

Space Missions

Propulsion technology in the 1980's to support space missions to the year 2000 [AIAA PAPER 80-1215] p0063 A80-41119

Manned remote work station - A flexible tool for Shuttle operations [DGLR PAPER 80-002] p0061 A80-41762

The Remote Manipulator System - for Space Shuttle astronauts and satellites [DGLR PAPER 80-002] p0061 A80-41607


Large space systems technology program [NASA-CR-163597] p0062 N80-34102
THE SPACEx STATIONS

The birth of the mechanical spacecraft - The Teleoperator Retrieval System p0061 A80-52466
Space Construction Automated Fabrication: Experiment Definition Study (SCAFEDS), part 3.
The space shuttle at work [NASA-SP-432] p0083 N80-30367

SPACE STATIONS

MT ORBITAL SPACE STATIONS
MT ORBITAL WORKSHOPS
MT SPACE BASE COMMAND CENTER
Background suppression and tracking with a staring mosaic sensor -- for space platforms p0051 A80-39104
Space Operations Center - Next goal for manned space flight p0081 A80-48797
Space assembly fixtures and aids [NASA-CR-160748] p0042 N80-27400
The dynamics and control of large flexible space structures, 3. Part A: Shape and orientation control of a platform in orbit using point actuators [NASA-CR-162535] p0053 N80-27419
Study of power management technology for orbital multi-100kWe applications. Volume 3: Requirements [NASA-CR-159834] p0058 N80-29045

SPACE SUITS


SPACE SURVEILLANCE

Future space power - The D.O.D. perspective p0081 A80-48174

SPACE SYSTEMS ENGINEERING

AEROSPACE ENGINEERING

SPACE TOOLS

Space operations - Future requirements and systems [DGLR PAPER 80-093] p0061 A80-47166

SPACE TRANSPORTATION

MT SPACE TRANSPORTATION SYSTEM

SPS emissions and comparison with ambient loadings -- effects on Earth Satellite Power System exhaust on atmosphere [AIAA PAPER 80-0883] p0067 A80-32869
Laser-boosted advanced LTA as a heavy lift launch vehicle [NASA-CR-160746] p0073 N80-27813

SPACE TRANSPORTATION SYSTEM

MT SPACE SHUTTLE ORBITERS
MT SPACE SHUTTLES
MT SPACE TRANSPORTATION SYSTEM FLIGHTS

Shuttle to the next space age; Proceedings of the Southeast Seminar for Reporters and Teachers, Huntsville, Ala., July 18, 19, 1979 p0077 A80-36598
OTV evolution to the 1990s --- Orbital Transfer Vehicles for STS [AIAA PAPER 80-3212] p0063 A80-38972
Solar electric propulsion -- A versatile stage for earth orbiting missions [DGLR PAPER 80-095] p0064 A80-41767
Orbital transfer of large space structures with nuclear electric rockets [AAS PAPER 80-093] p0064 A80-41897
Space Shuttle cargo processing at the Kennedy Space Center p0081 A80-51940

EVA manipulation and assembly of space structure columns [NASA-CR-13205] p0062 N80-23908
Space platform utilities distribution study [NASA-CR-159272] p0057 N80-26365
Discussion meeting on Gossamer spacecraft (ultralightweight spacecraft) [NASA-CR-163275] p0064 N80-26376
The space shuttle at work [NASA-SP-432] p0083 N80-30367
The space shuttle at work [NASA-CR-159272] p0057 N80-26365
SBD low-thrust mission studies p0065 N80-31455
Low-thrust vehicle concept studies p0065 N80-31457
NASA Workshop on Space Science Platform (ultralightweight spacecraft) [NASA-SP-82204] p0083 N80-32144
Design and technology of solar arrays for shuttle launched missions p0084 N80-33883

SPACE TRANSPORTATION SYSTEM FLIGHTS

STA equipment for satellite service [ASME PAPER AN-684-48] p0061 A80-43222
SPACE VEHICLE CONTROL

SPACE SHUTTLE CONTROL

SPACEBOAT EXPERIMENTS

First results of material charging in the space environment p0078 A80-45609
Prediction of loads on antenna ribs due to mesh deployment [AIAA-00-0040] p0047 A80-35905

SPACECRAFT ATTITUDES

MASCAP modelling computations on large optics spacecraft in geosynchronous substorm environments p0077 A80-32629
First results of material charging in the space environment p0078 A80-45609
Space systems and their interactions with earth's space environment --- Book p0078 A80-45609
Spacecraft charging - A review p0090 A80-46686
Spacecraft charging during eclipse passage p0080 A80-46687
Radial effects on space systems and their modeling p0080 A80-46687
Space environmental interactions with biased spacecraft surfaces p0080 A80-46687
Plasmoids - photophysics theory for large high-voltage space structures p0081 A80-46698
Environmental protection of the solar power satellite p0069 A80-46699
Dynamics of a rigid body in the space plasma p0081 A80-46600

SUBJECT INDEX
P-0071 A80-23348

Spacecraft Components
Sustainable maintenance disconnect valve (MDV)/for on-orbit component replacement
[ASME PAPER 80-EMAS-42] P-0061 A80-31231
ACROSS FOUR (Active Control of Space Structures) theory, volume 1
[AD-A085654] P-0058 A80-29421
ACROSS FOUR (Active Control of Space Structures) theory, volume 2: Appendix
[AD-A085656] P-0054 A80-29422

Spacecraft Configurations
Primary propulsion/large space system interactions
P-0065 A80-31456

Spacecraft Construction Materials
Manufacturing methods for graphite/polyamide composite reentry vehicle substructures
P-0077 A80-34752
Composite materials in a simulated space environment
[AA/S 80-0678] P-0059 A80-35104
Application of composite materials to space structures
[AA/S PAPER 80-79-45] P-0059 A80-36677
Composite structures for space systems
P-0059 A80-36994
Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links
--- for spacecraft thermal control coatings
P-0059 A80-38754
The future belongs to composites - From space to the ground
P-0059 A80-39850
Ion thruster plume effects on spacecraft surfaces
[AA/S PAPER 80-1228] P-0063 A80-41202
First results of material charging in the space environment
P-0078 A80-45609
A study of the effect of proton bombardment on the mechanical properties of polyars
P-0059 A80-46814
The solar power satellite concepts: The past decade and the next decade
P-0071 A80-25360
Outgassing data for spacecraft materials
[NASA-SP-1061] P-0060 A80-30441
Evaluation and prediction of long term space environmental effects on non-metallic materials
[NASA-CR-161565] P-0060 A80-33479

Spacecraft Componentization
Ion thruster plume effects on spacecraft surfaces
[AA/S PAPER 80-1228] P-0063 A80-41202

Spacecraft Control
NT SATELLITE ATTITUDE CONTROL
Optimal model-space control of flexible gyroscopic systems --- with application to dual spin large spacecraft
P-0051 A80-33284
Passive damping in large precision space structures
[AA/S 80-0677] P-0051 A80-35001
Automatic control in space; Proceedings of the Eighth Symposium, Oxford, England, July 2-6, 1979
P-0051 A80-37426
A survey of automatic control techniques for large space structures
P-0051 A80-37460
Station keeping of geostationary satellites by electrostatic propulsion
[DLG PAPER 80-009] P-0064 A80-41973
Control of a large flexible platform in orbit
[AA/S PAPER 80-1668] P-0052 A80-40501
On maneuvering large flexible spacecraft using an annular momentum control device
P-0052 A80-45042
P-0077 A80-45514
Dynamics and control of a continuum model for a solar power system
[AA/S 80-1790] P-0068 A80-45534
Parameter plane analysis for large scale systems --- large satellite controller design
[AA/S 80-1790] P-0052 A80-45565
Establishing approximate root loci using power series expansions with in control systems
P-0052 A80-45566
Modal damping enhancement in large spacecraft structures using ANC's --- Angular Momentum Control Device
P-0053 A80-47725
Controls for LSS
P-0054 A80-31464
Across three (active control of space structures), phase 1
[AD-A089142] P-0055 A80-33461
SATELLITE DESIGN
Composite materials in a simulated space environment
[AA/S 80-0678] P-0059 A80-35104
Application of composite materials to space structures
[AA/S PAPER 80-79-45] P-0059 A80-36677
Optical member damper controller design for large space structures
P-0051 A80-40748
Low thrust transfer of Large Space Systems
[AA/S PAPER 80-1265] P-0053 A80-41520
Possibilities of participating in the American Space Operations Center /SOC/
[DLG PAPER 80-039] P-0078 A80-46290
Environmental effects of particulate debris on spacecraft systems
P-0081 A80-48263
Integrated analysis capability for large space systems
P-0044 A80-31463

