Space Station Systems

A Bibliography
with Indexes

NASA SP-7056(04)
May 1987

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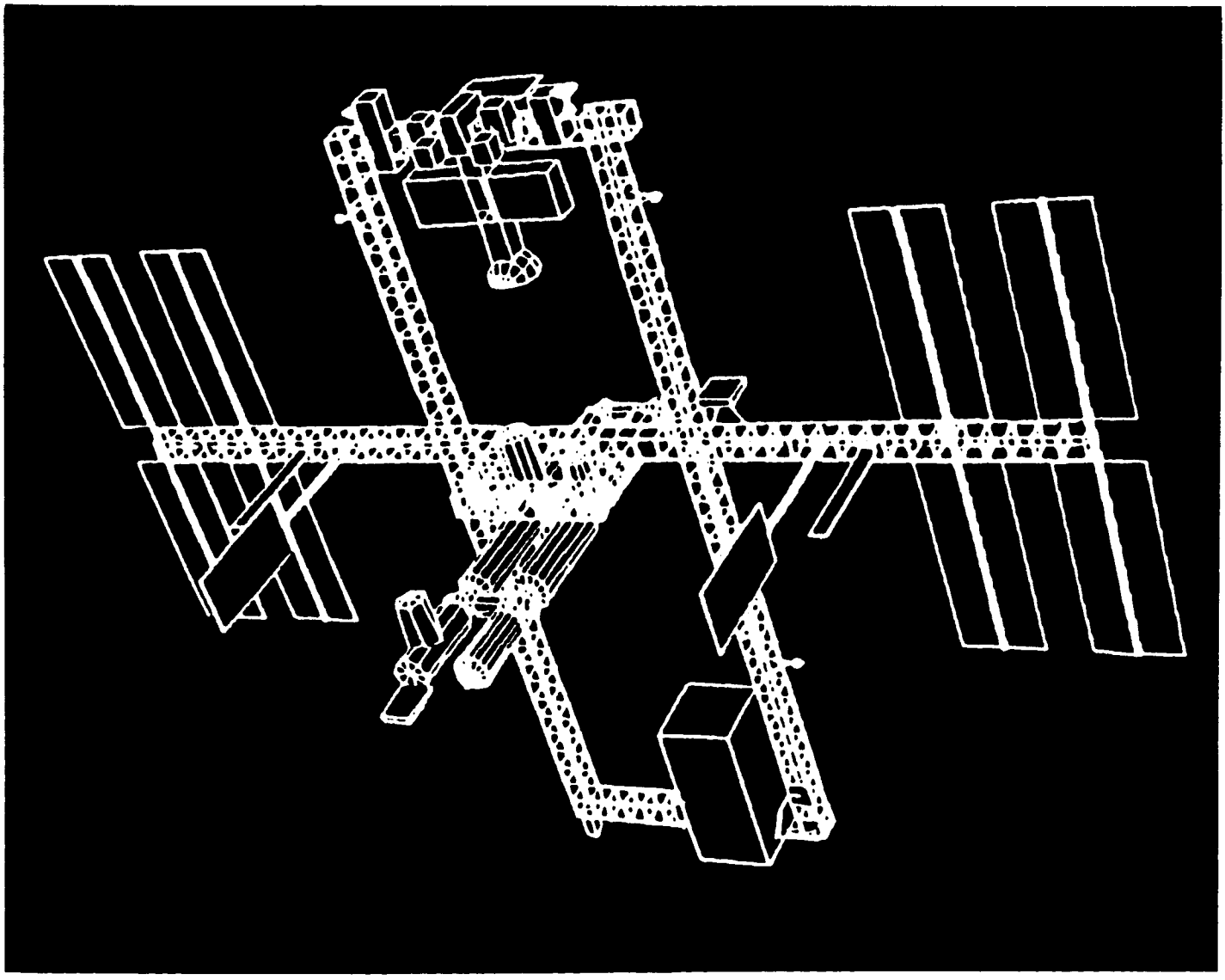

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The compilation of this bibliography results from a complete search of the *STAR* and *IAA* files. Many times a report or article is not identified because either the title, abstract, or key words did not contain appropriate words for the search. A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

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NASA SP-7056(04)

SPACE STATION SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 4

Compiled by
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A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between July 1 and December 31, 1986 in

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

Scientific and Technical Information Office 1987
National Aeronautics and Space Administration
Washington, DC

INTRODUCTION

This bibliography is designed to be helpful to the researchers, designers, and managers engaged in the design and development of technology, configurations, and procedures that enhance efficiencies of current and future versions of a Space Station.

This literature survey lists 832 reports, articles and other documents announced between July 1, 1986 and December 31, 1986 in *Scientific and Technical Aerospace Reports (STAR)*, and *International Aerospace Abstracts (IAA).*

The coverage includes documents that define major systems and subsystems, servicing and support requirements, procedures and operations, and missions for the current and future Space Station. In addition, analytical and experimental techniques and mathematical models required to investigate the different systems/subsystems and conduct trade studies of different configurations, designs, and scenarios are included. A general category completes the list of subjects addressed by this document.

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

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

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

(1) *IAA* entries identified by accession number series A86-10,000 in ascending accession number order;

(2) *STAR* entries identified by accession number series N86-10,000 in ascending accession number order.

After the abstract section there are seven indexes—subject, personal author, corporate source, foreign technology, contract number, report number, and accession number.

A companion continuing bibliography, *"Technology for Large Space Structures,"* is available as NASA SP-7046.

Jane A. Hagaman, *Space Station Office*
Sue K. Seward, *Technical Library Branch*

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Category 19 Support Spacecraft 107
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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

ON MICROFICHE

ACCESSION NUMBER → **N86-16940*#** Software and Engineering Associates, Inc., Carson City, Nev. ← CORPORATE SOURCE

TITLE → **ENGINEERING AND PROGRAMMING MANUAL: TWO-DIMENSIONAL KINETIC REFERENCE COMPUTER PROGRAM (TDK) Final Report**

AUTHORS → G. R. NICKERSON, L. D. DANG, and D. E. COATS Apr. 1985 ← PUBLICATION DATE

480 p refs

CONTRACT OR GRANT → (Contract NAS8-35931) ← AVAILABILITY SOURCE

REPORT NUMBERS → (NASA-CR-178628; NAS 1.26:168628; SN-63) Avail: NTIS HC A21/MF A01 CSCL 09B ← COSATI CODE

The Two Dimensional Kinetics (TDK) computer program is a primary tool in applying the JANNAF liquid rocket thrust chamber performance prediction methodology. The development of a methodology that includes all aspects of rocket engine performance from analytical calculation to test measurements, that is physically accurate and consistent, and that serves as an industry and government reference is presented. Recent interest in rocket engines that operate at high expansion ratio, such as most Orbit Transfer Vehicle (OTV) engine designs, has required an extension of the analytical methods used by the TDK computer program. Thus, the version of TDK that is described in this manual is in many respects different from the 1973 version of the program. This new material reflects the new capabilities of the TDK computer program, the most important of which are described. Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → **A86-22325*** National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.

JOURNAL TITLE → **CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS FOR SPACE HABITATS**

AUTHOR → P. BUCHANAN (NASA, Kennedy Space Center, Cocoa Beach, FL) ← AUTHOR'S AFFILIATION

REPORT NUMBERS → Japanese Journal of Aerospace and Environmental Medicine (ISSN 0387-0723), vol. 21, Dec. 1984, p. 70-74.

The development of regenerative life support systems to meet the physiological requirements of humans in space is described. A review of previous research on regenerative systems is presented. NASA's Controlled Ecological Life Support System (CELSS) program, which is to develop an environment for a human space crew, is discussed. The table of physiological requirements of an average human and the logical system approach to planning a closed system created by Spurlock and Modell (1976, 1978) are examined. The weight of food and oxygen with respect to lift-off weight is investigated. The creation of the proper atmosphere for space, by balancing all the necessary parameters is studied. The need for a mineral and fluid balance and methods of maintaining it are analyzed. The required cooperation between physicians, physiologists, and nutritionists for the success of the CELSS program is discussed. I.F.

SPACE STATION SYSTEMS

A Bibliography (Suppl. 4)

MAY 1987

01

SYSTEMS

Includes system requirements for proposed missions, mission models, overall conceptual configuration and arrangement studies; systems analyses for future required technology; and identification and description of technology developments and experiments for the elements of a complete Space Station system.

A86-32563
INTERFACE STANDARDS FOR SPACECRAFT AS A MEANS OF ENHANCING ON-ORBIT SERVICING
S. BAILY, R. R. NELSON, and W. B. STEWART (ARINC Research Corp., San Diego, CA) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 351-355. refs

This paper examines approaches to increased levels of standardization in military and commercial spacecraft. Areas where formal or de facto design standards exist are outlined. Previous analyses of opportunities for standardization are reviewed and summarized. Lessons learned from successful standardization initiatives from other segments of the aerospace industry are described and applied to the space segment design environment. The benefits and drawbacks of interface design standards are described in terms of reduced development and acquisition costs and enhanced on-orbit serviceability. Key interface standardization parameters (e.g., electrical, mechanical, thermal, physical, and functional) that should be established are described. An approach to the establishment of interface standards which permits incorporation of rapidly changing technology into spacecraft vehicle design is proposed. Author

A86-34992*# National Aeronautics and Space Administration, Washington, D.C.
ENABLING TECHNOLOGIES FOR TRANSITION TO UTILIZATION OF SPACE-BASED RESOURCES AND OPERATIONS
S. R. SADIN (NASA, Office of Aeronautics and Space Technology, Washington, DC) and J. D. LITTY (General Research Corp., Space Systems Div., McLean, VA) Canaveral Council of Technical Societies, Space Congress, 22nd, Cocoa Beach, FL, Apr. 23-26, 1985, Paper. 10 p.

This article explores a potential scenario for the further development of space infrastructure resources and operations management. It is a scenario that transitions from the current ground-based system to an architecture that is predominantly space-based by exploiting key mission systems in an operational support role. If this view is accurate, an examination of the range of potential infrastructure elements and how they might interact in a maximally productive space-based operations complex is needed, innovative technologies beyond the current Shuttle and Space Station legacy need to be identified, and research programs pursued. Development of technologies within the areas of telerobotics, machine autonomy, human autonomy, in-space manufacturing and construction, propulsion and energy is discussed. Author

A86-40521
EVA SUIT GLOVE DESIGN
B. PEACOCK, R. SHAMBAUGH, F. STRITZ (Oklahoma, University, Norman), and J. HORDINSKY (FAA, Oklahoma City, OK) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 8-14 to 8-25. refs

Traditional testing of gloves has been a subjective study by experienced designers and astronauts. An objective series of standardized tests were developed to test dexterity, strength, and tactility in a single-handed vacuum chamber. A finite element analysis simulates the effects of restraints and pleats at various glove pressures. For the finger, the incorporation of a lateral restraint and pleats on both the front and back of the joint led to near zero resistance to bending. A total glove model also was developed. A process was developed which used a computer to control the movement of an air jet to lay down continuous fiber on a fine mesh which overlaid a suction mechanism. With this technique, gloves can be quickly and economically produced with infinite selectibility of size, construction, and materials. Author

A86-40618*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ASSESSMENT OF INTERNATIONAL PAYLOAD REQUIREMENTS ON THE DUAL KEEL SPACE STATION - A SYSTEMS ANALYSIS CAPABILITIES EXAMPLE
C. L. ALLEN and G. C. ANDERSEN (NASA, Langley Research Center, Hampton, VA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 10 p. refs
(AIAA PAPER 86-1226)

In the early stages of spacecraft conceptual design, an investigation of subsystem requirements and their impacts on the total system provides insight into many aspects of the spacecraft design. Such an analysis has been performed on the dual keel space station to examine the system effects contributed by three international payloads provided by the Canadian, Japanese, and European Space Agencies. This example is used to illustrate some capabilities of available computer-driven tools and methods for a system analysis. Two space station configurations were examined, one without international payloads (the baseline configuration for the study) and one with the three international payloads. Each configuration was evaluated to define viewing limitations, rigid body dynamics and controls, structural dynamics, orbit lifetime, environmental control and life support, and thermal management effects. The performance, based on each subsystem evaluation, was then compared for the two configurations, and the results and recommendations are presented. Author

A86-46855
EXTERNAL TANK/AFT CARGO CARRIER ON ORBIT APPLICATIONS
T. MOBLEY and P. MITCHELL (Martin Marietta Corp., New Orleans, LA) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 83-92.

The use of the Space Shuttle external tank (ET) and aft cargo carrier (ACC) as orbital-platform structures is proposed. The ET and ACC are described; the relatively low cost of orbiting the ET rather than discarding it is indicated; and a basic orbital-platform design using the ET as strongback for payloads and an ACC module to provide utilities is presented. Consideration is given to a large-area gamma-ray telescope of gas-Cerenkov type (installed in the ET on orbit by EVA) and a solar furnace capable of melting the ET for use as an on-orbit materials resource. Photographs, drawings, diagrams, and graphs are provided. T.K.

A86-46947*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
SPACE STATION - AN INTEGRATED APPROACH TO OPERATIONAL LOGISTICS SUPPORT
G. J. HOSMER (NASA, Kennedy Space Center; Boeing Co., Cocoa Beach, FL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 13 p.
(AIAA PAPER 86-2321)

Development of an efficient and cost effective operational logistics system for the Space Station will require logistics planning early in the program's design and development phase. This paper will focus on Integrated Logistics Support (ILS) Program techniques and their application to the Space Station program design, production and deployment phases to assure the development of an effective and cost efficient operational logistics system. The paper will provide the methodology and time-phased programmatic steps required to establish a Space Station ILS Program that will provide an operational logistics system based on planned Space Station program logistics support. Author

A86-46952#
AN OPERATIONS MANAGEMENT SYSTEM FOR THE SPACE STATION
H. G. ROSENTHAL (TRW, Inc., Redondo Beach, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2329)

This paper presents an overview of the conceptual design of an integrated onboard Operations Management System (OMS). Both hardware and software concepts are presented and the integrated space station network is discussed. It is shown that using currently available software technology, an integrated software solution for Space Station management and control, implemented with OMS software, is feasible. Author

A86-48713* Kansas State Univ., Manhattan.
IMPROVED FLEXIBILITY OF AN EVA GLOVE
G. W. EGGEMAN and J. J. HELD (Kansas State University of Agriculture and Applied Science, Manhattan) IN: 1986 SEM Spring Conference on Experimental Mechanics, New Orleans, LA, June 8-13, 1986, Proceedings . Bethel, CT, Society for Experimental Mechanics, Inc., 1986, p. 788-792. NASA-supported research.

A student design contest was held between four universities. The project was to improve the flexibility of the NASA extra-vehicular activities (EVA) glove with the internal pressure increased from 4 psi to 8 psi. The Kansas State University team used an experimental design methodology and an industrial management scheme. This approach succeeded in making Kansas State University the winner of the competition. Author

A86-49558*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION OVERALL MANAGEMENT APPROACH FOR OPERATIONS
G. PAULES (NASA, Office of Space Station, Washington, DC) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 6 p.
(AIAA PAPER 86-2322)

An Operations Management Concept developed by NASA for its Space Station Program is discussed. The operational goals, themes, and design principles established during program development are summarized. The major operations functions are described, including: space systems operations, user support operations, prelaunch/postlanding operations, logistics support operations, market research, and cost/financial management. Strategic, tactical, and execution levels of operational decision-making are defined. C.D.

N86-23317*# TRW, Inc., Cleveland, Ohio.
A VIEW OF SOFTWARE DEVELOPMENT ENVIRONMENT ISSUES
B. BOEHM *In* NASA. Langley Research Center Space Station Software Recommendations p 84-117 Dec. 1985
Avail: NTIS HC A07/MF A01 CSCL 09B

The unique and challenging nature of the Space Station Program requires that software standards be effectively used to control costs, facilitate enhancements and ensure safety. The Software Standards Panel identified and developed recommendations in four areas to help the Space Station Program achieve these objectives. The areas in which recommendations are offered are policy, organization, process and candidate software standards for the Space Station Program. The concensus process employed by the panel is given and recommendations are made. Author

N86-29507*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SHOULDER AND HIP JOINTS FOR HARD SPACE SUITS AND THE LIKE Patent
H. C. VYKUKAL 8 Jul. 1986 12 p Filed 20 Aug. 1984
Supersedes N84-33021 (22 - 22, p 3633)
(NASA-CASE-ARC-11534-1; US-PATENT-4,598,428; US-PATENT-APPL-SN-642602; US-PATENT-CLASS-2-2.1A; US-PATENT-CLASS-285-168; US-PATENT-CLASS-285-184; US-PATENT-CLASS-285-227; US-PATENT-CLASS-138-120; US-PATENT-403-164) Avail: US Patent and Trademark Office
CSCL 06Q

For use in hard space suits and the like, a joint between the torso covering and the upper arm covering (i.e., shoulder) or between the torso covering and upper leg covering (i.e., hip) is disclosed. Each joint has an outer covering and a inner covering. The outer covering has plural perferably truncated toroidal sections decreasing in size proceeding outwardly. In one embodiment at each joint there are two bearings, the first larger than the second. The outer race of the larger bearing is attached to the outer edge of the smaller end of each section and the inner race of the larger bearing is attached to the end wall. The inner race of the smaller bearing is attached to the end wall. The outer race of the smaller bearing is attached to the larger end of the next section. Each bearing hask appropriate seals. Between each section is a rubber ring for the comfort of the wearer. Such rubber rings have radial flanges attached to the inner races of two adjacent bearings. Matching semicircular grooves are formed in the abutting overlapping surfaces. Bellows-like inner walls are also provided for each section fixed at one end to an inner cylindrical flange and, at the opposite end, to an end wall. Each outer section may rotate 360 deg relative to the next outer section, whereas the bellows sections do not rotate, but rather expand or contract locally as the rigid sections rotate relative to each other.

Official Gazette of the U.S. Patent and Trademark Office

N86-31425*# Stevens Inst. of Tech., Hoboken, N. J. Dept. of Electrical Engineering.
ENGINEERING GRAPHICS DATA ENTRY FOR SPACE STATION DATA BASE
R. C. LACOVARA *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 13 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 13B

The entry of graphical engineering data into the Space Station Data Base was examined. Discussed were: representation of graphics objects; representation of connectivity data; graphics capture hardware; graphics display hardware; site-wide distribution of graphics, and consolidation of tools and hardware. A fundamental assumption was that existing equipment such as IBM based graphics capture software and VAX networked facilities would be exploited. Defensible conclusions reached after study and simulations of use of these systems at the engineering level are: (1) existing IBM based graphics capture software is an adequate and economical means of entry of schematic and block diagram data for present and anticipated electronic systems for Space Station; (2) connectivity data from the aforementioned system may be incorporated into the envisioned Space Station Data Base with modest effort; (3) graphics and connectivity data captured on the IBM based system may be exported to the VAX network in a simple and direct fashion; (4) graphics data may be displayed site-wide on VT-125 terminals and lookalikes; (5) graphics hard-copy may be produced site-wide on various dot-matrix printers; and (6) the system may provide integrated engineering services at both the engineering and engineering management level.
Author

N86-31427*# Hawaii Univ., Honolulu. Dept. of Mechanical Engineering.
MATERIALS CONSIDERATIONS IN THE DESIGN OF A METAL-HYDRIDE HEAT PUMP FOR AN ADVANCED EXTRAVEHICULAR MOBILITY UNIT
B. E. LIEBERT *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 62 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 20D

A metal-hydride heat pump (HHP) has been proposed to provide an advanced regenerable nonventing thermal sink for the liquid-cooled garment worn during an extravehicular activity (EVA). The conceptual design indicates that there is a potential for significant advantages over the one presently being used by shuttle crew personnel as well as those that have been proposed for future use with the space station. Compared to other heat pump designs, a HHP offers the potential for extended use with no electrical power requirements during the EVA. In addition, a reliable, compact design is possible due to the absence of moving parts other than high-reliability check valves. Because there are many subtleties in the properties of metal hydrides for heat pump applications, it is essential that a prototype hydride heat pump be constructed with the selected materials before a committment is made for the final design. Particular care must be given to the evaporator heat exchanger worn by the astronaut since the performance of hydride heat pumps is generally heat transfer limited.
Author

02

MODELS, ANALYTICAL DESIGN TECHNIQUES, AND ENVIRONMENTAL DATA

Includes descriptions of computerized interactive systems design and development techniques, computer codes, internal and external environmental models and data.

A86-34970
APPLICATION OF SOLIDS MODELING TECHNOLOGY TO SPACE STATION CONCEPTUAL DESIGN AND ON-ORBIT ASSEMBLY
R. R. YORK and S. B. RIDER (Martin Marietta Corp., Denver, CO) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-1 to 7-13.

The 'Geomod' solids-modelling technology has been applied to NASA Space Station proposal development efforts, aiding in the conceptual design of the common module and the Materials Technology Laboratory (MTL) as well as generating animation sequences depicting the complex technique of on-orbit assembly for the modules comprising the habitable elements of the Space Station. Attention is given to the experience gained from the conceptual design of the MTL, and the construction method animations. A videotape has been prepared from the animation sequences.
O.C.

A86-35215* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTIMIZATION OF MASS PLACEMENT IN SPACE STATION APPLICATIONS
M. J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 17 p.
(SAWE PAPER 1672)

A methodology is presented by means of which the projected NASA Space Station's structural elements, primarily involving externally attached masses reresenting payloads, can be prearranged to meet all constraints imposed on Station design by mission type, safety, and physical criteria. Five different configurations are considered. The methodology has been automated in the form of a computer-aided engineering tool for the optimization of masses with respect to the products of inertia. By minimizing the induced gravity-gradient torques, the momentum buildup over an orbital period is also minimized.
O.C.

A86-36866#
FINITE ELEMENT ANALYSIS OF SUBREGIONS USING A SPECIFIED BOUNDARY STIFFNESS METHOD
C. C. JARA-ALMONTE and C. E. KNIGHT (Virginia Polytechnic Institute and State University, Blacksburg) IN: Computers in engineering 1985; Proceedings of the International Computers in Engineering Conference and Exhibition, Boston, MA, August 4-8, 1985. Volume 2 . New York, American Society of Mechanical Engineers, 1985, p. 407-411. refs

A new approach is presented to the problem of modeling subregions, important in order to accomplish finite element analysis of large, complex structures. The approach requires the specification of the stiffnesses and forces at the nodes on the boundary of the subregion model. These stiffnesses and forces would be those acting upon the subregion from the rest of the structure and would come from an analysis of the entire structure. Accurate displacement and stress solutions are obtained with this method because it takes into account the boundary loading and the interaction between the stiffnesses of the subregion and the rest of the structure. The approach combines the improved accuracy of the exact zooming method and the reduction in computer time inherent in the specified boundary displacement and linear constraint methods. Examples applying the method to

the problem of a plate with a center hole in tensile loading are presented. D.H.

A86-37184
MODELING OF A TETHERED TWO-BODY SYSTEM IN SPACE
D. K. LE (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 86-97.

A massive tether is treated as a chain of lumped point-mass beads connected by massless flexible strings. The Lagrangian approach yields a very convenient expression for the dynamics of this system relative to a moving frame which follows the 'central' direction of the tether. For all practical simulation purposes, it is enough to approximate this expression of the system's relative dynamics to the first order. A simple and numerically stable method is then presented for simulating the interaction between the tether dynamics and the orbital motions of the connected heavy bodies. Author

A86-38810*# West Virginia Univ., Morgantown.
TRANSFINITE ELEMENT METHODOLOGY TOWARDS A UNIFIED THERMAL/STRUCTURAL ANALYSIS
K. K. TAMMA and S. B. RAILKAR (West Virginia University, Morgantown) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 85-95. refs
(Contract NAG1-571)
(AIAA PAPER 86-0874)

The paper describes computational developments towards thermal/structural modeling and analysis via a generalized common numerical methodology for effectively and efficiently interfacing interdisciplinary areas. The proposed formulations use transform methods in conjunction with finite element developments for each of the heat transfer and structural disciplines, respectively, providing avenues for obtaining the structural response due to thermal effects. An alternative methodology for unified thermal/structural analysis is presented. The potential of the approach is outlined in comparison with conventional schemes and existing practices. Highlights and characteristic features of the approach are described via general formulations and applications to several problems. Results obtained demonstrate excellent agreement in comparison with analytic and/or conventional finite element schemes accurately and efficiently. Author

A86-38845#
OPTIMUM DESIGN OF LARGE STRUCTURES WITH MULTIPLE CONSTRAINTS
R. A. CANFIELD, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), and R. V. GRANDHI (Wright State University, Dayton, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 398-408. USAF-supported research. refs
(AIAA PAPER 86-0952)

Relative numerical efficiencies of different commonly used optimization techniques for solving problems with multiple constraints have been compared with an aim of developing an efficient optimization method for the automated design of large aerospace structures. A hybrid algorithm using both optimality criteria and mathematical programming methods is suggested. As a result of the study, the CONMIN computer program, and possibly NEWSUIT-A, will be used in conjunction with an optimality criteria algorithm built from OPTSTAT to develop the multidisciplinary hybrid optimization algorithm. I.S.

A86-38847*# Structural Dynamics Research Corp., San Diego, Calif.
SPACE STATION MULTIDISCIPLINARY ANALYSIS CAPABILITY - IDEAS2
M. BAKER, H. D. CHIGER, J. A. HABERMEYER, P. J. HIPOL, C. L. JOHNSON (Structural Dynamics Research Corp., San Diego, CA), and L. J. DERYDER (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 421-434.
(AIAA PAPER 86-0954)

A computer-aided engineering tool now in use at NASA for systems engineering and integration analysis of the Space Station is described. This tool, called IDEAS2, combines the spacecraft-specific analysis software from NASA IDEAS (truss synthesizer, rigid body controls, plume impingement, orbital lifetime, orbit heat loads, and life support systems) with the interactive graphics, geometric database, solids modeler, structural and thermal analysis capability of the SDRC I-DEAS to obtain an integrated package suitable for Space Station design. This integrated package was applied to a very recent study of growth scenarios of the Space Station dual keel configuration, in which a comparison was made between designs using a combination of photovoltaic solar arrays and solar dynamic collectors, and those using only solar dynamic collectors. Author

A86-38879#
REDUCED MODELING AND ANALYSIS OF LARGE REPETITIVE SPACE STRUCTURES VIA CONTINUUM/DISCRETE CONCEPTS
K. C. SAW and K. K. TAMMA (West Virginia University, Morgantown) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 720-729. refs
(AIAA PAPER 86-1022)

The paper describes reduced modeling/analysis approaches for repetitive lattice configurations with emphasis on tetrahedral type space structures although the basic concepts can be extended to general repetitive lattice structures as well. The approach is based on transforming the actual configuration to a significantly reduced discrete configuration using scaling transformations and constitutive properties derived via the concept of equivalent continuum. Therein, the approach seeks to model/analyze the much simpler and reduced configurations, wherein, transformations and extrapolation/interpolation procedures are utilized to relate back the response to that of the significantly complex actual configurations. The effectiveness and accuracy of the approach is demonstrated via comparisons with detailed analysis of the actual models. Results obtained are in good agreement and the approach offers potential for further extension. Author

A86-38953*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
AN IMPROVED MULTILEVEL OPTIMIZATION APPROACH FOR THE DESIGN OF COMPLEX ENGINEERING SYSTEMS
J.-F. M. BARTHELEMY (Virginia Polytechnic Institute and State University, Blacksburg) and M. F. RILEY (PRC Kentron, Inc., Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics, and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986. 15 p. refs
(Contract NAG1-145)
(AIAA PAPER 86-0950)

Multilevel optimization methods are being considered for the design of complex systems on distributed networks of computers or even parallel processors. An obstacle to the use of multilevel methods is that they can be computationally expensive because of the cycling necessary to account for the coupling between the subproblems. This research effort aims at increasing the efficiency of multilevel optimization by adapting two techniques that are widely used in conventional one-level optimization: constraint approximation and temporary constraint deletion. These

improvements are implemented and tested on three-, ten- and 52-bar planar truss designs. The results show that for larger problems (approximately 100 design variables and larger), the cost of analysis dominates the total cost so that multilevel optimization is no more expensive than one-level optimization. If parallel processing is used or the analysis process itself is decomposed, then multilevel optimization stands to become more economical than one-level optimization. Author

A86-40523
COMPUTER MOCK-UP - A TECHNIQUE FOR BUILDING DESIGNS
L. D. MCWATTERS and S. E. TICE (Rockwell International Corp., Downey, CA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 8-42 to 8-52. refs

CDAS (Core, Design, Analysis, and Simulation) is a new computer-aided design tool with human factors analysis capabilities. This tool is currently being used to test and design components for the Space Station Habitability Module. With CDAS, the designer has capabilities such as reach analysis, fit/interference analysis, comfort analysis, and view analysis available to him. CDAS provides the human factors engineer with a design tool which is cost-effective for preliminary concept development and evaluation. Author

A86-43225* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIPLE INSTRUMENT COVERAGE ANALYSIS
G. M. HORVAT (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 455-470. NASA-supported research.
(AAS PAPER 85-432)

In the Space Station era comprehensive investigations of the physical processes of the earth will rely on observations from several types of space-based instruments. Preliminary studies indicate that, due to projected limitations on spacecraft and launch-vehicle capability, these complementary instrument sets may have to be distributed among several spacecraft. The task of analyzing the coincident coverage areas between instruments operating from multiple spacecraft will be complex. Such factors as the instruments' observing capabilities, orbital parameters, and viewing constraints will have to be considered. To aid in this analysis a computer model is being developed. This model has the capability, among others, to compute the coincident coverage areas between two independently orbiting instruments. This paper describes the model, its capabilities, and several sample applications. Author

A86-46946#
SPACE STATION UTILIZATION OPTIMIZATION THROUGH AUTOMATED PLANNING
R. L. MCKINNEY (McDonnell Douglas Corp., Astronautics Div., Houston, TX) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p.
(AIAA PAPER 86-2318)

Software tools developed to automate mission planning within Space Station capabilities have been developed and have been seen wide application in analysis performed to support recommendations for Space Station sizing, station implementation approach, and station growth after International Space Station capability. These automated software tools were needed to manipulate the NASA Mission Requirements Data Base which describes hundreds of parameters for each of 324 missions and to optimally assign these missions such that the most efficient utilization of station and station resupply resources occurs. The tools are described at the functional level, several examples of analysis performed are presented along with typical results, and plans for the extension operation and growth into the next century are presented. Author

A86-47923#
MODELING AND SIMULATION OF SPACECRAFT SOLAR ARRAY DEPLOYMENT
B. WIE, N. FURUMOTO, A. K. BANERJEE, and P. M. BARBA (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 237-242. refs
(AIAA PAPER 86-2122)

This paper presents the dynamic and digital simulation of the deployment of rigid solar panels on Intelsat-V and INSAT spacecraft. Each spacecraft is characterized by very distinct mechanisms for its solar array deployment. The arrays on Intelsat-V are in a topological tree configuration, while the INSAT arrays are in a closed-loop configuration because of the four-bar linkage deployment mechanism. It is shown that the kinematic control rod on the INSAT has a synchronizing function very similar to that of the closed cable loop on the Intelsat-V spacecraft. Practical aspects of the modeling and simulation of complex deployment mechanisms are emphasized. The use and limitations of the DISCOS multibody code for deployment dynamics simulations are discussed, and the need for developing specialized simulation tools emphasized. Author

N86-28636*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
COMPUTER-AIDED MODELING AND ANALYSIS OF POWER PROCESSING SYSTEMS (CAMAPPS), PHASE 1 Final Report
S. KIM, J. LEE, B. H. CHO, and F. C. LEE 1986 211 p
(Contract NAG5-518)
(NASA-CR-177163; NAS 1.26:177163) Avail: NTIS HC A10/MF A01 CSCL 09B

The large-signal behaviors of a regulator depend largely on the type of power circuit topology and control. Thus, for maximum flexibility, it is best to develop models for each functional block a independent modules. A regulator can then be configured by collecting appropriate pre-defined modules for each functional block. In order to complete the component model generation for a comprehensive spacecraft power system, the following modules were developed: solar array switching unit and control; shunt regulators; and battery discharger. The capability of each module is demonstrated using a simplified Direct Energy Transfer (DET) system. Large-signal behaviors of solar array power systems were analyzed. Stability of the solar array system operating points with a nonlinear load is analyzed. The state-plane analysis illustrates trajectories of the system operating point under various conditions. Stability and transient responses of the system operating near the solar array's maximum power point are also analyzed. The solar array system mode of operation is described using the DET spacecraft power system. The DET system is simulated for various operating conditions. Transfer of the software program CAMAPPS (Computer Aided Modeling and Analysis of Power Processing Systems) to NASA/GSFC (Goddard Space Flight Center) was accomplished. B.G.

N86-28637*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
COMPUTER-AIDED MODELING AND ANALYSIS OF POWER PROCESSING SYSTEMS (CAMAPPS). PHASE 1: USERS HANDBOOK
S. KIM, J. LEE, B. H. CHO, and F. C. LEE 15 Mar. 1986 82 p
(Contract NAG5-518)
(NASA-CR-177123; NAS 1.26:177123) Avail: NTIS HC A05/MF A01 CSCL 09B

The EASY5 macro component models developed for the spacecraft power system simulation are described. A brief explanation about how to use the macro components with the EASY5 Standard Components to build a specific system is given through an example. The macro components are ordered according to the following functional group: converter power stage models, compensator models, current-feedback models, constant frequency control models, load models, solar array models, and shunt

regulator models. Major equations, a circuit model, and a program listing are provided for each macro component. B.G.

03

STRUCTURAL CONCEPTS

Includes analyses and descriptions of different Space Station structural concepts, arrangements, testing, methods of construction and/or manufacturing and specific rotary joints, structural nodes, and columns.

A86-32540*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ACCESS (ASSEMBLY CONCEPT FOR CONSTRUCTION OF ERECTABLE SPACE STRUCTURE) - A SHUTTLE FLIGHT EXPERIMENT
W. L. HEARD, JR. (NASA, Langley Research Center, Hampton, VA) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 157-165. refs

ACCESS is a planned Shuttle flight experiment to assess the potential of an on-orbit construction concept designed for efficient manual assembly of a space truss. The experiment, which is scheduled for launch November 27, 1985, on the Space Transportation System (STS) flight 61-B, uses two astronauts secured in fixed foot restraints located in the Shuttle cargo bay to assemble a 45-foot long aluminum truss beam from 93 tubular struts and 33 nodal joints. Neutral buoyancy simulations of the flight experiment indicate the truss can be assembled in less than thirty minutes. Structural assembly, structural repair, flexible cable attachment and manual manipulation of the truss is also planned for the experiment using an astronaut secured in the Manipulator Foot Restraint attached to the Remote Manipulator System arm. Flight assembly data will be generated for correlation of the neutral buoyancy ground test data. This paper describes the ACCESS flight experiment and presents results of the neutral buoyancy development and training tests. Author

A86-32929#
MOBILE GANTRY ROBOTS FOR LARGE STRUCTURES
D. FRAZIER (Martin Marietta Corp., Michoud Div., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 14 p.

A NASTRAN analysis was used to investigate the design and feasibility of transporting a large gantry robot for use in aerospace manufacturing. A model of a rectangular gantry of high tensile 4140 steel with a 400 pound carriage/manipulator mounted on top was constructed and tested by the sudden failure of one of the frictionless airskids on which the gantry was moving at constant speed. The locations and magnitudes of the extreme stresses are identified. C.D.

A86-34634* Howard Univ., Washington, D. C.
AN EVALUATION OF FOLDABLE ELASTIC TUBES FOR APPLICATION IN SPACE STRUCTURES
I. W. JONES (Howard University, Washington, DC), C. BOATENG (Exxon Co., Houston, TX), and C. D. WILLIAMS (Shell Oil Co., Houston, TX) IN: 1985 SEM Spring Conference on Experimental Mechanics, Las Vegas, NV, June 9-14, 1985, Proceedings . Brookfield Center, CT, Society for Experimental Mechanics, Inc., 1985, p. 590-598. refs
(Contract NSG-1320)

An experimental investigation and design study has been performed on one type of foldable elastic tube in order to assess its suitability as a member of deployable space structures. It is demonstrated that one or more slots inserted longitudinally in the center of the tube to alleviate strain serves to prevent collapse of the tube. The nonlinear spring characteristics of the tube that are required for computer-based deployment dynamic analysis of space structures are determined, and it is shown that strain energy levels over a certain range are realizable for tubes representing space structure members in the 15-20 ft length range. Approximate strain energy/geometric parameter relationships are developed which may be useful for preliminary design or concept studies. C.D.

A86-34987
TRUSS STRUCTURE ADVANCED DEVELOPMENT FOR SPACE STATION
J. F. DUBEL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 12-7 to 12-11.

This paper identifies three challenging structural aspects to the Space Station program. The first is to define the relationship between the structure and the attitude control system. The second is to determine the truss structure material that meets current initial operating capability and growth requirements. The third is to determine how much truss structure deployment will be automatic and how much will require crew interface operations. This mix of automatic and crew operations involves rigidizing joints, articulating utility lines and supports, packaging, accommodating requirements imposed by extravehicular activities (EVA), preparing for growth, and other automatic and crew interface provisions. Author

A86-37060*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONSTRUCTION AND CONTROL OF LARGE SPACE STRUCTURES
M. F. CARD, W. L. HEARD, JR. (NASA, Langley Research Center, Hampton, VA), and D. L. AKIN (MIT, Cambridge, MA) Israel Annual Conference on Aviation and Astronautics, 28th, Tel Aviv and Haifa, Israel, Feb. 19, 20, 1986, Paper. 21 p. refs

Recent NASA research efforts on space construction are reviewed. Preliminary results of the EASE/ACCESS Shuttle experiments are discussed. A 45-foot beam was constructed on orbit in 30 minutes using a manual assembly technique at a work station. A large tetrahedron was constructed several times using a free floating technique. The capability of repair, utilities installation, and handling the structures using a mobile foot restraint on the RMS was also demonstrated. Implications of the experiments for Space Station are presented. Models of 5-meter Space Station structure together with neutral buoyancy simulations suggest manual assembly techniques are feasible. Selected research on control of flexible structures is discussed. To support planned flight experiments, studies of the design and optimal placement of distributed active dampers are underway. Author

A86-38812#
SPACE FRAME OPTIMIZATION SUBJECT TO FREQUENCY CONSTRAINTS
T. H. WOO (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 103-115. Research supported by TRW Independent Research and Development Program. refs
(AIAA PAPER 86-0877)

An efficient structural optimization methodology is presented for the design of minimum weight space frames subject to multiple natural frequency constraints. A powerful class of generalized hybrid constraint approximations which require only the first order constraint function derivatives have been developed to overcome inherent nonlinearity of the frequency constraint. The generalized hybrid constraint functions are shown to be relatively conservative, separable and convex in the region bounded by the move limits based on the formula described in this paper. The optimization

methodology is implemented in an automated structural optimization system which has been applied to solve a variety of space frame optimization problems. Numerical results obtained for three example problems indicate that the optimization methodology requires fewer than 10 complete normal modes analyses to generate a near optimum solution. Author

A86-38826#
LOW-PRESSURE/LIGHTWEIGHT CRYOGENIC PROPELLANT TANK DESIGN FOR THE SPACE-BASED ORBITAL TRANSFER VEHICLE
C. N. TORRE (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 236-242.
(AIAA PAPER 86-0915)

A structural concept is presented for one of the low pressure/lightweight cryogenic propellant tank systems that will be used for the Space Orbital Transfer Vehicle S-4C. The core propellant vehicle is sized for a 12,000-lb delivery to geostationary orbit with 2000-lb return. To minimize boil-off from thermal conductivity of heat to the LO2 and LH2 tanks, the tanks are positioned and supported by struts made of a low thermal conductivity, low weight S-glass/epoxy composite. The spin forming technique is state-of-the-art for manufacturing the one-piece hemispheres of the tanks, and the 2090 Al-Li alloy is the material of choice. Preliminary fracture-fatigue analyses have demonstrated a long mission life in the thin gauges, and finite element models have shown acceptable stress distributions in the tank walls. I.S.

A86-40593*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
RESULTS OF THE ACCESS SPACE CONSTRUCTION SHUTTLE FLIGHT EXPERIMENT
W. L. HEARD, JR., J. J. WATSON (NASA, Langley Research Center, Hampton, VA), J. L. ROSS, S. C. SPRING, and M. L. CLEAVE (NASA, Johnson Space Center, Houston, TX) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 118-125. refs
(AIAA PAPER 86-1186)

The ACCESS (Assembly Concept for Construction of Erectable Space Structure) experiment was launched on the Orbiter Atlantis on November 26, 1985. ACCESS was designed to study manual assembly of a 45-foot long truss structure by two astronauts working in space suits in the Orbiter cargo bay. This paper describes the experiment and hardware used, and compares on-orbit construction timelines to underwater neutral buoyancy data. In-flight photographs of assembly tasks and comments made by the crew at the postflight debriefing are also included. It was found that all tasks could be accomplished and that assembly times compared favorably with neutral buoyancy data. Author

A86-42637#
LOW VAPOR PRESSURE CRYOGENIC PROPELLANT TANK DESIGN FOR THE SPACE-BASED ORBITAL TRANSFER VEHICLE
C. N. TORRE, R. C. MCCOOL, M. W. RINKER, F. O. BENNETT, J. R. KERR (General Dynamics Corp., Space Systems Div., San Diego, CA) et al. AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1428)

Orbital Transfer Vehicle concepts are currently being studied by aerospace contractors for NASA Marshall Space Flight Center to identify technology needs for development of these vehicles based at the Space Station in the mid-1990s. The Space-Based Orbital Transfer Vehicle (SBOTV) must be lightweight to minimize propellant mass while having durable structures and systems to minimize propellant mass while having durable structures and systems to minimize refurbishment/maintenance requirements and associated cost. Unlike ground-based vehicles, an SBOTV designed to operate solely in the vacuum environment of space does not require that propellant tank pressures be maintained above atmospheric pressure (14.7 psia). Reducing operating pressures results in a corresponding reduction in a corresponding reduction in vehicle inert weight, propellant weight, and operational costs. The economic and performance advantages of low vapor pressure aluminum tanks for the SBOTV system have been identified. Development of such tanks requires an examination of new low-density aluminum-lithium alloys, assessment of their micrometeoroid protection needs and thermal insulation characteristics, fracture and fatigue analyses of very thin gauges, and design of low-conductivity tank support concepts and low-pressure cryogenic liquid oxygen and hydrogen manufacturing and delivery. This paper describes a structural concept for one of many of the SBOTV cryogenic tank systems and presents the results of analytical models constructed to examine the feasibility of thin gauge tanks. Author

A86-46465#
INTEGRATED DESIGN OF SPACE STRUCTURES USING LATTICE PLATE FINITE ELEMENTS
S. E. LAMBERSON (U.S. Air Force Academy, Colorado Springs, CO) and T. Y. YANG (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 743-750) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 478-484. Previously cited in issue 13, p. 1856, Accession no. A85-30404. refs
(Contract AF-AFOSR-83-0204)

A86-49597*# Boeing Aerospace Co., Seattle, Wash.
A STEERABLE RADIATOR FOR SPACECRAFT APPLICATION
B. L. HEIZER, S. D. GOO, G. D. RHODES, D. W. THORESON (Boeing Aerospace Co., Seattle, WA), and R. C. PARISH (NASA, Johnson Space Center, Houston, TX) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 7 p.
(Contract NAS9-17310)
(AIAA PAPER 86-1298)

Future large space structures such as the Space Station will have high dissipation and long life requirements which dictate the requirements for steerable radiators. Several rotary coupling concepts were considered to accomplish heat transport across the steerable radiator system's rotating interface. Rotary fluid couplings were chosen over rotary contact couplings or flexible lines because of low temperature gradients and operational flexibility. A rotary fluid coupling has been designed for use on initial operating capability (IOC) and growth Space Station. Its internal seals have been demonstrated to a 10 year life with minimal (0.055 lbm NH3/year) leakage between internal passages. Materials compatibility tests have been conducted to demonstrate compatibility with ammonia. A seal leakage management system has been designed to: (1) monitor pressures between the internal seals, (2) remove leakage, and (3) store the leakage fluid in a reservoir. Author

N86-23623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYSIS OF A SINGLE-FOLD DEPLOYABLE TRUSS BEAM PRELOADED BY EXTENSION OF SELECTED FACE DIAGONAL MEMBERS
K. C. WU and M. S. LAKE Apr. 1986 17 p refs
(NASA-TM-87673; NAS 1.15:87673) Avail: NTIS HC A02/MF A01 CSCL 22B

A technique for preloading a deployable box truss beam by extension of one face diagonal per bay was studied to determine if it would result in uniform loading of truss joints without causing excessive truss deformations. Results indicate that it is possible to accomplish uniform loading in the beam region way from beam boundaries, whereas in the regions near boundaries the member loading becomes non-uniform with magnitudes greater than those in the uniform load region. Also, the type of deformation which results in the beam depends on the pattern of preloaded members. Author

N86-23632# Georgia Inst. of Tech., Atlanta. Center for the Advancement of Computational Mechanics.
SIMPLIFIED NONLINEAR ANALYSIS OF LARGE SPACE-TRUSSES AND SPACE-FRAMES, USING EXPLICITLY DERIVED TANGENT STIFFNESSES AND ACCOUNTING FOR LOCAL BUCKLING Final Report, 1 May 1983 - 30 Apr. 1985
K. KONDOH, K. TANAKA, and S. N. ATLURI Aug. 1985 193 p
(Contract F33615-83-K-3205)
(AD-A162319; GIT-CACM-SNA-14; AFWAL-TR-85-3079) Avail: NTIS HC A09/MF A01 CSCL 22B

Simplified finite element methods for finite deformation, post-buckling analysis of large space trusses and space frames are presented. Arbitrarily large rigid translations and rigid rotations of each member are accounted for. Each 3-D truss member is assumed to withstand an axial force, while each 3-D frame member is assumed to withstand two bending moments, a twisting moment, and transverse and axial forces at each node. The influence of local (member) buckling on global instability is systematically examined. For both 3-D truss and frame members, explicit tangent stiffness matrices are derived. By explicit; it is meant that no element-wise basis functions are assumed and that no element-wise numerical integrations are involved. These explicit tangent stiffness matrices are very simply evaluated at any point in the load deformation history of a space truss, or space frame, undergoing large deformations, as well as in the postbuckled region of behavior of these structures. An arc-length method is implemented to trace the postbuckling behavior of these large space structures. A large number of examples are included to: (1) bring out the economy as well as accuracy of the simplified method developed; (2) indicate the effectiveness of the present method in creating reduced-order models of large space structures; and (3) delineate the process whereby the overall behavior of the structure can be vastly improved by controlling the deformation of individual members through active or passive mechanisms. GRA

N86-24512*# Purdue Univ., Indianapolis, Ind. Dept. of Mechanical Engineering.
METHODOLOGY OF DESIGN AND ANALYSIS OF EXTERNAL WALLS OF SPACE STATION FOR HYPERVELOCITY IMPACTS BY METEOROIDS AND SPACE DEBRIS
F. A. BATLA *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 32 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 22B

The development of criteria and methodology for the design and analysis of Space Station wall elements for collisions with meteoroids and space debris at hypervelocities is discussed. These collisions will occur at velocities of 10 km/s or more and can be damaging to the external wall elements of the Space Station. The wall elements need to be designed to protect the pressurized modules of the Space Station from functional or structural failure due to these collisions at hypervelocities for a given environment and population of meteoroids and space debris. The design and analysis approach and the associated computer program presented is to achieve this objective, including the optimization of the design for a required overall probability of no penetration. The approach is based on the presently available experimental and actual data on meteoroids and space debris flux and damage assessments and the empirical relationships resulting from the hypervelocity impact studies in laboratories. Author

N86-24730*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
GENERALIZED PARITY RELATIONS FOR LARGE SPACE STRUCTURES WITH UNCERTAIN PARAMETERS M.S. Thesis
J. R. DUTILLOY Jan. 1986 72 p refs
(Contract NAG1-126)
(NASA-CR-176762; NAS 1.26:176762; REPT-2-86) Avail: NTIS HC A04/MF A01 CSCL 22B

The generalized parity relations method is a technique that can be used to detect sensor and actuator failures on a large space structure. A model of a grid structure was used to evaluate the performance of these relations. It shows their relative sensitivity to modeling errors. A method using sensor outputs and actuator inputs is required for the design of the generalized parity relations. Three different estimators are studied. The last estimator can generate relations optimized for the detection of a particular failure which are interesting when the level of sensor noise is high. E.A.K.

N86-24731*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STRUCTURAL PERFORMANCE OF SPACE STATION TRUSSES WITH MISSING MEMBERS
J. T. DORSEY May 1986 35 p refs
(NASA-TM-87715; NAS 1.15:87715) Avail: NTIS HC A03/MF A01 CSCL 22B

Structural performance of orthogonal tetrahedral and Warren-type full truss beams and platforms are compared. In addition, degradation of truss structural performance is determined for beams, platforms and a space station when individual struts are removed from the trusses. The truss beam, space station, and truss platform analytical models used in the studies are described. Stiffness degradation of the trusses due to single strut failures is determined using flexible body vibration modes. Ease of strut replacement is assessed by removing a strut and examining the truss deflection at the resulting gap due to applied forces. Finally, the reduction in truss beam strength due to a missing longeron is determined for a space station transverse boom model. Author

N86-24867*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEPLOYABLE GEODESIC TRUSS STRUCTURE A01 Patent Application
M. M. MIKULAS, JR., inventor (to NASA), M. D. RHODES, inventor (to NASA), and J. W. SIMONTON, inventor (to NASA) 20 Feb. 1986 15 p
(NASA-CASE-LAR-13113-1; NAS 1.71:LAR-13113-1; US-PATENT-APPL-SN-831371) Avail: NTIS HC A02/MF A01 CSCL 13B

A deployable geodesic truss structure which can be deployed from a stowed state to an erected state is described. The truss structure includes a series of bays, each bay having sets of battens connected by longitudinal cross members which give the bay its axial and torsional stiffness. The cross members are hinged at their mid point by a joint so that the cross members are foldable for deployment or collapsing. The bays are deployed and stabilized by actuator means connected between the mid point joints of the cross members. Hinged longerons may be provided to also connect the sets of battens and to collapse for stowing with the rest of the truss structure. The truss structure has the capability of serving a structural function even when only partly deployed. NASA

N86-25401*# Alabama Univ., University. Environmental and Energy Center.
PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT Progress Report
F. C. WESSLING 1 Jun. 1986 45 p refs
(Contract NAGW-847)
(NASA-CR-176832; NAS 1.26:176832) Avail: NTIS HC A03/MF A01 CSCL 22B

The use of nonmetallic or fabric structures for space application is considered. The following structures are suggested: (1) unpressurized space hangars; (2) extendable tunnels for soft docking; and (3) manned habitat for space stations, storage facilities, and work structures. The uses of the tunnel as a passageway: for personnel and equipment, eliminating extravehicular activity, for access to a control cabin on a space crane and between free flyers and the space station are outlined. The personnal occupied woven envelope robot (POWER) device is shown. The woven envelope (tunnel) acts as part of the boom of a crane. Potential applications of POWER are outlined. Several possible deflection mechanisms and design criteria are determined. E.A.K.

N86-25789* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYNCHRONOUSLY DEPLOYABLE TRUSS STRUCTURE Patent
H. G. BUSH, inventor (to NASA), M. MIKULAS, JR., inventor (to NASA), and E. WALLSOM, inventor (to NASA) (Kentron International, Inc., Hampton, Va.) 1 Apr. 1986 8 p Filed 30 Nov. 1983 Sponsored by NASA
(NASA-CASE-LAR-13117-1; US-PATENT-4,578,920; US-PATENT-APPL-SN-556512; US-PATENT-CLASS-52-645; US-PATENT-CLASS-52-111; US-PATENT-CLASS-52-648; US-PATENT-CLASS-244-159; US-PATENT-CLASS-244-173; US-PATENT-CLASS-343-881; US-PATENT-CLASS-343-882)
Avail: US Patent and Trademark Office CSCL 13I

A collapsible-expandable truss structure, including first and second spaced surface truss layers having an attached core layer is described. The surface truss layers are composed of a plurality of linear struts arranged in multiple triangular configurations. Each linear strut is hinged at the center and hinge connected at each end to a nodular joint. A passive spring serves as the expansion force to move the folded struts from a stowed collapsed position to a deployed operative final truss configuration. A damper controls the rate of spring expansion for the synchronized deployment of the truss as the folded configuration is released for deployment by the restrain belts. The truss is synchronously extended under the control of motor driven spools.

Official Gazette of the U.S. Patent and Trademark Office

N86-27364# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
THE EXTENDABLE AND RETRACTABLE MAST (ERM)
M. SCHMID and M. AGUIRRE *In* ESA Second European Space Mechanisms and Tribology Symposium p 69-74 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The Extendable and Retractable Mast (ERM) used to deploy and retract large foldable structures such as solar arrays and furlable spacecraft antennas is presented. The design is based on a telescopic carbon-fiber structure with high stiffness, strength, and pointing accuracy. To verify the chosen design a breadboard model of an ERM was built and tested under TV conditions.

ESA

N86-29892# Massachusetts Inst. of Tech., Cambridge.
FAILURE PROPAGATION IN CONTINUUM MODELS OF LSS (LARGE SPACE STRUCTURES), PART 1 Technical Report, 1 Sep. - 1 Nov. 1985
J. H. WILLIAMS, JR. and S. S. LEE 1 Nov. 1985 30 p
(Contract F49620-85-C-0148)
(AD-A166208; AFOSR-86-0094TR-PT-1) Avail: NTIS HC A03/MF A01 CSCL 13M

Large space structures (LSS) can often be modelled adequately as equivalent anisotropic continua. In this study concepts in failure mechanics and wave propagation are applied to analyze the dynamic failure (fracture, buckling, joint disassembly, etc.) and failure arrest behavior of such an equivalent continuum. For simplicity, the equivalent continuum is assumed to be orthotropic. Furthermore, the transverse shear deformation of the equivalent continuum is assumed to dominate. Double cantilever beam models are well established fracture mechanics models in the study of crack propagation in a continuum. An orthotropic double cantilever shear beam (DCSB) model is adopted here to study Mode I dynamic failure (which for convenience is assumed to be fracture) and arrest in continuum models of lattice structures. The orthotropic DCSB model consists of both a primary material and a finite width arrester section. The DCSB model has predicted that under the proper conditions the crack may arrest when any of the following conditions is satisfied: 1) When the initial reflected disturbance catches the crack tip, before the crack tip reaches the arrester section; 2) When the crack tip enters the arrester section; 3) When the crack tip exits the arrester section; or 4) When the initial reflected disturbance catches the crack tip, after the crack tip has exited from the arrester section. It is shown that condition (1) is absolute, meaning that the crack is always arrested. GRA

N86-30206*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FEASIBILITY STUDY OF A DISCRETE BEARING/ROLLER DRIVE ROTARY JOINT FOR THE SPACE STATION
S. H. LOEWENTHAL and F. T. SCHULLER Jul. 1986 43 p
(NASA-TM-88800; E-3138; NAS 1.15:88800) Avail: NTIS HC A03/MF A01 CSCL 13I

The most critical mechanism on board the proposed space station is the continously rotating joint which must accurately align the solar power units with the sun during earth orbit. The feasibility of a multiple, discrete bearing supported joint driven by a self-loading, pinch drive actuator was investigated for this application. This concept appears to offer greater protection against catastrophic jamming, less sensitivity to adverse thermal gradients, greater accessibility to inorbit servicing or replacement and greater adaptability to very large (5 m) truss members than to more conventional continuous support bearing/gear reducer joints. Analytical trade studies performed herein establish that a discrete cam roller bearing support system having eight hangers around a continuous ring would provide sufficient radial and bending stiffness to prevent any degradation in the fundamental frequencies of the solar wing structure. Furthermore, it appears that the pinch roller drive mechanism can be readily sized to meet or exceed system performance and service life requirements. Wear life estimates based on experimental data for a steel roller coated with an advanced polyimide film show a continuous service life more than two orders of magnitude greater than required for this application.

Author

N86-30234*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SIMPLE NONLINEAR JOINT MODEL
W. B. FICHTER Aug. 1986 7 p
(NASA-TM-87749; L-16169; NAS 1.15:87749) Avail: NTIS HC A02/MF A01 CSCL 20K

Hertzian contact theory is applied to a butt joint with specially mismatched bearing surfaces to devise a simple mathematical model of nonlinear axial force-displacement behavior in jointed members. Normalized tangent stiffness-force plots, for several values of a joint imperfection parameter, are presented for the sample case of solid structural members of circular section. The results illustrate the potential problem of high joint compliance at low axial-force levels, as well as the generally desirable stiffening and linearizing effects of preload. A nonlinear oscillator problem based on the static model is also formulated and solved to illustrate the effect of amplitude on natural frequency. As expected, natural frequency is low when amplitude is small. The results call attention to the important roles that tight tolerances and preload are expected to play in the design and fabrication of deployable and erectable truss-type space structures.

Author

N86-31630*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
PRELOADED SPACE STRUCTURAL COUPLING JOINTS Patent Application
M. D. RHODES, inventor (to NASA) 30 Jul. 1986 16 p
(NASA-CASE-LAR-13489-1; US-PATENT-APPL-SN-890445; NAS 1.71:LAR-13489-1) Avail: NTIS HC A02/MF A01 CSCL 22B

This invention relates to a coupling device for tubular members, of large truss structures, with a locking collar being the only moving part. Each tubular member is constructed with an end bell section that has a belled flange with a mating face, and a necked area which is smaller in diameter than the tubular members to be joined. A split ring is affixed to each tubular member and is constructed so that when two tubular members are laterally moved into axial alignment and the collar is rotated thereover, the split ring loads the joint with axial force by pressing the belled flange mating surfaces together, and a preloading force is provided by the collar mating with a taper on the outside of the split rings. All free play is thereby removed by preloaded force. A major object of the invention is to provide an ability to remove and replace individual tubular members without disturbing other structural parts of a truss

structure. An additional anticipated use of this joint is to couple high pressure fluid lines. NASA

04

THERMAL CONTROL

Includes descriptions of analytical techniques, passive and active thermal control techniques, external and internal thermal experiments and analyses and trade studies of thermal requirements.

A86-32943#
PREDICTED TEMPERATURE FIELD IN A THERMOMECHANICALLY HEATED VISCOPLASTIC SPACE TRUSS STRUCTURE
D. H. ALLEN and W. E. HAISLER (Texas A & M University, College Station) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 773-779) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Mar.-Apr. 1986, p. 178-183. Previously cited in issue 13, p. 1897, Accession no. A85-30311. refs
(Contract F49620-83-C-0067)

A86-38811#
A FINITE ELEMENT MODEL FOR THE THERMOELASTIC ANALYSIS OF LARGE COMPOSITE SPACE STRUCTURES
J. D. LUTZ, D. H. ALLEN, and W. E. HAISLER (Texas A & M University, College Station) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 96-102. refs
(Contract F49620-83-C-0067)
(AIAA PAPER 86-0875)
A finite element model is outlined for an integrated thermoelastic analysis of large composite space structures. The model allows for temperature gradients within structural member cross-sections and for bending of the members themselves. Nonlinear effects, such as radiation boundary conditions and temperature-dependent material properties are also included. Once the model is outlined, a preliminary investigation into the importance of thermally-induced forces and moments is carried out. The problem chosen is that of a long, cantilevered lattice beam in a geosynchronous orbit. For the structure and loading chosen, no significant dynamic responses, such as vibration, occurred. In addition, thermally induced axial forces were the predominant type of loading. For this problem, thermally-induced moments could be neglected. The magnitude of axial stresses generated by the transitioon from shadow to sunlight is on the order of 30 percent of yield stress. Author

A86-38823*# Old Dominion Univ., Norfolk, Va.
A TAYLOR-GALERKIN FINITE ELEMENT ALGORITHM FOR TRANSIENT NONLINEAR THERMAL-STRUCTURAL ANALYSIS
E. A. THORNTON and P. DECHAUMPHAI (Old Dominion University, Norfolk, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 210-220. NASA-USAF-supported research.
(AIAA PAPER 86-0911)
A Taylor-Galerkin finite element method for solving large, nonlinear thermal-structural problems is presented. The algorithm is formulated for coupled transient and uncoupled quasistatic thermal-structural problems. Vectorizing strategies ensure computational efficiency. Two applications demonstrate the validity of the approach for analyzing transient and quasistatic thermal-structural problems. Author

A86-39873*# OAO Corp., Greenbelt, Md.
FUNCTIONAL AND PERFORMANCE TESTS OF TWO CAPILLARY PUMPED LOOP ENGINEERING MODELS
J. KU, E. J. KROLICZEK, W. J. TAYLOR (OAO Corp., Greenbelt, MD), and R. MCINTOSH (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 12 p. refs
(AIAA PAPER 86-1248)
This paper presents the results of the functional and performance tests for two capillary pumped loop (CPL) engineering models. Both CPL systems are aluminum/ammonia transport systems which contain eight parallel evaporators and six parallel condensers in a single loop. Tests conducted include the transport limit, heat load shearing between evaporators, liquid inventory/temperature control by the reservoir, pressure priming under heat load, diode function of condensers, and isolation of a single deprimed evaporator. Consistent performance results were obtained for both systems. Transport capabilities of up to 70 kw-m with individual evaporators managing up to 1.7 kw, with a corresponding input heat flux of 15w/sq cm, were demonstrated. These tests demonstrated the ability of a CPL system to operate over a wide range of conditions and thus established the viability of these systems for high power thermal management of large spacecraft, such as the NASA Space Station. Author

A86-39888#
DEVELOPMENT OF A GENERALIZED RADIATOR WEIGHT OPTIMIZATION DESIGN CODE FOR HIGH POWER SPACECRAFT APPLICATIONS
S. J. MERTESDORF (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. refs
(AIAA PAPER 86-1268)
A heat pipe radiator weight optimization computer code is under development for high power spacecraft applications. The code can be used for preliminary design or for the assessment of radiator components. It is assumed that heat is supplied to the radiator by a constant temperature two-phase thermal bus. Included in the radiator weight are the heat pipe, radiating fin, and the thermal bus/radiator heat exchanger. The code minimizes the radiator weight with respect to both the heat pipe spacing and heat exchanger temperature drop. The fin efficiency may be chosen by the user or the code can optimize with respect to this parameter. Preliminary results indicate large weight penalties when utilizing high capacity heat pipes or contact heat exchangers. Additionally, a significant radiator weight reduction could be achieved by increasing the ratio of the fin thermal conductivity to density. Additional work is required to assess the weight penalty associated with the structural and micrometeoroid survivability requirements. Author

A86-39903#
APPLICATION OF CAPILLARY PUMPED LOOP HEAT TRANSPORT SYSTEMS TO LARGE SPACECRAFT
D. R. CHALMERS, J. J. PUSTAY (RCA, Astro-Electronics Div., Princeton, NJ), C. B. MOY, and E. J. KROLICZEK (OAO Corp., Greenbelt, MD) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 13 p. refs
(AIAA PAPER 86-1295)
The current developmental status of capillary pumped loop (CPL) technology, and the application of two-phased CPL heat transport systems in the future Space Station Free-Flying Platform (FFP) thermal control subsystem (TCS), advanced communications satellite TCSs, and high-powered spacecraft TCSs, are considered. The CPL permits the wick structure to be isolated in the evaporator section, and provides for the concurrent flow of liquid and vapor. An ammonia-based NASA/GSFC CPL II engineering model demonstrating a 7-kW heat transport capacity over 10 m was ground tested in 1985, and a 0.5-kW capacity model has been successfully flight tested. CPL system design concepts to satisfy

mission requirements, thermal/mechanical constraints, and operational needs are discussed. Future developments will focus on capillary pump design, isolator design, system evaporator design, the condensor/heat exchanger, and the reservoir. R.R.

A86-39904#
INITIAL TESTING OF A TWO-PHASE THERMAL LOOP
F. EDELSTEIN and R. BROWN (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p.
(AIAA PAPER 86-1296)

Testing of a NASA two-evaporator two-phase heat transport system whose design is configured to approximate Space Station requirements is reported. Nominal 0-g loop capacity is 25 kW using Freon-MF as the working fluid, but the loop is also designed for ammonia, permitting higher power levels. The monogroove cold plate and cold rails achieved loads in excess of the 3.1-kW maximum predicted value, and were operated either alone or in parallel with a combined load of 8 kW. The technique of condensor flooding to maintain bus set point temperature was demonstrated over a range of loads and sink temperatures, and the 8-kW load level of isothermality was about 1 F over a 50-m transport length, well within the design requirements. Pump, subcooler, regenerator, condensor, vapor NCG trap, and accumulator performance were as expected. Pump cavitation was alleviated by plumbing the accumulator upstream of the subcooler. R.R.

A86-39905*# Grumman Aerospace Corp., Bethpage, N.Y.
THE SHARE FLIGHT EXPERIMENT - AN ADVANCED HEAT PIPE RADIATOR FOR SPACE STATION
J. P. ALARIO and P. J. OTTERSTEDT (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 10 p. NASA-sponsored research. refs
(AIAA PAPER 86-1297)

This paper reports on the design and thermal vacuum certification testing of the Space Station Heat Pipe Advanced Radiator Element (SHARE) Shuttle flight experiment, with primary emphasis on the heat pipe radiator system. The main objective of the SHARE experiment is to demonstrate suitable 0 g heat transfer performance of a 50 ft-long high-capacity monogroove heat pipe radiator element being developed for possible Space Station application. All of the flight certification tests were achieved, including a maximum heat rejection of 2 kW and thawing of a frozen heat pipe; and uninterrupted operation under cycling environmental and evaporator heat loads. Author

A86-39907*# Grumman Aerospace Corp., Bethpage, N.Y.
HEAT PIPE RADIATOR TECHNOLOGY FOR SPACE POWER SYSTEMS
A. W. CARLSON, E. GUSTAFSON (Grumman Aerospace Corp., Space Systems Div., Bethpage, NY), and B. A. ERCEGOVIC (NASA, Lewis Research Center, Cleveland, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 11 p. refs
(Contract NAS3-24665)
(AIAA PAPER 86-1300)

High-reliability high-performance deployable monogroove and dual-slot heat pipe radiator systems to meet the requirements for electric power in future space missions, such as the 300-kW(e) electric powder demand projected for NASA's Space Station, are discussed. Analytical model trade studies of various configurations show the advantages of the dual-slot heat pipe radiator for high temperature applications as well as its weight reduction potential over the 50-350 F temperature range. The ammonia-aluminum monogroove heat pipe, limited to below-180 F operating temperatures, is under development, and can employ methanol-stainless steel heat pipes to achieve operating temperatures in excess of 300 F. Dual-slot heat pipe configuration proof-of-concept testing was begun in 1985. R.R.

A86-39923#
FLUID RECIRCULATION, DEPLOYMENT AND RETRACTION OF AN EXPANDABLE PULSE POWER RADIATOR
I. C. CHOW (Kentucky, University, Lexington) and E. T. MAHEFKEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 7 p. USAF-sponsored research. refs
(AIAA PAPER 86-1322)

Three methods for the stowage of a space power system radiator bag are considered in the present study. Fluid recirculation, as well as the deployment and retraction of this expandable, megawatt-pulse power radiator are discussed. Attention is given to the response of the radiator to a duty cycle, the rolling in and out of the radiator bag, and alternative wiper-, liquid channel-, and rotating bag-mechanisms of condensate return. O.C.

A86-39924#
CONCEPTUAL DESIGN OF AN 1 M LONG 'ROLL OUT FIN' TYPE EXPANDABLE SPACE RADIATOR
R. PONNAPPAN (Universal Energy Systems, Inc., Dayton, OH), J. E. BEAM, and E. T. MAHEFKEY (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. USAF-sponsored research. refs
(AIAA PAPER 86-1323)

Waste heat rejection in space at temperatures 300-423 K is posing technological problems for spacecraft of 100 KW capacity or more. The development of a light weight expandable type radiator is the prime objective of this work. A vapor pressure activated, expandable, near-room temperature, roll out type radiator fin working on phase change of fluid (evaporation and condensation) has been developed. The demonstration testing of a 1 m long 10 cm wide fin segment of the radiator is explained. A mass to radiating power ratio of the order of 1 Kg/KW is possible and large radiator panels can be constructed using modular concept. Author

A86-39941*# OAO Corp., Greenbelt, Md.
DEVELOPMENT OF AN ADVANCED TRAPEZOIDAL AXIALLY GROOVED (ATAG) HEAT PIPE
R. F. G. RICHTER, P. J. BRENNAN (OAO Corp., Greenbelt, MD), and J. G. RANKIN (NASA, Johnson Space Center, Houston, TX) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. refs
(AIAA PAPER 86-1342)

This paper discusses the breadboard development of an Advanced Trapezoidal Axially Grooved (ATAG) heat pipe, which will satisfy space constructible radiator heat rejection requirements for large space power systems. The ATAG heat pipe development program includes a technology demonstration of Space Station heat load and temperature requirements through the design, fabrication, and testing of breadboard and preprototype units. A parametric analysis was conducted to determine trapezoidal groove geometries that could meet the transport performance goal and could be fabricated by available extrusion technology for a diameter chosen to be compatible with an existing development test unit of a cylindrical, pressure-actuated contact heat exchanger. Performance test results for the breadboard heat pipes are presented. Author

A86-39962*# General Dynamics Corp., San Diego, Calif.
DEVELOPMENT OF A PROTOTYPE AUTOMATED ON-ORBIT CONTACT HEAT EXCHANGER
C. Y. LEE, J. R. SCHUSTER, J. W. WOHLWEND (General Dynamics Corp., Space Systems Div., San Diego, CA), and R. C. PARISH (NASA, Johnson Space Center, Houston, TX) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 12 p. refs
(AIAA PAPER 86-1269)

An automated contact heat exchanger is being developed for use aboard the manned Space Station, serving as an interface heat exchanger between the pressurized module internal thermal buses and the central external thermal bus. The concept makes

use of an array of flattened, thin-walled, flexible tubes that expand or contract to make or break the thermal connection as the internal pressure changes. Because of its simplicity, it permits on-orbit assembly by the remote manipulator system, thus eliminating the need for expensive EVA to make connections. A design methodology based on stress and thermal analyses has been developed and used to perform trade-offs between performance and cost, and to optimize design parameters. Simple verification tests have been performed to confirm the stress analysis model. Two conceptual variants of the contact heat exchanger are described, each designed for a 25 kW total heat load and a minimum uniform heat flux of 2.15 W/sq cm. Author

A86-40516* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMAL ANALYSIS OF THE ACCESS SPACE TRUSS
R. A. FOSS and O. H. BRADLEY (NASA, Langley Research Center, Hampton, VA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 7-1 to 7-10. refs

This paper introduces the Assembly Concept for the Construction of Erectable Space Structure (ACCESS) experiment and describes the thermal requirements in detail. The experiment, an erectable truss beam to be flown and assembled aboard the Space Shuttle, was thermally modeled using the TRASYS and SINDA computer codes. Results from the thermal analysis are presented. Development tests dictate the application of a metallized film insulation on the aluminum beam struts to control transient orbital temperature extremes. Author

A86-47924*# Howard Univ., Washington, D. C.
THE DEVELOPMENT OF AN ENVIRONMENTAL DISTURBANCE MODEL FOR LARGE SPACE STRUCTURES AFTER THE ONSET OF THERMAL SHOCK
N. HAMSATH, P. M. BAINUM (Howard University, Washington, DC), and R. KRISHNA (Advanced Technology and Research, Inc., Burtonsville, MD) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 243-249. Research supported by the Howard University and NASA. refs
(AIAA PAPER 86-2123)

Expressions for the temperature response across a thin large space structure during and immediately following the onset of thermal shock are obtained as a function of the properties of the material and the solar incidence angle. The thermal gradients induced due to solar radiation heating result in thermal deformation. From the temperature gradient information, expressions are developed for the time history of the thermally induced deflections based on the thermoelastic relationships. The effect of the variation of the solar incidence angle and the variation of the emissivity of the surface is considered. From the deflection time history, a model of the disturbance moments is developed and evaluated for different solar incidence angles. Author

A86-49621*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LIQUID DROPLET RADIATOR PROGRAM AT THE NASA LEWIS RESEARCH CENTER
A. F. PRESLER, C. E. COLES, P. S. DIEM-KIRSOP, and K. A. WHITE, III (NASA, Lewis Research Center, Cleveland, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 9 p. Previously announced in STAR as N86-12246. refs
(ASME PAPER 86-HT-15)

The NASA Lewis Research Center and the Air Force Rocket Propulsion Laboratory (AFRPL) are jointly engaged in a program for technical assessment of the Liquid Droplet Radiator (LDR) concept as an advanced high performance heat ejection component for future space missions. NASA Lewis has responsibility for the technology needed for the droplet generator, for working fluid qualification, and for investigating the physics of droplets in space; NASA Lewis is also conducting systems/mission analyses for potential LDR applications with candidate space power systems. For the droplet generator technology task, both micro-orifice fabrication techniques and droplet stream formation processes have been experimentally investigated. High quality micro-orifices (to 50 micron diameter) are routinely fabricated with automated equipment. Droplet formation studies have established operating boundaries for the generation of controlled and uniform droplet streams. A test rig is currently being installed for the experimental verification, under simulated space conditions, of droplet radiation heat transfer performance analyses and the determination of the effect radiative emissivity of multiple droplet streams. Initial testing has begun in the NASA Lewis Zero-Gravity Facility for investigating droplet stream behavior in microgravity conditions. This includes the effect of orifice wetting on jet dynamics and droplet formation. Results for both Brayton and Stirling power cycles have identified favorable mass and size comparisons of the LDR with conventional radiator concepts. B.W.

N86-23631# Texas A&M Univ., College Station.
A MODEL FOR PREDICTING THERMOMECHANICAL RESPONSE OF LARGE SPACE STRUCTURES Annual Technical Report, May 1984 - Apr. 1985
D. H. ALLEN and W. E. HAISLER Jun. 1985 196 p
(Contract F49620-83-C-0067)
(AD-A162139; MM-4875-85-11; AFOSR-85-1016TR) Avail: NTIS HC A09/MF A01 CSCL 22B

A model is being developed for predicting the thermomechanical response of large space structures to cyclic transient temperature loading conditions. The research is being conducted in the following stages: (1) selection and specialization of thermomechanical constitutive equations to be utilized in the analysis of large space structures; (2) construction (where necessary) of coupled energy balance equations (modified Fourier heat conduction equations) applicable to the constitutive models selected in item (1); (3) casting (where necessary) the resulting field laws into coupled and uncoupled variational principles suitable for use with the finite element method; (4) finite element discretization of the variational principles for several element types; (5) experimentation to determine material properties to be utilized in the constitutive models; and (6) parametric studies of the quasistatic and dynamic response of large space structures undergoing thermomechanically and environmentally degraded material properties. GRA

N86-24511*# Florida Inst. of Tech., Melbourne. Dept. of Chemical Engineering.
SPACE STATION COMMON MODULE THERMAL MANAGEMENT: DESIGN AND CONSTRUCTION OF A TEST BED
R. G. BARILE *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 25 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 22B

In this project, a thermal test bed was designed, simulated, and planned for construction. The thermal system features interior and exterior thermal loads and interfacing with the central-radiator thermal bus. Components of the test bed include body mounted radiator loop with interface heat exchangers (600 Btu/hr); an internal loop with cabin air-conditioning and cold plates (3400 Btu/hr); interface heat exchangers to the central bus (13,000 Btu/hr); and provisions for new technology including advanced radiators, thermal storage, and refrigeration. The apparatus will be mounted in a chamber, heated with lamps, and tested in a vacuum chamber with LN2-cooled walls. Simulation of the test bed was accomplished using a DEC PRO 350 computer and the software package TK! olver. Key input variables were absorbed solar radiation and cold plate loads. The results indicate temperatures on the two loops will be nominal when the radiation and cold plate loads are in the range of 25% to 75% of peak loads. If all loads fall to zero, except the cabin air system which was fixed, the radiator fluid will drop below -100 F and may cause excessive pressure drop. If all loads reach 100%, the cabin air temperature could rise to 96 F. R.J.F.

N86-27400*# Georgia Inst. of Tech., Atlanta. School of Mechanical Engineering.
DEVELOPMENT OF AN EMULATION-SIMULATION THERMAL CONTROL MODEL FOR SPACE STATION APPLICATION
Semiannual Status Report
G. T. COLWELL and J. G. HARTLEY 5 Jan. 1986 46 p
(Contract NAG1-551)
(NASA-CR-177298; NAS 1.26:177298) Avail: NTIS HC A03/MF A01 CSCL 22B

Analysis techniques to evaluate the effects of changing thermal loads and the methods utilized to control temperature distributions in the orbital space station are essential. Analysis techniques including a user-friendly computer program, were developed which should prove useful in thermal design and system analysis of the the space station. The program uses a data base and user input to compute costs, sizes, and power requirements for individual components and complete systems. User input consists of selecting mission parameters, selecting thermal acquisition configurations, transport systems and distances, and thermal rejection configurations. B.G.

N86-31634*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EFFECT OF AN OXYGEN PLASMA ON THE PHYSICAL AND CHEMICAL PROPERTIES OF SEVERAL FLUIDS FOR THE LIQUID DROPLET RADIATOR
D. A. GULINO and C. E. COLES 1986 12 p Proposed for presentation at the 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987; sponsored by the American Institute of Aeronautics and Astronautics
(NASA-TM-88839; E-3222; NAS 1.15:88839) Avail: NTIS HC A02/MF A01 CSCL 07D

The Liquid Droplet Radiator is one of several radiator systems currently under investigation by NASA Lewis Research Center. It involves the direct exposure of the radiator working fluid to the space environment. An area of concern is the potential harmful effects of the low-Earth-orbit atomic oxygen environment on the radiator working fluid. To address this issue, seven candidate fluids were exposed to an oxygen plasma environment in a laboratory plasma asher. The fluids studied included Dow Corning 705 Diffusion Pump Fluid, polymethylphenylsiloxane and polydimethlsiloxane, both of which are experimental fluids made by Dow Corning, Fomblin Z25, made by Montedison, and three fluids from the Krytox family of fluids, Krytox 143AB, 1502, and 16256, which are made by DuPont. The fluids were characterized by noting changes in visual appearance, physical state, mass, and infrared spectra. Of the fluids tested, the Fomblin and the three Krytoxes were the least affected by the oxygen plasma. The only effect noted was a change in mass, which was most likely due to an oxygen-catalyzed deploymerization of the fluid molecule. Author

05

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

Includes description of analytical techniques and models, trade studies of technologies, subsystems, support strategies, and experiments for internal and external environmental control and protection, life support systems, human factors, life sciences and safety.