SATELLITE ELECTRONIC EQUIPMENT
Cables and connectors for Large Space System Technology (LSS)
[NASA-CR-161423] P-0057 A80-28713
SATELLITE ENVIRONMENTS
Environmental effects of particulate debris on spacecraft systems
P-0081 A80-48263

SATELLITE GUIDANCE
P-0077 A80-45541

SATELLITE LAUNCHING
Space Shuttle cargo processing at the Kennedy Space Center
P-0081 A80-51940
Extravehicular Crewman Work System (ECWS) study program. Volume 3: Satellite service
[NASA-CR-163597] P-0062 A80-34103
SATELLITE MANEUVERS
NT ORBITAL MANEUVERS
On maneuvering large flexible spacecraft using an annular momentum control device
[AA/S PAPER 80-1668] P-0052 A80-45042
Optimal large angle maneuvers with simultaneous shape control/vibration arrest
P-0053 A80-28398
Extravehicular Crewman Work System (ECWS) study program. Volume 1: Executive Summary
[NASA-CR-163597] P-0062 A80-34103
Extravehicular Crewman Work System (ECWS) study program. Volume 3: Satellite service
P-0062 A80-34103

SATELLITE MOotion
Large motions of unrestrained space trusses
P-0044 A80-48127

SATELLITE ORBITAL ASSEMBLY
NT ORBITAL ASSEMBLY
SATELLITE ORBITALS
SATELLITE OBSERVATIONS
NT GEOSYNCHRONOUS ORBITS
NT SATELLITE ORBITS
NT TRANSFER ORBITS
--- SATELLITE POWER SUPPLIES
Photovoltaic power generators in space
P-0065 A80-46735
Space environmental interactions with biased spacecraft surfaces
P-0089 A80-46897
Future space power - The D.D.D. perspective
P-0081 A80-48174
Large area flexible solar array design for Space Shuttle application
P-0047 A80-48214
Advanced development of a programmable power processor
TECHNOLOGY ASSESSMENT

TECHNOLOGY ASSESSMENT

Satellite Power Systems (SPS) concept definition study, Volume 4: Transportation analysis
[NASA-CB-3321] p0075 880-31891

Satellite power system (SPS) concept definition study, Volume 3: Experimental verification
[NASA-CB-3320] p0076 880-32860

SYSTEMS DESIGN

SYSTEMS ENGINEERING

SATELLITE POWER SYSTEMS

SATELLITE POWER SYSTEMS

New directions for future satellite power systems
/SPS/ concepts
[AIAA 79-3069] p0067 880-36963

Optimization of space manufacturing systems
[NASA-TH-81142] p0079 880-463B9

An environmental assessment of the satellite power system reference design
[NASA-CM-161467] p0071 880-24978

Satellite power system for Western Europe - Problems and solution proposals
[NASA-CM-161547] p0074 880-30897

The solar power satellite concept - The past, decade and the next decade
[NASA-CM-161545] p0069 880-50951

SOLARES orbiting mirror system
[AS-79-304] p0041 880-52280

SPS phase control system performance via analytical simulation
[NASA-CM-160582] p0070 880-22378

Space construction system analysis. Part 2: Platform definition
[NASA-CM-160578] p0042 880-22392

Study of multi-kW solar arrays for Earth orbit applications: Sisterra performance review
[NASA-CM-161467] p0071 880-24978

Satellite power system (SPS) magnetron tube assessment study
[NASA-CM-161547] p0074 880-30897

Introduction: The challenge of optimum integration of propulsion systems and large space structures
[AS-79-304] p0064 880-31450

Large space systems technology program
[NASA-CM-3318] p0064 880-31451

Satellite power system (SPS) concept definition study, Volume 2, part 1: System engineering
[NASA-CM-3318] p0075 880-31890

Spacecraft systems overview of space power at geostationary Earth Orbit
[NASA-CM-3319] p0058 880-33469

Satellite Power Systems (SPS) concept definition study, Volume 2, part 2: System engineering -- cost and programatics
[NASA-CM-3319] p0076 880-33869

SYSTEMS STABILITY

Across three (active control of space structures), phase 1
[AD-A0659142] p0055 880-33461

TECHNOLOGICAL FORECASTING

Propulsion technology in the 1980's to support space missions to the year 2000
[AS-80-1216] p0063 880-41197

The potential global market in 2025 for Satellite Solar Power Stations
[AS-80-1216] p0068 880-46382

Solar power satellites - The present and the future
[AS-80-1216] p0069 880-47562

Future space power - The D.O.D. perspective
[AS-80-1216] p0081 880-48174

Space Operations Center - Next goal for manned space flight
[AS-80-1216] p0081 880-48179

Technology requirements for future Earth-to-geosynchronous orbit transportation systems. Volume 2: Technical results

TECHNOLOGIES

N T ELECTRIC TECHNOLOGY

TECHNOLOGY ASSESSMENT

Propulsion technology in the 1980's to support space missions to the year 2000
[AS-80-1216] p0063 880-41197

Satellite Power Systems (SPS) - Overview of system studies and critical technology
[AIAA PAPER 80-084] p0067 880-41898

[AD-A0659142] p0078 880-46376

Satellite Power Systems (SPS): Concept development and evaluation program, preliminary assessment
[DOE/ER-0041] p0072 880-27404

Satellite Power Systems (SPS): Concept development and evaluation program: Preliminary assessment
[NASA-TM-81142] p0073 880-29402

Selection of alternative central-station technologies for the Satellite Power System (SPS) comparative assessment
[DOE/ER-0052] p0074 880-28067

Satellite Power System (SPS) FY 79 program summary
[NASA-CM-163479] p0074 880-29900

Solar power satellite offshore rectenna study
[NASA-CM-161543] p0074 880-30891

Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems
[DOE/ER-0056] p0075 880-30916

Methodology for the comparative assessment of the Satellite Power System (SPS) and alternative technologies
[NASA-CM-163409] p0075 880-31951

Synchronous energy technology program
[NASA-CM-33466] p0058 880-33466

TECHNOLOGY UTILIZATION

Applications of an R&D propulsion system
[AJA PAPER 80-1225] p0063 880-41201

European technology applicable to Solar Power Satellites (SPS)
[SPA-CM-79-378-046] p0073 880-29876

TELECOMMUNICATION

NT SPACE COMMUNICATION

NT SPACECRAFT ANTENNAS

Now large is large - Reflections on future large telecommunications satellites
[NASA-CM-33475] p0041 880-46397

TELEOPERATORS

The Shuttle's remote manipulator system - Status and operation
[DGLR PAPER 80-075] p0061 880-41757

Space operations - Future requirements and systems
[DGLR PAPER 80-093] p0061 880-41766

The birth of the mechanical spaceman - The Teleoperator Retrieval System
[NASA-CM-33466] p0061 880-52466

TELESCOPES

NT ASTRONOMICAL TELESCOPES

THERMAL CONTROL

Heat transfer, thermal control, and heat pipes --- Book
[NASA-CM-33466] p0041 880-37014