A86-30167* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
IMPLEMENTING SUPERCRITICAL WATER OXIDATION TECHNOLOGY IN A LUNAR BASE ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM
M. MEYER SEDEJ (NASA, Johnson Space Center, Houston, TX) IN: Lunar bases and space activities of the 21st century . Houston, TX, Lunar and Planetary Institute, 1985, p. 653-661. refs

A supercritical water oxidation system (SCWOS) offers several advantages for a lunar base environmental control/life support system (ECLSS) compared to an ECLSS based on Space Station technology. In supercritically heated water (630 K, 250 atm) organic materials mix freely with oxygen and undergo complete combustion. Inorganic salts lose solubility and precipitate out. Implementation of SCWOS can make an ECLSS more efficient and reliable by elimination of several subsystems and by reduction in potential losses of life support consumables. More complete closure of the total system reduces resupply requirements from the earth, a crucial cost item in maintaining a lunar base. Author

A86-42619*# Boeing Aerospace Co., Huntsville, Ala.
SPACE STATION BENEFITS FROM ECLS - PROPULSION SYSTEM SYNERGISM
S. M. BRENNAN (Boeing Aerospace Co., Huntsville, AL) and R. M. DONOVAN (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 14 p. refs
(Contract NAS3-23353)
(AIAA PAPER 86-1407)

Benefits of integrating the Space Station Environmental Control and Life Support (ECLS) system with the propulsion system are addressed in this paper for various levels of ECLS closure. Effluents generated by the ECLS system are used to augment or even supplement the propulsion system. Potential benefits include reductions in logistic weights and volumes, fixed weights and volumes, power requirements, and in total station systems cost. Author

A86-45692* Life Systems, Inc., Cleveland, Ohio.
ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM FOR SPACE STATION
C. W. MILLER, D. B. HEPPNER, F. H. SCHUBERT, and M. J. DAHLHAUSEN (Life Systems, Inc., Cleveland, OH) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 2, 1986, p. 213-229. Research supported by Life Systems, Inc., and NASA.

The functional, operational, and design load requirements for the Environmental Control/Life Support System (ECLSS) are described. The ECLSS is divided into two groups: (1) an atmosphere management group and (2) a water and waste management group. The interaction between the ECLSS and the Space Station Habitability System is examined. The cruciform baseline station design, the delta and big T module configuration, and the reference Space Station configuration are evaluated in terms of ECLSS requirements. The distribution of ECLSS equipment in a reference Space Station configuration is studied as a function of initial operating conditions and growth orbit capabilities. The benefits of water electrolysis as a Space Station utility are considered. I.F.

A86-46943*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
GROWTH EVOLUTION OF THE SPACE STATION ECLSS
W. R. HUMPHRIES (NASA, Marshall Space Flight Center, Huntsville, AL) and R. G. SOSNAY (Martin Marietta Aerospace, Denver, CO) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2313)

This paper discusses the planned evolution and growth of the Space Station ECLSS. It discusses the planning on-going at the early design stages to enable growth from a man-tended configuration of the Space Station (wherein the Space Station would be manned only when visited by the Orbiter) to a fully operational configuration (called Initial Operational Capability - IOC) which includes a permanently manned, fully operational Space Station. The paper then also discusses how the IOC Space Station ECLSS can evolve to account for increase in crew sizes, increase in the number of attached modules, increase in the capability to handle more payload/customer support, and potential evolution of the ECLSS technologies. Author

A86-49557#
FLUID INDEPENDENCE OF THE SPACE STATION
J. E. GRAETCH and W. UNTERBERG (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2309)

The potential benefits and the implications of the Space Station's fluid independence during the early years of the 21st century are discussed. The Initial Operational Capability (IOC) Space Station, planned to be operational in 1995, is discussed, describing the hydrogen/oxygen architecture and economy and the human material balance of fluids and solids. The maturing Station's increasing fluid independence from earth is examined, stressing the Bosch and the Sabatier processes for gas revitalization. The transport of condensed phase substances from the earth to the Station and the subsequent on-Station transformation of fluids are addressed. A new propulsion baseline is demonstrated which serves as an enabling element for fluid independence for the Space Station, providing propulsive efficiency and the means to balance the fluids under a variety of scenarios. C.D.

N86-30864*# AiResearch Mfg. Co., Los Angeles, Calif.
SPACE STATION MOLECULAR SIEVE DEVELOPMENT Final Report
C. CHANG (Signal Research Center, Inc., Des Plaines, Ill.) and J. ROUSSEAU 1 May 1986 59 p
(Contract NAS8-36424)
(NASA-CR-178885; NAS 1.26:178885; REPT-86-30002) Avail: NTIS HC A04/MF A01 CSCL 07B

An essential function of a space environmental control system is the removal of carbon dioxide (CO2) from the atmosphere to control the partial pressure of this gas at levels lower than 3 mm Hg. The use of regenerable solid adsorbents for this purpose was demonstrated effectively during the Skylab mission. Earlier sorbent systems used zeolite molecular sieves. The carbon molecular sieve is a hydrophobic adsorbent with excellent potential for space station application. Although carbon molecular sieves were synthesized and investigated, these sieves were designed to simulate the sieving properties of 5A zeolite and for O2/N2 separation. This program was designed to develop hydrophobic carbon molecular sieves for CO2 removal from a space station crew environment. It is a first phase effort involved in sorbent material development and in demonstrating the utility of such a material for CO2 removal on space stations. The sieve must incorporate the following requirements: it must be hydrophobic; it must have high dynamic capacity for carbon dioxide at the low partial pressure of the space station atmosphere; and it must be chemiclly stable and will not generate contaminants. B.G.

06

DYNAMICS AND CONTROLS

Includes descriptions of analytical techniques and computer codes, trade studies, requirements and descriptions of orbit maintenance systems, rigid and flexible body attitude sensing systems and controls such as momentum wheels and/or propulsive schemes.

A86-31664#
UNIFORM DAMPING CONTROL OF SPACECRAFT
L. SILVERBERG (North Carolina State University, Raleigh) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 221-227. refs

This paper introduces the uniform damping control of flexible spacecraft. The dynamic characteristics of spacecraft are reviewed and a criterion for dynamic performance is described by a uniform damping control approach which exhibits three distinctly attractive features. It is shown that (1) the associated uniform damping control law is independent of the spacecraft stiffness, (2) the associated control forces are proportional to the spacecraft mass density, and (3) the uniform damping control law is decentralized. The uniform damping control solution is shown to represent a first-order approximation to a special globally optimal control problem. Also, the implementation of uniform damping control is considered using discrete (in space) actuation and sensing type devices. Robustness in the presence of errors due to implementing the control using discrete components is characterized. Author

A86-31665#
ROBUST BEAM-POINTING AND ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
J. S.-C. YUAN (Spar Aerospace, Ltd., Toronto, Canada) and M. E. STIEBER (Department of Communications, Ottawa, Canada) (Guidance, Navigation and Control Conference, Snowmass, CO, August 19-21, 1985, Technical Papers, p. 688-695) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 228-234. Sponsorship: Department of Supply and Services of Canada. Previously cited in issue 22, p. 3239, Accession no. A85-45950. refs
(Contract DSS-06ST-36001-3-2484)

A86-31666#
VARIABLE-STRUCTURE CONTROL OF SPACECRAFT LARGE-ANGLE MANEUVERS
S. R. VADALI (Iowa State University of Science and Technology, Ames) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Mar.-Apr. 1986, p. 235-239. Research supported by the Iowa State University of Science and Technology. refs

The spacecraft large-angle maneuver problem is treated using the principles of variable-structure control theory. A control law that constrains the state to follow a specified path (the so-called sliding mode) in the state-space is designed on the basis of a simplified model of the spacecraft dynamics. The sliding mode is obtained by solving an optimal control posed in a reduced space, the solution being the angular velocities of the spacecraft as functions of the attitude variables (Euler parameters or quaternions in the present context). It is shown that the motion along the sliding mode is insenstive to parameter variations and unmodeled effects. Author

A86-31794* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ORBITAL MANEUVERING VEHICLE GUIDANCE, NAVIGATION AND CONTROL
W. G. HUBER and W. FINNELL, III (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Guidance and control 1985; Proceedings of the Eighth Annual Rocky Mountain Conference, Keystone, CO, February 2-6, 1985 . San Diego, CA, Univelt, Inc., 1985, p. 285-295.
(AAS PAPER 85-043)

This paper describes the Orbital Maneuvering Vehicle (OMV) concept and its intended role. It recaps the past activities leading up to the current concept and summarizes the present status and plans. The various types of missions and operating modes required by the OMV are described as the basis of the guidance, navigation and control (GN&C) requirements. The general GN&C problem is outlined with potential hardware solutions. Author

A86-31796
SINGLE-STEP OPTIMAL CONTROL OF THE RPL EXPERIMENT
M. A. FLOYD (Integrated Systems, Inc., Palo Alto, CA) IN: Guidance and control 1985; Proceedings of the Eighth Annual Rocky Mountain Conference, Keystone, CO, February 2-6, 1985 . San Diego, CA, Univelt, Inc., 1985, p. 323-350. Research supported by the Fannie and John Hertz Foundation. refs
(Contract F04611-82-K-0037)
(AAS PAPER 85-045)

This paper presents a control strategy which is applicable to a broad class of large space structure control problems. The considered strategy makes it possible to handle diverse sets of control inputs, including on-off thrusters and linear-limited actuators, either individually or simultaneously. Attention is given to aspects of single-step optimal control, the selection of the state weighting matrix, rigid body mode costs for large angle slews using on-off thrusters, the acceleration phase, the deceleration/terminal phase, acceleration to deceleration phase transition logic, flexible mode costs, control input lumping, a description of the experiment, simulation results, and experimental results. G.R.

A86-32944*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
EXTENSION FOR GROUND-BASED TESTING FOR LARGE SPACE STRUCTURES
B. K. WADA, C. P. KUO, and R.J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structure, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 477-483) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Mar.-Apr. 1986, p. 184-188. NASA-supported research. Previously cited in issue 13, p. 1852, Accession no. A85-30375. refs

A86-33204
CONTROLLER DESIGN OF FLEXIBLE SPACECRAFT ATTITUDE CONTROL
S. MANABE (Mitsubishi Electric Corp., Kamakura Works, Japan) and K. TSUCHIYA (Mitsubishi Electric Corp., Central Research Laboratory, Amagasaki, Japan) IN: A bridge between control science and technology. Volume 5 . Oxford and New York, Pergamon Press, 1985, p. 2939-2944. refs

A controller design method for flexible spacecraft attitude control is presented. The design method uses the frequency domain approach. The system is first described by partial differential equation with internal damping model. Then the frequency response is analyzed, and the three basic characteristics of the flexible system, namely, average function, lower bound and upper bound are defined. A compensator design method is proposed on the basis of these characteristics. The result shows that the direct velocity feedback combined with weak lag networks seems to be the optimum in the sense that the bandwidth required for the actuator is the narrowest. This approach is very robust and immune to the parameter changes such as mode frequency variations. This is because the design method is based on only the general information of flexible structure and not on the specific ones. Some experiment is performed to investigate the validity of the method. Author

A86-33284* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEST AND ANALYSIS CORRELATION FOR STRUCTURAL DYNAMIC SYSTEMS
B. K. WADA and J.-C. CHEN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 632-647. NASA-supported research. refs

In this paper the authors summarize the activities at the Jet Propulsion Laboratory (JPL) in modifying the structural mathematical model to correlate with its modal test results. In addition to the results from the Viking and Galileo spacecrafts, developments in the parameter estimation of structural mathematical models of large flexible structures using Multiple Boundary Condition Tests (MBCT) are presented. Author

A86-33285* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC VERIFICATION OF VERY LARGE SPACE STRUCTURES
B. R. HANKS (NASA, Langley Research Center, Hampton, VA) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 648-655. refs

The dynamic verification of spacecraft relies heavily on ground-based tests. These tests usually simulate flight environments or validate analytical models used in establishing design loads and in designing control algorithms. They also provide security against failures resulting from unanticipated or unmodeled hardware behavior. Future orbital antennas, space stations, and solar power systems are likely to be of sizes difficult to test using current ground test technology. In addition to size, other factors such as low natural frequencies, lightweight construction, and the presence of many structural joints, cause significant sensitivity of the test process to the earth-gravity environment. Yet, accuracy requirements on the verification process will be more stringent because of modern flexible-structure control approaches. This paper describes some of the problems and discusses research on potential solutions. The importance of an integrated ground test, analysis, and flight test program is emphasized. An ongoing research program of this type focusing on a 60-meter, deployable, truss-beam test article is described. Author

A86-34174* Virginia Polytechnic Inst. and State Univ., Blacksburg.
MINIMUM-FUEL CONTROL OF HIGH-ORDER SYSTEMS
J. SHENHAR and L. MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Optimization Theory and Applications (ISSN 0022-3239), vol. 48, March 1986, p. 469-491. refs
(Contract NAG1-225)

The minimum-fuel control problem is of special interest in various space systems. To date, solutions of minimum-fuel control problems have been carried out for relatively low-order systems. Space structures, however, are generally characterized by a large number of degrees of freedom, so that minimum-fuel control of such systems requires a new approach. In the independent modal-space control (IMSC) method, the control laws are designed in the modal space for each mode independently. The minimum-fuel problem reduces to that of a set of independent second-order systems, so that minimum-fuel control is possible. This paper shows how the IMSC method can be used to control a space structure with a minimum amount of fuel. A numerical example is presented. Author

A86-35333* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

AN INVESTIGATION OF ADAPTIVE CONTROL TECHNIQUES FOR SPACE STATIONS

C.-H. C. IH, S. J. WANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and C. T. LEONDES (California, University, Los Angeles) IN: 1985 American Control Conference, 4th, Boston, MA, June 19-21, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 81-94. NASA-supported research. refs

The present paper is concerned with control problems which arise in connection with the establishment and maintenance of space stations. Some of the arising problems are related to great changes in mass and an intensive shock load accompanying Shuttle docking. Such problems can be solved by making use of a robust adaptive control system. Space station configurations developed by NASA and the corresponding mass properties are discussed along with dynamic models for space stations, aspects of problem formulation and control architecture, adaptive control algorithms, a performance analysis, and practical considerations. Attention is given to adaptive regulator control with initial transient, adaptive control during Shuttle docking, and cases involving Shuttle hard docking with model switching and disturbance modeling. G.R.

A86-36074* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

STABILITY OF MULTILOOP LQ REGULATORS WITH NONLINEARITIES. I - REGIONS OF ATTRACTION. II - REGIONS OF ULTIMATE BOUNDEDNESS

S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-31, April 1986, p. 364-370. refs

An investigation is conducted for the closed loop stability of linear time-invariant systems controlled by linear quadratic (LQ) regulators, in cases where nonlinearities exist in the control channels lying outside the stability sector in regions away from the origin. The estimate of the region of attraction thus obtained furnishes methods for the selection of performance function weights for more robust LQ designs. Attention is then given to the closed loop stability of linear time-invariant systems controlled by the LQ regulators when the nonlinearities in the loops escape the stability sector in a bounded region containing the origin. O.C.

A86-36216

AN ORTHOGONAL DECOMPOSITION APPROACH TO MODAL SYNTHESIS

H. FLASHNER (Southern California, University, Los Angeles, CA) International Journal for Numerical Methods in Engineering (ISSN 0029-5981), vol. 23, March 1986, p. 471-493. refs

Modal synthesis is a method of formulating the equations of motion for complex vibratory systems. This approach has many advantages in modelling systems that consist of an assembly of linear dynamic elements whose modal characteristics are given. Presented in the paper is a procedure for synthesizing linear dynamic models into one dynamic description in a numerically stable way. This task is achieved by an orthogonal co-ordinate transformation replacing the matrix inversions required when other procedures are used. The modal synthesis is formulated as a problem of finding the equations of motion for a linear system subject to a set of linear constraints. The numerical procedure to generate the equations of motion in terms of independent co-ordinates is presented. The paper concludes with several examples that demonstrate the properties of the proposed method and its application to the modeling of vibratory systems. Author

A86-37186* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

SPACE STATION DYNAMIC MODELING, CONTROL AND SIMULATION

C.-H. C. IH, S. J. WANG, and Y.-H. LIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Aerospace simulation II; Proceedings of the Second Conference, San Diego, CA, January 23-25, 1986 . San Diego, CA, Society for Computer Simulation, 1986, p. 109-142. NASA-supported research. refs

Dynamic disturbances of many orders of magnitude greater than those of conventional spacecraft will be routine for the Space Station. Accurate knowledge of inflight structural dynamics and disturbances will be lacking. System identification will reduce uncertainties. To deal with the remaining model errors and time-varying elements, adaptive control may be required. Dynamic models for two Space Station configurations are derived. A direct model reference adaptive control algorithm is synthesized and evaluated with respect to the station model parameter errors and plant dynamics truncations. Both the rigid body and the flexible modes are treated. Simulation results show that convergence of the adaptive algorithm can be achieved in 100 to about 300 seconds with reasonable performance even during Shuttle hard docking operations in which station mass and inertia are instantaneously changed by more than 100 percent. Author

A86-38542

A GLOBAL TECHNIQUE FOR ESTIMATION OF MODAL PARAMETERS FROM MEASURED DATA

R. N. COPPOLINO (MacNeal-Schwendler Corp., Los Angeles, CA) and R. C. STROUD (Synergistic Technology, Inc., Cupertino, CA) IN: Structural dynamic testing and analysis; Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985, Technical Papers . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 15-23. refs

(SAE PAPER 851926)

An automated method for estimation of structural vibration modes from measured frequency response data is described. The technique simultaneously treats an ensemble of measured responses and identifies a set of linearly independent displacement patterns exhibited by the data. In addition, generalized frequency response functions associated with the independent displacement patterns are identified. An effective dynamic system described by the generalized frequency responses is deduced from least squares considerations, from which modal parameters of the structure are estimated. Author

A86-38546* Jet Propulsion Lab., California Inst. of Tech., Pasadena.

MULTIPLE BOUNDARY CONDITION TEST (MBCT) APPROACH TO UPDATE MATHEMATICAL MODELS OF LARGE FLEXIBLE STRUCTURES

B. K. WADA, C.-P. KUO, and R. J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structural dynamic testing and analysis; Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985, Technical Papers . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 75-82. NASA-supported research. refs

(SAE PAPER 851933)

A major challenge to the structural dynamicist is to validate mathematical models of large space structures which cannot be ground tested because of its size and/or flexibility. The paper presents a Multiple Boundary Condition Test (MBCT) approach which allows a systematic validation of the mathematical model by performing a number of ground tests on a large structure with variable boundary conditions. A numerical simulation is presented which illustrates the validity of the MBCT including some of the potential limitations. Author

A86-38548
SYNTHESIS OF DISCRETE PASSIVE VIBRATION DAMPERS
S. S. SIMONIAN (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Structural dynamic testing and analysis; Aerospace Technology Conference and Exposition, Long Beach, CA, October 14-17, 1985, Technical Papers . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 97-109.
(SAE PAPER 851935)

The present study is a continuation of the effort in the application of viscoelastic (VE) damping to large and flexible space systems design. In particular, this work extends the analytical passive damping predictions reported previously. The analytical study completed here relates the number of discrete joint VE dampers, in typical large and flexible space optical systems, to the overall damping of the structure. This data is crucial for the optimal blending of passive damping and active control technologies in space systems design. Author

A86-38809*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERIFICATION OF LARGE BEAM-TYPE SPACE STRUCTURES
C.-F. SHIH, J. C. CHEN, and J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 78-84. NASA-supported research. refs
(AIAA PAPER 86-0860)

The verification approach here proposed for large, beam-type space structures consists of a first part, which removes the gravity effect on the substructure tested and identifies its on-orbit dynamic characteristics, on the basis of ground test measurements, and a second part which develops an adequate scaling law that extrapolates the dynamic characteristics of the prototype structure by using results from the substructure. These approaches are presently demonstrated for the cases of a wrap-rib antenna's feed support structure and a candidate Space Shuttle flight experiment. O.C.

A86-38813*# Massachusetts Inst. of Tech., Cambridge.
EXPERIMENTAL VERIFICATION OF DISTRIBUTED PIEZOELECTRIC ACTUATORS FOR USE IN PRECISION SPACE STRUCTURES
E. F. CRAWLEY and J. DE LUIS (MIT, Cambridge, MA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 116-124. refs
(Contract NAGW-21)
(AIAA PAPER 86-0878)

An analytic model for structures with distributed piezoelectric actuators is experimentally verified for the cases of both surface-bonded and embedded actuators. A technique for the selection of such piezoelectric actuators' location has been developed, and is noted to indicate that segmented actuators are always more effective than continuous ones, since the output of each can be individually controlled. Manufacturing techniques for the bonding or embedding of segmented piezoelectric actuators are also developed which allow independent electrical contact to be made with each actuator. Static tests have been conducted to determine how the elastic properties of the composite are affected by the presence of an embedded actuator, for the case of glass/epoxy laminates. O.C.

A86-38827*# State Univ. of New York, Buffalo.
MICROPROCESSOR CONTROLLED FORCE ACTUATOR
D. C. ZIMMERMAN, D. J. INMAN (New York, State University, Buffalo), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 243-251. refs
(Contract NGT-33-183-801)
(AIAA PAPER 86-0916)

The mechanical and electrical design of a prototype force actuator for vibration control of large space structures (LSS) is described. The force actuator is an electromagnetic system that produces a force by reacting against a proof-mass. The actuator has two colocated sensors, a digital microcontroller, and a power amplifier. The total weight of actuator is .998 kg. The actuator has a steady state force output of approximately 2.75 N from approximately 2 Hz to well beyond 1000 Hz. Author

A86-38844#
SYNTHESIS OF STRUCTURES WITH MULTIPLE FREQUENCY CONSTRAINTS
B. P. WANG (Texas, University, Arlington) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 394-397. refs
(AIAA PAPER 86-0951)

The problem of minimum weight design with several natural frequency constraints is considered in this paper. The problem is solved using a combined finite element-sequential linear programming (SCP) formulation. The unique features of the current approach include the use of assumed mode reanalysis formulation for repeated eigensolution and the associated sensitivity analysis. Additionally, a simple adaptive move limit strategy is developed to stabilize the SLP solutions. The present approach has been implemented with general purpose finite element programs (MSC/NASTRAN and a version of SAP4) and applied to several design problems. Author

A86-38885#
ERROR ESTIMATION AND COMPENSATION IN REDUCED DYNAMIC MODELS OF LARGE SPACE STRUCTURES
J.-S. FUH, B. GUSTAVSON, and A. BERMAN (Kaman Aerospace Corp., Bloomfield, CT) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-9. refs
(Contract F33615-84-C-3219)
(AIAA PAPER 86-0837)

The design of large space structures using the Guyan reduction (1965) is described. The development of linear reduced structure models to evaluate the dynamic characteristics of large space structures is discussed. The natural frequency errors that result from the Guyan reduction are examined. A minimum-ratio criterion is proposed for selecting a best set of retained degrees of freedom. The errors are reduced further using the analytical model improvement (AMI); the sensitivity of AMI under various conditions is studied. The ability of the reduced models to accurately represent the effects of structural changes is investigated. The design procedure is applied to a delta wing model and it is noted, based on the data of eigensolution and forced response computations, that the reduced models are useful for efficient structural design studies. I.F.

A86-38886*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC ANALYSIS AND EXPERIMENT METHODS FOR A GENERIC SPACE STATION MODEL
W. K. BELVIN (NASA, Langley Research Center, Hampton, VA) and H. H. EDIGHOFFER (Edighoffer, Inc., Newport News, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 10-18. refs
(AIAA PAPER 86-0838)

Modal vibration tests in conjunction with finite element analysis were used to characterize a generic dynamic model. The model consists of five substructures to simulate the multi-body, low frequency nature of large space structures. Static tests were used to refine the substructure analytical models prior to full assemblage analysis. The effects of a cable suspension system are analyzed using prestressed vibration analysis. Coupling between a cable suspension mode and model bending mode is shown to be influenced by the distance from the model center of gravity to the cable-to-model attachment location. A damping characterization method using noncontacting exciters was used to measure amplitude dependent damping. Frequency and damping measurements in ambient air and at near-vacuum conditions are presented. Author

A86-38887*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHARACTERISTIC WAVE APPROACH IN CONTROLLED LARGE SPACE STRUCTURES
M. ZAK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 19-22. USAF-sponsored research. refs
(Contract NAS7-918)
(AIAA PAPER 86-0839)

The modal approach in structural dynamics usually implies a truncation technique in the course of which the contribution of high frequencies is lost. This can lead to significant error in the case of impulsive loads. As an alternative to modal (or spectral) methods, the characteristic wave approach is developed. It appears that the application of this approach is most beneficial in the domains where spectral methods fail. That is why it can be used as a supplement to modal methods when the loads contain impulsive components. Author

A86-38888#
VARIABLE STRUCTURE CONTROL SYSTEM (VSCS) MANEUVERING OF FLEXIBLE SPACECRAFT
H. OZ (Ohio State University, Columbus) and O. MOSTAFA IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 23-34. refs
(AIAA PAPER 86-0840)

Variable Structure Control Systems (VSCS) are a class of nonlinear systems which change the structure of the controls when a set of prescribed hypersurfaces are reached in the phase space. The VSCS theory has desirable insensitivity properties under parameter uncertainties, nonlinear effects and external disturbances. The theory represents a real-time implementable approach to control in contrast to algorithmic approaches, and therefore eliminates the computational burden. This paper applies the VSCS theory to maneuvering of flexible spacecraft. General nonlinear equations of motion are presented for a single axis maneuver. Three methods are presented for designing variable structure control logics. The theory is demonstrated for set point regulation, tracking, disturbance accommodation, spin-up, and robust maneuvers of a specific spacecraft configuration. Author

A86-38889#
A SINGULAR-SOLUTION APPROACH FOR CONTROLLING THE NONLINEAR RESPONSE OF A CONTINUUM MODEL OF A LARGE SPACE STRUCTURE
P. E. ODONOGHUE (Southwest Research Institute, San Antonio, TX) and S. N. ATLURI (Georgia Institute of Technology, Atlanta) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 35-42. refs
(Contract AF-AFOSR-85-0020)
(AIAA PAPER 86-0841)

The topic of vibration control of large space structures which, in this instance are modeled by equivalent continua, is addressed here. A 'singular (or fundamental) solution' approach is utilized and the control algorithm is based on a fully coupled nodal system of equations which permits the effects of non-proportional damping to be monitored. Additionally, the structure will be allowed to undergo large deformations which will necessitate the implementation of a nonlinear control algorithm. In the scheme proposed here, the calculation of the feedback control forces will be based on the feedback gain matrix obtained from a solution of the linear optimal control problem. Examples will be presented to illustrate the controllability of the vibrations in both the linear and nonlinear cases. Author

A86-38907*# Purdue Univ., West Lafayette, Ind.
A GLOBAL-LOCAL APPROACH TO SOLVING VIBRATION OF LARGE TRUSS STRUCTURES
C. T. SUN and S. W. LIEBBE (Purdue University, West Lafayette, IN) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 248-255. refs
(Contract NAG1-581)
(AIAA PAPER 86-0872)

A global-local approach was proposed to solve dynamic problems involving truss beams. A continuum Timoshenko beam was used to model sections of truss beams wherever possible and accurate. Near applied loads the continuum model was not adequate and detailed truss finite elements (discrete model) were employed. This approach was also proven efficient for an odd-shaped truss structure connected to a truss beam. Between the continuum model and the discrete model, compatibility conditions were derived. Author

A86-38915*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MULTIPLE BOUNDARY CONDITION TESTS (MBCT) FOR VERIFICATION OF LARGE SPACE STRUCTURES
B. K. WADA, C. P. KUO, and R. J. GLASER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 336-341. NASA-supported research. refs
(AIAA PAPER 86-0905)

The Multiple Boundary Condition Tests (MBCT) approach is evaluated and recent modifications are described. For the application of MBCT, 12 different boundary conditions are selected and the results of applying MBCT in conjunction with a nonlinear formulation are indicated schematically. It is concluded that the nonlinear formulation enhances the ability to implement the MBCT test approach on large space structures which cannot be ground tested without the artificial boundary conditions incorporated in MBCT. In addition, it leads to significant improvements in the convergence to the correct solution. K.K.

A86-38917*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VIBRATION OF A LARGE SPACE BEAM UNDER GRAVITY EFFECT
C.-F. SHIH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 355-361. NASA-supported research. refs
(AIAA PAPER 86-0907)

The structural characteristics of a large simply supported beam subjected to gravity are described. The nonlinear governing equations for both the static and the dynamic response are derived and solved analytically. The results show the feasibility of verifying the on-orbit dynamic characteristics of a large space beam by utilizing ground test data of such a structure. It is noted that the gravity effect interacts mostly with the first vibration mode. It was also found that the system of a large space beam subjected to its own weight is a hardening system. The differential equation for the asymmetric mode is a Duffing type equation. However, the governing equation for the symmetric mode has an additional quadratic term. It is this term that causes the maximum vibration amplitudes at different phases to be non-identical. Author

A86-38918#
SOME CONSIDERATIONS ON EARTHBOUND DYNAMIC TESTING OF LARGE SPACE STRUCTURES
H. ASHLEY (Stanford University, CA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 362-375. refs
(Contract AF-AFOSR-82-0062)
(AIAA PAPER 86-0908)

Several issues are discussed which relate to the scale-model testing, in ground facilities, of large space structures composed of beam-like elements. A comparison is made with similar tests on aeroelastic models of aircraft. With special reference to the roles of gravity, control systems and damping, it is concluded that use of large replica models will often prove infeasible. It is proposed that low-frequency beam structures under active control can furnish useful verification of design methods. This leads into various analyses of a very flexible beam hanging in gravity and of simplified models of a suspended lattice with a counterweight. By means of the latter quite low frequencies seem attainable. A mathematical appendix gives details of some of the solutions. Author

A86-38933*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIDISCIPLINARY CAPABILITY FOR ANALYSIS OF THE DYNAMICS AND CONTROL OF FLEXIBLE SPACE STRUCTURES
P. A. COOPER, M. S. LAKE, J. W. YOUNG (NASA, Langley Research Center, Hampton, VA), and T. R. SUTTER (PRC-Kentron, Inc., Hampton, VA) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 525-532. refs
(AIAA PAPER 86-0961)

The paper describes a computerized data distribution capability, IMAT, in place at the NASA Langley Research Center for the multidisciplinary analysis of the dynamics and control of large flexible space structures. The paper includes results obtained in using IMAT to investigate the influence of the structural response of the space station framework on the control of a 300kw class, solar-dynamic-powered, dual-keel space station during an orbital reboost maneuver. The method of control, using an unfiltered proportional-plus-differential control law, led to a stable control system even with local flexible response measured at the control sensor location included as a part of the control error signal. The flexible response at the outboard solar dynamic system sun-line axis was close to the maximum rotation allowed for efficient operation; thus, active local control of each solar dynamic system may be necessary to limit sun-line axis rotations effectively during a reboost maneuver. Author

A86-38939*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NONLINEAR SENSITIVITY COEFFICIENTS AND CORRECTIONS IN SYSTEM IDENTIFICATION
C. P. KUO and B. K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 576-584. refs
(Contract NAS7-918)
(AIAA PAPER 86-0967)

The evaluation of sensitivity coefficients which are the changes in the eigencharacteristics with respect to changes in the structural parameters is important in the identification of structural systems. In such studies the commonly used linearized sensitivity coefficients for system identification have occasionally resulted in poor convergence or even divergence during the iteration process to update analytical models for better correlation with the test data. Nonlinear sensitivity coefficients and nonlinear correction terms, usually eliminated during the linearization process, have been developed to evaluate sensitivity coefficients of linear systems. Application to computer simulated example problems indicates a more rapid and stable convergence of the iteration processes to update the analytical model for the improvement of the correlation with test data. The successful application of combining the nonlinear sensitivity coefficients and nonlinear correction terms with the Multiple Boundary Condition Tests enhances the ability to validate large space structures by ground tests. Author

A86-39035#
THE OPTIMAL PROJECTION EQUATIONS FOR REDUCED-ORDER, DISCRETE-TIME MODELING, ESTIMATION, AND CONTROL
D. S. BERNSTEIN, L. D. DAVIS, and D. C. HYLAND (Harris Corp., Melbourne, FL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, May-June 1986, p. 288-293. refs

The optimal projection equations derived previously for reduced-order, continuous-time modeling, estimation, and control are developed for the discrete-time case. The design equations are presented in a concise, unified manner to facilitate their accessibility for the development of numerical algorithms for practical applications. As in the continuous-time case, the standard Kalman filter and linear-quadratic-Gaussian results are immediately obtained as special cases of the estimation and control results. Author

A86-39477*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ON-ORBIT PARAMETER AND DISTURBANCE IDENTIFICATION FOR SPACE STATION
D. S. BAYARD, F. Y. HADAEGH, and C. C. IH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 1-18. refs

This paper describes recent efforts directed at the problem of on-orbit parameter and disturbance identification for the Space Station. Techniques are developed for identification of rigid body parameters, flexible body parameters, and quasi-static disturbances relevant to the Power Tower configuration currently under investigation by NASA. The paper concludes with a case study investigating the identification of modal frequencies in a 15 degree of freedom planar model of the Space Station under a variety of operational settings. Author

A86-39478#
IDENTIFICATION OF A DAMPING MATRIX FROM MODEL DATA
W. L. HENDRICKSON and D. J. INMAN (New York, State University, Buffalo) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 19-26. refs

In modeling structures, the dissipation in the system is usually the most difficult element to model. This is especially true in complex arrangements such as large flexible space structures and composite materials. The work presented here examines a method of modeling the dissipation in a structure from experimental data combined with accepted nondissipation finite element data. The result of the described procedure is a linear nonconservative multiple degree of freedom model of a test structure that correctly predicts the transient response of the structure to arbitrary inputs. Author

A86-39479#
STRUCTURAL PARAMETER IDENTIFICATION USING MODAL RESPONSE DATA
N. G. CREAMER and S. L. HENDRICKS (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 27-38. refs

The identification of a set of physical structural parameters using simulated measurements of natural frequencies has been investigated to determine the minimum amount of apriori structural information required and the effects of closely spaced frequencies and model symmetry on the identification process. A necessary condition for identification is the knowledge of a mass and length scale; however, this is not always a sufficient condition. If symmetry exists in the structure, additional apriori knowledge is required. To identify the parameters of a large space structure with equal appendages using the proposed method, a sufficient condition is the knowledge of a mass and length scale for each appendage. Author

A86-39481#
NEUMANN SERIES APPROACH TO RANDOM VIBRATIONS
H. BENAROYA and M. REHAK (Weidlinger Associates, New York) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 61-76. refs
(Contract F49620-84-C-0009)

Linear, random differential equations are studied with the purpose of understanding the effects of parameter uncertainties on the random vibration of structures. In particular, a single degree-of-freedom oscillator is considered with random (stationary) stiffness and input, with deterministic, constant mass and damping. The method utilized is known as the Born expansion in physics. The mathematical formalism is based on an iterative method. The solution is of the Neumann series form. While no priori smallness assumptions are made, it becomes evident that there are restrictions in application. The restriction comes in the form of an upper bound on the variance of the stiffness parameter, i.e., its dispersion or randomness. It is demonstrated that parameter uncertainties can have an appreciable effect on the output process spectral density. The method used is complex and cumbersome, but the information derived is believed to be not otherwise available in analytic form. This framework appears useful for an initial study of random parameter systems. Author

A86-39483#
STABLE DIRECT ADAPTIVE CONTROL IN HILBERT SPACE
J. WEN and M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 93-108. refs

Model Reference Adaptive Control using the command generator tracker approach has been applied successfully to some finite-dimensional systems. The same approach has also been used for adaptive regulation. The present method differs from other adaptive control algorithms in that it has potential application to infinite-dimensional systems. Four main technical difficulties for such application are discussed in this paper: coercivity of the P operator in Lyapunov Equation, the strict positive realness condition, application of the LaSalle's invariance principle in infinite dimension and the existence and the uniqueness of solution. Some of the ramifications and the remedies of these issues are investigated. Author

A86-39485*# Duke Univ., Durham, N. C.
FREQUENCY DOMAIN SOLUTIONS TO MULTI-DEGREE-OF-FREEDOM, DRY FRICTION DAMPED SYSTEMS UNDER PERIODIC EXCITATION
A. A. FERRI and E. H. DOWELL (Duke University, Durham, NC) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 125-144. refs
(Contract AF-AFOSR-83-0346; NAG3-516)

The anticipated low damping level in large space structures (LSS) has been a major concern for the designers of these structures. Low damping degrades the free response and complicates the design of shape and attitude controllers for flexible spacecraft. Dry friction damping has been considered as a means of increasing the passive damping of LSS, by placing it in the joints and connecting junctures of structures. However, dry friction is highly nonlinear and, hence, analytical investigations are difficult to perform. Here, a multi-harmonic, frequency domain solution technique is developed and applied to a multi-DOF, dry friction damped system. It is seen that the multi-harmonic method is much more accurate than traditional, one harmonic solution methods. The method also compares well with time integration. Finally, comparisons are made with experimental results. Author

A86-39486#
UNIFORM DAMPING CONTROL OF SPACECRAFT
L. M. SILVERBERG (North Carolina State University, Raleigh) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 145-161. refs

This paper describes the uniform damping control of flexible spacecraft. The dynamic characteristics of spacecraft are reviewed and a criterion for a dynamic performance is described by a uniform damping control which exhibits three distinctly attractive features. It is shown that (1) the associated uniform damping control law is independent of the spacecraft stiffness, (2) the associated control forces are proportional to the spacecraft mass density and (3) the uniform damping control law is decentralized. The uniform damping control solution is shown to represent a first-order approximation to a special globally optimal control problem. The implementation of uniform damping control is considered using discrete (in space) actuation and sensing type devices. Robustness in the presence of errors due to implementing the control using discrete components is characterized. Author

A86-39487#
CONTROL OF TRAVELING WAVES IN FLEXIBLE STRUCTURES
L. MEIROVITCH and J. K. BENNIGHOF (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 163-182.
(Contract AF-AFOSR-83-0017)

This paper is concerned with the control of a traveling wave in a structure by the independent modal-space control method. It is demonstrated that the control forces tend to concentrate in the immediate vicinity of the disturbance, and there are virtually no control forces acting at any point of the structure before the arrival of the disturbance. Two numerical examples are included, one for a string in transverse vibration and one for a beam in bending. Satisfactory control was achieved in spite of the fact that only a finite number of modes was retained for control. Author

A86-39489#
FLEXIBILITY FORMULATION IN STRUCTURAL CONTROL
H. OZ (Ohio State University, Columbus) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 207-229. refs
(Contract NSF MEA-82-04920)

Structural Control is studied within the framework of 'Flexibility Formulation'. Approximate methods of structural dynamics, specifically Galerkin method, minimum quadratic equation error, point-control and collocation techniques are applied to design compatible load distribution fields for desired displacement fields. Open-loop and closed-loop derivations are presented for desired modal model behavior of the structure. It is shown that continuously distributed proportional damping and stiffness control can be affected by a finite number of point-inputs. In this regard, 'spatial modal input-distributors' are introduced as dual in control of spatial modal filters. Effects of spillover and/or spatially discrete inputs are evaluated on the basis of control design model without explicit knowledge of residual dynamics. Practical implementation is discussed and examples of feedback control are given. Author

A86-39492#
FINITE DIMENSIONAL STABILIZATION OF LINEAR DISTRIBUTED PARAMETER SYSTEMS VIA GALERKIN'S TECHNIQUE
J. G. HSIEH and M. J. BALAS (Rensselaer Polytechnic Institute, Troy, NY) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 261-273. refs

Control of the Distributed Parameter Systems (DPS) involves dynamical descriptions on infinite-dimensional Hilbert or Banach spaces of functions. Generally, it is not possible to implement an infinite-dimensional controller for the DPS. Consequently, the reduced order modeling of DPS becomes extremely crucial for design of the finite-dimensional feedback controllers. In this paper, Galerkin (or finite element) methods are presented as a way to develop finite-dimensional controllers for linear DPS. The behavior of Galerkin methods is examined, the existence of a finite-dimensional stabilizing controller for a given linear DPS is shown, and its order is specified. Author

A86-39493#
CLOSED-LOOP STABILITY OF LARGE SPACE STRUCTURES WITH REDUCED-ORDER CONTROLLERS
M. AHMADIAN (Clemson University, SC) and D. J. INMAN (New York, State University, Buffalo) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 275-289. refs

Modal truncation in the dynamic models of large space structures can cause well-known stability problems when these models are used as the design basis for active structural control. In other words, the asymptotic stability of a full-order closed-loop system cannot necessarily be ensured by the asymptotic stability of the reduced-order model. The main goal of the present study is to develop conditions which will ensure asymptotic stability of the full-order closed-loop system, when the reduced-order closed-loop system is asymptotically stable. A finite dimensional model of large space structures is exploited here to provide such conditions. These conditions are in terms of submatrices of the coefficient matrices as they are partitioned according to the modeled and residual modes. This may serve as a means of improving, or guiding, the design of a reduced-order controller. Author

A86-39494#
DYNAMICS OF GYROELASTIC VEHICLES
G. M. T. DELEUTERIO (Toronto, University, Downsview, Canada) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 291-306. NSERC-supported research. refs

A model for a flexible spacecraft having a distribution of control moment gyros and/or momentum wheels is presented. The model treats the spacecraft as a continuum in mass, stiffness and gyricity (stored angular momentum). Internal rigid-body degrees of freedom are permitted in the analysis. The equation of motion for the spacecraft is derived in operator form. Orthogonality conditions among the vibration modes are shown and the general motion is expanded in terms of these modes. As demonstrated with the aid of a simple example, the modes of gyroelastic vehicles undergo a metamorphosis of certain critical levels of gyricity. Moreover, a gyroelastic vehicle generally exhibits scleromorphic modes in which the vehicle, or part thereof (if internal rigid-body degrees of freedom are present), rotates uniformly in a deformed state. In the absence of gyricity, these modes would be uniform rotations with the vehicle undeformed. Author

A86-39495#
HOMOGENIZATION AND CONTROL OF LATTICE STRUCTURES
G. L. BLANKENSHIP (Maryland, University, College Park) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 307-324. refs
(Contract F49620-84-C-0118)

Under certain natural conditions, the dynamics of large, low-mass lattice structures with a regular infrastructure are well approximated by the dynamics of continua, e.g., trusses may be modeled by beam equations. Using a technique from the mathematics of asymptotic analysis called homogenization, it is shown how such approximations may be derived in a systematic way which avoids errors made using 'direct' averaging methods. A model is also developed for the combined problem of homogenization and control of vibrations in lattice structures, and a preliminary analysis of this problem is presented. Author

A86-39499#
TRANSIENT DYNAMICS DURING THE EXTENSION OF FLEXIBLE MEMBERS
V. J. MODI and A. M. IBRAHIM (British Columbia, University, Vancouver, Canada) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 365-380. refs
(Contract NSERC-67-1547)

Using a rather general formulation of the problem representing a large class of space platforms with flexible, extensible members, the paper attempts to study complex interactions between deployment, attitude dynamics and flexural rigidity. The governing nonlinear, nonautonomous and coupled equations of motion are extremely difficult to solve even with the help of a computer, not to mention the cost involved. The procedure is used to study dynamics during the NASA/Lockheed Solar Array Flight Experiment

(SAFE). Response of the hybrid system is obtained over a range of physical parameters and external disturbances. Both transient as well as post-deployment phases are considered. Results suggest significant influence of flexibility, inertia, deployment time history and orbital parameters on the system stability. The presence of free molecular and solar radiation induced environmental forces may further accentuate this tendency. Author

A86-39500*# California Univ., Los Angeles.
A ROBUST NONLINEAR ATTITUDE CONTROL LAW FOR SPACE STATIONS WITH FLEXIBLE STRUCTURAL COMPONENTS
P. K. C. WANG (California, University, Los Angeles) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 381-398. NASA-supported research. refs

In this paper, a nonlinear attitude control law for space stations with flexible structural components is derived using a rigid-body model. This control law, depending on the Cayley-Rodriguez parameters, globally stabilizes the equilibrium of the rigid-body model. The effect of elastic deformations of the flexible structural components on the resulting feedback system dynamics is analyzed. It is found that the system's stability property is highly robust with respect to structural vibrations and inertial variations. The time-domain behavior of the feedback system is studied numerically using a model of a typical space station with flexible solar panels. Author

A86-39502*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL OF FLEXIBLE STRUCTURES (COFS) FLIGHT EXPERIMENT PROGRAM
A. FONTANA and B. R. HANKS (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 413-422.

The Control of Flexible Structures (COFS) Flight Experiment Program consists of a series of four Shuttle-attached experiments specifically designed to systematically evaluate algorithms and techniques for on-orbit systems identification and flexible body control of large flexible structures, and as such, develops the enabling technologies for future NASA missions such as the evolutionary Space Station and large orbital antennas. These flight experiments are conducted on 1-year centers starting in 1989. This paper presents a description of the test article for the first two flights (COFS-I) and a discussion of the strategy for conducting the various experiments. A guest investigator program provides the opportunity for the research community to participate in the structures/controls research associated with the multi-flight COFS Program. Author

A86-39503#
EXPERIMENTS IN OPTIMAL CONTROL OF A FLEXIBLE ARM WITH PASSIVE DAMPING
T. E. ALBERTS, G. G. HASTINGS, W. J. BOOK, and S. L. DICKERSON (Georgia Institute of Technology, Atlanta) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 423-435. Research supported by the Georgia Institute of Technology. refs (Contract NSF MEA-83-03539)

This paper presents a hybrid active and passive control scheme for controlling the motion of a lightweight flexible arm. A straightforward development of LaGrange's equations using a series expansion of assumed flexible modes provides a time domain model for controller design. The active controller design was approached as a steady state linear quadratic continuous regulator. A constrained viscoelastic layer treatment was employed to achieve passive damping. The passive damping treatment serves to enhance the system's stability while providing sound justification for the use of a highly truncated dynamic model and reduced order controller. Initial experimental results comparing controller performance with and without passive damping demonstrate the merit of the proposed combined active/passive approach. Author

A86-39505*# State Univ. of New York at Buffalo, Amherst.
VIBRATION CONTROL OF FLEXIBLE BEAMS USING AN ACTIVE HINGE
H. H. CUDNEY, JR., D. J. INMAN (New York, State University, Amherst), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 455-470. refs (Contract NGT-33-183-802)

The use of an active hinge to attenuate the transverse vibrations of a flexible beam is examined. A slender aluminum beam is suspended vertically, cantilevered at the top. An active hinge is placed at the node of the second vibration mode. The active hinge consists of a torque motor, strain gauge, and tachometer. A control law is implemented using both beam-bending strain and the relative angular velocity measured at this hinge, thereby configuring the hinge to act as an active damper. Results from implementing this control law show little improvement in the first mode damping ratio, 130 percent increase in the second mode damping ratio, and 180 percent increase in the third mode damping ratio. The merits of using a motor with a gearbox are discussed. Author

A86-39507#
ACTUATOR FAILURE DETECTION IN THE CONTROL OF DISTRIBUTED SYSTEMS
H. BARUH (Rutgers University, New Brunswick, NJ) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 503-523. refs

A method is presented for the detection of actuator failures in the control of distributed-parameter systems. The method can be used with any control scheme, and is based on identifying the actuators input from the system response by modal analysis. First, the modal excitations are identified. Estimates of the external forces are then synthesized as a linear combination of the modal forces. The identified external forces are compared with the actuator commands to detect failure and isolate the faulty component(s). The effects of actuator failure on the performance of control systems are investigated, as well as factors that affect the reliability of the failure detection, such as measurement noise and observation spillover. A guideline is proposed to locate the actuators in a way to aid the failure detection process. Author

A86-39509*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A SLEWING CONTROL EXPERIMENT FOR FLEXIBLE STRUCTURES
J.-N. JUANG, L. G. HORTA (NASA, Langley Research Center, Hampton, VA), and H. H. ROBERTSHAW (Virginia Polytechnic Institute and State University, Blacksburg) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 547-570. refs

A hardware set-up has been developed to study slewing control for flexible structures including a steel beam and a solar panel. The linear optimal terminal control law is used to design active controllers which are implemented in an analog computer. The objective of this experiment is to demonstrate and verify the dynamics and optimal terminal control laws as applied to flexible structures for large angle maneuver. Actuation is provided by an electric motor while sensing is given by strain gages and angle potentiometer. Experimental measurements are compared with analytical predictions in terms of modal parameters of the system stability matrix and sufficient agreement is achieved to validate the theory. Author

A86-40607*# Houston Univ., Clear Lake, Tex.
A LINEAR QUADRATIC TRACKER FOR CONTROL MOMENT GYRO BASED ATTITUDE CONTROL OF THE SPACE STATION
J. T. KAIDY (Houston, University, Clear Lake; Rockwell International Corp., Houston, TX) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 239-244. refs
(Contract NAS9-16715; NAS9-18000)
(AIAA PAPER 86-1194)

The paper discusses a design for an attitude control system for the Space Station which produces fast response, with minimal overshoot and cross-coupling with the use of Control Moment Gyros (CMG). The rigid body equations of motion are linearized and discretized and a Linear Quadratic Regulator (LQR) design and analysis study is performed. The resulting design is then modified such that integral and differential terms are added to the state equations to enhance response characteristics. Methods for reduction of computation time through channelization are discussed as well as the reduction of initial torque requirements. Author

A86-40613*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTEGRATED ANALYSIS TOOLS FOR TRADE STUDIES OF SPACECRAFT CONTROLLER AND SENSOR LOCATIONS
L. F. ROWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 14 p. refs
(AIAA PAPER 86-1192)

The present investigation was conducted with the aim to evaluate the practicality and difficulties of modern control design methods for large space structure controls. The evaluation is used as a basis for the identification of useful computer-based analysis tools which would provide insight into control characteristics of a spacecraft concept. A description is presented of the wrap-rib antenna and its packaging concept. Attention is given to active control requirements, a mathematical model of structural dynamics, aspects of sensor and actuator location, the analysis approach, controllability, observability, the concept of balanced realization, transmission zeros, singular value plots, analysis results, model reduction, and an interactive computer program. It is pointed out that the application of selected control analysis tools to the wrap-rib antenna demonstrates several capabilities which can be useful during conceptual design. G.R.

A86-40843* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPLINE-BASED RAYLEIGH-RITZ METHODS FOR THE APPROXIMATION OF THE NATURAL MODES OF VIBRATION FOR FLEXIBLE BEAMS WITH TIP BODIES
I. G. ROSEN (NASA, Langley Research Center, Hampton, VA; Southern California, University, Los Angeles) Quarterly of Applied Mathematics (ISSN 0033-569X), vol. 44, April 1986, p. 169-185. Previously announced in STAR as N85-23100. refs
(Contract AF-AFOSR-84-0393; NAS1-17070)

Rayleigh-Ritz methods for the approximation of the natural modes for a class of vibration problems involving flexible beams with tip bodies using subspaces of piecewise polynomial spline functions are developed. An abstract operator-theoretic formulation of the eigenvalue problem is derived and spectral properties investigated. The existing theory for spline-based Rayleigh-Ritz methods applied to elliptic differential operators and the approximation properties of interpolatory splines are used to argue convergence and establish rates of convergence. An example and numerical results are discussed. Author

A86-41740#
EFFECT OF DEGRADATION OF MATERIAL PROPERTIES ON THE DYNAMIC RESPONSE OF LARGE SPACE STRUCTURES
S. KALYANASUNDARAM, J. D. LUTZ, W. E. HAISLER, and D. H. ALLEN (Texas A&M University, College Station) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 545-551) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 297-302. Previously cited in issue 13, p. 1855, Accession no. A85-30382. refs
(Contract F49620-83-C-0067)

A86-42855
SINGULAR PERTURBATION METHODS FOR DISCRETE TIME SYSTEMS
E. C. BEKIR (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 86-94. refs

Some problems associated with applications of the singular perturbation method to the two-time scale discretized time systems are addressed. In practice, the small parameter of the fast time system is often implicit or unknown. A redefinition of the two-time scale property is proposed to resolve this and other related problems. Application to optimal regulators, design tradeoffs, and performance evaluation are also discussed. A practical example of a large space structure system is used to demonstrate the design procedure for implementing the singular perturbation techniques. Author

A86-42938*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FAILURE DETECTION AND ACCOMMODATION IN STRUCTURAL DYNAMICS SYSTEMS USING ANALYTIC REDUNDANCY
J. P. WILLIAMS and R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 906-910. refs

The concept of analytic redundancy is extended to identify nonzero constant output failures in large spacecraft active control sensors and actuators, using a set of distributed sensors which do not nominally produce equivalent signals but are related through the structural dynamics of the system. The suboptimal technique uses a Sequential Probability Ratio Test on the residual sequence of a Kalman filter based on a modal structure model, to determine failure of a component based on an assumed failure hypothesis. The specific failure is identified and then the Kalman filter gains are reconfigured for the identified remaining working sensor set. Experimental data using an apparatus whose dynamics are representative of a large spacecraft show the nominal filter performance under failed and unfailed conditions. R.R.

A86-42939
INTEGRATION OF STRUCTURES AND CONTROLS - SOME COMPUTATIONAL ISSUES
D. F. MILLER (Wright State University, Dayton, OH), V. B. VENKAYYA, and V. A. TISCHLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 924-931. refs

This paper discusses issues related to the integration of the structural and control design processes for large scale structural systems. These issues are discussed in the context of vibration suppression for large space structures using linear regulator theory. The controlled system is modeled, via finite element analysis, as a system of linear differential equations in modal space. Attention is focused upon the specification of meaningful weighting matrices for the quadratic performance index, reduced order model selection and control design, and the combined optimization of structural

and control designs. Numerical simulations for two and three bay trusses illustrate the concepts presented. Author

A86-42960
ESTIMATION OF FREQUENCIES OF VIBRATION USING LATTICES
D. M. WIBERG and J. T. GILLIS (Aerospace Corp., Los Angeles, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1157-1162. Research supported by the Aerospace Corp. refs

On-line structural identification by use of lattice-form linear least-square algorithms is discussed. Some background is given concerning lattices and their uses in structural identification. The collapsed form of the lattice (vibration lattice) is compared with the usual lattice using simulated data from the ACOSS II (Active Control of Space Structures) model. Methods for extracting natural frequencies from parameters determined by the lattices are discussed, and the inverse system for multiple inputs and multiple outputs is derived. Problems concerning extending the vibration lattice to the known input case are addressed. It is concluded that the vibration lattice is numerically superior to, and faster converging than, the usual lattice for the case of free vibration with no noise, especially when many sensors are used. C.D.

A86-42965
IDENTIFICATION OF SPACE STATION DYNAMICS
B. SRIDHAR (Lockheed Research Laboratories, Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1264, 1265.

The dynamic parameters of the Space Station (SS) for the early 1990s are identified by applying the maximum likelihood estimation (MLE) method in a finite element model of the SS configuration as chosen by NASA. The amount of computation in the MLE approach is reduced by using the method of successive approximation. The finite element analysis uses 19 modes and the initial operational capability (IOC) shows a 75 KW configuration. Numerical results based on simulated data are presented. B.A.

A86-42997
DECENTRALIZED CONTROL OF SEQUENTIALLY ASSEMBLED LARGE SPACE STRUCTURES
D. P. LOOZE, M. ATHANS, and J. S. ETERNO (Alphatech, Inc., Burlington, MA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1844-1851. refs

A novel design approach for the decentralized robust control systems of large space structures (LSS) is presented. A decentralized design approach whereby each subsystem controller is designed independently based on a subsystem design model, subsystem performance goals and subsystem errors is adopted so as to address the following issues: (1) the necessary architecture of the control system must be determined from the system structure, performance requirements and hardware implementations of the LSS; (2) the procedure must be able to handle a large number of variables that will be present in a realistic design problem; and (3) the procedure must incorporate LSS performance specifications and dynamic modeling errors. The advantages inherent in this approach are outlined and it is noted that the major technical difficulty which arises is that the coordination between the subsystem designs is accomplished through the subsystem performance and error specifications. In the present analysis, a number of techniques are developed which enable the decentralized design procedure to be applied to a specific simplified problem. The specific problem that is considered is the sequential assembly problem for two subassemblies. K.K.

A86-43213
A MULTIBODY DYNAMICS EQUATION FORMULATION BY MOMENTUM PRINCIPLE
M. TONG (Aerospace Corp., Control Analysis Dept., Los Angeles, CA) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 219-238. refs
(Contract F04701-83-C-0084)
(AAS PAPER 85-391)

Equations of motion are obtained using the momentum principle for an arbitrary collection of N rigid bodies that are interconnected by hinges in a tree configuration. Rotational and translational motions are permitted at the hinges. The derived equations are a set of first order nonlinear differential equations in Hamiltonian form, in that the system states are the generalized coordinates and the generalized momenta of the system. Also presented in this paper are the treatment of the equations of motion with constraints, and the computer implementation of the derived equations for multibody dynamics simulations. Author

A86-43214
ON THE DYNAMICS OF BEAM TYPE STRUCTURAL MEMBERS DURING DEPLOYMENT
A. M. IBRAHIM and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 239-256. refs
(Contract NSERC-G-1547)
(AAS PAPER 85-392)

Using a rather general formulation of the problem representing a large class of space platforms with flexible, extensible members, the paper attempts to study complex interactions between deployment, attitude dynamics and flexural rigidity. The governing nonlinear, nonautonomous and coupled equations of motion are extremely difficult to solve even with the help of a computer, not to mention the cost involved. Effectiveness of the versatile formulation is demonstrated through its application to dynamical situations of practical interest involving beam-type appendages. Response of the hybrid systems is obtained over a range of physical parameters and external disturbances. Both transient as well as postdeployment phases are considered. Results suggest significant influence of flexibility, inertia, deployment time history and orbital parameters on the system stability. The presence of free molecular and solar radiation induced environmental forces may further accentuate this tendency. The study represents a necessary first step towards development of a suitable control strategy. Author

A86-43217* Howard Univ., Washington, D. C.
THE DEVELOPMENT OF OPTIMAL CONTROL LAWS FOR ORBITING TETHERED PLATFORM SYSTEMS
P. M. BAINUM, S. WOODARD (Howard University, Washington, DC), and J.-N. JUANG (NASA, Langley Research Center, Hampton, VA) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 291-314. Research supported by NASA and Howard University. refs
(AAS PAPER 85-360)

A mathematical model of the open and closed loop in-orbit plane dynamics of a space platform-tethered-subsatellite system is developed. The system consists of a rigid platform from which an (assumed massless) tether is deploying (retrieving) a subsatellite from an attachment point which is, in general, offset from the platform's mass center. A Lagrangian formulation yields equations describing platform pitch, subsatellite tether-line swing, and varying tether length motions. These equations are linearized about the nominal station keeping motion. Control can be provided by both modulation of the tether tension level and by a momentum type platform-mounted device; system controllability depends on the presence of both control inputs. Stability criteria are developed in terms of the control law gains, the platform inertia ratio, and tether offset parameter. Control law gains are obtained based on linear quadratic regulator techniques. Typical transient responses of both the state and required control effort are presented. Author

A86-43219
AN ASYMPTOTIC PERTURBATION METHOD FOR NONLINEAR OPTIMAL CONTROL PROBLEMS
J. L. JUNKINS (Texas A & M University, College Station) and R. C. THOMPSON (Virginia Polytechnic Institute and State University, Blacksburg) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 333-348. refs
(Contract F49620-83-K-0032)
(AAS PAPER 85-364)

A quasi-analytical method is presented for solving nonlinear, open-loop, optimal control problems. The approach combines a simple analytical, straightforward expansion from perturbation methods with powerful numerical algorithms (due to Ward and Van Loan) to solve a series of nonhomogeneous, linear, optimal control problems. In the past, the only recourse for solving such nonlinear problems relied almost exclusively on iterative numerical methods whereas the asymptotic perturbation approach may produce accurate solutions to nonlinear problems without iteration. The nonlinear state and costate equations are derived from the optimal control formulation and expanded in a power series in terms of a small parameter contained either explicitly in the equations or implicitly in the boundary conditions. Each order of the expansion is shown to be governed by a nonhomogeneous, ordinary differential equation. Representing the generally nonintegrable, nonhomogeneous terms by a finite Fourier series, efficient matrix exponential algorithms are then used to solve the system at each order, where the order of the expansion is extended to achieve the appropriate precision. The asymptotic perturbation method is broadly applicable to weakly nonlinear optimal control problems, including higher order systems frequently encountered in aerospace vehicle dynamics and control. A number of numerical examples demonstrating the perturbation approach are included. Author

A86-43238
NONLINEAR FEEDBACK CONTROL FOR REMOTE ORBITAL CAPTURE
J. W. WIDHALM (USAF, Institute of Technology, Wright-Patterson AFB, OH) and B. A. CONWAY (Illinois, University, Urbana) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 697-714. refs
(AAS PAPER 85-368)

The problem of detumbling a freely spinning and precessing axially symmetric target satellite with feedback control by an axially symmetric retriever spacecraft or orbital maneuvering vehicle is considered. The two bodies are connected by a joint allowing two rotational degrees of freedom, and the joint itself is translated relative to the orbital maneuvering vehicle. The two-body system is modeled with Eulerian-based equations of motion based on the equations developed by Hooker and Margulies. A Liapunov technique is applied to derive a nonlinear feedback control law for the thruster torques applied by the orbital maneuvering vehicle and the motor torques applied at the joint to drive the two-body system to a final spin-stabilized state asymptotically. State and control histories are presented and illustrate that the detumbling process is quite benign and that required control magnitudes are small. Constraint loads at the joint are also presented and indicate no excessive loading of the joint during detumbling. Author

A86-43772
CONTROL OF DYNAMIC RESPONSE OF A CONTINUUM MODEL OF A LARGE SPACE STRUCTURE
S. N. ATLURI (Georgia Institute of Technology, Atlanta) and P. E. ODONOGHUE Computers and Structures (ISSN 0045-7949), vol. 23, no. 2, 1986, p. 199-209. refs
(Contract AF-AFOSR-84-0020)

The problem of active control of the transient dynamic response of large space structures, modeled as equivalent continua, is investigated here. The effects of initial stresses, in the form of in-plane stress resultants in an equivalent plate model, on the controllability of transverse dynamic response, are studied. A singular solution approach is used to derive a fully coupled set of nodal equations of motion which also include nonproportional passive damping. One approach considers a direct attack on this system of nodal equations. An alternative scheme implements a reduced-order model of coupled ordinary differential equations which are obtained in terms of the amplitudes of the pseudomodes of the nominally undamped system. Optimal control techniques are employed to develop a feedback control law. Algorithms for the efficient solution of the Riccati equation are implemented. Several examples are presented which involve the suppression of vibration of the transient dynamic response of the structure using an arbitrary number of control force actuators. Author

A86-44884*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VIBRATION OF A LARGE SPACE BEAM UNDER GRAVITY EFFECT
C.-F. SHIH, J. C. CHEN, and J. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA Journal (ISSN 0001-1452), vol. 24, July 1986, p. 1213-1216. NASA-supported research. refs

Future space structures will have a low mass density and high flexibility, with ground test dynamic behavior differing significantly from that in zero-G orbit. Attention is presently given to the vibration behavior of a beam deformed by its own weight; the results obtained by the differential equations for both the static and dynamic responses of a large, simply supported beam, which are derived and solved analytically, allow ground test experiment measurements to be used for orbital dynamic characteristics verification efforts. O.C.

A86-46462*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
PREDICTIVE MOMENTUM MANAGEMENT FOR THE SPACE STATION
P. D. HATIS (Charles Stark Draper Laboratory Inc., Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 454-461. refs
(Contract NAS9-16023)

Space station control moment gyro momentum management is addressed by posing a deterministic optimization problem with a performance index that includes station external torque loading, gyro control torque demand, and excursions from desired reference attitudes. It is shown that a simple analytic desired attitude solution exists for all axes with pitch prescription decoupled, but roll and yaw coupled. Continuous gyro desaturation is shown to fit neatly into the scheme. Example results for pitch axis control of the NASA power tower Space Station are shown based on predictive attitude prescription. Control effector loading is shown to be reduced by this method when compared to more conventional momentum management techniques. Author

A86-46463#
TRAVELING WAVE CONTROL FOR LARGE SPACECRAFT STRUCTURES
A. H. VON FLOTOW (MIT, Cambridge, MA) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 152-160) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, July-Aug. 1986, p. 462-468. USAF-supported research. Previously cited in issue 13, p. 1854, Accession no. A85-30337. refs

A86-47403#
MODEL REFERENCE ADAPTIVE CONTROL UNDER UNCERTAINTY OF NONLINEAR FLEXIBLE MANIPULATORS
J. M. SKOWRONSKI (Queensland, University, Brisbane, Australia) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 11-18. refs
(AIAA PAPER 86-1976)

The manipulator is modelled as an open chain with n DOF, highly nonlinear characteristics and coupling, with elastic links, subject to uncertain gravity and payload and driven by n actuators

collocated with joints. It is made to follow a compatible nonlinear but simple rigid model within prescribed accuracy of convergence and in real time, by the introduced signal adaptive feedback controller and subject to specified adaptive laws. The state for the controller is supplied not by time consuming solving of the hybrid state equations but by a much simpler observer integrable in closed form, allowing the control to be implemented by small on-board computer. Author

A86-47411#
CONCEPTUAL DESIGN OF POINTING CONTROL SYSTEMS FOR SPACE STATION GIMBALLED PAYLOADS
R. O. HUGHES (General Electric Co., Space Div., Philadelphia, PA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 78-87. refs
(AIAA PAPER 86-1986)

A conceptual design of the control system for Payload Pointing Systems (PPS) is developed using classic Proportional-Integral-Derivative (PID) techniques. The major source of system pointing error is due to the disturbance-rich environment of the Space Station in the form of gimbal baseplate motions. These baseplate vibrations are characterized using Fast Fourier Transform (FFT) techniques. Both time domain and frequency domain dynamic models are developed to assess control system performance. Three basic methods exist for the improvement of PPS pointing performance: increase control system bandwidth, add Image Motion Compensation, and/or reduce (or change) the baseplate disturbance environment. Author

A86-47412*# Illinois Univ., Urbana.
VARIABLE STRUCTURE CONTROL OF SPACECRAFT REORIENTATION MANEUVERS
H. SIRA-RAMIREZ and T. A. W. DWYER, III (Illinois, University, Urbana) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 88-96. refs
(Contract N00014-84-C-0149; NAG1-436; NSF ECS-85-16445)
(AIAA PAPER 86-1987)

A Variable Structure Control (VSC) approach is presented for multi-axial spacecraft reorientation maneuvers. A nonlinear sliding surface is proposed which results in an asymptotically stable, ideal linear sliding motion of Cayley-Rodriques attitude parameters. By imposing a desired equivalent dynamics on the attitude parameters, the approach is devoid of optimal control considerations. The single axis case provides a design scheme for the multiple axes design problem. Illustrative examples are presented. Author

A86-47430#
MOMENTUM MANAGEMENT CONCEPTS FOR A SPACE STATION
H. H. WOO, H. D. MORGAN, and E. T. FALANGAS (Rockwell International Corp., Downey, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 277-286. Research sponsored by Rockwell International Corp. refs
(AIAA PAPER 86-2047)

A momentum management concept applicable to the dual-keel configuration of the Space Station is presented. The system dynamic equation is given, and the dominant environmental disturbances, gravity-gradient torque and aerodynamic torques, are discussed. Induced dynamic disturbances, including both unscheduled and scheduled disturbances as well as disturbances that exceed control moment gyro (CMG) capability are specified, including their magnitude and direction. The sizing of CMG momentum storage is briefly addressed, as are unscheduled and scheduled momentum requirements. The integrated momentum management concept for transition and steady-state operation is then identified and developed for keeping torque equilibrium attitude maneuvers to a minimum in order to provide a stable environment for experiments. For more dynamic conditions, a logic is developed for handling the situation responsively while maintaining the momentum within bounds. C.D.

A86-47432#
A SQUARE ROOT METHOD FOR THE IDENTIFICATION OF LARGE SPACE STRUCTURES
T. WILLIAMS (Kingston Polytechnic, Kingston upon Thames, England) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 296-302. SERC-supported research. refs
(AIAA PAPER 86-2049)

A new algorithm for identifying the dynamics of a flexible large space structure from in-flight vibration measurements is presented. The novel aspect of this method is that it directly identifies a square root of the mass matrix rather than the matrix itself, resulting in all the well-documented accuracy improvements typical of algorithms based on matrix factorization techniques. The properties of this algorithm are analyzed in detail and illustrated with examples. C.D.

A86-47433#
DESIGN OF DYNAMIC OUTPUT FEEDBACK CONTROLLERS WITH PARAMETER VARIATION INSENSITIVITY
Z.-Q. GU and R. W. LONGMAN (Columbia University, New York) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 303-313. refs
(AIAA PAPER 86-2050)

Two fundamental contributions of modern control theory are the Linear-Quadratic and pole placement design methods. Since it is often impractical to measure the full state vector, both these methods can suffer from controller dimension problems and from robustness problems when parameter uncertainties are present. These difficulties are addressed here for both approaches. Necessary conditions for optimality are derived, and a steepest descent algorithm is generated, to design fixed-order controllers that are optimal with respect to a quadratic performance index which includes quadratic penalties on the performance sensitivity with respect to parameter variation. A second algorithm is developed to accomplish pole placement with fixed order controllers where the freedom remaining after pole placement is used to minimize the eigenvalue sensitivities. Both steepest descent algorithms are shown to be effective design methods in worked examples. Author

A86-47435#
ROBUST REDUCED-ORDER CONTROL OF FLEXIBLE STRUCTURES USING THE OPTIMAL PROJECTION/MAXIMUM ENTROPY DESIGN METHODOLOGY
A. GRUZEN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) and W. E. VANDER VELDE (MIT, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 319-327. refs
(Contract F04611-85-K-0051)
(AIAA PAPER 86-2052)

This paper describes the capabilities of the Optimal Projection/Maximum Entropy (OP/ME) design methodology for the development of an active vibration damper. A full-state LQG compensator was generated to provide a reference design for both robustification and order reduction studies. The compensator is shown to be sensitive to presumed variations in plant parameters through application to a set of perturbed plants. The LQG compensator displays degraded performance over the set of plants and in some cases results in closed-loop instability. Subsequently, reduced-order compensators were designed, illustrating the capabilities of the optimal projection design approach. The maximum entropy methodology is envoked to robustify the compensators, and the resulting designs are shown to be tolerant of all postulated modeling errors. Author

A86-47436#
A PARAMETRIC EXAMINATION OF THE STABILITY ROBUSTNESS CHARACTERISTICS OF TWO DECOUPLED CONTROLLERS DESIGNED FOR LARGE SPACE STRUCTURE CONTROL
J. W. HESS (U.S. Air Force Academy, Colorado Springs, CO) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 328-337. refs
(AIAA PAPER 86-2053)

The system model for a large space structure is developed, and some of the destabilizing spillovers are presented. Two controllers are designed, one with an observer and one which uses direct output feedback, which eliminate the destabilizing spillover by decoupling their several reduced order sub-controllers. An error model is then developed which uses the structure of the model to determine the potentially most destabilizing directions. Reasonable errors are then examined to determine which lie in the most critical directions. Armed with this reasonable set of potentially destabilizing errors, perturbed models are then determined. The decoupled control design for the nominal case is then applied to the perturbed models and the system eigenvalues are examined for instabilities. The results indicate that the two control designs have different robustness characteristics, but one design is not necessarily more robust than the other. Finally, all of the information gleaned in determining the robustness of the two designs is used to design a more robust controller. Author

A86-47460#
PRELIMINARY EVALUATION OF A REACTION CONTROL SYSTEM FOR A SPACE STATION
H. H. WOO, E. T. FALANGAS, and J. A. FINLEY (Rockwell International Corp., Downey, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 538-546. Research sponsored by Rockwell International Corp.
(AIAA PAPER 86-2152)

The Space Station reaction control system (RCS) functions include disturbance damping, reboost maneuvers, and rotation maneuvers. This paper presents the design concepts and methodology used to define the RCS and simulation results used to evaluate the design performance. The objective is to present a preliminary RCS concept that meets the given functional, operational, and performance goals and requirements. RCS design concepts incorporate notch-bending filters, multiple-level switching functions, and integral trims. To evaluate these concepts in terms of performance, simulation data including attitude, rate, torque, and deflection time histories are presented for cases involving reboost, attitude maneuvers, disturbance conditions, and maneuvers during assembly. The RCS accommodation of a blowdown propulsion system with distributed propellant tanks is also evaluated. Author

A86-47471#
CONTROL-MOTIVATED DYNAMIC TAILORING OF TRUSS-WORK STRUCTURES
A. H. VON FLOTOW (MIT, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 622-628. USAF-supported research. refs
(AIAA PAPER 86-2190)

This paper reviews past approaches to control-motivated dynamic tailoring and their impact upon the problem of active control of structural dynamics. The costs and benefits of passive damping augmentation are estimated; the conclusion is drawn that the optimum structural design will be in the 'left-half s-plane'. New results on dynamic tailoring of truss-work structures are presented. The proposed techniques exploit inherent characteristics of such structures to reduce the mass penalty associated with passive damping augmentation. Author

A86-47473#
MANEUVERING OF FLEXIBLE SPACECRAFT
H. OZ (Ohio State University, Columbus) and O. MOSTAFA IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 635-643. refs
(AIAA PAPER 86-2193)

Variable Structure Control Systems (VSCS) are a class of nonlinear systems which change the structure of the controls when a set of prescribed hypersurfaces are reached in the phase space. The VSCS theory has, desirable insensitivity properties under parameter uncertainties, nonlinear effects, and external disturbances. The theory represents a real-time implementable approach to control in contrast to algorithmic approaches, and therefore eliminates the computational burden. However, a practical problem in the implementation of VSC theory is the possibility of chatter about hypersurfaces known as 'sliding regimes'. This paper extends the previous applications by the authors of VSCS theory to maneuvering of flexible spacecraft. Three methods of chatter alleviation are introduced. Specifically, the methods are: a boundary layer approach, asymptotic reaching of sliding regimes, and digital input prefiltering. Illustrative examples are given for a single-axis rest-to-rest maneuver of a flexible spacecraft, demonstrating the success of the three methods in alleviating the chatter phenomenon. In association, robustness to parameter uncertainties is also illustrated. Author

A86-47510#
EMULATING STRUCTURAL MOTION BY ARRAY PROCESSORS
E. K. PARSONS and P. J. RESHATOFF (Lockheed Research Laboratories, Palo Alto, CA) AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 10 p. refs
(AIAA PAPER 86-1988)

This paper describes the use of an array processor to simulate the motion of flexible structures in real time. The array processors is fast enough to emulate hundreds of modes less than 20 Hz, or a single mode up to 2.5 KHz. This method makes it possible to design and test real control hardware when the real flexible system is unavailable or too fragile. For example, this technique can benefit optical systems whose performance critically depends upon flexibility. As an illustration, the paper describes the emulation of a steering mirror with four bending modes, the two highest at 950 Hz. The main result is the demonstrated ability to isolate errors in either the dynamic model or the control hardware. Sampling rate and proper smoothing of the outputs of the D/A convertors limit the use of this method. To address these problems, special techniques are presented for programming the AP and carrying out the emulation. Author

A86-47518#
OPTIMUM DETUMBLING OF SPACE PLATFORMS VIA A DYNAMIC PROGRAMMING ALGORITHM
R. G. MELTON (Pennsylvania State University, University Park), D. S. RUBENSTEIN, and H. L. FISHER AIAA, Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986. 9 p. Research supported by Pennsylvania State University. refs
(AIAA PAPER 86-2154)

A method for determining the optimum detumbling control for a space platform is described which uses internal motions to dissipate kinetic energy, thereby converting the tumble into a simple spin about the major inertia axis. Dynamic programming to automatically generate embedded solutions makes optimum closed-loop control possible. A moveable mass controller is employed. R.R.