Power management
[NASA-CM-33466] p0058 880-33475

THERMAL TESTS

Uniaxial and biaxial tensioning effects on thin membrane materials --- large space structures
[NASA-CM-33466] p0060 880-26395

THERMAL

Large space structures and the remote sensing of soil moisture
[DOE/ER-0052] p0041 880-38794

THERMAL FLX_3

NT EARTH (PLANET)

DATA TRANSPORTATION SYSTEM FLIGHTS

TELECOMMUNICATION

THERMAL CONTROL INSPACE

INVESTIGATION OF RADIATION EFFECTS ON SPACECRAFT THERMAL CONTROL COATINGS

Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links --- for spacecraft thermal control coatings
[NASA-CM-33466] p0059 880-38754

Systems definition study for shuttle demonstration flights of large space structures. Volume 3: Thermal analyses
[NASA-CM-161536] p0043 880-29376

THERMAL PROPERTIES

U THERMODYNAMIC PROPERTIES

THERMAL STRESSES

Systems definition study for shuttle demonstration flights of large space structures. Volume 1: Executive summary
[NASA-CM-161534] p0044 880-29376

Systems definition study for shuttle demonstration flights of large space structures, Volume 2:
<table>
<thead>
<tr>
<th>SUBJECT INDEX</th>
<th>VIBRATION DAMPING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Report</td>
<td>VIBRATION DAMPING</td>
</tr>
<tr>
<td>THERMONIC CONVERTERS</td>
<td>THERMONIC CONVERTERS</td>
</tr>
<tr>
<td>NY SOLAR BLANKETS</td>
<td>NY SOLAR BLANKETS</td>
</tr>
<tr>
<td>THERMONIC DIODES</td>
<td>THERMONIC DIODES</td>
</tr>
<tr>
<td>A computer model of solar panel-plasma interactions</td>
<td>A computer model of solar panel-plasma interactions</td>
</tr>
<tr>
<td>(NASA-CR-16095)</td>
<td>(AIAA-80-0679)</td>
</tr>
<tr>
<td>THERMONIC PROPERTIES</td>
<td>THERMONIC PROPERTIES</td>
</tr>
<tr>
<td>NY VOLATILITY</td>
<td>NY VOLATILITY</td>
</tr>
<tr>
<td>Continuous modeling of the mechanical and thermal behavior of discrete large</td>
<td>Continuous modeling of the mechanical and thermal behavior of discrete large</td>
</tr>
<tr>
<td>structures</td>
<td>structures</td>
</tr>
<tr>
<td>(AIAA-80-0679)</td>
<td>(AIAA-80-0679)</td>
</tr>
<tr>
<td>THERMONIC PROPERTIES</td>
<td>THERMONIC PROPERTIES</td>
</tr>
<tr>
<td>NY VOLATILITY</td>
<td>NY VOLATILITY</td>
</tr>
<tr>
<td>Development of ultraviolet rigidizable materials</td>
<td>Development of ultraviolet rigidizable materials</td>
</tr>
<tr>
<td>--- expandable space erectable structures</td>
<td>--- expandable space erectable structures</td>
</tr>
<tr>
<td>THRUST</td>
<td>THRUST</td>
</tr>
<tr>
<td>NY LOW THRUST</td>
<td>NY LOW THRUST</td>
</tr>
<tr>
<td>THRUST DISTRIBUTION</td>
<td>THRUST DISTRIBUTION</td>
</tr>
<tr>
<td>Auxiliary control of LSS</td>
<td>Auxiliary control of LSS</td>
</tr>
<tr>
<td>p0054 N80-31459</td>
<td>p0054 N80-31459</td>
</tr>
<tr>
<td>THRUST LOADS</td>
<td>THRUST LOADS</td>
</tr>
<tr>
<td>Control-structure interaction in a free beam --- large space structures</td>
<td>Control-structure interaction in a free beam --- large space structures</td>
</tr>
<tr>
<td>([NASA-TR-81029])</td>
<td>([NASA-TR-81029])</td>
</tr>
<tr>
<td>Effect of orbital transfer loads on large platforms</td>
<td>Effect of orbital transfer loads on large platforms</td>
</tr>
<tr>
<td>p0054 N80-28742</td>
<td>p0044 N80-31640</td>
</tr>
<tr>
<td>Influence of interorbit acceleration on the design</td>
<td>Influence of interorbit acceleration on the design</td>
</tr>
<tr>
<td>of large space antennas</td>
<td>of large space antennas</td>
</tr>
<tr>
<td>p0044 N80-31640</td>
<td>p0044 N80-31640</td>
</tr>
<tr>
<td>TRANSISTORS</td>
<td>TRANSISTORS</td>
</tr>
<tr>
<td>U ROCKET ENGINES</td>
<td>U ROCKET ENGINES</td>
</tr>
<tr>
<td>TIMOSHENKO BEAMS</td>
<td>TIMOSHENKO BEAMS</td>
</tr>
<tr>
<td>Preliminary investigations into the active control of large space structures</td>
<td>Preliminary investigations into the active control of large space structures</td>
</tr>
<tr>
<td>Solution of the Timoshenko beam equations by the method of characteristics</td>
<td>Solution of the Timoshenko beam equations by the method of characteristics</td>
</tr>
<tr>
<td>[NASA-163408]</td>
<td>[NASA-163408]</td>
</tr>
<tr>
<td>TOOLS</td>
<td>TOOLS</td>
</tr>
<tr>
<td>NY SPACE TOOLS</td>
<td>NY SPACE TOOLS</td>
</tr>
<tr>
<td>TOPOGRAPHY</td>
<td>TOPOGRAPHY</td>
</tr>
<tr>
<td>NT TERRAIN</td>
<td>NT TERRAIN</td>
</tr>
<tr>
<td>TORQUE</td>
<td>TORQUE</td>
</tr>
<tr>
<td>Dynamics of a rigid body in the space plasma</td>
<td>Dynamics of a rigid body in the space plasma</td>
</tr>
<tr>
<td>p0081 A80-46900</td>
<td>p0081 A80-46900</td>
</tr>
<tr>
<td>TRACKING (POSITION)</td>
<td>TRACKING (POSITION)</td>
</tr>
<tr>
<td>NT OPTICAL TRACING</td>
<td>NT OPTICAL TRACING</td>
</tr>
<tr>
<td>TRAJECTORIES</td>
<td>TRAJECTORIES</td>
</tr>
<tr>
<td>NY INTERORBITAL TRAJECTORIES</td>
<td>NY INTERORBITAL TRAJECTORIES</td>
</tr>
<tr>
<td>TRANSFER ORBITS</td>
<td>TRANSFER ORBITS</td>
</tr>
<tr>
<td>Orbital transfer of large space structures with nuclear electric rockets</td>
<td>Orbital transfer of large space structures with nuclear electric rockets</td>
</tr>
<tr>
<td>([NASP PAPER 80-003])</td>
<td>([NASP PAPER 80-003])</td>
</tr>
<tr>
<td>Maintainable maintenance disconnect valve /MDV/</td>
<td>Maintainable maintenance disconnect valve /MDV/</td>
</tr>
<tr>
<td>for on-orbit component replacement</td>
<td>for on-orbit component replacement</td>
</tr>
<tr>
<td>([ASHE PAPERS 80-ERA5-42])</td>
<td>([ASHE PAPERS 80-ERA5-42])</td>
</tr>
<tr>
<td>Effect of orbital transfer loads on large platforms</td>
<td>Effect of orbital transfer loads on large platforms</td>
</tr>
<tr>
<td>p0064 A80-41897</td>
<td>p0064 A80-41897</td>
</tr>
<tr>
<td>TRANSFORMERS</td>
<td>TRANSFORMERS</td>
</tr>
<tr>
<td>Study of power management technology for orbital multi-100 kW applications</td>
<td>Study of power management technology for orbital multi-100 kW applications</td>
</tr>
<tr>
<td>Volume 2: Study</td>
<td>Volume 2: Study</td>
</tr>
<tr>
<td>([NASA-CR-159834=VOL-2])</td>
<td>([NASA-CR-159834=VOL-2])</td>
</tr>
<tr>
<td>TRANSIENT RESPONSE</td>
<td>TRANSIENT RESPONSE</td>
</tr>
<tr>
<td>Super mode rejection technique and complex variable bending mode representation</td>
<td>Super mode rejection technique and complex variable bending mode representation</td>
</tr>
<tr>
<td>(AIAA-80-1797)</td>
<td>(AIAA-80-1797)</td>
</tr>
<tr>
<td>TRANSISTORS</td>
<td>TRANSISTORS</td>
</tr>
<tr>
<td>NT FIELD EFFECT TRANSISTORS</td>
<td>NT FIELD EFFECT TRANSISTORS</td>
</tr>
<tr>
<td>TRANSITION METALS</td>
<td>TRANSITION METALS</td>
</tr>
<tr>
<td>NT PALLADIUM</td>
<td>NT PALLADIUM</td>
</tr>
<tr>
<td>TRANSMISSION</td>
<td>TRANSMISSION</td>
</tr>
<tr>
<td>NT CONDUCTIVE HEAT TRANSFER</td>
<td>NT CONDUCTIVE HEAT TRANSFER</td>
</tr>
<tr>
<td>NT ELECTRIC POWER TRANSMISSION</td>
<td>NT ELECTRIC POWER TRANSMISSION</td>
</tr>
<tr>
<td>NT NITROPHERIC PROPAGATION</td>
<td>NT NITROPHERIC PROPAGATION</td>
</tr>
<tr>
<td>NT MICROWAVE TRANSMISSION</td>
<td>NT MICROWAVE TRANSMISSION</td>
</tr>
<tr>
<td>NT RADIATIVE HEAT TRANSFER</td>
<td>NT RADIATIVE HEAT TRANSFER</td>
</tr>
<tr>
<td>NT SATELLITE TRANSMISSION</td>
<td>NT SATELLITE TRANSMISSION</td>
</tr>
<tr>
<td>TRANSMISSION LINES</td>
<td>TRANSMISSION LINES</td>
</tr>
<tr>
<td>NT NITROGEN TRANSMISSION LINES</td>
<td>NT NITROGEN TRANSMISSION LINES</td>
</tr>
<tr>
<td>NT POWER LINES</td>
<td>NT POWER LINES</td>
</tr>
<tr>
<td>Space platform utilities distribution study</td>
<td>Space platform utilities distribution study</td>
</tr>
<tr>
<td>TRANSPORT PROPERTIES</td>
<td>TRANSPORT PROPERTIES</td>
</tr>
<tr>
<td>NT ELECTRICAL RESISTIVITY</td>
<td>NT ELECTRICAL RESISTIVITY</td>
</tr>
<tr>
<td>PERSONAL AUTHOR</td>
<td>TITLE</td>
</tr>
<tr>
<td>-----------------</td>
<td>-------</td>
</tr>
<tr>
<td>ALLABY, B.</td>
<td>Large Deployable Reflector (LDR)</td>
</tr>
<tr>
<td>ANDERSON, R. G.</td>
<td>Buckling of periodic structures</td>
</tr>
<tr>
<td>ARD, G. D.</td>
<td>Solar power satellites - The present and the future</td>
</tr>
<tr>
<td>ASHER, R. L.</td>
<td>Parameter plane analysis for large scale systems</td>
</tr>
<tr>
<td>AUBURN, J. J.</td>
<td>Hydrometers for large space structures</td>
</tr>
<tr>
<td>AYER, H.</td>
<td>Structural distortions of space systems due to dynamic, and stability of large Earth pointing</td>
</tr>
<tr>
<td>BOYD, B. L.</td>
<td>Solar energy economics - Orbiting reflectors for world energy</td>
</tr>
<tr>
<td>BOYD, S. W.</td>
<td>SPS phase control system performance via analytical simulation</td>
</tr>
<tr>
<td>BOWEN, L. L.</td>
<td>The Remote Manipulator System</td>
</tr>
<tr>
<td>BOYD, S. W.</td>
<td>The birth of the mechanical spacecar - The Teleoperator Retrieval System</td>
</tr>
<tr>
<td>BROWN, R. M.</td>
<td>Control of a large flexible platform in orbit</td>
</tr>
<tr>
<td>BROWN, R. M.</td>
<td>Maintainable maintenance disconnect valve /MDV/ for on-orbit component replacement</td>
</tr>
<tr>
<td>BROWN, R. M.</td>
<td>Discussion meeting on Gossamer spacecraft (ultralightweight spacecraft)</td>
</tr>
<tr>
<td>BROOK, L. M.</td>
<td>Adaptive techniques for large space apertures</td>
</tr>
<tr>
<td>BROOK, L. M.</td>
<td>Maintainable maintenance disconnect valve /MDV/</td>
</tr>
</tbody>
</table>
for on-orbit component replacement
[AIAA PAPER 80-ENAS-42] p0061 A80-43216
BROWN, W. C.
Micro-wave beamed power technology improvement
NASA-CR-163049] p0072 N80-26785
BUDABIK, R. L.
SPS emissions and comparison with ambient loadings
AIAA PAPER 80-0063] p0067 A80-32869
CABTBB, V. C.
Thermophic effects of satellite power systems
AIAA PAPER 80-0086] p0067 A80-32870
BUBABCH, R.
Space structure - To-day and to-morrow
AIAA PAPER NT 79-46] p0059 A80-36878
BOCK, P. A.
Space construction system analysis Part 2: Construction analysis
NASA-CR-160579] p0041 N80-22375
BOER, R.
Space nuclear reactor power plants
IA-6223-M3] p0082 N80-27177
BURNING, W.
Methodology for the comparative assessment of the Satellite Power System (SPS) and alternative technologies
NASA-CR-163049] p0075 N80-31951
BOHR, T. E.
Maintainable maintenance disconnect valve / MDV/ for on-orbit component replacement
[ AIAA PAPER 80-ENAS-42] p0061 A80-43216
BUSH, B. H.
Structural sizing considerations for large space platforms
[ AIAA 80-0680] p0047 A80-35003
Experimental study of the structural elements
NASA-CASE-LAB-12462-1] p0048 N80-22704
Effect of orbital transfer loads on large platforms
[ AIAA PAPER 80-0683] p0064 N80-31460
BUSHWELL, D.
Predictions of loads on antenna riser due to mesh deployment
[ AIAA 80-0084] p0047 A80-35095
BYERS, D. C.
Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures
NASA PAPER 80-1223] p0063 A80-38975
Orbital transfer of large space structures with nuclear electric rockets
AIAA PAPER 80-0683] p0064 A80-41197
Electric propulsion and power
NASA-CR-160580] p0065 N80-31465
C
CALDREN, Y. A.
Technology requirements for future earth-to-geosynchronous orbit transportation systems. Volume 2: Technical results
NASA CR-3206] p0082 N80-26374
CAMPBELL, W. A., JR.
Outgassing data for spacecraft materials
[ NASA-HF-1061] p0060 N80-30441
CARD, R. F.
Large space structures - Fantasies and facts
[ AIAA 80-0074] p0077 A80-34999
CARLISLE, R. P.
Introduction: The challenge of options integration of propulsion systems and large space structures
NASA-CR-160580] p0041 N80-22376
Spacecraft systems overview of space power at geostationary Earth Orbit
NASA-CR-160580] p0056 N80-33469
CARROLL, R. B., JR.
Ion thruster plasma effects on spacecraft surfaces
AIAA PAPER 80-1228] p0063 A80-41202
CARVER, V. C.
Electrically conductive palladium containing polyimide films
NASA-CASE-LAB-12705-1] p0060 N80-29549
CASTH, R.
Design and technology of solar arrays for shuttle launched missions
NASA-CR-160580] p0064 N80-33883
CHAMPION, P. A.
Telescopic masts for deployment of flexible solar arrays
NASA-CR-160580] p0049 N80-33881
CHARTS, C. J.
SPS phase control system performance via analytical simulation
CHIN, L. M.
Argon-ion contamination of the plasmasphere
Effects of construction and operation of a satellite power system upon the magnetosphere
[ AIAA 80-1792-1] p0072 N80-25365
CBO, R. W.
Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems
NASA-CR-163049] p0075 N80-30916
CIOCO, R. R.
Methodology for the comparative assessment of the Satellite Power System (SPS) and alternative technologies
NASA-CR-163049] p0075 N80-31951
CIOCO, R. R.
Comparative analysis of net energy balance for Satellite Power Systems (SPS) and other energy systems
NASA-CR-163049] p0075 N80-30916
CLARKE, J. B.
Sagatopropic effects of solar power satellite
[ AIAA PAPER 80-0892] p0067 N80-32875
CLAYERS, J.
The potential global market in 2025 for Satellite Solar Power Stations
COLLINS, F. M.
Increasing power input to a single solar power satellite rectenna by using a pair of satellites
NASA-CR-160580] p0067 N80-32942
Feasibility of siting SPS rectennas over the sea
NASA-CR-160580] p0070 N80-50955
COKER, R.
Electrostatic protection of the Satellite Power Satellite and rectenna
NASA-CR-161438] p0071 N80-23348
COKER, W.
Environmental protection of the solar power satellite
[ AIAA PAPER 80-1792-1] p0069 N80-46899
A computer model of solar panel-plasma interactions
COOPER, R.
Space construction system analysis Part 2: Cost and producibilities
NASA-CR-160580] p0041 N80-22376
COVINGTON, C.
Collision avoidance in space
NASA-CR-160580] p0047 N80-35084
COWE, R.
Space Operations Center - Next goal for manned space flight
NASA-CR-160580] p0081 N80-48797
COWE, R.
Adaptive techniques for large space apertures
[ AIAA PAPER 80-14631] p0048 N80-27581
COWE, R.
Large solar arrays
COWE, R.
Scaling and the start-up phase of space industrialization
COWE, R.
First results of material charging in the space environment
COWE, R.
A survey of automatic control techniques for large space structures
NASA-CR-160580] p0051 N80-37460
COWE, R.
Satellite Power Systems (SPS) cost review
NASA-CR-160580] p0076 N80-32928
COWE, R.
Electric propulsion for SPS
NASA-CR-160580] p0075 N80-31466
HANBY, G. H.