A86-47925#
ROBUST MULTIVARIABLE CONTROL OF LARGE SPACE STRUCTURES USING POSITIVITY
G. L. SLATER (Cincinnati, University, OH) and M. D. MCLAREN IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 250-259. refs
(AIAA PAPER 86-2125)

This paper examines the robust, multivariable control of large space structures by controllers designed on a reduced-order model using positivity concepts. Controllers are designed using the DRAPER I and DRAPER II structures. Three different controller methodologies are compared: the familiar multivariable control, individual mode control, and individual sensor control. Controller robustness is measured qualitatively from the plots of the minimum singular value of the return difference matrix as a function of the frequency. All controllers, when designed to give the same total average control cost, have a very similar line-of-sight (LOS) response. All controlled systems have guaranteed asymptotic stability even in the presence of actuator and/or sensor failures. Author

A86-47955#
SOME CONSIDERATIONS OF ACTUATOR DYNAMICS IN THE ATTITUDE CONTROL OF A FLEXIBLE BEAM
K. C. HOWELL and M. J. BAXTER (Purdue University, West Lafayette, IN) AIAA and AAS, Astrodynamics Conference, Williamsburg, VA, Aug. 18-20, 1986. 25 p. refs
(Contract F49620-82-C-0035)
(AIAA PAPER 86-2124)

In the control system design for large, flexible structures, it is usually assumed that any actuating and sensing devices are of infinite bandwidth, and their dynamic characteristics are not included as part of the system model. Actual sensors and actuators do not respond ideally and different types of devices have different dynamics. This study considers the effects of some finite actuator dynamics in the model of a flexible beam in earth orbit. From some initial attitude disturbance, the system is to be returned to its nominal state using a prescribed set of actuators along the beam. The results of including actuator dynamics are observed in the effects on the actuator placement design and dynamic response in simulation. Initially, a quadratic cost decomposition algorithm is used to determine actuator effectiveness which in turn determines the most effective actuator locations among a finite number of positions available. Controlled simulations are used to study the system response with different linear actuator models. Finally, simulations are also done with a controller which utilizes on/off thrusters and which includes linear actuator dynamics. Author

A86-49822#
OPTIMAL STRUCTURAL MODIFICATIONS TO ENHANCE THE ACTIVE VIBRATION CONTROL OF FLEXIBLE STRUCTURES
N. S. KHOT, V. B. VENKAYYA (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH), and F. E. EASTEP (Dayton, University, OH) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 134-142) AIAA Journal (ISSN 0001-1452), vol. 24, Aug. 1986, p. 1368-1374. Previously cited in issue 13, p. 1854, Accession no. A85-30335. refs

N86-22997*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXPERIMENAL AND ANALYTICAL GENERIC SPACE STAION DYNAMIC MODELS
W. K. BELVIN and H. H. EDIGHOFFER (Edighoffer, Inc.) Mar. 1986 90 p refs
(NASA-TM-87696; NAS 1.15:87696) Avail: NTIS HC A05/MF A01 CSCL 20K

A dynamic model used for verification of analytical and experimental methods is documented. The model consists of five substructures to simulate the multibody, low frequency nature of large space structures. Design considerations which led to a fundamental vibration frequency of less than one Hz are described. Finite element analysis used to predict the vibration modes and frequencies of the experimental model is presented. In addition, modeling of cable suspension effects using prestressed vibration analysis is described. Details of the expermental and analytical models are included to permit replication of the study. Results of the modal vibration tests and analysis are presented in a separate document. Author

N86-23343*# Scientific Systems, Inc., Cambridge, Mass.
FAULT-TOLERANT CONTROL OF LARGE SPACE STRUCTURES USING THE STABLE FACTORIZATION APPROACH Final Report
H. C. RAZAVI, R. K. MEHRA, and M. VIDYASAGAR (Waterloo Univ., Ontario) Washington NASA Mar. 1986 38 p refs
(Contract NAS1-17946)
(NASA-CR-3964; NAS 1.26:3964; SSI-1103) Avail: NTIS HC A03/MF A01 CSCL 09B

Large space structures are characterized by the following features: they are in general infinite-dimensional systems, and have large numbers of undamped or lightly damped poles. Any attempt to apply linear control theory to large space structures must therefore take into account these features. Phase I consisted of an attempt to apply the recently developed Stable Factorization (SF) design philosophy to problems of large space structures, with particular attention to the aspects of robustness and fault tolerance. The final report on the Phase I effort consists of four sections, each devoted to one task. The first three sections report theoretical results, while the last consists of a design example. Significant results were obtained in all four tasks of the project. More specifically, an innovative approach to order reduction was obtained, stabilizing controller structures for plants with an infinite number of unstable poles were determined under some conditions, conditions for simultaneous stabilizability of an infinite number of plants were explored, and a fault tolerance controller design that stabilizes a flexible structure model was obtained which is robust against one failure condition. Author

N86-24738# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
CONTROL OF A LARGE SPACE STRUCTURE USING DIRECT OUTPUT FEEDBACK AND MODAL SUPPRESSION M.S. Thesis
E. E. KELLER Dec. 1985 106 p refs
(AD-A163960; AFIT/GAE/AA/85D-10) Avail: NTIS HC A06/MF A01 CSCL 22B

Direct output feedback control using one or two controllers is applied to the NASA Ground Test Facility offset antenna model. This is a test structure designed to have the vibration characteristics associated with large space structures. The control problem is transformed from physical variables into modal variables and reformulated into a first order system. This system is truncated to a reduced order model with residual modes used only in performance evaluation. Optimal linear quadratic regulator techniques are used to design the gain matrices and full state feedback is approximated by use of generalized inverses of the observation matrices. Spillover is eliminated through the use of transformation matrices. The structure is shown to be controllable with this method. Alternative sensor placement is explored and found to cause improvement in performance. The torsion modes are found to be particularly important to the performance of the structure but need more sensing and actuation to be adequately controlled. Two controller systems require more sensors and actuators than available to achieve acceptable performance with this structure. GRA

N86-24739# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
THE EFFECT OF ENERGY DISSIPATION DUE TO FRICTION AT THE JOINT OF A SIMPLE BEAM STRUCTURE M.S. Thesis
R. P. DONNELLY, JR. Dec. 1985 81 p refs
(AD-A163975; AFIT/GAE/AA/85D-5) Avail: NTIS HC A05/MF A01 CSCL 22B

The Strategic Defense Initiative has generated new interest in the development of more stable space structures. This interest

has increased the need for more detailed knowledge of the behavior of engineering structures under dynamic loading. Interests lie in decreasing the amount of vibration by both passively and actively damping the structure. A means exists to passively damp structures by friction damping resulting from relative slip between joint interfaces. It may be feasible to increase the damping in a structure by allowing more friction damping than is normal and thereby controlling the vibration response. This thesis incorporates friction damping in a one-dimensional model. Finite element techniques are used to accomplish the numerical analysis. A clamped-clamped beam is used as the physical model. The mid-point of the two element beam is allowed to slip in rotation, but not in translation. Because the one-dimensional program cannot handle rotations at continuous nodes, the beam is modeled by symmetry about the joint and a cantilever beam with an applied end moment is studied. Results for the response of a beam in vibration are presented showing displacement of the joint, relative rotation at the joint, and relative angular velocity at the joint; all versus time. Various clamping pressures and initial loads are explored. Diagrams of the beam shape versus time show the shape the beam takes on when slip occurs at the joint. GRA

N86-24740# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MOVING-BANK MULTIPLE MODEL ADAPTIVE ALGORITHMS APPLIED TO FLEXIBLE SPACECRAFT CONTROL M.S. Thesis
P. G. FILIOS Dec. 1985 182 p refs
(AD-A164016; AFIT/GE/ENG/85D-14) Avail: NTIS HC A09/MF A01 CSCL 22B

Critical to the performance of the moving-bank multiple model adaptive estimator is the decision logic used to determine which elemental filters are implemented in the bank, and when to change this decision. The decision logics discussed focus on three situations: initial acquisition of the unknown parameter values through reducing bank discretization; tracking the unknown parameter values through bank movement; and reacquisition of the unknown parameters following a large jump change in their values through expanding bank discretization. Ambiguity function analysis is used to predict performance in these situations. The system to be controlled is a simplified model of a large scale space structure. Its equations of motion are developed and placed in state space form, the states being the positions and velocities of the rigid body mode and the second and fourth bending modes. The state space matrices describing the system are computed based on nominal values for all physical parameters with the exception of the mass density of the structure arms and their modulus of elasticity. GRA

N86-24742# Integrated Systems, Inc., Palo Alto, Calif.
ADAPTIVE CONTROL TECHNIQUES FOR LARGE SPACE STRUCTURES Annual Technical Report, 1 Jun. 1984 - 31 May 1985
R. L. KOSUT and M. G. LYONS 18 Oct. 1985 121 p refs
(Contract F49620-84-C-0054)
(AD-A164240; ISI-63; AFOSR-85-1241TR) Avail: NTIS HC A06/MF A01 CSCL 22B

The Large Space Structure (LSS) research program was originally formulated in late 1982 in response to the increasing concern that performance robustness of Air Force LSS type systems would be inadequate to meet mission objectives. In particular, uncertainties in both system dynamics and disturbance spectra characterizations (both time varying and stochastic uncertainty) significantly limit the performance attainable with fixed gain, fixed architecture controls. Therefore, the use of an adaptive system, where disturbances and/or plant models are identified prior to or during control, gives systems designers more options for minimizing the risk in achieving performance objectives. The aim of adaptive control is to implement in real time and on-line as many as possible of the design functions now performed off-line by the control engineer; to give the controller intelligence. To realize this aim, both a theory of stability and performance of such inherently nonlinear controls is essential as well as a technology capable of achieving the implementation. As has been noted, recent advances in each of these fronts have brought us to the position where adaptive control has been applied to many processes and standard adaptive controllers can be purchased. GRA

N86-25337# Massachusetts Inst. of Tech., Cambridge. Sea Grant College Program.
WIDE BANDWIDTH POSITIONING SYSTEMS FOR SPACE AND UNDERWATER VEHICLES
H. KAZEROONI and T. B. SHERIDAN Jun. 1985 20 p
(Contract NA84AA-D-00046)
(PB86-152394; MITSG-85-34) Avail: NTIS HC A02/MF A01 CSCL 17G

The report presents a method for wide bandwidth stiff position control of unmanned underwater and space vehicles. With feedback alone the vehicle may not behave like a stiff platform in the presence of a wide frequency range of disturbances. Given this limitation, the authors suggest that the vehicle must be connected to environmental structures by means of cables or grabbers. These connecting cables will develop dynamic and kinematic constraints on the vehicle motion. This problem led to the development of a method that allows for control of the motion of constrained underwater or space vehicles. This method is called impedance control. The authors explain how, with the help of this method, a vehicle connected to a structure by means of cables can be positioned with high stiffness while at the same time the cable tensions are also under control. Author (GRA)

N86-25402# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MODAL ASSIGNMENT EFFECTS ON DECENTRALIZED CONTROL OF A LARGE SPACE STRUCTURE M.S. Thesis
J. B. SUMNER Dec. 1985 158 p refs
(AD-A163977; AFIT/GA/AA/85D-9) Avail: NTIS HC A08/MF A01 CSCL 22B

The more modes a designer can keep in the model of the system/space structure, the less inaccurate it will be. But the computational burden to an online computer, functioning as the controller, grows also. The thrust of this thesis is to implement time response output for the nontrivial model and investigate the effect on time response of certain modal assignments by fixed groups to any of the three controllers with another fixed group assigned as residuals. The inclusion of residuals provides in a limited sense a truth model for the analysis of stability and performance. There may be significant differences in time response caused by the fact that a controller is known to provide more relative controllability and less observability, or vice versa for its assigned modes. The investigation will involve initially the fixing of certain baseline parameters to allow a parallel comparison of reasonable results. Then line-of-sight pointing and defocus performance will be generated for comparison among various cases. The simulation model is a version of the so-called Draper-2 space structure model. The next section describes the selected model configuration and discusses its finite element representation. Then the modal control and matrix transformation methods will be explained. The implementation of the simulation program will be discussed. The last sections will detail the investigation, results, conclusions and recommendations. GRA

N86-26074# Stevens Inst. of Tech., Hoboken, N. J. Dept. of Mechanical Engineering.
TINE DOMAIN DESIGN OF ROBUST CONTROLLERS FOR LQG (LINEAR QUADRATIC GAUSSIAN); APPLICATION TO LARGE SPACE STRUCTURES Final Report, May 1984 - Aug. 1985
R. K. YEDAVALLI Dec. 1985 104 p
(Contract F33615-84-K-3606)
(AD-A163635; AFWAL-TR-85-3093) Avail: NTIS HC A06/MF A01 CSCL 20K

The aspect of Robustness for linear multivariable systems in time domain is the central theme of the research under the present contract. Upper bonds on the linear, structured, time varying perturbation of an asymptotically stable linear time invariant regulator are obtained to maintain both stability and acceptable

regulation, using Lyapunov approach. Improvement of the proposed measures over existing measures is illustrated with the help of examples. It is shown that by employing a scaling transformation on the nominal system, it is possible to further improve the upper bound. The proposed Perturbation Round Analysis is used to design robust controllers for Linear Quadratic Regulators with structured uncertainity. Introducing quantitative measures called Stability Robustness Index and Performance Robustness Index, design algorithms are presented by which one can achieve a trade off between nominal performance, stability robustness and performance robustness. Applications considered include aircraft control problems, large space structure control problems having uncertain modal data and mode truncation as the perturbations. GRA

N86-26222# Massachusetts Inst. of Tech., Cambridge.
FEEDFORWARD CONTROL OF WAVES IN LATTICE ELEMENTS Technical Report, 1 Feb. - 1 Aug. 1985
J. H. WILLIAMS, JR., G. A. NORRIS, and S. S. LEE 1 Aug. 1985 74 p refs
(Contract F49620-83-C-0092)
(AD-A164009; AFOSR-85-1233TR) Avail: NTIS HC A04/MF A01 CSCL 20K

The motion in a lattice substructural element, within which longitudinal stress waves propagate nondispersively and without attenuation, is assumed to be governed by the classical wave equation. A feedforward controller configuration is proposed to isolate a portion of the substructure from longitudinal wave disturbances. The governing equations for the propagation of incoming and controller-generated stress waves in the substructure are determined. To prevent instability, the controller must respond to incoming stress waves only, disregarding self-generated outgoing waves. The transfer function for the controlled substructure system is derived. The dependence of the transfer function magnitude on the input waveform frequency as well as on controller error parameters is demonstrated. The ranges of acceptable controller error are determined for the operational goals of disturbance cancellation and disturbance amplitude attenuation. GRA

N86-26357*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC CHARACTERISTICS OF POWER-TOWER SPACE STATIONS WITH 15-FOOT TRUSS BAYS
J. T. DORSEY Jul. 1986 72 p
(NASA-TM-87684; L-16094; NAS 1.15:87684) Avail: NTIS HC A04/MF A01 CSCL 22B

A power tower space station concept which generates power with photovoltaic arrays and where the truss structure has a bay size of 15 ft is described. Rigid body and flexible body dynamic characteristics are presented for a 75-kW Initial Operating Capability (IOC) and 150-kW and 300-kW growth stations. The transient response of the IOC and 300-kW growth stations to shuttle dock, orbit reboost, and mobile remote manipulator system translation loads are studied. Displacements, accelerations, and bending moments at various locations on the IOC and 300-kW growth stations are presented. Author

N86-27401*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES USING RECURSIVE LATTICE FILTERS Final Report
N. SUNDARARAJAN and G. L. GOGLIA Dec. 1985 80 p
(Contract NAG1-429)
(NASA-CR-177270; NAS 1.26:177270) Avail: NTIS HC A05/MF A01 CSCL 22B

The use of recursive lattice filters for identification and adaptive control of large space structures is studied. Lattice filters were used to identify the structural dynamics model of the flexible structures. This identification model is then used for adaptive control. Before the identified model and control laws are integrated, the identified model is passed through a series of validation procedures and only when the model passes these validation procedures is control engaged. This type of validation scheme prevents instability when the overall loop is closed. Another important area of research, namely that of robust controller synthesis, was investigated using frequency domain multivariable controller synthesis methods. The method uses the Linear Quadratic Guassian/Loop Transfer Recovery (LQG/LTR) approach to ensure stability against unmodeled higher frequency modes and achieves the desired performance. E.R.

N86-27655*# Howard Univ., Washington, D. C. Dept. of Mechanical Engineering.
THE DEVELOPMENT OF OPTIMAL CONTROL LAWS FOR ORBITING TETHERED PLATFORM SYSTEMS
P. M. BAINUM *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 325-355 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

A mathematical model of the open and closed loop in orbit plane dynamics of a space platform-tethered-subsatellite system is developed. The system consists of a rigid platform from which an (assumed massless) tether is deploying (retrieving) a subsatellite from an attachment point which is, in general, offset from the platform's mass center. A Langrangian formulation yields equations describing platform pitch, subsatellite tetherline swing, and varying tether length motions. These equations are linearized about the nominal station keeping motion. Control can be provided by both modulation of the tether tension level and by a momentum type platform-mounted device; system controllability depends on the presence of both control inputs. Stability criteria are developed in terms of the control law gains, the platform inertia ratio, and tether offset parameter. Control law gains are obtained based on linear quadratic regulator techniques. Typical transient responses of both the state and required control effort are presented. Author

N86-28113*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROL/STRUCTURES INTERACTION STUDY OF TWO 300 KW DUAL-KEEL SPACE STATION CONCEPTS
J. W. YOUNG, F. J. LALLMAN, P. A. COOPER, and D. P. GIESY (PRC Kentron, Inc., Hampton, Va.) May 1986 61 p
(NASA-TM-87679; NAS 1.15:87679) Avail: NTIS HC A04/MF A01 CSCL 22B

The results of an investigation of the influence of structural stiffness of the space station framework on the controllability of two 300 kw class, solar dynamic powered, dual-keel space station designs are presented. The two design concepts differed only in the truss bay dimensions of the structural framework of the stations. Two control studies were made: (1) A study of the interaction of the framework structural response with the reaction control system used for attitude control during an orbital reboost maneuver; and (2) A study of the stability of the space station attitude control system with sensors influenced by the elastic deformations of the station framework. Although both configurations had acceptable control characteristics, the configuration with the larger truss bay dimension and its increased structural stiffness had more attractive characteristics for pointing control of the solar dynamic system during reboost and for attitude control during normal in-orbit operations. Author

N86-28981*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NONLINEAR DYNAMIC ANALYSIS OF DEPLOYING FLEXIBLE SPACE BOOMS
P. E. MCGOWAN and J. M. HOUSNER Sep. 1985 34 p
(NASA-TM-87617; NAS 1.15:87617) Avail: NTIS HC A03/MF A01 CSCL 22B

A fundamental investigation of the planar deployment and lock-up of two flexible boom type appendages which have attached tip masses and are connected to a central rigid body through a rotational spring is presented. Nondimensional parameters are identified and it is shown that, in general, the solution depends only on two mass ratios and one nondimensional stiffness parameter. Results are presented for boom tip deflections, deployment time and root moments at lock-up. A threshold value of the nondimensional stiffness parameter is identified beyond

which boom deflections become large. Also, a thorough examination of the effect of nonlinear terms in the equations governing the deployment phase is performed. Nonlinear terms in the deployment equations due to kinematics and structural deformation are required to predict more accurately boom deflections, but retention of an inconsistent set of nonlinear terms leads to erroneous results. In particular, retaining nonlinear kinematic terms while neglecting nonlinear structural terms can produce inaccurate results even below the threshold stiffness value. Author

N86-28985# Control Dynamics Co., Huntsville, Ala.
ASCOT (ADVANCED STRUCTURAL CONTROL TECHNIQUES) Final Report, Nov. 1983 - Jan. 1985
S. M. SELTZER, D. K. TOLLISON, T. G. HOWSMAN, R. D. IRWIN, and W. P. MAGGARD Sep. 1985 164 p
(Contract F30602-84-C-0012; ARPA ORDER 4828; DA PROJ. D82-8)
(AD-A165917; CDC-223-1284-FR-ASC; RADC-TR-85-166) Avail: NTIS HC A08/MF A01 CSCL 09B

This is the Control Dynamics Company final technical report on Advanced Structural Control Techniques (ASCOT). Included is the description and application of a novel technique for the design of low order digital controllers for very high order system models. Also included is an investigation of a digital prefiltering technique which incorporates non-uniform rate sampling. GRA

N86-29272*# Stanford Univ., Calif. Guidance and Control Lab.
THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF SENSOR LOCATION FOR OPTIMAL AEROELASTIC SYSTEM STATE ESTIMATION Final Report
G. LIU Sep. 1985 182 p
(Contract NSG-4002)
(NASA-CR-177115; NAS 1.26:177115; SU-SUDAAR-552) Avail: NTIS HC A09/MF A01 CSCL 20K

One of the major concerns in the design of an active control system is obtaining the information needed for effective feedback. This involves the combination of sensing and estimation. A sensor location index is defined as the weighted sum of the mean square estimation errors in which the sensor locations can be regarded as estimator design parameters. The design goal is to choose these locations to minimize the sensor location index. The choice of the number of sensors is a tradeoff between the estimation quality based upon the same performance index and the total costs of installing and maintaining extra sensors. An experimental study for choosing the sensor location was conducted on an aeroelastic system. The system modeling which includes the unsteady aerodynamics model developed by Stephen Rock was improved. Experimental results verify the trend of the theoretical predictions of the sensor location index for different sensor locations at various wind speeds. Author

N86-29890# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ACOSS ELEVEN (ACTIVE CONTROL OF SPACE STRUCTURES) S Final Report, Oct. 1983 - Jul. 1984
D. R. HEGG, G. J. KISSEL, N. H. MCCLAMROCH, M. J. VILLALBA, and I. G. ROSEN Sep. 1985 286 p
(Contract F30602-81-C-0180; ARPA ORDER 3655; AF PROJ. C65-5)
(AD-A165864; CSDL-R-1721; RADC-TR-85-165) Avail: NTIS HC A13/MF A01 CSCL 15D

The main lines of effort in flexible structure control have been: (1)synthesis of reduced order control for vibration suppression; (2)system identification, with special attention to the resolution of closely spaced modes; and (3)generation of smooth large angle slew control. Highlights of current results are as follows. A final account is given of insights obtained during a systematic investigation of mutual interactions within the overall active control systhesis process between reduced order modeling, actuator and sensor selection, and controller feedback strategy determination. Using linear multivariate loop transfer recovery, full order stability robustness to unmodeled high frequency dynamics in the presence of wideband disturbances is demonstrated on ACOSS model no. 2. A perspective on electromechanical actuator dynamics modeling is presented. Interface constraints with the controller synthesis process associated with the use of high resolution spectrum estimation for reduced order modeling are analyzed. Parametric use of the data sampling period to assist in the resolution of closely spaced modes is discussed or demonstrated. An improved technique for parameter estimation in distributed parameter systems is generated. Author

N86-29891# Massachusetts Inst. of Tech., Cambridge.
WAVE PROPAGATION MEASUREMENTS ON TWO-DIMENSIONAL LATTICE Technical Report, 1 Feb. - 15 Sep. 1985
J. H. WILLIAMS, JR., J. J. ZHANG, and S. S. LEE 15 Sep. 1985 32 p
(Contract F49620-83-C-0092)
(AD-A166207; AFOSR-86-0095TR) Avail: NTIS HC A03/MF A01 CSCL 22B

Wave propagation characteristics of large space structures (LSS) affect their performance, integrity and the ability to nondestructively assess their integrity. In this study, wave propagation characteristics of a periodic lattice structure are determined experimentally. The structure considered is an aluminum multi-bay planar lattice. Two ultrasonic piezoceramic longitudinal transducers are mounted at various locations on the structure. Wave measurements are obtained by injecting an impulsive load via the transmitting transducer and recording the response via the receiving transducer. The waves injected into the structure are longitudinal waves, transverse to the surface, although a complex stress distribution which may be described by directivity functions is actually realized. The impulsive loading signal has a broad frequency spectrum containing frequencies greater than 0.5 MHz. This preliminary experimental study demonstrates that wave propagation characteristics of a lattice structure can be obtained. In particular, the wave speed, the frequency at the maximum amplitude of the output spectrum, and the attenuation of the maximum amplitude of the output spectrum per lattice bay traversed appear to be useful parameters in the characterization of wave propagation properties of LSS. Further study should investigate the effects of boundaries, lattice member connectivities, and structural defects on these parameters. GRA

N86-30680# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ANALYSIS-TEST CORRELATION OF DYNAMIC MATHEMATICAL MODELS
B. CAESAR *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 617-624 1985
(Contract ESTEC-5597/83/NL-PB(SC))
Avail: NTIS HC A99/MF E03

The reasons for correlation of test and analysis results as well as for the mathematical model update process are summarized and related to the total development flow of a spacecraft structure. Correlation methods such as modal scale factor, assurance criteria, and enhanced frequency response functions are reviewed. Berman's method symmetry, and orthogonality conditions with a least squares deviation of updated against previous mass and stiffness matrices is improved by taking into account rigid body masses. The algorithmic approaches are discussed leading to linear least squares problems under equality constraints. Applications of this method based on simulated test data and recommendations for improvements in related modal tests are given. ESA

N86-30682*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEST AND ANALYSIS CORRELATION FOR STRUCTURAL DYNAMIC SYSTEMS
B. K. WADA and J. C. CHEN *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 632-647 1985 Sponsored by NASA
Avail: NTIS HC A99/MF E03 CSCL 01B

Activities in modifying a structural mathematical model to correlate with its modal test results are summarized. Results from the Viking and Galileo spacecraft, and developments in the parameter estimation of structural mathematical models of large flexible structures using multiple boundary condition tests are presented. ESA

N86-30683*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC VERIFICATION OF VERY LARGE SPACE STRUCTURES
B. R. HANKS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 648-655 1985
Avail: NTIS HC A99/MF E03 CSCL 01B

A research program in spacecraft structures, structural dynamics, and controls verification using a relatively large, flexible beam as a focus is introduced. This research effort addresses fundamental problems applicable to the verification of large, flexible space structures and combines ground tests, flight behavior prediction, and instrumented orbital tests. The program is expected to produce quantitative results for use in improving the validity of ground tests for verifying flight performance analyses. ESA

N86-30803# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
CONTROL OF LARGE FLEXIBLE SYSTEMS BY SPATIAL MODAL INPUT-DISTRIBUTION CONTROL M.S. Thesis
C. V. BENDORF 1985 113 p
(AD-A166912; AFIT/CI/NR-86-47T) Avail: NTIS HC A06/MF A01 CSCL 22B

A common problem in controlling a large flexible structure with a reduced order model is the excitation of the residual (non-modeled) modes by the control inputs resulting in control spillover. In this thesis a new approach to eliminate control spillover is examined. This approach, based on the independent modal-space control method, uses a finite number of spatially distributed input points to eliminate control spillover. Control of an undamped beam and a finite degree of freedom truss is accomplished through computer simulation. The results of the seven example problems shows that this new approach does effectively eliminate control spillover. GRA

N86-31336*# Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.
VIBRATION AND STRUCTUREBORNE NOISE IN SPACE STATION Progress Report, 1 Jan. - 30 Jun. 1986
R. VAICAITIS 1986 23 p
(Contract NAG1-541)
(NASA-CR-177146; NAS 1.26:177146) Avail: NTIS HC A02/MF A01 CSCL 20A

Analytical models and computer programs for structural response calculations under action of mechanical point loads were developed for single wall shells (composite or aluminum), double wall shells (composite or aluminum), and single wall or double wall circular plates (aluminum). The design configuration of the habitability modules of the space station concept are expected to be discretely stiffened cylindrical shells with truncated cone type end caps or flat but stiffened circular end plates. Analytical formulations and response calculations were performed for the case where the stiffened shell is represented by an orthotropic shell model. The natural frequencies can be calculated. For application to low frequency (below 1000Hz) vibrations and noise generation, such a model might be adequate to evaluate vibration and noise transmission characteristics of space station habitability modules. Parametric studies are now being performed to assess interior noise environment inside a habitability module to mechanically induced vibrations. B.G.

N86-31434*# Stevens Inst. of Tech., Hoboken, N. J. Dept. of Electrical Engineering.
CSTAR STAR CATALOGUE DEVELOPMENT
J. A. UHDE-LACOVARA *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 14 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 03A

The Continuous Stellar Tracking Attitude Reference (CSTAR) system is an in-house project for the Space Station to provide high accuracy, drift free attitude and angular rate information for the GN&C system. Constraints exist on the star catalogue incorporated in the system. These constraints include the following: mass memory allocated for catalogue storage, star tracker imaging sensitivity, the minimum resolvable separation angle between stars, the width of the field of view of the star tracker, and the desired number of stars to be tracked in a field of view. The Smithsonian Astrophysical Observatory (SAO) catalogue is the basis reference for this study. As it stands, the SAO does not meet the requirements of any of the above constraints. Star selection algorithms have been devised for catalogue optimization. Star distribution statistics have been obtained to aid in the development of these rules. VAX based software has been developed to implement the star selection algorithms. The software is modular and provides a design tool to tailor the catalogue to available star tracker technology. The SAO catalogue has been optimized for the requirements of the present CSTAR system. Author

N86-32511*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALYSIS OF THE EFFECTS OF FIRING ORBITER PRIMARY REACTION CONTROL SYSTEM JETS WITH AN ATTACHED TRUSS STRUCTURE
M. KASZUBOWSKI (PRC Kentron, Inc., Hampton, Va.) and J. P. RANEY Aug. 1986 24 p
(NASA-TM-89031; NAS 1.15:89031) Avail: NTIS HC A02/MF A01 CSCL 22B

A study was conducted to determine the dynamic effects of firing the orbiter primary reaction control jets during assembly of protoflight space station structure. Maximum longeron compressive load was calculated as a function of jet pulse time length, number of jet pulses, and total torque imposed by the reaction control jets. The study shows that it is possible to fire selected jets to achieve a pitch maneuver without causing failure of the attached structure. Author

N86-32512*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
RELIABILITY ISSUES IN ACTIVE CONTROL OF LARGE FLEXIBLE SPACE STRUCTURES Semiannual Status Report, 16 May - 15 Nov. 1985
W. E. VANDERVELDE 4 Feb. 1986 14 p
(Contract NAG1-126)
(NASA-CR-179758; NAS 1.26:179758) Avail: NTIS HC A02/MF A01 CSCL 22B

Efforts in this reporting period were centered on four research tasks: design of failure detection filters for robust performance in the presence of modeling errors, design of generalized parity relations for robust performance in the presence of modeling errors, design of failure sensitive observers using the geometric system theory of Wonham, and computational techniques for evaluation of the performance of control systems with fault tolerance and redundancy management Author

07

POWER

Includes descriptions of analyses, systems, and trade studies of electric power generation, storage, conditioning and distribution.

A86-34973
SPACE STATION POWER SYSTEM TECHNOLOGY ISSUES AND DEVELOPMENT APPROACH
J. M. FRIEFELD, G. J. HALLINAN, and T. H. SPRINGER (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-31 to 7-42.

Two alternatives are under consideration for the NASA Space Station's electrical power system: the photovoltaic and the solar dynamic. The latter promises to reduce collector area by a factor of 3-4. In both cases, the accommodation of high loads and their variability remains a problem in terms not only of voltage level and frequency but also of the power management architecture needed to accommodate requirements. An additional design problem is the approach to electrical energy storage during eclipses in orbit, irrespective of system type. O.C.

A86-34994#
DYNAMIC POWER - A KEY TO THE PROMISE OF SPACE
C. N. HALL and J. P. MULLIN (Sundstrand Corp., Sundstrand Advanced Technology Group, Rockford, IL) Canaveral Council of Technical Societies, Space Congress, 22nd, Cocoa Beach, FL, Apr. 23-26, 1985, Paper. 22 p. refs

The evolution of Rankine cycle power conversion equipment is traced, beginning with early designs of solar dynamic power conversion applications based on a mature terrestrial data base. This development then moves through applications which use various energy sources including radioisotopes and particular types of stored chemical energy. Current equipment designs viable for use on Space Station and possible SDI applications are described and compared with possible alternative solutions. Methods for accommodating growth to much larger power levels using solar power and chemical energy sources as well as nuclear heat sources are also discussed. K.K.

A86-38883*# Martin Marietta Aerospace, Denver, Colo.
HYBRID DEPLOYABLE/ERECTABLE SOLAR DYNAMIC BOX TRUSS SYSTEM
J. V. COYNER, JR. (Martin Marietta Corp., Denver, CO) and T. B. IRVINE (NASA, Lewis Research Center, Cleveland, OH) IN: Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1 . New York, American Institute of Aeronautics and Astronautics, 1986, p. 764-768.
(AIAA PAPER 86-0955)

The design of a hybrid deployable/erectable solar dynamic box truss power generation system for the initial operation capability (IOC) of the Space Shuttle is examined. An organic Rankine cycle heat engine for IOC solar power generation is studied. The design configuration is a simple parabolic concentration where the receiver is located in the focal plane with its aperture at the focal point. The relationship between concentrator size and collection efficiency is analyzed. The geometry of the deployable graphite/epoxy box truss ring and the reflective panels of the system are described. Mass properties and dynamic analyses are performed to evaluate the center of gravity location and moments of inertia characteristics of the energy conversion subsystem (ECS). The deployable/erectable truss is applicable for large IR space telescopes and center and offset fed ECSs. I.F.

A86-39906*# TRW, Inc., Redondo Beach, Calif.
SOLAR DYNAMIC POWER FOR THE SPACE STATION
J. S. ARCHER and E. S. DIAMANT (TRW, Inc., Redondo Beach, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 8 p.
(Contract NAS3-24655)
(AIAA PAPER 86-1299)

This paper describes a computer code which provides a significant advance in the systems analysis capabilities of solar dynamic power modules. While the code can be used to advantage in the preliminary analysis of terrestrial solar dynamic modules its real value lies in the adaptions which make it particularly useful for the conceptualization of optimized power modules for space applications. In particular, as illustrated in the paper, the code can be used to establish optimum values of concentrator diameter, concentrator surface roughness, concentrator rim angle and receiver aperture corresponding to the main heat cycle options - Organic Rankine and Brayton - and for certain receiver design options. The code can also be used to establish system sizing margins to account for the loss of reflectivity in orbit or the seasonal variation of insolation. By the simulation of the interactions among the major components of a solar dynamic module and through simplified formulations of the major thermal-optic-thermodynamic interactions the code adds a powerful, efficient and economic analytical tool to the repertory of techniques available for the design of advanced space power systems. Author

A86-40610#
RECENT ADVANCES IN SOLAR DYNAMIC POWER FOR SPACE
E. F. BINZ, W. J. GROSSKOPF, and G. J. HALLINAN AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 13 p.
(AIAA PAPER 86-1165)

A hybrid power configuration which incorporates all photovoltaic and solar dynamic attributes has been recommended for the Space Station IOC. The approach utilizes a heat receiver that absorbs concentrated sunlight from a parabolic dish and stores the energy in a phase-change material (PCM). Large-scale system tests with PCM in cylindrical canisters within a heat exchanger were performed using a parabolic concentrator to characterize thermodynamic performance in an environment similar to that of LEO. PCM performance revealed that the LEO intermittent sunlight characteristic can be converted to the constant energy stream necessary for dynamic engine operation. K.K.

A86-44459
NASA CHOOSES HYBRID POWER SYSTEM FOR SPACE STATION
D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, June 1986, p. 28-32.

The hybrid solar power system being developed for the Space Station is characterized. Major components of the 75-kW system required for the initial operational phase of the Station are 25-kW photovoltaic arrays (with Ni-H storage batteries for eclipse-phase power and some means of conversion to ac for distribution) and a 50-kW solar dynamic system comprising a reflecting concentrator, a thermal-energy storage unit, and a heat engine based either on an organic Rankine cycle (described by Holt, 1985) or on a closed Brayton cycle. The design and operating principle of a Brayton-cycle engine using an He-Xe mixture as the working fluid, gas-foil journal bearings, an LiF/MgF2 thermal-storage unit, and a 95-percent-effectiveness plate-fin-type recuperator are described and illustrated with drawings. This engine is designed to operate at 25,000-50,000 rpm with overall day/night cycle efficiency 27.6 percent for 95-min orbits, and to be restartable under zero-g conditions. T.K.

A86-46181
POWERING FUTURE SPACE SYSTEMS
R. A. HASLETT (Grumman Corp., Bethpage, NY) Horizons (ISSN 0095-7615), vol. 22, no. 1, 1986, p. 8-13.

An examination is made of candidate power systems for such major NASA spacecraft projects as the Space Station, for which 75-kW initial and 300 kW full development power demand levels have been specified. Attention is given to Space Station temperature control architecture, candidate photovoltaic and solar heat engine systems, the problems of heat transfer and heat rejection, nuclear powerplant miniaturization prospects, and the liquid droplet heat radiator design, which uses microscopic working fluid droplets to radiate heat directly into space and thereby dispenses with hardware. O.C.

A86-46962#
RECENT ADVANCES IN SOLAR DYNAMIC POWER FOR SPACE
E. F. BINZ, W. J. GROSSKOPF, and G. J. HALLINAN (Rockwell International Corp., Canoga Park, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 12 p.
(AIAA PAPER 86-2350)

The development of a hybrid power system for the Space Station is discussed. The hybrid system consists of photovoltaic modules, solar dynamic modules, and power management and distribution subsystems; the design and components of the modules and subsystems are described. The capabilities of closed Brayton cycle (CBC) and organic Rankine cycle (ORC) solar receivers are examined. The behavior of phase-change materials (PCMs) for ORC and CBC is characterized. It is observed that LiOH with a melting point of 471 C is appropriate for an ORC that operates in the 399 C range, and the LiOH which has a heat fusion of 877 kJ/g can be contained with Ni and Ni-Cr alloys. A mixture of CaF2-LiF was selected for CBC which operates at 732 C; the salt mixture has a melting point of 768 C, a heat fusion of 791 kJ/kg, and can be contained with Ni-Cr and Co-base alloys. Large-scale system tests with PCMs in cylindrical canisters were conducted using a parabolic concentrator to evaluate thermodynamic performance in a LEO environment. The data reveal that the PCM can convert the sunlight of LEO to the constant energy stream necessary for dynamic engine operation. I.F.

A86-48206#
OPERATION AND CONTROL OF SPACE-BASED SOLAR ENERGY POWER PLANTS WITH CCGT USING HELIUM AS A WORKING MEDIUM
A. SUTSCH (Institute for Computer-Assisted Research in Astronomy, Alterswil, Switzerland) ASME, International Gas Turbine Conference and Exhibit, 31st, Duesseldorf, West Germany, June 8-12, 1986. 8 p. refs
(ASME PAPER 86-GT-152)

The generation of both electricity and process heat for industrial manufacturing systems aboard a large space station is presently addressed by a solar energy powerplant employing a closed cycle gas turbine that uses helium as its working fluid. Attention is given to the optical properties of the parabolic solar concentrator disk used, as well as to the thermodynamics of the helium cycle and the design features of the turbomachinery used. It is noted that the turbomechanical component of the helium-based system is substantially more compact than that of a steam-based system of comparable output. A 50-MW electrical output and a 60 MW thermal output are projected. O.C.

A86-49555#
EVALUATION OF ALTERNATIVE POWER DISTRIBUTION ARCHITECTURES FOR THE SPACE STATION
A. L. GUNBY, C. H. BAILEY, and J. KAPLAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 14 p.
(AIAA PAPER 86-2305)

Three basic bus architectures were evaluated for the Space Station (SS) Power Management and Distribution System (PMAD): ring bus, radial bus, and backbone. To facilitate comparison, a set of expected loads was assumed and a failure - tolerance criterion was adopted. Key considerations in the evaluation were system weight and ease of fault detection/isolation. The ring bus has a slightly lower system weight (less than 1 percent), while the radial bus configuration has potential advantages for growth, and fault detection and isolation. A modified radial bus architecture was selected for further conceptual design. However, the evaluation of architecture alternatives should continue into preliminary design. Author

A86-49556#
AUTOMATED POWER MANAGEMENT FOR THE SPACE STATION
C. BAILEY, P. OHLER, F. RODRIGUEZ, and J. KAPLAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 20 p.
(AIAA PAPER 86-2306)

A basic structure for the International Space Station data acquisition and control system is presented. From this architecture, a method of implementing an automated power management system is discussed. The use of artificial intelligence techniques as a solution to the power system control problem is introduced, and the software modules are detailed. Author

A86-49561#
ELECTRICAL POWER SYSTEM INTEGRATION FOR THE SPACE STATION
R. HINNRICHS, J. WHITSETT, R. PHILLIPS, W. ALLEN, and J. CECKA (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 14 p. refs
(AIAA PAPER 86-2351)

The design and development of the Space Station electrical power system (EPS), the complexities of which include high electrical power requirements, multiple ac and dc power sources, and diverse loads located throughout a large space structure, are discussed. A series of trade studies conducted to define the baseline EPS architecture and preliminary design implementation are described. An Initial Operating Capabilities power generation system, providing 50 kW of photovoltaic power along with a ring power-distribution architecture, has been baselined. Special attention is given to a hierarchical software/processor which provides monitoring and control functions for the EPS. Multiple block diagrams are included. I.S.

N86-23053# Sandia National Labs., Albuquerque, N. Mex.
DESIGN CONSIDERATIONS FOR LARGE PHOTOVOLTAIC SYSTEMS
G. J. JONES, H. N. POST, J. W. STEVENS, and T. S. KEY 1985 19 p Presented at the 18th IEEE Photovoltaic Specialists Conference, Las Vegas, Nev., 21 Oct. 1985
(Contract DE-AC04-76DP-00789)
(DE86-002125; SAND-85-1189C; CONF-851043-14) Avail: NTIS HC A02/MF A01

The design of large photovoltaic systems has been the subject of many years of system and subsystem research. This research information can now be supplemented with data from numerous operating systems ranging in size from kilowatts to multi megawatts. The compilation of all results verify that the design process for the photovoltaic system is simple. Construction should be based on good engineering practice coupled with PV specific hardware and a few PV specific design guidelines. These guidelines include considerations related to the selection of collector type, hardware specification, array field configuration, and system installation and checkout. This paper presents a discussion of these photovoltaic specific design considerations. DOE

N86-24515*# Tuskegee Inst., Ala. Dept. of Electrical Engineering.
INVESTIGATION OF POTENTIAL DRIVER MODULES AND TRANSMISSION LINES FOR A HIGH FREQUENCY POWER SYSTEM ON THE SPACE STATION
H. T. BRUSH *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 36 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 09C

The objective was to assess the feasibility of using the Series Resonant inverter as the driver module for the high frequency power system on the Space Station. This study evaluates the performance of the Series Resonant driver when it was operated with a dc input voltage and run through a series of tests to determine its start-up performance, response to load changes, load regulation, and efficiency. Also, this study compares the Series Resonant driver to another kind of driver that uses a Power Transistor snubber. An investigation of the various types of transmission lines is initiated. In particular, a simplified approach is utilized to describe the optimal transmission line. Author

N86-24747*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION 20-KHZ POWER MANAGEMENT AND DISTRIBUTION SYSTEM
I. G. HANSEN and G. R. SUNDBERG 1986 11 p refs Presented at the Power Electronics Specialists Conference, Vancouver, Bristish Columbia, 23-27 Jun. 1986; sponsored by Inst. of Electrical and Electronics Engineers
(NASA-TM-87314; E-3045; NAS 1.15:87314) Avail: NTIS HC A02/MF A01 CSCL 22B

During the conceptual design phase a 20-kHz power distribution system was selected as the reference for the space station. The system is single-phase 400 VRMS, with a sinusoidal wave form. The initial user power level will be 75 kW with growth to 300 kW. The high-frequency system selection was based upon considerations of efficiency, weight, safety, ease of control, interface with computers, and ease of paralleling for growth. Each of these aspects will be discussed as well as the associated trade-offs involved. An advanced development program has been instituted to accelerate the maturation of the high-frequency system. Some technical aspects of the advanced development will be discussed. Author

N86-25053# Oak Ridge National Lab., Tenn.
TESTIMONY OF FRED R. MYNATT, ASSOCIATE DIRECTOR FOR NUCLEAR AND ENGINEERING TECHNOLOGIES, OAK RIDGE NATIONAL LABORATORY, BEFORE THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY, US HOUSE OF REPRESENTATIVES
9 Oct. 1985 8 p
(Contract DE-AC05-84OR-21400)
(DE86-002234; DOE/OR-21400/T204) Avail: NTIS HC A02/MF A01

Space nuclear power technology, current activities at Martin Marietta Energy Systems, future directions of research and development, and proposed recommendations are discussed. B.G.

N86-27706* National Aeronautics and Space Administration. Pasadena Office, Calif.
PROTECTIVE TELESCOPING SHIELD FOR SOLAR CONCENTRATOR Patent
M. J. ARGOUD (Jet Propulsion Lab., California Inst. of Tech., Pasadena), W. L. WALKER, and L. V. BUTLER, inventors (to NASA) 6 May 1986 7 p Filed 22 Feb. 1984 Supersedes N84-25164 (22 - 15, p 2361) Sponsored by NASA. Pasadena Office
(NASA-CASE-NPO-16236-1; US-PATENT-4,586,487; US-PATENT-APPL-SN-582495; US-PATENT-CLASS-126-418; US-PATENT-CLASS-126-419; US-PATENT-CLASS-126-438)
Avail: US Patent and Trademark Office CSCL 10A

An apparatus is described for use with a solar concentrator such as a parabolic dish which concentrates sunlight onto a small opening of a solar receiver, for protecting the receiver in the event of a system failure that could cause concentrated sunlight to damage the receiver. The protective apparatus includes a structure which can be moved to a stowed position where it does not block sunlight, to a deployed position. In this position, the structure forms a tube which substantially completely surrounds an axis connecting the receiver opening to the center of the concentrator at locations between the receiver and the concentrator.
Official Gazette of the U.S. Patent and Trademark Office

N86-28122*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A 20 KILOHERTZ SPACE STATION POWER SYSTEM
I. G. HANSEN and F. J. WOLFF 1986 10 p Proposed for presentation at the 19th Annual Electronics and Aerospace Conference, Washington, D.C., 9 Sep. 1986; sponsored by IEEE
(NASA-TM-88801; E-3140; NAS 1.15:88801) Avail: NTIS HC A02/MF A01 CSCL 10B

The space station represents the next major U.S. commitment in space. The efficient delivery of power to multiple user loads is key to that success. In 1969, NASA Lewis Research Center began a series of studies with component and circuit developments that led to the high frequency, bi-directional, four quadrant resonant driven converter. Additional studies and subsequent developments into the early 1980's have shown how the high frequency ac power system could provide overall advantages to many aerospace power systems. Because of its wide versatility, it also has outstanding advantages for the Space Station Program and its wide range of users. High frequency ac power provides higher efficiency, lower cost, and improved safety. The 20 kHz power system has exceptional flexibility, is inherently user friendly, and is compatible with all types of energy sources - photovoltaic, solar dynamic, rotating machines or nuclear. Lewis has recently completed development under contract a 25 kW, 20 kHz ac power distribution system testbed. The testbed demonstrates flexibility, versatility, and transparency to user technology as well as high efficiency, low mass, and reduced volume. Author

N86-31113# Oak Ridge National Lab., Tenn.
DEVELOPMENT OF A SIMULATION CODE FOR A LATENT HEAT THERMAL ENERGY STORAGE SYSTEM IN A SPACE STATION
A. D. SOLOMON, M. D. MORRIS, J. MARTIN, and M. OLSZEWSKI Apr. 1986 48 p
(Contract DE-AC05-84OR-21400)
(DE86-010070; ORNL-6213) Avail: NTIS HC A03/MF A01

A conceptual design of a space station power system based on a Brayton cycle and solar powered has been developed. A key part of such a system is the thermal energy storage module, which is of crucial importance during periods of darkness. We have developed a simulation code for one possible storage configuration. In this report, we describe the considerations entering into the code development, and some results obtained thus far. DOE

N86-31418*# Prairie View Agricultural and Mechanical Coll., Tex. Dept. of Electrical Engineering.
AN IBM PC-BASED MATH MODEL FOR SPACE STATION SOLAR ARRAY SIMULATION
E. M. EMANUEL *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 28 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 10A

This report discusses and documents the design, development, and verification of a microcomputer-based solar cell math model for simulating the Space Station's solar array Initial Operational Capability (IOC) reference configuration. The array model is developed utilizing a linear solar cell dc math model requiring only five input parameters: short circuit current, open circuit voltage, maximum power voltage, maximum power current, and orbit inclination. The accuracy of this model is investigated using actual solar array on orbit electrical data derived from the Solar Array Flight Experiment/Dynamic Augmentation Experiment (SAFE/DAE), conducted during the STS-41D mission. This simulator provides real-time simulated performance data during the steady state portion of the Space Station orbit (i.e., array fully exposed to sunlight). Eclipse to sunlight transients and shadowing effects are not included in the analysis, but are discussed briefly. Integrating the Solar Array Simulator (SAS) into the Power Management and Distribution (PMAD) subsystem is also discussed. Author

N86-31793*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE SOLAR CELL RESEARCH: PROBLEMS AND POTENTIAL
D. J. FLOOD 1986 13 p Presented at the Conference on Photovoltaics for Commercial Solar Power, Cambridge, Mass., 15-19 Sep. 1986; sponsored by the Society of Photo-Optical Instrumentation Engineers
(NASA-TM-88833; E-3212; NAS 1.15:88833) Avail: NTIS HC A02/MF A01 CSCL 10A

The value of a passive, maintenance-free, renewable energy source was apparent in the early days of the space program, and the silicon solar cell was pressed into service. Efficiencies of those early space solar arrays were low, and lifetimes shorter than hoped for, but within a decade significant advances had been made in both areas. Better performance was achieved through improvements in silicon single crystal material, better device designs, and a better understanding of the factors that affect the performance of a solar cell in space. Chief among the latter, particularly for the mid-to-high altitude (HEO) and geosynchronous (GEO) orbits, are the effects of the naturally occurring particulate radiation environment. Although not as broadly important to the photovoltaic community at large as increased efficiency, the topic of radiation damage is critically important to use of solar cells in space, and is a major component of the NASA research program in space photovoltaics. A brief overview of some of the opportunities and challenges for space photovoltaic applications is given, and some of the current research directed at achieving high efficiency and controlling radiation damage in space solar cells is discussed. Author

N86-32507*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SYSTEM IMPACTS OF SOLAR DYNAMIC AND GROWTH POWER SYSTEMS ON SPACE STATION
J. T. FARMER, W. F. CUDDIHY, U. M. LOVELACE, and D. M. BADI Jul. 1986 47 p
(NASA-TM-87667; NAS 1.15:87667) Avail: NTIS HC A03/MF A01 CSCL 22B

Concepts for the 1990's space station envision an initial operational capability with electrical power output requirements of approximately 75 kW and growth power requirements in the range of 300 kW over a period of a few years. Photovoltaic and solar dynamic power generation techniques are contenders for supplying this power to the space station. A study was performed to identify growth power subsystem impacts on other space station subsystems. Subsystem interactions that might suggest early design changes for the space station were emphasized. Quantitative analyses of the effects of power subsystem mass and projected area on space station controllability and reboost requirements were conducted for a range of growth station configurations. Impacts on space station structural dynamics as a function of power subsystem growth were also considered. Author

N86-32520*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ELECTRICAL POWER SYSTEM FOR THE U.S. SPACE STATION
D. L. NORED and G. J. HALLINAN (Rockwell International Corp., Canoga Park, Calif.) 1986 12 p Presented at the 37th Congress of the International Astronautical Federation, Innsbruck, Austria, 4-11 Oct. 1986
(NASA-TM-88856; E-3249; NAS 1.15:88856; IAF-86-37) Avail: NTIS HC A02/MF A01 CSCL 84O

The Space Station Electrical Power System presents many interesting challenges. It will be much larger than previous space power systems, and it must be designed for on-orbit maintenance and replacement, along with having a growth capability. The power generation, energy storage, and power management and distribution (PMAD) subsystems comprise the primary elements of the overall system. Each was analyzed by NASA Lewis Research Center and its two contractors -- Rocketdyne and TRW -- in the definition studies of the program to determine the optimum approach to minimize initial costs and life cycle costs. For the PMAD subsystem, a ring bus architecture operating at 440 V, 20 kHz, single phase, was selected. Photovoltaic and solar dynamic power generation subsystems were both studied. Major tradeoffs were made for each subsystem and for the overall system, and a hybrid system (both photovoltaic and solar dynamic) was selected. Author

N86-32521*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE SPACE STATION POWER SYSTEM
C. R. BARAONA 1986 12 p Presented at the Fifth Conference on Photovoltaic Generators in Space, Noordwijk, Netherlands, 30 Sep. - 4 Oct. 1986; sponsored by ESA
(NASA-TM-88847; E-3237; NAS 1.15:88847) Avail: NTIS HC A02/MF A01 CSCL 22B

The manned space station is the next major NASA program. It presents many challenges to the power system designers. The power system in turn is a major driver on the overall configuration. In this paper, the major requirements and guidelines that affect the station configuration and the power system are explained. The evolution of the space station power system from the NASA program development-feasibility phase through the current preliminary design phase is described. Several early station concepts, both fanciful and feasible, are described and linked to the present concept. The recently completed Phase B trade study selections of photovoltaic system technologies are described in detail. A summary of the present solar dynamic and power management and distribution systems is also given for completeness. Author

09

PROPULSION/FLUID MANAGEMENT

Includes descriptions, analyses, and subsystem requirements for propellant/fluid management and propulsion systems for attitude control and orbit maintenance and transfer for the station and supporting elements such as the OMV and OTV.

A86-32905#
MANAGING FLUIDS IN SPACE
R. N. EBERHARDT and D. A. FESTER (Martin Marietta Corp., Denver, CO) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 23 p. refs

Methods of managing fluids in space for the Space Station, orbit maneuvering vehicles, military systems, and scientific payloads are studied. Fluid management is needed for propulsion, power generation, environmental control and life support, and material processing. The use of dedicated resupply tankers and propellant scavenging from Shuttle tanks to resupply space-based systems is examined. Storable and cryogenic fluid management technologies, such as mass gaging and venting, for liquid storage/supply, thermal control, and fluid transfer/resupply are described. Experimental fluid management test beds are proposed for obtaining low-G technology data. Current and planned fluid management programs are evaluated by performing ground testing, low-G drop tower and aircraft testing, and flight demonstrations. An operational scenario which describes the loading and launch of a resupply tanker, the transfer of fluid to a space-based depot, and the resupply of a space-based user system from a depot is presented. I.F.

A86-32906*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA LEWIS RESEARCH CENTER LOW-GRAVITY FLUID MANAGEMENT TECHNOLOGY PROGRAM
J. C. AYDELOTT, M. J. CARNEY (NASA, Lewis Research Center, Cleveland, OH), and J. I. HOCHSTEIN (Washington, University, St. Louis, MO) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 56 p. Previously announced in STAR as N86-11218. refs

A history of the Lewis Research Center in space fluid management technology program is presented. Current programs which include numerical modeling of fluid systems, heat exchanger/radiator concept studies, and the design of the Cryogenic Fluid Management Facility are discussed. Recent analytical and experimental activities performed to support the Shuttle/Centaur development activity are highlighted. Author

A86-34969
PROPELLANT TRANSPORTATION TO SPACE OPERATIONS
D. A. FESTER (Martin Marietta Corp., Denver, CO) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 6-19 to 6-49.

Large quantities of propellants are needed to support Space Station operations with space-based Orbital Transfer Vehicles. The supply of cryogens for these operations is considered. Two methods are available for supplying propellants from earth. These are by transporting in dedicated tankers or through scavenging unused STS propellant remaining at the end of the mission. Because of the potential cost savings available through scavenging, this approach was evaluated in detail using a variety of mission scenarios, including the use of an aft cargo carrier system. A combination of both scavenging and manifesting propellant as payload provides the best scavenging approach. Dedicated tanker flights would still be needed to supplement the scavenged quantities to meet projected OTV needs over the year 1991 to year 2000 time period evaluated. By employing optimum scavenging, the cost of propellant on orbit can be reduced to about one-third that of dedicated STS tankers along. Author

A86-34972
PROPULSION SYSTEM CONCEPT ASSESSMENT AND TECHNOLOGY REQUIREMENTS FOR SPACE STATION
W. F. RECTOR, III and M. W. HENLEY (General Dynamics Corp., Convair Div., San Diego, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-21 to 7-30.

A development status assessment is presented for the alternative Space Station propulsion systems under consideration, identifying potential advantages and disadvantages of each. An outline is given of an advanced development program for the promising initial operational capability alternative of gaseous hydrogen and oxygen propellants; the advanced development work for such a system could support an early decision for the Space Station design. Maintainability, commonality and growth potential are among the major propulsion system evaluation criteria. O.C.

A86-39875#
LIQUID HYDROGEN PRESSURIZATION, VENTING, AND RESUPPLY IN LOW-G
R. S. RUDLAND, J. P. GILLE, and R. N. EBERHARDT (Martin Marietta Corp., Denver, CO) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 8 p. refs
(AIAA PAPER 86-1251)

A fluid and thermal analysis program has been developed for evaluating cryogenic system storage, thermal control, supply and resupply in a low-gravity space environment. The program models cryogenic fluid system pressurization, chilldown, no-vent fill, and venting. Representative liquid hydrogen tankage predictions are included, considering both gaseous helium and gaseous hydrogen (autogenous) pressurization. The extent of subscale ground test data is discussed as it relates to model correlation and design verification. Author

A86-39877*# Washington Univ., St. Louis, Mo.
EFFECT OF SUBCOOLING ON THE ON-ORBIT PRESSURIZATION RATE OF CRYOGENIC PROPELLANT TANKAGE
J. I. HOCHSTEIN, H.-C. JI (Washington University, St. Louis, MO), and J. C. AYDELOTT (NASA, Lewis Research Center, Cleveland, OH) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 10 p. refs
(Contract NAG3-578)
(AIAA PAPER 86-1253)

The SOLA-ECLIPSE code is being developed to enable prediction of the behavior of cryogenic propellants in spacecraft tankage. A brief description of the formulations used for modeling heat transfer and for determining thermodynamic state is presented. Code performance is verified through comparison to experimental data for the self-pressurization of scale model liquid hydrogen tanks. SOLA-ECLIPSE is used to examine the effect of initial subcooling of the liquid phase on the self-pressurization rate of an on-orbit full scale liquid hydrogen tank typical for a chemical propulsion Orbital Transfer Vehicle. The computational predictions show that even small amounts of subcooling will significantly decrease the self-pressurization rate. Further, if the cooling is provided by a Thermodynamic Vent System, it is concluded that small levels of subcooling will maximize propellant conservation. Author

A86-42608#
NUCLEAR POWERED ION ENGINE ORBIT TRANSFER VEHICLE DESIGN AND OPERATIONAL EFFECTIVENESS
S. P. MAHONEY (USAF, Satellite Test Center, Sunnyvale Air Force Station, CA) and M. M. MEKARU (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1391)

The feasibility and the cost effectiveness for using nuclear powered electric propulsion orbit transfer vehicles (EOTV) to move Block 3 Navstar Global Positioning System (GPS) satellites from low earth orbit (LEO) to a 10,900 nm orbit are determined. The electric propulsion systems considered are present and 1990's technology ion engines using mercury, xenon or argon for a propellant. A systems cost model which combines payload, power source, trajectory, and earth-to-LEO launch parameters with algorithms characterizing the electric propulsion system is used. The least costly systems which had an outbound triptime equal to or less than 90 days are determined. These systems are then compared with the PAM D-II, Centaur-G, and IUS in terms of total deployment costs for 28 GPS satellites launched at a rate of four per year for seven years. The study finds that a reusable EOTV with 37 Xenon ion engines powered by a nuclear reactor can perform the mission for less cost than the chemical systems. Author

A86-42615*# Rockwell International Corp., Canoga Park, Calif.
SPACE STATION PROPULSION TEST BED - A COMPLETE SYSTEM
G. L. BRILEY, A. M. NORMAN (Rockwell International Corp., Rocketdyne Div., Canogo Park, CA), L. JONES, and H. CAMPBELL (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1402)

A test bed was fabricated under NASA/MSFC (Marshall Space Flight Center) Contract NAS8-36418 to demonstrate hydrogen/oxygen propulsion technology readiness for the Initial Operating Conditions Space Station application and for use as a means to test evolving technology for the growth station. This paper describes the test bed and its function. Author

A86-42616*# Technion, Inc., Irvine, Calif.
A 10,000 HOUR LIFE MULTIPROPELLANT ENGINE FOR SPACE STATION APPLICATIONS
T. K. PUGMIRE, G. L. CANN (Technion, Inc., Irvine, CA), B. HECKERT (Rockwell International Corp., Canoga Park, CA), and J. S. SOVEY (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. Research supported by Johnson Matthey, Inc. and Engelhard Corp. refs
(AIAA PAPER 86-1403)

A review of the design background and operating objectives of a multipropellant resistojet is presented. An engine has been designed to operate with carbon dioxide, methane, water, hydrazine decomposition products and hydrogen. Design performance has been constrained to ensure a 10,000-hour life. The engine, constructed primarily of grain stabilized platinum, is to operate at temperatures up to 1400 C. General performance guidelines, design and fabrication methods are reported. Author

A86-42617*# Textron Bell Aerospace Co., Buffalo, N. Y.
A LONG-LIFE 50 LBF H2/O2 THRUSTER FOR SPACE STATION AUXILIARY PROPULSION
J. M. SENNEFF (Bell Aerospace Textron, Buffalo, NY) and G. P. RICHTER (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1404)

In preparation for the development of a manned Space Station, the National Aeronautics and Space Administration (NASA) is conducting a program to develop technology related to on-board Auxiliary Propulsion Systems. To develop the required thruster technology to support the Space Station project, the NASA Lewis Research Center has sponsored a development program based on a unique 'reverse flow' concept where the fuel is injected 'backwards' in the chamber to cool the spherical combustor wall. This combustor was based on previous developments at the 50-lbf, 1000-lbf, and 1500-lbf thrust levels. This paper describes the design and test program carried out to demonstrate a new 50-lbf thruster, the design which was based on this previous technology. Included are the test results for the initial mixture ratio 4 thruster which can operate with uncooled Cres (stainless steel) combustor walls. In addition, the effort to operate a thruster redesigned for operation at a mixture ratio of eight for potential integration with the life support system is described. Author

A86-42618#
LIFE CYCLE COST METHODOLOGY FOR SPACE STATION PROPULSION SYSTEM
C. J. MEISL (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. refs
(AIAA PAPER 86-1405)

A Life Cycle Cost (LCC) model was developed for the space station propulsion system to support the requirement and configuration trade studies. The model was conceived to be flexible in its structure in order to handle the large variations in propulsion concepts with regard to propellants, hardware, space station characteristics and operational support schemes. The model categorizes LCC into four cost segments, i.e., development, production, transportation, and operational support. The methodology is described with regard to model structure, assumptions and ground rules, types of Cost Estimating Relationships (CERs) used, validation, and input/output features. Typical cost analysis results are presented to illustrate the application of the methodology. These cover several propulsion concepts using hydrazine and oxygen/hydrogen as propellants. A comparison is made with previously published cost data by JPL, and the cost differences are explained. The methodology includes cost risk, and a description of the risk approach and the different elements of risk are provided. Author

A86-42640*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE AND ENDURANCE TESTS OF A MULTIPROPELLANT RESISTOJET FOR SPACE STATION AUXILIARY PROPULSION
W. E. MORREN, M. V. WHALEN (NASA, Lewis Research Center, Cleveland, OH), and J. S. SOVEY AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Previously announced in STAR as N86-24748. refs
(AIAA PAPER 86-1435)

This paper presents the results of an effort to demonstrate the technology readiness of a long-life multipropellant resistojet for space station auxiliary propulsion. Experiments were performed to evaluate the compatibility of grain-stabilized platinum tubes at temperatures up to 1400 deg C in environments of CO2, CH4, NH3, H2O, and H2. All samples tested showed extrapolated lifetimes in excess of 10,000 hr based on 10 percent mass loss as end-of-life. However, samples tested in an ammonia atmosphere at 1400 deg C showed severe pitting, which raised concerns about the compatibility of grain-stabilized platinum with ammonia-containing atmospheres. Additional tests showed that reducing the metal temperature to about 900 deg C (+ or - 100 deg C) significantly reduced this adverse effect. Author

A86-42713#
A PROVEN 25-LBF H2/O2 THRUSTER FOR SPACE STATION AUXILIARY PROPULSION
P. J. ROBINSON and S. E. ROSENTHAL (Aerojet TechSystems Co., Sacramento, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1560)

A 25-lbF GO2/GH2 thruster for the Space Station propulsion system has been designed, fabricated and successfully tested under a NASA Lewis Research Center-sponsored technology program. Analytical models have been developed to predict thermal and performance characteristics of the thruster. Although originally designed to operate over a mixture ratio range of 3.0 to 5.0, the thruster has been tested over the range from 2.2 to 8.1. The total accumulated firing time and impulse to date are 22,198 seconds (6.166 hours) and 538,457 lbF-sec, respectively, with the longest steady state burn being 2200 seconds at 7.5 mixture ratio.
Author

A86-42714*# Rockwell International Corp., Canoga Park, Calif.
OXYGEN/HYDROGEN SPACE STATION PROPULSION SYSTEM CONCEPT DEFINITION FOR IOC
J. M. SHOJI, C. J. MEISL, J. F. GLASS, W.-H. TU, S. J. EBERT, S. A. EVANS (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA), L. W. JONES, and H. CAMPBELL (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 23 p. refs
(AIAA PAPER 86-1561)

The potential for the reduction in propulsion system life cycle costs through the use of on-board water electrolysis to generate oxygen and hydrogen propellants, as well as the potential advantages of improved system safety and contamination impact, led to a study to evaluate candidate oxygen-/hydrogen-based propulsion systems. In this study a representative set of propulsion system requirements were compiled and candidate oxygen/hydrogen-based propulsion systems synthesized. These candidate concepts were screened and a systems evaluation was performed on the remaining eight candidate concepts. Detailed system schematics were prepared. Operational design conditions were determined and system weight, volume, energy requirements, and costs were calculated. Evaluation results indicated that the oxygen/hydrogen propulsion systems can provide simple, low cost, and viable systems for the IOC Space Station. Based on these data, a relative concept evaluation was conducted using as selection criteria reliability, safety, cost, technical risk, contamination, operational utility, growth potential, and integration potential. Top ranked candidate systems were recommended to NASA/MSFC for consideration for the IOC Space Station.
Author

A86-42715#
MONOPROPELLANT HYDRAZINE SYSTEMS FOR SPACE STATION APPLICATIONS
H. S. HILLBRATH and J. C. CONCEPCION (Boeing Aerospace Co., Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1562)

Hydrazine systems using catalytic monopropellant decomposition thrusters are attractive candidates for space station propulsion applications. They offer low technical risk, low initial cost and favorable contamination characteristics. The modular configuration seems to offer some advantages in maintainability and safety. Hydrazine toxicity hazards in the space station environment are a principal source of concern. Other systems under evaluation are also attractive, especialy several types of GO2/GH2 systems which have higher initial cost, but lower operating cost due to higher specific impulse. Evaluation of the testing done in this program and others indicates that thruster life time may not be as significant a cost driver as was initialy thought. Testing has confirmed that mixing waste gasses with the hydrazine thruster exhaust products results in substantially more total impulse that would be obtained from the two fluids separately. A self-testing fluid connector has been designed, constructed and tested. Design concepts for a minimum spill disconnect are being developed. Both concepts are applicable to hydrazine and other hazardous fluid system.
Author

A86-42716*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED PROPULSION FOR POLAR-ORBITING AND COORBITING FREE FLYERS
B. A. PALASZEWSKI (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. NASA-supported research. refs
(AIAA PAPER 86-1564)

Advanced propulsion systems for polar-orbiting and coorbiting free flyers were investigated. Resistojet, arcjet, ion, magnetoplasmadynamic and chemical-bipropellant nitrogen tetroxide/monomethyl hydrazine (NTO/MMH) propulsion systems were compared to the baseline free-flyer hydrazine (N2H4)-propulsion-system performance. Advanced resistojet, arcjet, ion, and NTO/MMH propulsion systems enable significant propellant-mass savings over the baseline N2H4-propulsion system. Using free-flyer mission requirements from the Langley Research Center Mission-Data Base, detailed propulsion requirements for over thirty free-flyer missions were analyzed. The Polar-Platform trip-time constraints may preclude using a low-thrust electric-propulsion system. Electric propulsion will, however, allow a significant coorbiter propellant-mass reduction. Frequent servicing and nodal-regression effects on the coorbiting free-flyer's orbit increase the required mission velocity change and propellant mass. For many coorbiter missions high-specific-impulse resistojet-, arcjet- and ion-propulsion systems allow substantial life-cycle propellant-mass savings.
Author

A86-42717#
SPACE STATION PROPULSION SYSTEM COMPUTER MODELING
J. F. GLASS, W.-H. TU, S. J. EBERT, and M. J. ADAMS (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p.
(AIAA PAPER 86-1566)

The task of the selection and the preliminary design of the optimum propulsion system for the Space Station requires the employment of a suitable computerized model. The present study is concerned with such a model, taking into account the design and development of computer codes for the analysis of pressure-fed oxygen/hydrogen propulsion systems, such as might be used on the Space Station. Attractive candidate propulsion systems include bipropellant oxygen/hydrogen systems and monopropellant (warm hydrogen) systems. The computer codes developed provide nonlinear mathematical models of the entire propulsion system. Attention is given to a technical description, a variable-schematic design, an optimizer routine based upon the Box Complex algorithm, a code description and general flow logic, an input data list, propellant properties, performance prediction methodology, resistojet performance prediction, a tankage model, and heat exchanger models.
G.R.

A86-42727#
INTEGRATED STAGE CONCEPT - SYSTEM STUDY RESULTS
G. G. MCPARLAND, D. R. BENNETT, J. W. COON, and N. P. MITTERMEIER (Aerojet Strategic Propulsion Co., Sacramento, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p. Research supported by the Aerojet Strategic Propulsion Independent Research and Development Program and USAF.
(AIAA PAPER 86-1581)

The Integrated Stage Concept (ISC) under development for the Air Force combines two rocket motor stages using common hardware components to increase performance of multistage missile systems. This results in the more efficient use of available

propulsion system volume. In addition, it can result in higher motor reliability and significant reductions in fabrication costs. During the past several years, the application of the ISC to several future systems using component design concepts and materials not previously available has been investigated. Detailed IR&D and contract studies recently completed have identified stage performance improvements approaching 30 percent for volume-limited systems and 15 percent for weight-limited systems. This paper summarizes the results of these system studies. Specific systems that are addressed include: an Advanced Intercontinental Ballistic Missile, an air-launched Boost Glide Vehicle, a Fast Burn Booster, and an Orbital Transfer Vehicle. Finally, the basis for ISC's reduced cost predications and future plans for development are discussed. Author

A86-42743#
ORBITAL CONSUMABLES RESUPPLY REQUIREMENTS IMPACT ON THE EVOLUTION OF OSCRS
D. L. PERRY and R. BEMIS (Rockwell International Corp., Downey, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1603)

Development of the Orbital Spacecraft Consumables Resupply System (OSCRS) is an essential and logical step in the progression of man's utilization of space. Present and future space assets that would benefit from resupply provide specific design-related requirements. These requirements integrated with the role OSCRS will play in the industrialization of space provide an optimized utilitarian vehicle. Specific requirements and their impact on OSCRS design include the potential user resupply requirements and mission scenarios, unique user spacecraft handling needs and other OSCRS uses, and the accompanying integration concerns. These and other elements and their effect on the evolution of an OSCRS design are discussed. The paper closes with a focus on the influence the bipropellant resupply scenario has on the design and development of the generic resupply tanker. Author

A86-42744*# Martin Marietta Aerospace, Denver, Colo.
ORBITAL SPACECRAFT RESUPPLY TECHNOLOGY
R. N. EBERHARDT, T. R. TRACEY (Martin Marietta Corp., Denver, CO), and W. J. BAILEY AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 16 p. refs
(Contract NAS9-17585)
(AIAA PAPER 86-1604)

The resupplying of orbital spacecraft using the Space Shuttle, Orbital Maneuvering Vehicle, Orbital Transfer Vehicle or a depot supply at a Space Station is studied. The governing factor in fluid resupply designs is the system size with respect to fluid resupply quantities. Spacecraft propellant management for tankage via diaphragm or surface tension configurations is examined. The capabilities, operation, and application of adiabatic ullage compression, ullage exchange, vent/fill/repressurize, and drain/vent/no-vent fill/repressurize, which are proposed transfer methods for spacecraft utilizing tankage configurations, are described. Selection of the appropriate resupply method is dependent on the spacecraft design features. Hydrazine adiabatic compression/detonation, liquid-free vapor venting to prevent freezing, and a method for no-vent liquid filling are analyzed. Various procedures for accurate measurements of propellant mass in low gravity are evaluated; a system of flowmeters with a PVT system was selected as the pressurant solubility and quantity gaging technique. Monopropellant and bipropellant orbital spacecraft consumable resupply system tanks which resupply 3000 lb of hydrazine and 7000 lb of MMH/NTO to spacecraft on orbit are presented. I.F.

A86-42799*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA ELECTROTHERMAL AUXILIARY PROPULSION TECHNOLOGY
J. R. STONE (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 19 p. Previously announced in STAR as N86-24749. refs
(AIAA PAPER 86-1703)

Electrothermal auxiliary propulsion systems provide high performance options which can have major mission benefits. There are several electrothermal concepts which offer a range of characteristics and benefits. Resistojets are the highest thrust to power option and are currently operational at mission average values of specific impulse, I sub sp approximately 295 sec. Long life, multipropellant resistojets are being developed for the Space Station, and resistojet technology advancements are being pursued to improve the I sub sp by more than 20 percent for resistojets used in satellite applications. Direct current arcjets have the potential of I sub sp over 400 sec with storable propellants and should provide over 1000 sec with hydrogen. Advanced concepts are being investigated to provide high power density options and possible growth to primary propulsion applications. Broad based experimental and analytical research and technology programs of NASA are summarized and recent significant advances are reviewed. Author

A86-42809#
ANALYSIS AND MODELING OF FLUID TRANSFER IN ORBIT
J. P. GILLE (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1718)

The need for future systems to resupply fluids to vehicles in orbit is clearly defined. Transfer of liquid between tanks is not straight-forward because of the low-g environment. The normal procedure of venting a tank as it is filled is not applicable because of the uncertainty of liquid and gas location. A good alternative is to perform a no-vent transfer. This operation will be more difficult for cryogenic liquids, and the transfer rate is difficult to predict because of a lack of basic information on low-g processes. Two approaches are investigated. The first uses the kinetic transfer energy to promote random mixing within the receiver tank to achieve required heat transfer. The second relies on centrifugal positioning and a fine spray of liquid to achieve the same purpose. The latter approach appears to offer the advantage of being less dependent on low-g mechanisms, and is not restricted by tank size. Author

A86-42831#
EXPANDABLE RESUPPLY FLUID SYSTEM DESIGN ISSUES
F. O. CHANDLER (Rockwell International Corp., Downey, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1758)

Resupply of expendable fluids is an important way to extend the life of today's costly and complex satellites and is required for future space industrialization. Key users of expendables resupply include the Gamma Ray Observatory and Leasecraft. Important elements in the design of resupply systems include the propellant and pressurant transfer-process description and selection (including considerations for heating during resupply) safety and contamination accommodations, spacecraft impact assessments, and any associated advanced development requirements. These design-related issues are discussed as to their importance in fluids resupply. Author

A86-43206
PARAMETRIC DESIGN AND PRELIMINARY MISSION ANALYSIS OF A PROPOSED HYBRID OTV WITH TOS/AMS (TM) SOLID-FUEL BOOSTERS, AND RING-CUSP ION RETURN ENGINES
L. W. MADDOX (USAF, Space Command, Colorado Springs, CO) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 75-92. refs
(AAS PAPER 85-304)

This study addresses the problem of slow transfer time inherent in low-thrust electric propulsion. The study consists of two parts. The first part defines the partially reuseable Hybrid Orbit Transfer Vehicle (HOTV) parametrics. The TOS/AMS system boosts the vehicle from Shuttle or Space Station orbit to operational orbits and the ring-cusp ion system brings payload(s) and vehicle back to low orbit. The second part of the study uses first order dynamics to evaluate the HOTV operating envelope and examines possible missions in earth orbit. Missions found to be feasible with the HOTV include: observe and return, replace, service, retrieve, and satellite rescue. This HOTV is primarily limited to inspection missions at GEO, but still has clear advantages over refuelable liquid-rocket and aerobraked OTVs. Author

A86-46950#
ORBIT MAINTENANCE PROPULSION CANDIDATES FOR SPACE STATION
P. J. KNOWLES (Boeing Aerospace Co., Huntsville, AL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2327)

Attention is given to the screening and selection of propulsion systems for the Space Station as well as to related recommendations. The following candidates were evaluated for minimum cost, safety, reliability, technology readiness, contamination and maintainability: (1) cold gas, (2) storable monopropellants, (3) storable bipropellants, (4) cryogenic bipropellents and (5) thermally augmented systems. The screening process reduced the candidate list to hydrazine (N2Hu), hydrogen/oxygen (O2H2), monomethylhydrazine/nitrogen tetroxide and neon propulsion systems. During the final selection process, where detailed systems and cost were the primary criteria, O2/H2 and N2H4 emerged as the most advantageous propulsion systems. It is noted that an attractive system would use neon on the four module corners for ACS and a fifth dedicated module placed at or near the station center of gravity/pressure; the module with N2H4, O2/H2 and/or waste gas thrusters would be used to do all the reboost propulsion. K.K.

A86-47446*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A GUIDANCE-MOTIVATED SENSITIVITY ANALYSIS OF AN AERO-ASSISTED BOOST VEHICLE
L. W. TAYLOR, C. GRACEY (NASA, Langley Research Center, Hampton, VA), and C. D. ARMSTRONG IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 420-428. refs
(AIAA PAPER 86-2103)

A simple model of an aero-assisted booster is used to examine the contributions of propulsion system type, aerodynamic lift and flight trajectory to the efficiency with which payloads can be placed into low earth orbit. The higher propulsive efficiency of ramjet and scramjet propulsion has the potential of increasing the payload mass ratio significantly. The contributions of turbojet propulsion and aerodynamic lift are less significant. The additional complexity involved in using aerodynamic propulsion and lift requires dealing with a more comprehensive set of design variables than for rocket boosters. The approach taken is to derive a set of sensitivity functions which relate booster performance to the design variables. The problems of optimum mixing of aerodynamic lift with thrust and determining the optimal boost trajectory is treated. The potential payload capacity of a horizontal take-off air-breathing boost vehicle is examined. The optimization problem which considers propulsive efficiency, aerodynamic configuration, and control and guidance issues is discussed. Author

A86-47969#
A DESIGN FOR FLUID MANAGEMENT IN SPACE
N. E. SEARBY AIAA Student Journal (ISSN 0001-1460), vol. 23, Winter 1986, p. 6-9, 15. refs

Liquid-gas degassification, solid-liquid-gas separation, and algae growth, separation and harvesting are the problems primarily addressed by the present low energy system for fluids management in space conditions. The system incorporates a centrifugal approach in which a divergent, truncated conical spinning separation chamber is coupled with density-dependent valving. The degassification of fluids and separation of multiphased media are achieved while the pumping pressures required for the movement of the separated media to storage areas are generated. O.C.

A86-49553*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FLUID MANAGEMENT AND ITS ROLE IN THE FUTURE OF SPACE STATION
J. SALZMAN, R. VERNON, M. HILL, and T. PETERSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 14 p. refs
(AIAA PAPER 86-2301)

Technological challenges and suggested plans for meeting them pertaining to fluid management in the Space Station are discussed. A short overview is given of the major Space Station systems and operations which employ or rely on fluid management, followed by a description of the general system issues and challenges encountered in managing fluids in space. Examples of some current and near term activities directed toward providing the understanding and technologies necessary to overcome relevant problems are presented. Finally, suggested plans for similar but longer range research and development activities are offered. These plans emphasize the requirements and benefits of expanded in-space experiments, with the ultimate aim of using the Space Station as a facility for fluid management research and technology development efforts. C.D.

N86-24746*# Martin Marietta Aerospace, Denver, Colo.
ADVANCED ORBIT TRANSFER VEHICLE PROPULSION SYSTEM STUDY Final Report
J. A. CATHCART, T. W. COOPER, R. M. CORRINGRATO, S. T. CRONAU, S. C. FORGIE, M. J. HARDER, J. G. MCALLISTER, T. J. RUDMAN, V. W. STONEBACK et al. Feb. 1985 174 p refs
(Contract NAS3-23858)
(NASA-CR-174843; NAS 1.26:174843) Avail: NTIS HC A08/MF A01 CSCL 21H

A reuseable orbit transfer vehicle concept was defined and subsequent recommendations for the design criteria of an advanced LO2/LH2 engine were presented. The major characteristics of the vehicle preliminary design include a low lift to drag aerocapture capability, main propulsion system failure criteria of fail operational/fail safe, and either two main engines with an attitude control system for backup or three main engines to meet the failure criteria. A maintenance and servicing approach was also established for the advanced vehicle and engine concepts. Design tradeoff study conclusions were based on the consideration of reliability, performance, life cycle costs, and mission flexibility. B.G.

N86-24748*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE AND ENDURANCE TESTS OF A MULTIPROPELLANT RESISTOJET FOR SPACE STATION AUXILIARY PROPULSION
W. E. MORREN, M. V. WHALEN, and J. S. SOVEY 1986 19 p refs Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; sponsored by AIAA, ASME, SAE, and ASEE
(NASA-TM-87278; E-2981; NAS 1.15:87278) Avail: NTIS HC A02/MF A01 CSCL 21H

This paper presents the results of an effort to demonstrate the technology readiness of a long-life multipropellant resistojet for space station auxiliary propulsion. Experiments were performed to evaluate the compatibility of grain-stabilized platinum tubes at temperatures up to 1400 deg C in environments of CO2, CH4, NH3, H2O, and H2. All samples tested showed extrapolated lifetimes in excess of 10,000 hr based on 10 percent mass loss as end-of-life. However, samples tested in an ammonia atmosphere at 1400 deg C showed severe pitting, which raised concerns about the compatibility of grain-stabilized platinum with ammonia-containing atmospheres. Additional tests showed that reducing the metal temperature to about 900 deg C (+ or − 100 deg C) significantly reduced this adverse effect. Author

N86-24749*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
NASA ELECTROTHERMAL AUXILIARY PROPULSION TECHNOLOGY
J. R. STONE 1986 26 p refs Presented at the 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986; sponsored by AIAA, ASME, SAE and ASEE
(NASA-TM-87281; E-2986; NAS 1.15:87281; AIAA-86-1703)
Avail: NTIS HC A02/MF A01 CSCL 21H

Electrothermal auxiliary propulsion systems provide high performance options which can have major mission benefits. There are several electrothermal concepts which offer a range of characteristics and benefits. Resistojets are the highest thrust to power option and are currently operational at mission average values of specific impulse, I sub sp approximately 295 sec. Long life, multipropellant resistojets are being developed for the space station, and resistojet technology advancements are being pursued to improve the I sub sp by more than 20 percent for resistojets used in satellite applications. Direct current arcjets have the potential of I sub sp over 400 sec with storable propellants and should provide over 1000 sec with hydrogen. Advanced concepts are being investigated to provide high power density options and possible growth to primary propulsion applications. Broad based experimental and analytical research and technology programs of NASA are summarized and recent significant advances are reviewed. Author

N86-26358*# Evansville Univ., Ind. Dept. of Physics.
THEORETICAL STUDY ON THE EFFECT OF THE DESIGN OF SMALL (MILLI-NEWTON) THRUSTER JETS ON MOLECULAR CONTAMINATION FOR THE SPACE STATION Final Report, 15 Nov. 1985 - 30 Jun. 1986
B. R. RILEY 1986 44 p refs
(Contract NAG3-674)
(NASA-CR-177263; NAS 1.26:177263) Avail: NTIS HC A03/MF A01 CSCL 22B

The self-induced molecular contamination around the space station could have adverse effects on space station components (for example solar panels) as well as scientific experiments that might be done on or near the space station. Aerospace engineers need to design a space station (SS) propulsion system that keeps the SS in a stable orbit and at the same time does not allow the propellant gases to interfere with the experiments of the user. One scenario that might accomplish the above requirements is to use an electrothermal propulsion system, resistojet, that will thrust continuously in the hundreds of milli-Newton range which will provide a constant altitude for the SS with a low g environment. As a first attempt to understand the contamination from such a propulsion system, a point source model was developed. The numerical results of the point source model are given. Number column densities for CO2 are presented as a function of direction of observation (line of sight), temperature of the exit gas, and mean exit velocity. All the results are for a constant exhaust rate of 5,000 kg/year. In addition, a mathematical model to study the effect of nozzle design on the induced molecular environment around the space station produced by simple gas propellants is described. The mathematical model would allow one to follow the expansion of the gas from the throat of a nozzle to the nozzle exit plane and then into the space external to the nozzle. M.G.