HiBBB, B. A.

BALE, A. L.

GUPTA, H. S.

HABEGGBB, L.

GBBY, J.

GBEESE, I. B.

GB1ZIAHI, F.

GBAH, B.

6BAH, E.

GBBENBEB6, B. S.

GBEBOiSKI, J. H.

6BAVBS, J.

Bockwell Satellite Power System /SPS/ concept

Satellite Power Systems (SPS) concept definition

Control of large flexible platform in orbit

Large space structures and the remote sensing of soil moisture

Energetic ion beam magnetosphere injection and solar power satellite transport

Space construction system analysis. Part 2: Construction analysis

Space construction system analysis. Part 2: Space construction experiments concepts

Space construction system analysis. Part 2: Platform definition

A design procedure for a tension-wire stiffened truss-column

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STA equipment for satellite service

Optimal mass damper controller design for large space structures

Modal damping enhancement in large space structures using ACD's

Across three (active control of space structures), phase 1

Methodology for the comparative assessment of the Satellite Power System (SPS) and alternative technologies

A general dynamic synthesis for structures with discrete substructures

Control of a large flexible platform in orbit

New directions for future satellite power system /SPS/ concepts

Rockwell Satellite Power System /SPS/ concept definition studies


Satellite power systems (SPS) concept definition study. Volume 1: Executive summary

Satellite power systems (SPS) concept definition study. Volume 2, part 1: System engineering

Satellite Power System (SPS) concept definition study. Volume 4: Transportation analysis

Satellite Power Systems (SPS) concept definition study. Volume 6: In-depth element investigations
PERSONAL AUTHOR INDEX

BIBAHO, L. H.,
Laser-boosted advanced LTAV as a heavy lift launch vehicle
p0079 A80-46391

BIBAHO, L. H.
Continuous modeling of the mechanical and thermal behavior of discrete large structures
[ AIAA PAPER 80-0679 ]
p0043 A80-35002
Geometric modeling and analysis of large lattice surfaces
[ NASA-CR-3156 ]
p0044 A80-22736

NATHAN, C. A.
Manned remote work station - A flexible tool for
Shuttle operations
[ RELB PAPER 80-082 ]
p0061 A80-41762

NAYFEH, E. E.
Methodology for the comparative assessment of the
Satellite Power System (SPS) and alternative
electric energy technologies
[ NASA-CR-163327 ]
p0073 A80-29866
Methodology for the comparative assessment of the
Satellite Power System (SPS) and alternative
technologies
[ NASA-CR-163049 ]
p0075 A80-31951

NOOG, L. E.
Micropolar beam models for lattice grids with
rigid joints
p0044 A80-53845

OLSTAD, W. R.
Heat transfer, thermal control, and heat pipes
p0043 A80-37014

OFFERT, J. M.
Spectrophotovoltaic orbital power generation
[ NASA-CR-161451 ]
p0071 B80-24757

OK, H.
Optical modal-space control of flexible gyroscopic
systems
p0051 A80-33284
On maneuvering large flexible spacecraft using an
annular momentum control device
[ AIAA PAPER 80-1669 ]
p0052 A80-45041

PARKHROVA, L. N.
Investigation of radiation effects on
polyorganosiloxanes containing silafluorenil links
p0059 A80-38754

PARK, J. J.
Outgassing data for spacecraft materials
[ NASA-RP-1061 ]
p0060 A80-30441

PARKER, K. W.
Plasma-beam-photosheet theory for large
high-voltage space structures
p0081 A80-46898

PETERS, J. D.
Nonlinear dynamic analysis of space trusses
p0064 A80-54318

PIKE, C. P.
Space systems and their interactions with earth's
space environment
p0079 A80-46879
Prediction of spacecraft potentials at
geosynchronous orbit
p0082 B80-24684

PILAND, E. O.
Space Operations Center - Next goal for manned
space flight
p0081 A80-48797
The solar power satellite concept - The past
decade and the next decade
p0069 A80-50951

PIPPS, W. B.
Propulsion technology in the 1980's to support
space missions to the year 2000
[ AIAA PAPER 80-1216 ]
p0063 A80-41197

FOD low-thrust mission studies
p0065 B80-31455

PIKE, C. P.
Chemical propulsion technology
p0065 B80-31453

PRNew, C.
Control of large communication satellites
p0053 A80-47561

PURR, E. C.
EVA manipulation and assembly of space structure
columns
[ NASA-CR-3285 ]
p0062 A80-23968

PUSH, C. G.
JASCAP modeling computations on large optics
spacecraft in geosynchronous substorm environments
p0077 A80-32829

PUSH, C. G.
The Magnetometer booms
p0048 B80-23517

RANDBR, C. L.
Progress in space power technology
p0057 A80-48173

RABEN, R. A.
Space nuclear reactor power plants
[ IA-6223-NS ]
p0082 B80-27177

RADBEN, R. A.
Background suppression and tracking with a staring
mosaic sensor
p0051 A80-39104

BRAD, A. S. S.
Control of a large flexible platform in orbit
[ AIAA PAPER 80-1668 ]
The dynamics and control of large flexible space
structures, 3. Part A: Shape and orientation
control of a platform in orbit using point
actuators
[ NASA-CR-163253 ]
p0053 A80-27419