N86-28417*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
US GRAVITY UTILIZATION OF TETHERS ACTIVITY
K. KROLL *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 223-238 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The feasibility, requirements, and limitations of fluid transfer on a tethered system is evaluated. The study is conducted to simplify fluid transfer and to improve safety. The effects of gravity on these factors is also noted. Tether orbital refueling is used to settle fluid and to overcome the surface tension forces that are in space with the gravity level. It also allows a separation, when on the space station, from contamination and also from explosion hazards. Once the cryogenic propellant is settled the most important thing is the fluid slosh. Future plans of a gravity laboratory and a demonstration of gravity utilization using a TSS type of deployer are considered. E.R.

N86-31647*# Rockwell International Corp., Canoga Park, Calif. Propulsion Programs.
SPACE STATION PROPULSION TECHNOLOGY Annual Progress Report, 24 May 1985 - 23 May 1986
G. L. BRILEY 1986 92 p
(Contract NAS8-36418)
(NASA-CR-178897; NAS 1.26:178897; RI/RD86-226; REPT-0737P-105-; APR-1) Avail: NTIS HC A05/MF A01 CSCL 21H

The progress on the Space Station Propulsion Technology Program is described. The objectives are to provide a demonstration of hydrogen/oxygen propulsion technology readiness for the Initial Operating Capability (IOC) space station application, specifically gaseous hydrogen/oxygen and warm hydrogen thruster concepts, and to establish a means for evolving from the IOC space station propulsion to that required to support and interface with advanced station functions. The evaluation of concepts was completed. The accumulator module of the test bed was completed and, with the microprocessor controller, delivered to NASA-MSFC. An oxygen/hydrogen thruster was modified for use with the test bed and successfully tested at mixture ratios from 4:1 to 8:1. B.G.

N86-32522*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PROVEN, LONG-LIFE HYDROGEN/OXYGEN THRUST CHAMBERS FOR SPACE STATION PROPULSION
G. P. RICHTER and H. G. PRICE 1986 20 p Presented at the 1986 JANNAF Propulsion Meeting, New Orleans, La., 26-28 Aug. 1986; sponsored by JANNAF Interagency Propulsion Committee
(NASA-TM-88822; E-3171; NAS 1.15:88822) Avail: NTIS HC A02/MF A01 CSCL 21H

The development of the manned space station has necessitated the development of technology related to an onboard auxiliary propulsion system (APS) required to provide for various space station attitude control, orbit positioning, and docking maneuvers. A key component of this onboard APS is the thrust chamber design. To develop the required thrust chamber technology to support the Space Station Program, the NASA Lewis Research Center has sponsored development programs under contracts with Aerojet TechSystems Company and with Bell Aerospace Textron Division of Textron, Inc. During the NASA Lewis sponsored program

with Aerojet TechSystems, a 25 lb sub f hydrogen/oxygen thruster has been developed and proven as a viable candidate to meet the needs of the Space Station Program. Likewise, during the development program with Bell Aerospace, a 50 lb sub f hydrogen/oxygen Thrust Chamber has been developed and has demonstrated reliable, long-life expectancy at anticipated space station operating conditions. Both these thrust chambers were based on design criteria developed in previous thruster programs and successfully verified in experimental test programs. Extensive thermal analyses and models were used to design the thrusters to achieve total impulse goals of 2 x 10 to the 6th power lb sub f-sec. Test data for each thruster will be compared to the analytical predictions for the performance and heat transfer characteristics. Also, the results of thrust chamber life verification tests will be presented. Author

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MECHANISMS, AUTOMATION, AND ARTIFICIAL INTELLIGENCE

Includes descriptions of simulations, models, analytical techniques, and requirements for remote, automated and robotic mechanical systems.

A86-32538*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ARTIFICIAL INTELLIGENCE - NASA
J. D. ERICKSON (NASA, Johnson Space Center, Houston, TX) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 145-150. refs

Artificial Intelligence (AI) represents a vital common space support element needed to enable the civil space program and commercial space program to perform their missions successfully. It is pointed out that advances in AI stimulated by the Space Station Program could benefit the U.S. in many ways. A fundamental challenge for the civil space program is to meet the needs of the customers and users of space with facilities enabling maximum productivity and having low start-up costs, and low annual operating costs. An effective way to meet this challenge may involve a man-machine system in which artificial intelligence, robotics, and advanced automation are integrated into high reliability organizations. Attention is given to the benefits, NASA strategy for AI, candidate space station systems, the Space Station as a stepping stone, and the commercialization of space. G.R.

A86-34957
ADVANCED MANIPULATOR SYSTEM ARCHITECTURAL REQUIREMENTS FOR SPACE STATION
P. KUMAR and S. SACHDEV (Spar Aerospace, Ltd., Remote Manipulator Systems Div., Toronto, Canada) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 2-1 to 2-8.

Remote manipulator systems must be governed by concepts and requirements related to maintainability and autonomy for indefinite life. It is required that these systems provide operational autonomy resulting in operations independent of ground and machine autonomy resulting in routine tasks being performed by automated and expert system features. Moreover, these systems must be space maintainable. These requirements embody the lower tier requirements of automation, reliability, safety, fault tolerancing and artificial intelligence features. The requirement for manipulator mobility is discussed, and a Space Station era manipulator system is presented with function-allocation to various levels of control hierarchy and constituents of a system data base. K.K.

A86-34971
EVOLUTIONARY PATHS FOR ARTIFICIAL INTELLIGENCE TECHNOLOGIES IN OPERATOR INTERACTIONS WITH SPACE STATION ROBOTS
R. A. HAMMOND, D. C. DORROUGH (Boeing Computer Services Co., Bellevue, WA), and D. P. MEYER (Boeing Aerospace Co., Seattle, WA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 7-14 to 7-20.

Two paths have been proposed for the evolution of technologies supporting human interfacing with robots aboard the NASA Space Station: (1) the use of teleoperators (so that human operators are in the control loop as the robot operates) followed by the adoption of autonomous robotics, as the technology advances; and (2) the use of fully independent robots from the outset, but using simple task menus until more autonomous robotic technology is developed. Attention is given to the relative merits of each approach in the illustrative case of EVA robots for routine station keeping tasks. The route of essential robot autonomy is concluded to provide the better EVA system. O.C.

A86-37047*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE TELEROBOTICS - A FEW MORE HURDLES
J. E. PENNINGTON (NASA, Langley Research Center, Hampton, VA) IEEE, International Conference on Robotics and Automation, San Francisco, CA, Apr. 8-10, 1986, Paper. 5 p. refs

In the early 1990's, a telerobotic work system which can be used with the Mobile Remote Manipulator System (MRMS) on the Space Station is to become available. However, a number of difficulties have to be overcome before these plans can be realized. The word 'telerobotics' is used in connection with a system which can function as teleoperator, and which, in addition, has also autonomous functions. Thus, as a robot, the system would automatically perform selected operations using multisensory internal feedback for control. A role for telerobotics is defined, taking into account EVA servicing and repair work, remote satellite refueling, and operations during the Space Station development period. Attention is also given to the definition of a telerobotic system, the definition of the telerobotics technology set, and approaches related to the development of a telerobotic system. G.R.

A86-40508
RECENT ADVANCES IN TELEOPERATION - IMPLICATIONS FOR THE SPACE STATION
M. M. CLARKE (Rockwell International Corp., Downey, CA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 4-1 to 4-10. refs

The paper describes recent advances in teleoperation in nonaerospace hostile environments and discusses their applicability to space-related teleoperation. For example, remotely maintainable manipulators can increase system availability while continuing to exclude the crew from the hostile environment. Force reflection and supervisory control can reduce the operator's fatigue and workload. The Universal Master Controller can increase the system control flexibility. Author

A86-40509
ROBOTIC NONDESTRUCTIVE INSPECTION OF AEROSPACE STRUCTURES
G. L. WORKMAN and W. TEOH (Alabama, University, Huntsville) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 4-11 to 4-24.

Nondestructive inspection of critical components and systems used in aerospace structures requires that the inspection system provide a consistent scanning capability to determine structural integrity in a timely and cost-effective manner. The scanning system may be single-ended, as in pulse echo electronics or eddy currents, or double-ended as in through transmission ultrasonics or X-ray

applications. Many of the scanning systems developed in the past for automated nondestructive inspection of large structures such as aircraft wings or fuselages usually are designed specifically for that application and can be very expensive. There is no built-in flexibility for scanning other types of structures; hence there is a need for general purpose scanning systems which use the industrial robot as a programmable scanning device. Author

A86-40586#
AN ARTIFICIAL INTELLIGENCE APPROACH TO COORDINATED FAULT DIAGNOSIS, CONTROL AND PLANNING FOR THE SPACE STATION ELECTRICAL POWER SYSTEM
T. L. ADAMS, G. L. ORR, and C. J. TOLLANDER (Advanced Decision Systems, Mountain View, CA) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 69-78. Research supported by the Boeing Aerospace Corp. refs
(AIAA PAPER 86-1176)

A model-based reasoning approach is utilized for detecting and diagnosing faults in a spacecraft electrical power system. The approach is based on a domain independent inference engine that employs constraint propagation to interpret the sensor data and circuit models that are expressed as constraints. The continuous-state and discrete-state variables, and the instantiation of the other components are examined. The five modules of the inference engine, which are a truth maintenance system, constraint propagation machinery, a constraint evaluation code, a hypothesization mechanism, and a prediction mechanism, are described. The knowledge sources of the prototype electrical power system are discussed and the prototype is applied to a circuit analysis and diagnosis problem. It is noted that artificial intelligence techniques enhance the performance of mixed-initiative diagnosis and control systems. I.F.

A86-41000
EVALUATING SPACE STATION APPLICATIONS OF AUTOMATION AND ROBOTICS
J. F. BARD (Texas, University, Austin) IEEE Transactions on Engineering Management (ISSN 0018-9391), vol. EM-33, May 1986, p. 102-111. refs

A methodology is presented which can be used to evaluate and rank different approaches to the automation of functions and tasks planned for the NASA Space Station, giving attention to the impact of advanced automation on human productivity. The Analytic Hierarchy Process employed by the methodology allows the introduction of individual judgment to resolve the conflict that arises when incomparable criteria underlie the selection process. The problem is decomposed into simpler subproblems that focus on human productivity, economics, design, and operations. The results from each are then combined to yield final rankings. The selection of an on-orbit assembly system is treated as an illustrative example that encompasses five possible alternatives, yielding computation results and their implications. O.C.

A86-43884
STATE OF THE ART IN INTELLIGENT/BRILLIANT ROBOTS
R. HONG (Grumman Aerospace Corp., Bethpage, NY) IN: AUTOTESTCON '85; Proceedings of the International Automatic Testing Conference, Uniondale, NY, October 22-24, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 75-80. refs

The state of the art of intelligent/brilliant robots of various types which will be in operation in the next decades is addressed. These are robots which will possess human-like capabilities and beyond. As such, they will generally be implemented with artificial intelligence technology such as knowledge based/expert systems. Learning and self adaptive capabilities are also being applied to these future robots. Author

A86-46385* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
OPTICAL PROCESSING AND SPACE STATION AUTOMATION
D. J. ENNIS (NASA, Ames Research Center, Moffett Field, CA) and D. A. JARED (Sterling Software, Palo Alto, CA) Optical Engineering (ISSN 0091-3286), vol. 25, July 1986, p. 808-820. refs

Optical information processing research aimed at Space Station automation applications is reviewed. The emphasis of the NASA Ames Research Center program is on intelligent optical pattern recognition and optical control processing. Attention is given to the primary functions of an overall scene understanding system: distortion-invariant optical feature generation, dimensionality reduction, object classification, and contextual information processing. A method of using synthetic discriminant functions to facilitate learning in a high-speed optical correlator is described. A discussion is presented of candidate analog and digital architectures for the optical implementation of state-estimation algorithms needed for the control of high-dimension dynamic systems. The multivariate system chosen for the optical control technology demonstration - a segmented, adaptive mirror and interferometrically based wavefront sensor - is also described. Author

A86-46390*
MICROCOMPUTER-BASED PROGRAMMABLE OPTICAL SIGNAL PROCESSOR
F. T. S. YU, M. F. CAO (Pennsylvania State University, University Park), and J. E. LUDMAN (USAF, Rome Air Development Center, Bedford, MA) Optical Engineering (ISSN 0091-3286), vol. 25, July 1986, p. 846-852. refs
(Contract F19628-84-K-0031)

A microcomputer-based real-time programmable optical signal processing system utilizing a magneto-optic spatial light modulator (MOSLM) and a liquid crystal light valve (LCLV) is described. This system can perform a myriad of complicated optical operations, such as image correlation, image subtraction, and matrix multiplication. Its important asserts are its programmability and the capability of real-time addressing. These are important for telerobotic vision in space automation applications. Design specifications and suggestions for practical implementation of the system are discussed. Some preliminary experimental demonstrations are conducted to demonstrate applications of the proposed system to image correlation for optical pattern recognition, image subtraction for IC chip inspection, and matrix multiplication for optical computing. Author

A86-46391* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REAL-TIME OPTICAL ASSOCIATIVE RETRIEVAL TECHNIQUE
H.-K. LIU (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), S. Y. KUNG (Southern California, University, Los Angeles, CA), and J. A. DAVIS (San Diego State University, CA) Optical Engineering (ISSN 0091-3286), vol. 25, July 1986, p. 853-856. NASA-Army-supported research. refs

A real-time optical associative retrieval technique is presented. The associative retrieval model enables a large amount of data to be stored and recalled by partial information optically in real time. The real-time capability is achieved by using an electronically addressed spatial light modulator based on the pocket-size liquid crystal display television. The potential application of the technique to the perceptive vision requirements in telerobotics for achieving NASA's goals of automation in space is described. Author

A86-46944#
IMPACT OF AUTOMATION ON SPACE STATION MMI DESIGN
P. G. JAMAR (Honeywell Systems and Research Center, Minneapolis, MN) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 5 p. refs
(AIAA PAPER 86-2316)

Space-based crews are expected to interact with highly automated and possibly intelligent systems, to perform these interactions with often little or no prior training, and to do so on

an infrequent or sporadic basis. These activities will characterize a new role for space-based crews, that of supervisory control. Supervisory control tasks in turn define a new set of requirements for Space Station man-machine interface (MMI) design: (1) multi-function display and control hardware, (2) displays that enhance the crew person's 'mental model' of invisible processes, (3) highly supportive man-machine dialogue, including special features to support dialogue with expert systems, and (4) incorporation of machine intelligence into the MMI itself to provide a seemingly uniform interface to numerous processes, data bases, and expert systems. A discussion of these concepts is illustrated by examples from recent MMI designs, including a multi-function display and control system developed for the Space Shuttle, and MMI system developed for NASA JSC for the Space Station environmental control and life support system, and ATOZ - an intelligent interface system. Author

A86-46945*# Boeing Aerospace Co., Huntsville, Ala.
ADVANCED OPERATOR/SYSTEM INTERFACE CONCEPTS FOR THE SPACE STATION
C. M. CASE and P. S. Y. LIN (Boeing Aerospace Co., Huntsville, AL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p.
(Contract NAS8-36526)
(AIAA PAPER 86-2317)

Concepts and data developed as part of the Preliminary Space Station Automation and Robotics Plan are reviewed as well as candidate selection criteria, technology assessments, and preliminary candidate recommendations. A need for development of advanced operator/systems interface (OSI) concepts to support future Space Station automation and robotics applications is identified. Four candidate applications, illustrating the potential benefits of an advanced OSI, are described. These include: (1) a conversational OSI system, (2) a laboratory experiment manipulator system, (3) a module safety advisor, and (4) an integrated maintenance/training system. These specific automation and robotics applications are expected to occur relatively early in the growth of the Space Station and to provide significant commercial and station benefits throughout the life of the station. Author

A86-47048#
AI APPLICATIONS FOR THE SPACE STATION PROGRAM - TECHNOLOGY, DESIGN AND INTEGRATION CHALLENGES
T. M. COOK (Martin Marietta Aerospace, Denver, CO) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 4 p. refs
(AIAA PAPER 86-2315)

Initial and growth configurations of the Space Station strongly suggest that advanced command, control and information management techniques and technologies will be required for both ground and on-board functions. Such advanced technologies are expected to significantly increase crew productivity, reduce long-term support and maintenance costs, and facilitate the transfer of such technologies to the general economy. The area of artificial intelligence offers considerable promise for achieving many of these important national and international goals. This paper addresses some of the most important issues associated with incorporating artificial intelligence into the design of the Space Station, and the integration of such technologies with more traditional automation approaches. Specificially, the following challenges are discussed: (1) technology readiness, (2) function allocation/implementation criteria, (3) knowledge transfer from man to machine (knowledge engineering), and (4) test, verification and validation methods. Author

A86-47404#
EXPERIMENTS ON THE END-POINT CONTROL OF A TWO-LINK ROBOT WITH ELASTIC DRIVES
M. G. HOLLARS and R. H. CANNON, JR. (Stanford University, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 19-27. refs
(Contract F49620-82-C-0092)
(AIAA PAPER 86-1977)

This paper discusses the use of end-point feedback to improve the position control performance of manipulators that have lumped sources of flexibility within the drive trains or joints. The links are assumed to be rigid. Four different control strategies are discussed and compared. Classical control using only position and rate sensors colocated at the motors gives limited performance and poor rejection of disturbances at the end-effector. Linear-Quadratic-Regulator full-state feedback with end-point position and rate sensing dramatically improves performance and disturbance rejection, but only for a certain class of trajectories in which linearized models are effective. Robust controllers designed for larger regions of motion improve the average performance of the manipulator but at the cost of specific performance. None of the above three constant-gain controllers performs well for a large class of desired trajectories in which the non-linear dynamics dominate. Non-linear computed-torque methods offer better performance for these cases. An experimental two-link manipulator has been constructed and experimental verification of these control strategies is in progress. Author

A86-47440*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN FOR A GOAL-ORIENTED TELEROBOTIC SYSTEM
R. W. WILL and N. O. SLIWA (NASA, Langley Research Center, Hampton, VA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 357-363. refs
(AIAA PAPER 86-2090)

Robotic systems will play an increasingly important role in space operations. This paper describes the objective and design of a proposed goal-oriented telerobotic system for space operations. This design effort encompasses the elements of the system executive and user interface, and the distribution and general structure of the knowledge bases, the displays, and the task sequencing. The objective of the design effort is to provide an evolutionary structure for a telerobotic system, i.e., one that can progress from strictly teleoperated through phases of serving as an assistant, a colleague, and an expert, to eventually serve as a truly autonomous unit, requiring only minimal supervision. A preliminary design for such a system involving 'mixed initiative', or the flexible shared control between the human operator and the software system, is complete and described in this paper. Author

A86-47467#
ON-ORBIT MANIPULATORS - SENSORY AND CONTROL APPROACHES
J. MCLAUGHLIN, B. STAUNTON, and L. WARD (Aerospace Corp., El Segundo, CA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 591-598. Research supported by the Aerospace Corp. refs
(AIAA PAPER 86-2185)

This paper presents an overview of ongoing research, describing work on some control issues relevant to space applications of robotics and teleoperation. Problems in manipulator path tracking, absolute position control, and link flexibility are addressed. A hardware experiment demonstrates the application of modern control design to trajectory control of a manipulator with nonlinear dynamics. Work on camera modeling and the use of computer vision and estimation in closed-loop position control is detailed. A

two link, flexible manipulator is modeled and a linearization approach to controlling end-effector oscillations is simulated.
Author

A86-47468#
A LABORATORY ROBOT FOR SPACE APPLICATION RESEARCH
H. FLASHNER, G. SHIFLETT (Southern California, University, Los Angeles), Y. GUO, and V. SPECTOR IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 599-607.
(AIAA PAPER 86-2186)
This paper discusses the development of the USC manipulator system, designed specifically for test and verification of control algorithms for space based robot applications. The robot features a simple but well defined mechanical configuration with modular components. Various dynamic characteristics can be easily modified allowing evaluation of their influence on system performance. A hybrid approach using digital and analog controllers was taken for the electromechanical design. Author

A86-47469#
AN ADAPTIVE VISION-BASED MANIPULATOR CONTROL SCHEME
S. B. SKAAR, W. H. BROCKMAN (Iowa State University of Science and Technology, Ames), and R. HANSON IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 608-614. refs
(Contract NSF MEA-83-18867)
(AIAA PAPER 86-2187)
A control strategy for manipulation of objects in space or under water is discussed and early experimental results for this strategy are reported. The strategy involves determining the relationship between servoable manipulator joint coordinates and the camera-space location of 'manipulatable' cues. If, due to camera motion of motion of the objects, the cues that are placed on the object of interest are nonstationary in camera space, the strategy uses models to predict the camera-space trajectories. A camera-space trajectory plan for the cues is then developed which is compatible with the limitations of the physical system and that results in the desired camera-space cue configurations. C.D.

A86-49552*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AUTOMATION AND ROBOTICS FOR SPACE STATION IN THE TWENTY-FIRST CENTURY
K. F. WILLSHIRE (NASA, Langley Research Center, Hampton, VA) and D. L. PIVIROTTO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 7 p. refs
(AIAA PAPER 86-2300)
Space Station telerobotics will evolve beyond the initial capability into a smarter and more capable system as we enter the twenty-first century. Current technology programs including several proposed ground and flight experiments to enable development of this system are described. Advancements in the areas of machine vision, smart sensors, advanced control architecture, manipulator joint design, end effector design, and artificial intelligence will provide increasingly more autonomous telerobotic systems. Author

N86-25791* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LATCHING MECHANISM FOR DEPLOYABLE/RE-STOWABLE COLUMNS USEFUL IN SATELLITE CONSTRUCTION Patent
E. L. AHL, JR., inventor (to NASA) 6 May 1986 11 p Filed 2 May 1984 Supersedes N84-25063 Sponsored by NASA
(NASA-CASE-LAR-13169-1; US-PATENT-4,587,526; US-PATENT-APPL-SN-606431; US-PATENT-CLASS-343-883; US-PATENT-CLASS-343-DIG.2; US-PATENT-CLASS-52-110)
Avail: US Patent and Trademark Office CSCL 13I
A column longeron latch assembly provides the securing mechanism for the deployable, telescoping column of a hoop/column antenna. The column is an open lattice structure with three longerons disposed 120 deg apart as the principle load bearing member. The column is deployed from a pair of eleven nested bays disposed on opposite sides of a center section under the influence of a motor-cable-pulley system. The longeron latch is a four bar linkage mechanism using the over-center principle for automatically locking the longeron sections into position during deployment. The latch is unlocked when the antenna is to be restowed. A spring pack disposed in the end of each longeron serves to absorb stress forces on the deployed column through the cam head piston and abutting latch from an adjacent longeron.
Official Gazette of the U.S. Patent and Trademark Office

N86-27388# Sener, S.A., Madrid (Spain).
A SENER LATCH DESIGN FOR DOCKING MECHANISMS
F. ABARRATEGUI, M. FUENTES, J. RIVACOBA, and J. A. ROS *In* ESA Second European Space Mechanisms and Tribology Symposium p 233-238 Dec. 1985
(Contract ESA-5195/82-NL-BI)
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)
Latch mechanisms were designed for the docking of two spacecrafts at relatively short distances and with small relative velocity between them. The mechanism mounted on one of the spacecrafts has to receive the passive element of the other, guide it, dissipate as much as possible the small relative kinetic energy, stop it, bring it to the final rest position, and rigidize the interface between both spacecraft. The mechanism elements necessary to carry out this task and the operation of the latch in the process of docking and undocking are explained. A model of the latch was built and tested in a bidimensional air bearing set-up. ESA

N86-27398*# General Electric Co., Philadelphia, Pa. Space Systems Div.
SPACE STATION AUTOMATION STUDY: AUTOMATION REQURIEMENTS DERIVED FROM SPACE MANUFACTURING CONCEPTS,VOLUME 2 Final Report
27 Nov. 1984 125 p
(Contract NAS5-25182)
(NASA-CR-177862-VOL-2; NAS 1.26:177862-VOL-2) Avail: NTIS HC A06/MF A01 CSCL 22B
Automation reuirements were developed for two manufacturing concepts: (1) Gallium Arsenide Electroepitaxial Crystal Production and Wafer Manufacturing Facility, and (2) Gallium Arsenide VLSI Microelectronics Chip Processing Facility. A functional overview of the ultimate design concept incoporating the two manufacturing facilities on the space station are provided. The concepts were selected to facilitate an in-depth analysis of manufacturing automation requirements in the form of process mechanization, teleoperation and robotics, sensors, and artificial intelligence. While the cost-effectiveness of these facilities was not analyzed, both appear entirely feasible for the year 2000 timeframe. B.G.

N86-27399*# General Electric Co., Philadelphia, Pa. Space Systems Div.
SPACE STATION AUTOMATION STUDY: AUTOMATION REQUIREMENTS DERIVED FROM SPACE MANUFACTURING CONCEPTS. VOLUME 1: EXECUTIVE SUMMARY Final Report
9 Jul. 1984 34 p
(Contract NAS5-25182)
(NASA-CR-177862-VOL-1; NAS 1.26:177862-VOL-1) Avail: NTIS HC A03/MF A01 CSCL 22B

The electroepitaxial process and the Very Large Scale Integration (VLSI) circuits (chips) facilities were chosen because each requires a very high degree of automation, and therefore involved extensive use of teleoperators, robotics, process mechanization, and artificial intelligence. Both cover a raw materials process and a sophisticated multi-step process and are therfore highly representative of the kinds of difficult operation, maintenance, and repair challenges which can be expected for any type of space manufacturing facility. Generic areas were identified which will require significant further study. The initial design will be based on terrestrial state-of-the-art hard automation. One hundred candidate missions were evaluated on the basis of automation portential and availability of meaning ful knowldege. The design requirements and unconstrained design concepts developed for the two missions are presented. B.G.

N86-27408*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND FOR THE US ECONOMY Progress Report, Oct. 1985 - Mar. 1986
Mar. 1986 57 p
(NASA-TM-88785; NAS 1.15:88785; ATAC-PR-2) Avail: NTIS HC A04/MF A01 CSCL 22B

In April 1985, as required by Public Law 98-371, the NASA Advanced Technology Advisory Committee (ATAC) reported to Congress the results of its studies on advanced automation and robotics technology for use on the Space Station. This material was documented in the initial report (NASA Technical Memorandum 87566). A further requirement of the Law was that ATAC follow NASA's progress in this area and report to Congress semiannually. This report is the second in a series of progress updates and covers the period between October 4, 1985, and March 31, 1986. NASA has accepted the basic recommendations of ATAC for its Space Station efforts. ATAC and NASA agree that thrust of Congress is to build an advanced automation and robotics technology base that will support an evolutionary Space Station Program and serve as a highly visible stimulator effecting the U.S. long-term economy. The progress report identifies the work of NASA and the Space Station study contractors, research in progress, and issues connected with the advancement of automation and robotics technology on the Space Station. Author

N86-29513*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE TELEOPERATION RESEARCH. AMERICAN NUCLEAR SOCIETY EXECUTIVE CONFERENCE: REMOTE OPERATIONS AND ROBOTICS IN THE NUCLEAR INDUSTRY; REMOTE MAINTENANCE IN OTHER HOSTILE ENVIRONMENTS
A. J. MEINTEL, JR. and R. W. WILL 1985 51 p Presented at the Executive Conference on Remote Operations and Robotics in the Nuclear Industry, Pine Mountain, Ga., 21 Apr. 1985
(NASA-TM-89234; NAS 1.15:89234; DE85-902186; CONF-850425-5) Avail: NTIS HC A04/MF A01 CSCL 05H

This presentation consists of four sections. The first section is a brief introduction to the NASA Space Program. The second portion summarized the results of a congressionally mandated study of automation and robotics for space station. The third portion presents a number of concepts for space teleoperator systems. The remainder of the presentation describes Langley Research Center's teleoperator/robotic research to support remote space operations. DOE

N86-29886*# Massachusetts Inst. of Tech., Cambridge. Space Systems Lab.
STUDY OF ONBOARD EXPERT SYSTEMS TO AUGMENT SPACE SHUTTLE AND SPACE STATION AUTONOMY Final Report, 1 Aug. 1984 - 31 Dec. 1985
C. R. KURTZMAN, D. L. AKIN, D. KRANZLER, and E. ERLANSON 31 Jul. 1986 91 p
(Contract NAG5-445)
(NASA-CR-176958; NAS 1.26:176958; SSL-16-86) Avail: NTIS HC A05/MF A01 CSCL 22B

The feasibility of onboard crew activity planning was examined. The use of expert systems technology to aid crewmembers in locating stowed equipment was also investigated. The crew activity planning problem, along with a summary of past and current research efforts, was discussed in detail. The requirements and specifications used to develop the crew activity planning system was also defined. The guidelines used to create, develop, and operate the MFIVE Crew Scheduler and Logistics Clerk were discussed. Also discussed is the mathematical algorithm, used by the MFIVE Scheduler, which was developed to aid in optimal crew activity planning. B.G.

N86-30805*# Martin Marietta Corp., Denver, Colo.
SPACE STATION AUTOMATION STUDY. VOLUME 1: EXECUTIVE SUMMARY. AUTONOMOUS SYSTEMS AND ASSEMBLY Final Report
Nov. 1984 64 p
(Contract NAS8-35042)
(NASA-CR-176860; NAS 1.26:176860; DE85-902179; MCR-84-1878-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 22B

The purpose of the Space Station Automation Study (SSAS) was to develop informed technical guidance for NASA personnel in the use of autonomy and autonomous systems to implement space station functions. DOE

N86-31412*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
EVALUATING SPACE STATION APPLICATIONS OF AUTOMATION AND ROBOTICS TECHNOLOGIES FROM A HUMAN PRODUCTIVITY POINT OF VIEW
J. F. BARD *In its* NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 46 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 05H

The role that automation, robotics, and artificial intelligence will play in Space Station operations is now beginning to take shape. Although there is only limited data on the precise nature of the payoffs that these technologies are likely to afford there is a general consensus that, at a minimum, the following benefits will be realized: increased responsiveness to innovation, lower operating costs, and reduction of exposure to hazards. Nevertheless, the question arises as to how much automation can be justified with the technical and economic constraints of the program? The purpose of this paper is to present a methodology which can be used to evaluate and rank different approaches to automating the functions and tasks planned for the Space Station. Special attention is given to the impact of advanced automation on human productivity. The methodology employed is based on the Analytic Hierarchy Process. This permits the introduction of individual judgements to resolve the confict that normally arises when incomparable criteria underly the selection process. Because of the large number of factors involved in the model, the overall problem is decomposed into four subproblems individually focusing on human productivity, economics, design, and operations, respectively. The results from each are then combined to yield the final rankings. To demonstrate the methodology, an example is developed based on the selection of an on-orbit assembly system. Five alternatives for performing this task are identified, ranging from an astronaut working in space, to a dexterous manipulator with sensory feedback. Computational results are presented along with their implications. A final parametric analysis shows that the outcome is locally insensitive to all but complete reversals in preference. Author

N86-33016*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
CONTROL OF A FREE-FLYING ROBOT MANIPULATOR SYSTEM Semiannual Report, Feb. - Jul. 1985
H. ALEXANDER and R. H. CANNON, JR. Jul. 1985 8 p
(Contract NCC2-333)
(NASA-CR-179717; NAS 1.26:179717; SAR-1) Avail: NTIS HC A02/MF A01 CSCL 05H

The goal of the research is to develop and test control strategies for a self-contained, free flying space robot. Such a robot would perform operations in space similar to those currently handled by astronauts during extravehicular activity (EVA). The focus of the work is to develop and carry out a program of research with a series of physical Satellite Robot Simulator Vehicles (SRSV's), two-dimensionally freely mobile laboratory models of autonomous free-flying space robots such as might perform extravehicular functions associated with operation of a space station or repair of orbiting satellites. The development of the SRSV and of some of the controller subsystems are discribed. The two-link arm was fitted to the SRSV base, and researchers explored the open-loop characteristics of the arm and thruster actuators. Work began on building the software foundation necessary for use of the on-board computer, as well as hardware and software for a local vision system for target identification and tracking. Author

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MATERIALS

Includes mechanical properties of materials, and descriptions and analyses of different structural materials, films, coatings, bonding materials and descriptions of the effects of natural and induced space environments.

A86-30323
THE SHUTTLE GLOW AS AN INDICATOR OF MATERIAL CHANGES IN SPACE
B. D. GREEN (Physical Sciences, Inc., Andover, MA) and E. MURAD (USAF, Geophysics Laboratory, Bedford, MA) Planetary and Space Science (ISSN 0032-0633), vol. 34, Feb. 1986, p. 219-224. refs
(AD-A167300; AFGL-TR-86-0082)

Observations of the glow occurring above the spacecraft surfaces and the theories used to explain this phenomena are reviewed. The interaction between the energetic ambient flux and the Shuttle near-field environment, and the reactions of energetic ambient ions and neutrals with the Shuttle surface are examined. It is observed that the reactions which produce the glow affect the composition and properties of the surface and alter the thermal, structural, or electrical characteristics. The glow also affects the ability of the astronauts to make remote observations from the spacecraft and causes material erosion. The spectral emissions that could arise from the surface reaction products are analyzed. It is concluded that the Shuttle glow is observed only on the surface and in the ram direction, and the composition of the surface material and the interaction of this material with the ambient at orbital velocities produces the emission. I.F.

A86-32406
SPACE ENVIRONMENT EFFECTS ON SPACECRAFT SURFACE MATERIALS
H. K. A. KAN (Aerospace Corp., El Segundo, CA) IN: Radiation effects in optical materials; Proceedings of the Thirteenth Critical Reviews of Technology Conference, Albuquerque, NM, March 6, 7, 1985 . Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1985, p. 164-179. Research supported by the Aerospace Corp. refs

A review is given of the effect of the space environment on the external surfaces of satellites. The early development of thermal control materials in the 1960's and the 1970's is summarized. Selected recent results, based on flight experiments from the SCATHA satellite (P78-2) of the Space Test Program and the Space Shuttle, are reviewed along with laboratory experiments designed to understand the often unexpected results of the flight experiments. The topics include long-term stability of thermal control materials, contamination, spacecraft charging, and the effect of oxygen atoms on materials. Several areas of future research are proposed. Author

A86-32917#
APPLICATION AND POTENTIAL FUTURE OF ADVANCED COMPOSITES IN SPACE
W. A. SIGUR (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 33 p. refs

Historical composite spacecraft systems are reviewed, and the performance of advanced composites in space is discussed. The advanced composites of greatest usefulness in space applications are described, and the specific applications of such composites in various historical space missions are summarized. Pertinent space applications of advanced composites over the next 30 years are given, stating what particular functions composites are to be used for in various missions. Developments and trends in reinforcements, matrix materials, and advanced composite systems which may be instrumental in future spacecraft composites are listed, and unique manufacturing and design concepts which should contribute to potential composite usage are mentioned. C.D.

A86-37107
THERMAL ENGINEERING OF SPACECRAFT COMPOSITE STRUCTURES
R. D. KARAM (Fairchild Space Co., Germantown, MD) IN: Composite structures 3; Proceedings of the Third International Conference, Paisley, Scotland, September 9-11, 1985 . London, Elsevier Applied Science Publishers, 1985, p. 100-117. refs

Standard methods in thermal engineering are extended for application to spacecraft composites. The mathematical formulation is shown to reduce to the two-dimensional case when applied to configurations commonly encountered in spacecraft design, and the controllable parameters which affect temperature and associated distortion are identified. Thermal control is discussed in terms of treatment with surface coatings, insulation, and the use of heaters and thermostats. Vacuum testing is recommended to determine conductance and long-term operation in space. The results of trade-off studies on the Fairchild Leasecraft mounting structure are presented. Author

A86-39892#
A PROTOTYPE TEST SYSTEM TO MEASURE THE MASS LOSS OF CONDENSABLE OUTGASSED PRODUCTS IN AN ISOTHERMAL VACUUM
R. KAYS and W. MAHONE (Lockheed Engineering and Management Services Co., Las Cruces, NM) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 6 p. refs
(AIAA PAPER 86-1278)

A throughput test method for NASA's White Sands Test Facility prototype test system, is being developed to determine the condensable product outgas rate from configured items in chambers simulating vacuum environments such as the Space Transportation System Orbiter payload bay. The prototype system will consist of a high-vacuum chamber with an isothermal vessel and two or more quartz crystal microbalances (QCM) to measure the condensation rate. Preliminary tests using palmitic acid as the outgassing source in a chamber evacuated to below 0.003 Pa, give an experimental to calculated total mass loss ratio of 0.803. Furthermore, the experimental heat of sublimation values are within 3 percent of the value in the literature, demonstrating the relationship between the vapor pressure of the outgassing source and the condensable outgassing rate. R.R.

A86-40503
CONTINUOUS FIBER COMPOSITE HOOPS
R. R. VARIN (Varinit Corp., Greenville, SC) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 2-1 to 2-3.

Low-cost, low-weight fiber-reinforced hoops up to 12 feet in diameter have been developed as reinforcement for space assemblies, rocket casings, tanks, fly wheels, etc. Their properties are described. Author

A86-40530*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE THERMAL AND MECHANICAL STABILITY OF COMPOSITE MATERIALS FOR SPACE STRUCTURES
S. S. TOMPKINS, G. F. SYKES, and D. E. BOWLES (NASA, Langley Research Center, Hampton, VA) ASM, ASME, IEEE, et al., Conference and Exposition on Space Tech, Anaheim, CA, Sept. 23-25, 1985, Paper. 19 p. refs

A continuing research objective of the National Aeronautical and Space Administration (NASA) is to develop advanced composite materials for space structures. The thrust of this research is to gain fundamental understanding of the performance of advanced composites in the space environment. The emphasis has been to identify and model changes in the thermal-physical properties due to induced damage and develop improved materials. Author

A86-40594#
HIGH MODULUS COMPOSITE PROPERTIES
M. J. MICHNO, JR. (Union Carbide Corp., Specialty Polymers and Composites Div., Bound Brook, NJ) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 126-131. refs
(AIAA PAPER 86-1187)

Reliable component design with high modulus composites systems requires a mechanical and physical property data base, including both average property levels and a measure of property variability. Composite properties are presented for a number of Thornel Advanced Composites Systems based on P-55S, P-75S, and P-100S high modulus fibers. Specific composite laminate properties presented include: RT longitudinal tension and compression; RT transverse tension, longitudinal shear and flexural strength (RT to 300 F) and coefficients of thermal expansion valid for the temperature range of -200 F to +200 F. Thermomechanical stability data are presented for quasi-isotropic laminates cycled over the temperature range of -300 F to +200 F. Data indicate that the materials tested may be well suited to harsh thermal environments. However, the performance of candidate materials must be judged in terms of requirements for specific applications. Author

A86-40611*# National Aeronautics and Space Administration, Washington, D.C.
FUTURE DIRECTIONS IN MATERIALS AND STRUCTURES FOR SPACE APPLICATIONS
S. L. VENNERI and R. J. HAYDUK (NASA, Washington, DC) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 29 p. refs
(AIAA PAPER 86-1185)

A comprehensive evaluation is made of materials and structural technology requirements for future space transportation systems, large spacecraft, and space structures. Exceptional promise is noted in carbon-carbon composites for large area thermal protection systems. High temperature test facilities, techniques, and instrumentation systems have unfortunately been neglected, and a materials systems data base suitable for high confidence design of long life space structures has yet to be compiled with a view to material environments in low earth and geosynchronous orbits. A coordinated analysis, ground test, and in-orbit experimentation program for candidate structure designs is called for. O.C.