REDDY, C. M.
Antenna arrays. Citations from the Engineering
Index data base
[ 7800-00759 ]
p0083 B80-28626

REDDY, C. M.
Structural sizing considerations for large space
platforms
[ AIAA 80-0660 ]
p0047 A80-35003
Effect of orbital transfer loads on large platforms
p0044 A80-31460

REDY, W. E.
Environmental protection of the solar power
satellite
p0069 B80-46899
Electrostatic protection of the Solar Power
Satellite and rectenna
[ NASA-CR-161438 ]
p0071 B80-23348

REINDAR, H. E.
Photovoltaic power generators in space
p0069 B80-46735

RICHARDS, R. A.
The Magnetometer booms
p0048 B80-23517

RICHARDS, R. A.
Adaptive techniques for large space apertures
[ 10-4004631 ]
p0048 B80-27581

RICHARDS, R. A.
Control-structure interaction in a free beam
[ NASA-TR-81029 ]
p0053 B80-28742

ROCK, B. E.
Space Shuttle cargo processing at the Kennedy
Space Center
p0081 B80-51940

ROBEE, J. L.
Space construction system analysis. Part 2:
Construction analysis
[ NASA-CR-160579 ]
p0041 B80-22375

ROGERS, L. C.
Passive damping in large precision space structures
[ AIAA 80-0677 ]
p0051 A80-35001

ROBINS, B. M.
A study of the effect of proton bombardment on the
mechanical properties of polymers
p0059 B80-46814

ROSE, R. M.
Environmental effects of space systems - A review
p0079 B80-46680

RUBIN, A. C.
Prediction of spacecraft potentials at
geosynchronous orbit

Solari power

SPS-related ionospheric heating

Satellite power systems for Western Europe - Problems and solution proposals

SPS-related ionospheric heating

Selection of alternative central-station Satellite power systems for Western Europe - Orbital transfer of large space structures with Control-structure interaction in a free beam

Investigation of radiation effects on Argon-ion contamination of the plasmasphere

Manufacturing methods for graphite/polyimide composite reentry vehicle substructures

First results of material charging in the space environment

Space environmental interactions with biased spacecraft surfaces

The SPS concept - An overview of status and outlook

European technology applicable to Solar Power Satellite Systems (S2P)

Workshop on Satellite Power Systems (SPS) Effects on Optical and Radio Astronomy

A survey of automatic control techniques for large space structures

ACOSS Four (Active Control of Space Structures) theory. Volume 1

ACOSS Four (Active Control of Space Structures) theory. Volume 2: Appendix

Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links

An overview of status and outlook

Super mode rejection technique and complex variable bending mode representation

Parameter plane analysis for large scale systems

Decentralized control for large communication systems

First results of material charging in the space environment

Space environmental interactions with biased spacecraft surfaces

ACOSS Four (Active Control of Space Structures) theory

ACOSS Four (Active Control of Space Structures) theory. Volume 2: Appendix

Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links

Electrically conductive palladium containing polyimide films

Low-thrust vehicle concept studies

Nuclear electric propulsion system utilization for LEO-to-GEO low thrust chemical propulsion

Evaluation and prediction of long term space environmental disturbances

Problems and solution proposals

Hagsat magnetometer boom

First results of material charging in the space environment

Space environmental interactions with biased spacecraft surfaces

ACOSS Four (Active Control of Space Structures) theory

ACOSS Four (Active Control of Space Structures) theory. Volume 2: Appendix

Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links

Electricaly conductive palladium containing polyimide films

Low-thrust vehicle concept studies

Nuclear electric propulsion system utilization for LEO-to-GEO low thrust chemical propulsion

Evaluation and prediction of long term space environmental disturbances
ZHBLIZHIKOVA, B. V.
Investigation of radiation effects on polyorganosiloxanes containing silafluorenil links
p0059 A80-38759

ZINGLER, E. J.
Satellite Power Systems (SPS) cost review
(DOE/TIC-11190)
p0076 H80-32928

ZIMMERMANN, K. J.
On the design verification of large flexible solar arrays: First experiences gained
p0045 H80-33997

ZIMM, J.
Solar power satellites - The ionospheric connection
p0068 A80-46397

ZISLIN, L.
Control of large communication satellites
p0053 A80-47561

ZOLLARS, G. F.
Solar power satellites. Citations from the International Aerospace Abstracts data base
Space Colonies. Citations from the International Aerospace Abstracts data base
### Typical Corporate Source Index Listing

<table>
<thead>
<tr>
<th>CORPORATE SOURCE</th>
<th>TITLE</th>
<th>REPORT NUMBER</th>
<th>PAGE NUMBER</th>
<th>ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEROSPACE CORP., EL SEGUNDO, CALIF.</td>
<td>Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures</td>
<td>[AIAA PAPER 80-1223]</td>
<td>p0063</td>
<td>880-38975</td>
</tr>
<tr>
<td>ARESOAM ENGINEERING OFFICE, ZURICH (SWITZERLAND).</td>
<td>On the design verification of large flexible solar arrays: First experiences gained</td>
<td>[AAS PAPER 80-083]</td>
<td>p0064</td>
<td>880-41897</td>
</tr>
<tr>
<td>AIR FORCE GEOPHYSICS LAB., HOMSCOM AFB, MASS.</td>
<td>Prediction of spacecraft potentials at geosynchronous orbit</td>
<td>[AD-A084806]</td>
<td>p0082</td>
<td>880-28420</td>
</tr>
<tr>
<td>AIR FORCE RESEARCH LAB., WRIGHT-PATTERSON AFB, OHIO.</td>
<td>First results of material charging in the space environment</td>
<td>[AD-A084810]</td>
<td>p0083</td>
<td>880-28422</td>
</tr>
<tr>
<td>APPLIED PHYSICS LAB., JOHN HOPKINS UNIV., LABER, MD.</td>
<td>The MagSat magnetometer boom</td>
<td>[NASA-CR-163327]</td>
<td>p0071</td>
<td>880-29886</td>
</tr>
</tbody>
</table>

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.
Continuum modeling of the mechanical and thermal behavior of discrete large structures

Geometric modeling and analysis of large planar and cylindrical structures

Adaptive and learning control of large space structures

Geometric modeling and analysis of large planar and cylindrical structures

Satellite systems: status and planned activities

European technology applicable to Solar Power

European technology applicable to Solar Power

Design and technology of solar arrays for satellite launched missions

Satellite power systems: Status and planned activities

Study of power management technology for orbital multi-100kW applications. Volume 1: Requirements

Study of power management technology for orbital multi-100kW applications. Volume 3: Results
Adaptive techniques for large space structures

LITTLE (ARTHUR D.), INC., CAMBRIDGE, MASS.

Solar power satellite offshore retenna study

[NASA-CR-158062]

p0070 880-22378

LOCKEHO AIRCRAFT CORP., PALO ALTO, CALIF.

Gyrodampers for large space structures

[NASA-CR-159171]

p0053 880-29417

LOCKHEED Missiles and space CO., PAHO ALTO, CALIF.

Across three (active control of space structures), phase 1

[AD-A089142]

p0055 880-33461

LOCKHEED Missiles and space CO., SUMMITVILLE, CALIF.

Solar electric propulsion - A versatile stage for earth orbiting missions

[DLR PAPER 80-0955]

p0064 880-41767

Large area flexible solar array design for space shuttle application

[NASA-CR-161653]

p0047 880-48214

Study of multi-kW solar arrays for Earth orbit application

[ NASA-CR-161453 ]

p0071 880-24344

Large Deployable Reflector (LDR)

[LA-823-485]

p0049 880-33319

LOS ALAMOS SCIENTIFIC LAB., N. MEX.

Space nuclear reactor power plants

[LA-222-485]

p0062 880-27177


Scaling and the start-up phase of space industrialization

p0078 880-46386

M

MARTIN MARIETTA AEROSPACE, DENVER, COLO.

Advanced development of a programmable power processor

p0057 880-48264

Adaptive techniques for large space spectrometers

[AD-A089431]

p0048 880-27581

MARTIN MARIETTA CORP., BETHESDA, MD.

DOD low-thrust mission studies

p0065 880-31455

Primary propulsion/large space system interactions

p0065 880-31456

MARTIN MARIETTA CORP., DENVER, COLO.

Evaluation and prediction of long term space environmental effects on non-metallic materials

[NASA-CR-152842]

p0060 880-33479

MASSACHUSETTS INST. OF TECH., CAMBRIDGE.

Optimization of space manufacturing systems

p0079 880-46389

McDONNELL-DOUGLAS AEROSPACE CO., HUNTINGTON BEACH, CALIF.

LST system analysis and integration task for an advanced science and application space platform

[NASA-CR-161528]

p0042 880-28046

N

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,

WASHINGTON, D.C.

Satellite Power Systems /SPS/: - Overview of system studies and critical technology

[AAS PAPER 80-084]

p0048 880-41898

Progress in space power technology

p0057 880-48173

The SPS concept - An overview of status and outlook

p0069 880-48353

Satellite Power Systems (SPS): Concept development and evaluation program:

Preliminary assessment

[ NASA-TM-81142 ]

p0073 880-29842

The space shuttle at work

[ NASA-GP-132 ]

p0083 880-30367

NASA program plan

[ NASA-SP-81136 ]

p0063 880-31269

Introduction: The challenge of optimum integration of propulsion systems and large space structures

p0064 880-31450

Spacecraft system overview of space power at geostationary Earth Orbit

p0058 880-33469

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

NASA RESEARCH CENTER, COPEPER, FIELD, CALIF.

Solar electric propulsion - A versatile stage for earth orbiting missions

[ AAS 79-300 ]

p0041 880-52280

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

GOODFORD SPACE FLIGHT CENTER, GREENBELT, MD.

Energetic ion beam magnetosphere injection and solar power satellite transport

p0063 880-32702

Outgassing data for spacecraft materials

p0060 880-30441

Integrated analysis of large space systems

p0044 880-31462

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

LINDON R. JOHNSON SPACE CENTER, HOUSTON, TEX.

Collision avoidance in space

p0047 880-35854

Solar power satellites - The present and the future

p0069 880-47562

The solar power satellite concept - The past decade and the next decade

p0069 880-48797

Space Operations Center: A concept analysis

[ NASA-TM-81062 ]

p0042 880-24343

The solar power satellite concepts: The past decade and the next decade

[ NASA-TM-81000 ]

p0071 880-25360

Control-structure interaction in a free beam

[NASA-TM-81029]

p0053 880-28742

Electric propulsion for SPS

p0075 880-31466

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

JOHN F. KENNEDY SPACE CENTER, COCOA BEACH, FLA.

Space Shuttle cargo processing at the Kennedy Space Center

p0081 880-51940

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

LANGLEY RESEARCH CENTER, HAYFORT, VA.

Large space structures - Fantasies and facts

[ AIAA 80-0674 ]

p0077 880-34999

Structural sizing considerations for large space platforms

[ AIAA 80-0680 ]

p0047 880-35003

Buckling of periodic structures

[ AIAA 80-0681 ]

p0047 880-35004

Optical member damper controller design for large space structures

p0051 880-40748

Control of a large flexible platform in orbit

[ AIAA PAPER 80-1668 ]

p0052 880-45042

On maneuvering large flexible spacecraft using an annular momentum control device

[ AIAA PAPER 80-1669 ]

p0052 880-45042

Adaptive and learning control of large space structures

[ AIAA 80-1739 ]

p0052 880-45533

Modal damping enhancement in large space structures using AMCD's

p0053 880-47725

Mechanical end joint system for structural column elements

[ NASA-CASE-LAB-12482-1 ]

p0048 880-22704

Proceedings of the 14th Aerospace Mechanisms Symposium

[ NASA-CP-1127 ]

p0082 880-23495

Electrically conductive palladium containing polyimide films

[ NASA-CASE-LAB-12705-1 ]

p0060 880-24549

Positional and biaxial tensioning effects on thin membrane materials

[ NASA-TM-81812 ]

p0060 880-26395

Large space systems technology program

p0042 880-31451

Effect of orbital transfer loads on large platforms

p0044 880-31460

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

LEWIS RESEARCH CENTER, CLEVELAND, OHIO.

NASCAP modeling computations on large optics spacecraft in geosynchronous substations environments

p0077 880-32029
Nuclear electric propulsion system utilization for earth orbit transfer of large spacecraft structures
[AIAA PAPER 80-1223] p0063 A80-38975
Orbital transfer of large space structures with nuclear electric rockets
[AAS PAPER 80-083] p0064 A80-61897
First results of material charging in the space environment
p0078 A80-65609
Space environmental interactions with biased spacecraft surfaces
p0080 A80-66987
Power management for multi-100 KWe space systems
p0057 A80-68357
Large Space Systems/Low-Thrust Propulsion Technology
p0083 N80-31449
Electric propulsion technology
p0064 N80-31452
Chemical propulsion technology
p0065 N80-31453
LSS/propulsion interactions studies
p0042 N80-31454
Low-thrust vehicle concept studies
p0065 N80-31457
Electric propulsion and power
p0065 N80-31465
Synchronous Energy Technology
p0058 N80-33465
Synchronous energy technology program
p0058 N80-33466
NATIONAL AEROSPACE AND SPACE ADMINISTRATION,
MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALA.
Large space structures activity at MSFC
[AIAA 80-0675] p0047 A80-35000
Advanced development of a programmable power processor
p0057 A80-48264
NASA Workshop on Space Science Platform
[NASA-M-82204] p0083 N80-32941
Large solar arrays
p0084 N80-33471
Power management
p0058 N80-33475
NATIONAL TECHNICAL INFORMATION SERVICE,
SPRINGFIELD, VA.
Antenna arrays. Citations from the Engineering Index data base
[PB80-809759] p0083 N80-28626
NEW MEXICO UNIV., ALBUQUERQUE,
Solar power satellites. Citations from the International Aerospace Abstracts data base
Space Colonizers. Citations from the International Aerospace Abstracts data base
OLD DOMINION UNIV., NORFOLK, VA.
Optimal memer damper controller design for large space structures
p0051 A80-60748
Preliminary investigations into the active control of large space structures: Solution of the Timoshenko beam equations by the method of characteristics
[NASA-CR-163408] p0054 N80-29418
P "PEO ENERGY ANALYSIS CO., MCLEAN, VA.
Some questions and answers about the Satellite Power System (SPS)
[NASA-CR-163329] p0074 880-29897
R "HAYTHEW CO., WALTHAM, MASS.
Microwave based power technology improvement
Satellite power system (SPS) magnetron tube assessment study
[NASA-CR-161547] p0074 N80-30897
RICE UNIV., HOUSTON, TEX.
Environmental protection of the solar power satellite
p0069 A80-66899
Electrostatic protection of the Solar Power Satellite and rectenna
[NASA-CR-161648] p0071 880-23348
Solar power satellite offshore rectenna study
[NASA-CR-161543] p0074 880-30891
A computer model of solar panel-plasma interactions
ROCKWELL INTERNATIONAL CORP., DOWNTON, CALIF.
Space construction system analysis. Part 2: Construction analysis
Space construction system analysis. Part 2: Cost and programs
Space construction system analysis. Part 2: Space construction experiments concepts
[NASA-CR-160581] p0081 880-22377
Space construction system analysis. Part 2: Platform definition
p0062 880-22392
A mechanical adapter for installing mission equipment on large space structures
p0061 880-23515
Space platform utilities distribution study
Satellite and rectenna

INDEX

BASA-CB-163043] p0072 B80-26785
BASA-CB-163329] p0074 B80-30891
BASA-CB-163408] p0054 B80-29418

Corporation Source Index

C-4
Electrically conductive palladium containing polyimide films

[ NASA-CASE-LAB-12705-1] p0060 N80-24549

Optimal large angle maneuvers with simultaneous shape control/vibration arrest

p0053 N80-28398
## CONTRACT NUMBER INDEX

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

**JANUARY 1981**

### Typical Contract Number Index Listing

<table>
<thead>
<tr>
<th>CONTRACT NUMBER</th>
<th>PAGE NUMBER</th>
<th>NASA ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAS8-32711</td>
<td>p0003</td>
<td>N80-13066</td>
</tr>
<tr>
<td>p0065 N80-33461</td>
<td></td>
<td></td>
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<tr>
<td>p0052 N80-28420</td>
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<tr>
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<td></td>
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<tr>
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</tr>
<tr>
<td>p0068 N80-27581</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
</tr>
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<td>p0067 A80-32875</td>
<td></td>
</tr>
<tr>
<td>AF-AFOSB-78-3694-A</td>
<td>p0059 A80-35104</td>
<td></td>
</tr>
<tr>
<td>ABPA 0088 3654</td>
<td>p0054 N80-29421</td>
<td></td>
</tr>
<tr>
<td>p0054 N80-29422</td>
<td></td>
<td></td>
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<tr>
<td>DAA29-78-0-C003</td>
<td>p0063 A80-23348</td>
<td></td>
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<tr>
<td>DOE-31-109-ERS-38</td>
<td>p0067 A80-32269</td>
<td></td>
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<tr>
<td>DOE-31-109-38-3P75</td>
<td>p0067 A80-32069</td>
<td></td>
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<td>p0067 A80-32069</td>
<td></td>
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<td>p0067 A80-32069</td>
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<tr>
<td>DOE-31-109-38-5023</td>
<td>p0067 A80-32069</td>
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<tr>
<td>P04611-79-C-0007</td>
<td>p0065 N80-31700</td>
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<tr>
<td>P04611-79-C-0032</td>
<td>p0065 N80-31955</td>
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<tr>
<td>P04701-79-C-0000</td>
<td>p0076 A80-45609</td>
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<td>P03602-78-C-0268</td>
<td>p0052 A80-45532</td>
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<tr>
<td>F03602-79-C-0011</td>
<td>p0054 N80-29421</td>
<td></td>
</tr>
<tr>
<td>F03602-79-C-0017</td>
<td>p0054 N80-29422</td>
<td></td>
</tr>
<tr>
<td>p0048 N80-27581</td>
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<td></td>
</tr>
<tr>
<td>F03602-79-C-0087</td>
<td>p0069 A80-46899</td>
<td></td>
</tr>
<tr>
<td>p0055 N80-33461</td>
<td></td>
<td></td>
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<tr>
<td>F33615-75-C-3016</td>
<td>p0077 A80-47452</td>
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<td>p0053 N80-26417</td>
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<tr>
<td>NAS1-15322</td>
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<td>p0062 N80-26366</td>
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<td>NAS1-16000</td>
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<td>p0057 N80-28062</td>
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<td>p0056 N80-29055</td>
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</tr>
<tr>
<td>p0065 N80-31467</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Typical Report/Accession Number Index Listing

<table>
<thead>
<tr>
<th>REPORT NUMBER</th>
<th>PAGE NUMBER</th>
<th>NASA DOCUMENT SYMBOL</th>
<th>MICROFICHE SYMBOL</th>
<th>NASA ACCESSION NUMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAAP PAPER 79-46</td>
<td>p0059</td>
<td>A80-36877</td>
<td>#</td>
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</tr>
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<td>AAAP PAPER 79-46</td>
<td>p0059</td>
<td>A80-36876</td>
<td>#</td>
<td></td>
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<td>AAS PAPER 80-088</td>
<td>p0064</td>
<td>A80-41897*</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>AAS PAPER 80-084</td>
<td>p0067</td>
<td>A80-41898*</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>AAS 79-304</td>
<td>p0041</td>
<td>A80-52280*</td>
<td>#</td>
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</tr>
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<td>p0048</td>
<td>A80-27561</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>AD-AD-000067</td>
<td>p0082</td>
<td>A80-28420</td>
<td>#</td>
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<td>AD-A000567</td>
<td>p0054</td>
<td>A80-29421</td>
<td>#</td>
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</tr>
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<td>AD-A005816</td>
<td>p0054</td>
<td>A80-29422</td>
<td>#</td>
<td></td>
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<td>AD-A005814</td>
<td>p0055</td>
<td>A80-33461</td>
<td>#</td>
<td></td>
</tr>
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<td>AGNP-APSF-420</td>
<td>p0083</td>
<td>A80-28422</td>
<td>#</td>
<td></td>
</tr>
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<td>AGNP-ERF-673</td>
<td>p0082</td>
<td>A80-28420</td>
<td>#</td>
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<td>AIAA PAPER 80-085A</td>
<td>p0043</td>
<td>A80-32850</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>AIAA PAPER 80-0883</td>
<td>p0067</td>
<td>A80-32870</td>
<td>#</td>
<td></td>
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<td>AIAA PAPER 80-0884</td>
<td>p0067</td>
<td>A80-32873</td>
<td>#</td>
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<tr>
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<td>p0067</td>
<td>A80-32875</td>
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<td>AIAA PAPER 80-1212</td>
<td>p0063</td>
<td>A80-38792</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>AIAA PAPER 80-1216</td>
<td>p0063</td>
<td>A80-41197</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>AIAA PAPER 80-1223</td>
<td>p0063</td>
<td>A80-38975*</td>
<td>#</td>
<td></td>
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<tr>
<td>AIAA PAPER 80-1225</td>
<td>p0063</td>
<td>A80-41201*</td>
<td>#</td>
<td></td>
</tr>
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<td>p0063</td>
<td>A80-41202*</td>
<td>#</td>
<td></td>
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<td>AIAA PAPER 80-1265</td>
<td>p0063</td>
<td>A80-41520**</td>
<td>#</td>
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<td>AIAA PAPER 80-1668</td>
<td>p0052</td>
<td>A80-45041*</td>
<td>#</td>
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<td>AIAA PAPER 80-1669</td>
<td>p0052</td>
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<td>#</td>
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<td>AIAA 79-3069</td>
<td>p0067</td>
<td>A80-36973</td>
<td>#</td>
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<td>p0077</td>
<td>A80-36973</td>
<td>#</td>
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<tr>
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<td>p0047</td>
<td>A80-35053</td>
<td>#</td>
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<td>p0047</td>
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<tr>
<td>AIAA 80-0678</td>
<td>p0059</td>
<td>A80-35104</td>
<td>#</td>
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<td>p0043</td>
<td>A80-35002</td>
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<td>p0047</td>
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<td>p0043</td>
<td>A80-35080</td>
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<td>p0052</td>
<td>A80-45515</td>
<td>#</td>
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<td>p0052</td>
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<td>p0061</td>
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<td>p0061</td>
<td>A80-43222</td>
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<td>p0072</td>
<td>A80-25365</td>
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<td>p0048</td>
<td>A80-27399*</td>
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<td>p0072</td>
<td>A80-26004</td>
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<td>p0075</td>
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<td>p0073</td>
<td>A80-29878</td>
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<td>A80-41973</td>
<td>#</td>
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<td>p0070</td>
<td>A80-29890</td>
<td>#</td>
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<td>p0061</td>
<td>A80-41757</td>
<td>#</td>
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<td>p0061</td>
<td>A80-41762</td>
<td>#</td>
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<tr>
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<td>p0061</td>
<td>A80-41766</td>
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<td>p0072</td>
<td>A80-25874</td>
<td>#</td>
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<td>A80-25874</td>
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<td>p0046</td>
<td>A80-23876*</td>
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</tbody>
</table>

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