A86-41739*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MATERIAL DAMPING OF SIMPLE STRUCTURES IN A SIMULATED SPACE ENVIRONMENT
D. L. EDBERG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; Stanford, University, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 288-296. refs
(Contract AF-AFOSR-82-0062)

The need for accurate, quantitative knowledge of the vibration dissipation of large space structures is explained. The sources of experimental error in vibrational measurements are detailed. A new method for such testing based on the use of a miniature telemetry system is presented, which allows the testing of structures in a simulated space environment consisting of free-fall inside of a vacuum chamber. Theoretical relations are given for the damping ratios of metals and composites. Measured damping ratios for both aluminum and composite beams and plates, and aluminum planar trusses, are presented. Experimental results are used to evaluate the theoretical damping relations. Author

A86-41750*# Auburn Univ., Ala.
ANALYSES OF SPACECRAFT POLYMERIC MATERIALS
S. D. WORLEY, A. T. FROMHOLD, K. DANESHVAR (Auburn University, AL), A. F. WHITAKER, S. A. LITTLE (NASA, Marshall Space Flight Center, Huntsville, AL) et al. Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 350-352. refs
(Contract NAS8-35914)

Partial analytical characterizations are made by four different techniques of three polymeric materials used in conjunction with the Space Telescope for samples flown on mission STS-8. The polymers were Tedlar, Kapton H, and Kapton F. The surfaces of the three polymers were attacked and oxidized by atomic oxygen, and fluorine is lost from the surface of Kapton F, largely due to displacement by atomic oxygen. O.C.

A86-42638*# Aerojet Strategic Propulsion Co., Sacramento, Calif.
EXPERIMENTAL EVALUATION OF CANDIDATE CARBON-CARBON MATERIALS FOR OTV ENGINE NOZZLE EXTENSIONS
J. P. SUHOZA (Aerojet Strategic Propulsion Co., Sacramento, CA) and R. L. BICKFORD (Aerojet TechSystems Co., Sacramento, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(Contract NAS8-35971)
(AIAA PAPER 86-1429)

Advanced carbon-carbon nozzle materials can reduce the weight and improve the efficiency of the proposed reusable Orbit Transfer Vehicle (OTV) liquid rocket engine. Experimental evaluations of eight carbon-carbon materials in an O2/H2 rocket nozzle environment have been performed. The hot fire testing will support the choice of the materials for the OTV nozzle design. The OTV nozzle requirements and operating environment are defined. The rocket device used to simulate the OTV hot-fire nozzle environment for material specimen evaluation is described. The results of hot-fire testing for eight carbon-carbon materials are discussed. Results for coated and uncoated materials, evaluated in side-by-side testing, are compared. Plans for further testing of the leading materials are described. Author

A86-47337
SPACECRAFT MATERIALS TEST IN A CONTINUOUS, BROAD ENERGY-SPECTRUM ELECTRON BEAM
M. BLEZ, J. THAYER, and J. E. NANEVICZ (SRI International, Menlo Park, CA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 485-497. refs

The discharge behavior of several samples made of Kapton, a material used in spacecraft thermal control systems was studied

under conditions of a simulated space environment, comparing the results of exposure to two types of electron beams. The first was a constant monoenergetic electron beam, used in past studies; the second was a continuous broad-energy-spectrum electron beam, generated by a novel multienergy multipactor electron gun. It has been found that the discharges produced by a multienergetic beam, which represents a more realistic environment situation, had longer (by a factor of 2) rise times than the discharges produced by a monoenergetic beam, indicating lower penetration efficiency by the multienergetic beam. However, while the samples exposed to a monoenergetic beam have stopped discharging after a few minutes, the same samples exposed to a multienergetic beam continued discharging indefinitely. The hitherto uncontrolled physical parameters, such as the manner of cleaning the sample and the production run of a sample, were found to influence the material response. I.S.

N86-22594*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPOSITE MATERIALS FOR SPACE STRUCTURES
D. R. TENNEY, G. F. SYKES, and D. E. BOWLES *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environments p 9-21 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

The use of advanced composites for space structures is reviewed. Barriers likely to limit further applications of composites are discussed and highlights of research to improve composites are presented. Developments in composites technology which could impact spacecraft systems are reviewed to identify technology needs and opportunities. Author (ESA)

N86-22597# Aerospace Corp., El Segundo, Calif. Chemistry and Physics Lab.
PHOTO-ENHANCED SPACECRAFT CONTAMINATION DEPOSITION
D. F. HALL, T. B. STEWART, and R. R. HAYES (Hughes Aircraft Corp., El Segundo, Calif.) *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 39-47 Nov. 1985 refs
(Contract AFOSR-F04701-83-C-0084)
Avail: NTIS HC A13/MF A01

Contaminant molecule adhesion to sunlit spacecraft surfaces, particularly radiators, was examined in laboratory experiments to determine the magnitude of this phenomenon and to study the underlying photochemical processes. Flight and laboratory evidence indicates that photolysis plays an important role in the deposition of contamination on spacecraft surfaces. The implications of this effect for the spacecraft contamination community are discussed. Author (ESA)

N86-22601*# National Aeronautics and Space Administration. White Sands Test Facility, N. Mex.
MATERIALS TEST LABORATORY ACTIVITIES AT THE NASA-JOHNSON SPACE CENTER WHITE SANDS TEST FACILITY (WSTF)
J. STRADLING and D. L. PIPPEN *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials Space Environment p 71-74 Nov. 1985
Avail: NTIS HC A13/MF A01

The NASA Johnson Space Center White Sands Test Facility (WSTF) performs aerospace materials testing and evaluation. Established in 1963, the facility grew from a NASA site dedicated to the development of space engines for the Apollo project to a major test facility. In addition to propulsion tests, it tests materials and components, aerospace fluids, and metals and alloys in simulated space environments. Author (ESA)

N86-22602*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex. Materials Branch.
EFFECTS OF THE LOW EARTH ORBITAL ENVIRONMENT ON SPACECRAFT MATERIALS
L. J. LEGER *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 75-80 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Recession of organic-polymer-based surfaces due to oxidation by atomic oxygen, the major component of the LEO environment, was studied in Space Shuttle flights 5, 8, and 41-G to measure reaction rates and the effects of various parameters on reaction rates. Surface recession on the flights indicates reaction rates of 3 x10 to the minus 24th power cc atom for unfilled organic polymers. Application of these rates to Space Station-type exposure for main structural items indicates that as much as 0.075 cm of surface recession occurs in 30 yr. Because of the importance of this effect on Space Station systems, additional experiments are planned to obtain better reaction rate measurements ensuring and adequate data base for Space Station design. Author (ESA)

N86-22603*# Communications Research Centre, Ottawa (Ontario).
THE EFFECT OF LOW EARTH ORBIT SPACE ENVIRONMENT ON POLYMERIC SPACECRAFT MATERIALS
D. G. ZIMCIK, R. C. TENNYSON (Toronto Univ., Ontario), L. J. KOK (Toronto Univ., Ontario), and C. R. MAAG (JPL, Pasadena, Calif.) *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 81-89 Nov. 1985 refs Sponsored by NASA
Avail: NTIS HC A13/MF A01

The Advanced Composite Materials Exposure to Space Experiment flown on shuttle mission STS-41G was designed to investigate the effect of low Earth orbit space environment on polymeric spacecraft materials. The effect of the phenomenon attributed to atomic oxygen on Kapton and advanced composite materials of carbon-epoxy and kevlar epoxy is described. The results of true space exposure are compared to duplicate specimens subjected to a simulated environment in an Earth-based nozzle beam test facility utilizing microwave discharge to form atomic oxygen. Although the energy level for atomic oxygen in the beam facility did not achieve the orbital energy level of 5 eV, similar effects of surface erosion and degradation are observed after equivalent exposure times. Author (ESA)

N86-22604# Lockheed Aircraft Corp., Palo Alto, Calif.
LABORATORY INVESTIGATION OF THE STABILITY OF ORGANIC COATINGS FOR USE IN A LEO ENVIRONMENT
M. MCCARGO, R. A. DAMMANN, T. CUMMINGS, and C. CARPENTER *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 91-97 Nov. 1985 refs Sponsored by LMSC
Avail: NTIS HC A13/MF A01

The results of a laboratory investigation of protective coatings, and of the use of an oxygen plasma reactor to generate engineering data related to the orbit lifetime of the coated substrates are discussed. Changes in the surface optical and morphological properties and the rate of material mass loss are presented. Possible modes of degradation are suggested to explain the observed effects. Laboratory data are correlated with the flight data from shuttle missions, Solar Maximum Mission (SMM), and an experimental flight package. Author (ESA)

N86-22608# AEG-Telefunken, Wedel (West Germany).
DEVELOPMENTS OF SOLAR GENERATOR SUBSTRATES: SIMPLE ANTICHARGING (AC) AND CONDUCTIVE THERMAL CONTROL (TC) MATERIALS (GEO), AND SOME LEO ASPECTS
W. SCHMITZ *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 133-141 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Development work performed during the design phase for a large flexible solar blanket (L-SAT) requiring protection against electrostatic discharge anticharging (AC) on the whole substrate rearside and thermal control in certain blank (cell free) areas on the frontside is described. Efforts focused on the compromise with regard to conductivity (particularly important for AC) and thermooptical behavior and on the need for a simple solution concerning workability and adaptability. Soot and silver dispersions are discussed. Author (ESA)

N86-22610# Imperial Chemical Industries, Wilton (England). New Science Group.
MECHANICAL AND FIRE PROPERTIES OF AROMATIC POLYMER COMPOSITES
D. C. LEACH, P. J. BRIGGS, and D. R. CARLILE *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 153-160 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Mechanical and fire properties of aromatic polymer composite APC-2 are discussed. Room temperature tensile properties of APC-2 are equivalent to or greater than those of a typical, thermosetting matrix composite using the same carbon fiber reinforcement. In damage tolerance, APC-2 shows significant improvements over thermosetting composites due to the high interlaminar fracture toughness of APC-2. The changes in mechanical properties with temperature are not large and even above the glass transition temperature of the Victrex PEEK matrix, APC-2 retains good mechanical performance due to the semicrystalline nature of the polymer. It is difficult to ignite and exhibits low flame propagation rates in standard laboratory tests. Flame penetration times at temperatures 1000 C are significantly longer for APC-2 sheets than for aluminum alloy sheets. Smoke and toxic emission from APC-2 during a fire is amongst the lowest of all plastics. Author (ESA)

N86-26434*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
OXIDATION PROTECTING COATINGS FOR POLYMERS Patent Application
J. S. SOVEY, inventor (to NASA), B. A. BANKS, inventor (to NASA), and M. J. MIRTICH, inventor (to NASA) 27 Feb. 1986 12 p
Sponsored by NASA
(NASA-CASE-LEW-14072-3; NAS 1.71:LEW-14072-3; US-PATENT-APPL-SN-834977) Avail: NTIS HC A02/MF A01 CSCL 11B

A polymeric substrate is coated with a metal oxide film to provide oxidation protection in low Earth orbital environments. The film contains about four volume percent polymer to provide flexibility. NASA

N86-28195*# College of William and Mary, Williamsburg, Va.
RADIATION EFFECTS ON HIGH PERFORMANCE POLYMERS Final Technical Report, 1 Jun. 1985 - 28 Feb. 1986
R. A. ORWOLL 1986 10 p
(Contract NAG1-593)
(NASA-CR-177191; NAS 1.26:177191) Avail: NTIS HC A02/MF A01 CSCL 11B

Polymer matrix materials are candidates for use in large space antennas and space platforms that may be deployed in geosynchronous orbit 22,500 miles above the Earth. A principal concern is the long term effects of an environment that is hostile to organic polymers, including high energy electromagnetic radiation, bombardment by charged particles, and large abrupt changes in temperature. Two polyarylene ethers which might be utilized as models for polymers in space applications were subjected to dosages of 70 keV electrons up to 3.4 x 10 to the 10th power rad. The irradiated films were then examined to determine the effects of the high-energy electrons. Author

N86-29893# Toronto Univ. (Ontario). Dept. of Electrical Engineering.
CHARGE ACCUMULATION AND ARC DISCHARGES ON SPACECRAFT MATERIALS AND COMPONENTS Final Report, 1 Sep. 1984 - 31 Aug. 1985
K. G. BALMAIN 11 Nov. 1985 62 p
(Contract AF-AFOSR-0342-84)
(AD-A166216; AFOSR-86-0057TR) Avail: NTIS HC A04/MF A01 CSCL 22B

A study of arc discharge strength was carried out, emphasizing its variation with the thickness of the dielectric-sheet specimens which had been exposed to an incident 20 keV electron beam at a current density of a thickness at which the peak current and the energy released into a load resistor are maximized. The addition of a low-energy ion beam was found to reduce discharge strength without significantly altering thickness-scaling. Also, experimental evidence was presented for a new effect called the ion spot phenomenon in which the incident ions are focussed into a central spot which then glows due to electron-impact luminescence. The first stage in the analysis of the ion spot phenomenon has been carried out and is described in this report. A two-dimensional analysis reveals complex ion trajectories which produce not only a strip (equivalent to a spot) of ion deposition, but are also such as to produce a spot with very sharply defined edges, just as observed experimentally. As for the spacecraft-charging experimental facility, a chamber capable of holding specimens up to 30 cm diameter has been completed. Arc discharges of 700 A peak have been recorded for the largest specimens and a system for making surface potential measurements has been tested. GRA

N86-29989*# Boeing Aerospace Co., Seattle, Wash.
DEVELOPMENT OF COMPOSITE TUBE PROTECTIVE COATINGS Final Report
H. DURSCH and C. HENDRICKS Jul. 1986 109 p
(Contract NAS1-16854)
(NASA-CR-178116; NAS 1.26:178116; D180-29767-1) Avail: NTIS HC A06/MF A01 CSCL 11G

Protective coatings for graphite/epoxy (Gr/Ep) tubular structures proposed for the Space Station are evaluated. The program was divided into four parts; System Definition, Coating Concept Selection and Evaluation, Scale-up and Assembly, and Reporting. System Definition involved defining the structural and environmental properties required of the Gr/Ep tubes. The prepreg and ply sequence selected was a P75S/934 (O2, + or - 20, O2)sub s layup which meets the various structural requirements of the Space Station. Coating Concept and Selection comprised the main emphasis of the effort. Concepts for protectively coating the Gr/Ep tubes included the use of metal foil and electroplating. The program results demonstrated that both phosphoric and chromic acid anodized Al foil provided adequate adhesion to the Gr/Ep tubes and stability of optical properties when subjected to atomic oxygen and thermal cycling representative of the LEO environment. SiO2/Al coatings sputtered onto Al foils also resulted in an excellent protective coating. The electroplated Ni possessed unacceptable adhesion loss to the Gr/Ep tubes during atomic oxygen testing. Scale-Up and Assembly involved fabricating and wrapping 8-ft-long by 2-in-diameter Gr/EP tubes with chromic acid anodized foil and delivering these tubes, along with representative Space Station erectable end fittings, to NASA LaRC. Author

N86-30595*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
EFFECTS OF THE LOW EARTH ORBITAL ENVIRONMENT ON SPACECRAFT MATERIALS Abstract Only
L. J. LEGER *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 67 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

It is evident from space flights during the last three years that the low Earth orbital (LEO) environment interacts with spacecraft surfaces in significant ways. One manifestation of these interactions is recession of, in particular, organic-polymer-based surfaces presumably due to oxidation by atomic oxygen, the major component of the LEO environment. Three experiments have been conducted on Space Shuttle flights 5, 8 and 41-G to measure reaction rates and the effects of various parameters on reaction rates. Surface recession on these flights indicates reaction efficiencies approximately 3 x 10(-24) cu cm/atoms for unfilled organic polymers. Of the metals, silver and osmium are very reactive. Effects on spacecraft or experiment surfaces can be evaluated using the derived reaction efficiencies and a definition of the total exposure to atomic oxygen. This exposure is obtained using an ambient density model, solar activity data and spacecraft parameters of altitude, attitude and operational date. Oxygen flux on a given surface is obtained from the ambient density and spacecraft velocity and can then be integrated to provide the total exposure or fluence. Such information can be generated using simple computational programs and can be converted to various formats. Overall, the extent of damage is strongly dependent on the type of surface and total exposure time. Author

N86-30764# Southampton Univ. (England). Inst. of Sound and Vibration Damping.
DAMPING OF COMPOSITES
T. A. WILLWAY *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 47-52 Feb. 1986
Avail: NTIS HC A16/MF A01

Methods of predicting the damping characteristics of composite materials and the effects of various parameters on that damping are reviewed. Experimentally determined values of the damping of composite materials are given. ESA

N86-30775# European Space Agency, Paris (France). Mechanical Systems Div.
DIMENSIONAL STABILITY OF CFRP TUBES FOR SPACE STRUCTURES
G. G. REIBALDI *In its* Proceedings of a Workshop on Composites Design for Space Applications p 141-147 Feb. 1986
Avail: NTIS HC A16/MF A01

Dimensional stability of CFRP tubes used in spacecraft structures was investigated as a function of the number of thermal cycles. Length and weight decrease with the number of cycles. Thermal cycling generates microcracking, which increases desorption rate for the weight and length. For the SPAS tube T006 the length increases with respect to the initial value, probably due to large microcracking. The polythene bag does not influence the absorption rate. No clear asymptotic value for the weight and length variation with the increasing of thermal cycles is found. Permanent deformations are expected in orbit, about 25 microns after 300 thermal cycles. Lay-up of the CFRP tube is important for dimensional stability. A CIBA-GEIGY tube shows lower length variation, even if the weight loss is similar to that of the SPAS. ESA

N86-31668# Martin Marietta Aerospace, Denver, Colo.
DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES Quarterly Letter Report
10 Apr. 1986 6 p
(Contract N00014-85-C-0857)
(AD-A167792; MCR-85-721) Avail: NTIS HC A02/MF A01
CSCL 11D

Damping test data of Gr/Al composites, from previous measurements at Martin Marietta Denver Aerospace, CO suggest that composites exhibit higher damping than aluminum and titanium base structural alloys. Enhanced material damping of metal matrix composite (MMC), as a structural material will significantly improve the stability control and reliability of space structures. The objectives of the present investigation are: (1) to identify the mechanism and the source of damping in MMC (P55 Gr/6061 Al); (2) to determine the role of microstructural parameters, e.g., fiber volume, fiber orientation and interfiber spacing, and (3) to define the role of fiber matrix interfaces. GRA

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INFORMATION AND DATA MANAGEMENT

Includes descriptions, requirements, and trade studies of different information and data system hardware and software, languages, architecture, processing and storage requirements for managing and monitoring of different systems and subsystems.

A86-34981
INFORMATION SYSTEMS IN SPACE
D. S. WEHRLY (IBM Corp., Endicott, NY) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 9-11 to 9-13.

The application of information management techniques to space is proposed. Examples of ground-based industrial information systems are described. The development of space information system from existing ground-based designs, and the formation of a space-earth interface are examined. I.F.

A86-37531
A FREQUENCY HOPPING MULTIPLE-ACCESS COMMUNICATION SYSTEM FOR A LOW EARTH ORBITING MANNED SPACE STATION
K. TU and Y. C. LOH (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: ICC '85; International Conference on Communications, Chicago, IL, June 23-26, 1985, Conference Record. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 208-212. refs

This paper presents a concept for the design of a Space Station radio frequency (RF) multiple-access communication system. A fast frequency hopping system with multibeam offset parabolic reflector antenna system, dual-k convolutional encoding, and M-ary frequency-shift-keying modulation is proposed to accommodate and satisfy the requirements. System requirements, RF coverage, antenna system, system configuration, performance evaluation, and link parameters are described. Author

A86-37857#
DATA AND COMMUNICATION INFRASTRUCTURE FOR THE SPACE STATION
S. BOESSO, C. LEGNAIOLI (Selenia Spazio S.p.A., Rome, Italy), and E. SAGGESE (Telespazio S.p.A., Rome, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 97-110.

An attempt is made to extrapolate the data and communications processing needs and capabilities for the Space Station, based on related systems of Skylab and the Space Shuttle. As a preliminary step, since the details of the U.S.-International collaboration have not yet been worked out, ESA has approved the Columbus Program for a progressive implementation of elements of a small European Space Station, with the double aim of identifying the European needs that should be satisfied by the NASA Space Station and inducing European industry to acquire the technology needed to actively cooperate with NASA. A possible architecture for the Space Station Data Management System is presented, and the communications needs are considered for the

Columbus elements with the mission Operation Control Center, highlighting the importance of a European relay satellite with a 500 Mbps capability in view of future increasing demand. D.H.

A86-40529* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS AND TRACKING - THE KEYS TO SPACE STATION UTILIZATION
R. S. SAWYER, O. L. SCHMIDT, and O. L. GRAHAM (NASA, Johnson Space Center, Houston, TX) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 11-1 to 11-11.

An overview of the Space Station Communications and Tracking System is presented, along with a description of its component parts and the numerous interacting control links. Emphasis is given to explaining the television and data control routing within the confines of the system. The growth expectations for the Space Station are discussed in light of the communications and tracking requirements. Author

A86-40589*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
MATURE DATA TRANSPORT AND COMMAND MANAGEMENT SERVICES FOR THE SPACE STATION
R. D. CARPER (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 94-100.
(AIAA PAPER 86-1181)

The duplex space/ground/space data services for the Space Station are described. The need to separate the uplink data service functions from the command functions is discussed. Command management is a process shared by an operation control center and a command management system and consists of four functions: (1) uplink data communications, (2) management of the on-board computer, (3) flight resource allocation and management, and (4) real command management. The new data service capabilities provided by microprocessors, ground and flight nodes, and closed loop and open loop capabilities are studied. The need for and functions of a flight resource allocation management service are examined. The system is designed so only users can access the system; the problems encountered with open loop uplink access are analyzed. The procedures for delivery of operational, verification, computer, and surveillance and monitoring data directly to users are reviewed. I.F.

A86-40592#
EXPLORING AUTONOMY - THE T(2)C(2) SYSTEM
T. TURNER (Gulton Industries, Inc., Data Systems Div., Albuquerque, NM) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 111-117. refs
(AIAA PAPER 86-1184)

The functions of command and data handling systems are described. The command and telemetry system is applicable to satellites, rockets, satellite propulsion stages, experimental platforms, planetary exploration vehicles, and Space Stations. The benefits provided by an autonomous system and the implementation of autonomy in the areas of health and welfare maintenance are discussed. The architecture and capabilities of the Telemetry, Timing Command, and Control system, which is a spacecraft whose command and telemetry system is designed to facilitate the design of an autonomous spacecraft, is examined. On-board processing is integrated into this system; three methods of integration are proposed. The use of fault tolerance, defined by fault detection, diagnosis, and correction, to satisfy the system's reliability requirements is studied. I.F.

A86-43229* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE EARTH OBSERVING SYSTEM
R. E. HARTLE (NASA, Goddard Space Flight Center, Greenbelt, MD) and A. TUYAHOV (NASA, Washington, DC) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 529-550.
(AAS PAPER 85-397)

This paper summarizes concepts for an Earth Observing System (EOS) for the 1990s that will provide the observational capabilities and an information system needed to understand how the earth works as a system. The concept diverges somewhat from past practices in that it considers EOS as an information system, where mission operation, EOS data bases and information about other relevant data sets are tied together by an information network. Three EOS instrument packages were chosen on the basis of synergistic groupings of instruments to make simultaneous observations of selected phenomena over a variety of wavelengths. Author

A86-44533
IN-ORBIT DATA PROCESSING AND MANAGEMENT
C. R. ROBERTS (TRW, Inc., Cleveland, OH) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 81-90.

The performance requirements of the data processing system (DPS) on board the Manned Space Station (MSS) are described, along with data system techniques which may serve to fulfill the requirements. The DPS will handle, e.g., interactive materials processing, synthetic aperture radar, life support systems, communications, etc., as well as accommodating scientific, commercial, and stationkeeping operations. A minimum payload data handling rate of 120 Mbps has been set, and will provide on-line displays and interactive control of experiments. The DPS hardware will be distributed, with modules close to equipment to which DPS subsystems are dedicated. The projected functions have been broken down into categories guided by functional groups and the total in-orbit database storage capability has been projected at 1 Gbyte. Mass storage will be achieved with optical disks and tape drives; all programming is expected to be done in ADA. Operations are to be autonomous of ground control. M.S.K.

A86-46387
SYSTOLIC OPTICAL CELLULAR ARRAY PROCESSORS
H. J. CAULFIELD (Alabama, University, Huntsville) Optical Engineering (ISSN 0091-3286), vol. 25, July 1986, p. 825-827.
(Contract N00014-85-K-0479)

Using space-variant pattern recognition of up to 256 3 x 3 patterns of 1s and 0s in parallel and inserting image information sequentially in a well-defined pattern, an optical systolic cellular array processor for 3 x 3 neighborhoods has been constructed, that produces output points at one-third the rate at which points are input. This allows reprogrammable preprocessing of data input. Author

A86-46939#
SPACE STATION COMMUNICATION NETWORKS
T. R. SAVAGE (TRW, Inc., Redondo Beach, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 9 p. refs
(AIAA PAPER 86-2307)

The selection of a proper transmission media for Space Station communications is examined. A model for evaluating different network topologies based on complexity, robustness, connectivity, and wastefulness is developed. The usefulness of the model is studied by applying it to the analysis of dual-linear bus, single-linear bus, ring, and star network topologies. The characteristics and capabilities of a coaxial broad-band cable and a fiber optic cable are compared in terms of topological considerations. The advantages provided by the coaxial broad-band cable are described. It is noted that the coaxial broad-band cable is applicable

for near-term communications on the Space Station; however, the possible future transmission of high-speed data will require the use of fiber optics. I.F.

A86-46940*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STANDARD DATA SYSTEMS ARCHITECTURE FOR THE SPACE STATION
E. GREENBERG, A. J. HOOKE, R. B. POMPHREY, and J. F. SMITH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 43 p. NASA-supported research. refs
(AIAA PAPER 86-2308)

Attention is given to an end-to-end Space Station Data System (SSDS) architecture which is based on internationally-recommended standards developed by the Consultative Committee for Space Data Systems (CCSDS). The proposed system uses simple modular building blocks that are recursively replicated and linked to construct essentially any desired data system configuration. The SSDS concept provides for a user-transparent data transport system which is entirely independent of the characteristics of the user data being transported, and in addition, has the flexibility to accommodate mission-induced changes in data traffic. SSDS physical elements include the following: (1) on-orbit local area networks, (2) space-to-ground, ground-to-space, and space-to-space data links, and (3) ground mission support facilities containing telemetry anbd telecommand data handling termini and preprocessing services. K.K.

A86-50282*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ELECTRONIC CONTROLS AND DISPLAYS FOR A SPACE STATION WORKSTATION
A. M. BUSQUETS, R. V. PARRISH, and T. W. HOGGE (NASA, Langley Research Center, Hampton, VA) Association for Computing Machinery and IEEE, Fall Joint Computer Conference, Dallas, TX, Nov. 2-6, 1986, Paper. 15 p. refs

A workstation to serve as a man/machine interface for one of the test beds used in the NASA-Space Station development effort is described which will also serve as a demonstrator of the advanced technologies anticipated for the Space Station workstation. Thin-film electroluminescent flat-panels may replace the presently used CRTs for image generation, and the development of multifunctional controls, advanced graphic generators, and videodisc technology are considered. A generalized window management algorithm will control the large volume of information required, and conventional office automation tools such as spread sheets and database managers will be applied to workstation image management. R.R.

A86-50284#
SIMULATION OF THE SPACE STATION DATA SYSTEM REAL-TIME CONTROL FUNCTION
E. VOLANSKY (TRW, Inc., TRW Defense Systems Group, Redondo Beach, CA) International Association of Science and Technology for Development, International Conference and Exhibition, 14th, Vancouver, Canada, June 4, 1986, Paper. 26 p.

Four Space Station Data System Real-Time Control functions are described and studied for port-to-port timing. These are: Executive Control, Real-time Scheduling, Resource Management, and Command Management. A transaction flow for the processing required to handle an emergency was built and studied for performance implications. The discrete event simulation, RST, utilized to predict the performance of the above functions is described, and the results of parametric studies undertaken to assess disk and processor performance are presented. K.K.

N86-23314*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION SOFTWARE RECOMMENDATIONS
S. VOIGT, ed. Dec. 1985 142 p refs Forum held in Huntsville, Ala., 24-25 Apr. 1985
(NASA-CP-2394; L-16063; NAS 1.55:2394) Avail: NTIS HC A07/MF A01 CSCL 09B

Four panels of invited experts and NASA representatives focused on the following topics: software management, software development environment, languages, and software standards. Each panel deliberated in private, held two open sessions with audience participation, and developed recommendations for the NASA Space Station Program. The major thrusts of the recommendations were as follows: (1) The software management plan should establish policies, responsibilities, and decision points for software acquisition; (2) NASA should furnish a uniform modular software support environment and require its use for all space station software acquired (or developed); (3) The language Ada should be selected for space station software, and NASA should begin to address issues related to the effective use of Ada; and (4) The space station software standards should be selected (based upon existing standards where possible), and an organization should be identified to promulgate and enforce them. These and related recommendations are described in detail in the conference proceedings.

N86-23315*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION: THE ROLE OF SOFTWARE
D. HALL *In* NASA. Langley Research Center Space Station Software Recommendations p 3-38 Dec. 1985
Avail: NTIS HC A07/MF A01 CSCL 09B

Software will play a critical role throughout the Space Station Program. This presentation sets the stage and prompts participant interaction at the Software Issues Forum. The presentation is structured into three major topics: (1) an overview of the concept and status of the Space Station Program; (2) several charts designed to lay out the scope and role of software; and (3) information addressing the four specific areas selected for focus at the forum, specifically: software management, the software development environment, languages, and standards. NASA's current thinking is highlighted and some of the relevant critical issues are raised. Author

N86-23316*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A VIEW OF SOFTWARE MANAGEMENT ISSUES
J. H. MANLEY (Computing Technology Transition, Inc.) *In its* Space Station Software Recommendations p 39-83 Dec. 1985
Avail: NTIS HC A07/MF A01 CSCL 09B

The Software Development Environment (SDE) Panel addressed key programmatic, scope, and structural issues raised by its members and the general audience regarding the proposed software development environment for the Space Station program. The general team approach taken by this group led to a consensus on 18 recommendations to NASA mangament regarding the acquisition and definition of the SDE. This approach was keyed by the initial issues presentation given to the general audience. Additional issues (for a total of 23) were developed by the panelists in their first closed session from which key areas were selected and discussed in open session. These discussions led to key recommendations which are summarized and described. Author

N86-23318*# Tektronix, Inc., Beaverton, Oreg.
NASA SPACE STATION SOFTWARE STANDARDS ISSUES
G. D. TICE, JR. *In* NASA. Langley Research Center Space Station Software Recommendations p 118-131 Dec. 1985 refs
Avail: NTIS HC A07/MF A01 CSCL 09B

The selection and application of software standards present the NASA Space Station Program with the opportunity to serve as a pacesetter for the United States software in the area of software standards. The strengths and weaknesses of each of

the NASA defined software standards issues are summerized and discussed. Several significant standards issues are offered for NASA consideration. A challenge is presented for the NASA Space Station Program to serve as a pacesetter for the U.S. Software Industry through: (1) Management commitment to software standards; (2) Overall program participation in software standards; and (3) Employment of the best available technology to support software standards Author

N86-24525*# Oakwood Coll., Huntsville, Ala. Dept. of Systems Software.
A STUDY OF THE VERY HIGH ORDER NATURAL USER LANGUAGE (WITH AI CAPABILITIES) FOR THE NASA SPACE STATION COMMON MODULE
E. N. GILL *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 36 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 09B

The requirements are identified for a very high order natural language to be used by crew members on board the Space Station. The hardware facilities, databases, realtime processes, and software support are discussed. The operations and capabilities that will be required in both normal (routine) and abnormal (nonroutine) situations are evaluated. A structure and syntax for an interface (front-end) language to satisfy the above requirements are recommended. Author

N86-24533*# New Mexico State Univ., University Park. Dept. of Mathematical Sciences.
ANALYSIS OF HIGH-ORDER LANGUAGES FOR USE ON SPACE STATION APPLICATION SOFTWARE
A. KNOEBEL *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 20 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 09B

Considered in this study is the general and not easily resolved problem of how to choose the right programming language for a particular task. This is specialized to the question of which versions of what languages should be chosen for the multitude of tasks that the Marshall Space Flight Center will be responsible for in the Space Station. Four criteria are presented: theoretical considerations, quantitative matrices, qualitative benchmarks, and the monitoring of programmers. Specific recommendations for future studies are given to resolve these questions for the Space Station. Author

N86-24737*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A COMPUTER MODELING METHODOLOGY AND TOOL FOR ASSESSING DESIGN CONCEPTS FOR THE SPACE STATION DATA MANAGEMENT SYSTEM
W. R. JONES Apr. 1986 45 p refs
(NASA-TM-87647; NAS 1.15:87647) Avail: NTIS HC A03/MF A01 CSCL 22B

A computer modeling tool is being developed to assess candidate designs for the Space Station Data Management System (DMS). The DMS is to be a complex distributed computer system including the processor, storage devices, local area networks, and software that will support all processing functions onboard the Space Station. The modeling tool will allow a candidate design for the DMS, or for other subsystems that use the DMS, to be evaluated in terms of parameters. The tool and its associated modeling methodology are intended for use by DMS and subsystem designers to perform tradeoff analyses between design concepts using varied architectures and technologies. Author

N86-25291*# Ecosystems International, Inc., Gambrills, Md.
A DEFINITION STUDY OF AN ADVANCED DATA COLLECTION AND LOCATION SYSTEM (ADCLS) Final Report
Jan. 1986 126 p refs
(Contract NAS5-28791)
(NASA-CR-177868; NAS 1.26:177868) Avail: NTIS HC A07/MF A01 CSCL 05B

The technical and economic advantages of developing an Advanced Data Collection and Location System (ADCLS) to operate within the Earth Observation System (EOS) planned for Polar Platform, as a replacement and/or augmentation of the existing ARGOS data collection system were assessed. The cost/effectiveness of ADCLS with respect to ARGOS hinges on the traffic and quality of service demand of the future user constituency. Author

N86-27947*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HYBRID ROUTING TECHNIQUE FOR A FAULT-TOLERANT, INTEGRATED INFORMATION NETWORK
B. D. MEREDITH Jul. 1986 20 p
(NASA-TP-2605; L-16034; NAS 1.60:2605) Avail: NTIS HC A02/MF A01 CSCL 09B

The evolutionary growth of the space station and the diverse activities onboard are expected to require a hierarchy of integrated, local area networks capable of supporting data, voice, and video communications. In addition, fault-tolerant network operation is necessary to protect communications between critical systems attached to the net and to relieve the valuable human resources onboard the space station of time-critical data system repair tasks. A key issue for the design of the fault-tolerant, integrated network is the development of a robust routing algorithm which dynamically selects the optimum communication paths through the net. A routing technique is described that adapts to topological changes in the network to support fault-tolerant operation and system evolvability. Author

N86-29116*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WORKLOAD CHARACTERIZATION FOR THE SPACE STATION DATA COMMUNICATIONS SYSTEM
K. C. SEVCIK Jan. 1986 15 p
(NASA-TM-89396; RIACS-TR-86.4; NAS 1.15:89396) Avail: NTIS HC A02/MF A01 CSCL 17B

NASA plans to launch a permanent manned space station in the early 1990's. The station will be used to support a wide variety of activities involving Earth and space observation, satellite maintenance, scientific experimentation, and commercial manufacturing. The control and monitoring of many of these activities will require extensive computer and communications system support. In order to identify an appropriate computer and communication system for supporting the space station, an attempt to characterize the space station's data communications subsystem workload is currently underway. Some of the special aspects of the workload characterization problem are discussed in connection with the space station, and some possible approaches are presented. Author

N86-31417*# City Univ. of New York, N.Y. Bronx Community Coll.
INVESTIGATION OF LOCAL AREA NETWORKS FOR AN OBITING SPACE STATION Final Report
L. A. DEACETIS *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 4 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 09B

An investigation and test of various equipment was conducted to determine its state of repair and suitability for use in a test-bed computer network (to be used to simulate a space station configuration of computers for control and monitoring). A research study was also made of various network types, including the IEEE network standards: (1) Carrier Sense Multiple Access with Collision Detection. (2) Token Passing Bus (3) Token Passing Ring, and

(4) the draft ANSI standard for a High Speed Local Network, CSMA with Collision Avoidance. No firm conclusions are possible at this time as to which would be most suitable. An evaluation of the user interface of a space station database program, FREDSS (Formatted Retrieval and Entry of Data for Space Station, preliminary version), was also conducted and recommendations were made for possible improvements. Author

N86-31432*# Missouri Univ., St. Louis. Dept. of Computer Science.
INTEGRATION OF AN EXPERT SYSTEM INTO A USER INTERFACE LANGUAGE DEMONSTRATION
D. C. STCLAIR *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 47 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 09B

The need for a User Interface Language (UIL) has been recognized by the Space Station Program Office as a necessary tool to aid in minimizing the cost of software generation by multiple users. Previous history in the Space Shuttle Program has shown that many different areas of software generation, such as operations, integration, testing, etc., have each used a different user command language although the types of operations being performed were similar in many respects. Since the Space Station represents a much more complex software task, a common user command language--a user interface language--is required to support the large spectrum of space station software developers and users. To assist in the selection of an appropriate set of definitions for a UIL, a series of demonstration programs was generated with which to test UIL concepts against specific Space Station scenarios using operators for the astronaut and scientific community. Because of the importance of expert system in the space station, it was decided that an expert system should be embedded in the UIL. This would not only provide insight into the UIL components required but would indicate the effectiveness with which an expert system could function in such an environment. Author

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ACCOMMODATIONS

Includes descriptions of simulations, analyses, trade studies, and requirements for safe efficient procedures, facilities, and support equipment on the ground and in space for processing, servicing, verification and checkout of cargo and equipment.

A86-34958
ALTERNATIVES FOR REMOTE SPACE STATION MAINTENANCE
M. M. CLARKE (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 2-9 to 2-13.

A five-step method is suggested to optimize allocation of space maintenance tasks to three maintainer systems: (1) extravehicular activity, (2) teleoperators, and (3) robots. The steps are: (1) the listing of major global components of the Space Station; (2) the acquisition of detailed information on component and subcomponent definition; (3) the classification of information into a maintenance task definition matrix; (4) the definition of the three maintainer options to include estimates of technical advances; and (5) the development of a system alternative technical evaluation method to quantify the relative worth of maintaining each group of tasks by each of the maintainer options. It is concluded that such a method would ultimately maximize funds and crew time available to accomplish the real missions of the Space Station such as microgravity manufacturing, communications, and astronomical/earth observations. K.K.

A86-35184#
MAINTENANCE, MODIFICATION, AND REPAIR OF EXPERIMENT FACILITIES ONBOARD SPACE STATION
H. LENSKI (Dornier System GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 9 p.
(DGLR PAPER 85-146)

The designing of Space Station facilities to ensure easy maintenance, reliability, and growth potential is discussed. An example of a high-temperature furnace designed to meet these requirements is presented. The testing of new space facilities, and the training of the crew for operational and maintenance tasks are examined. I.F.

A86-35435* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION CREW WORKLOAD - STATION OPERATIONS AND CUSTOMER ACCOMMODATIONS
G. L. SHINKLE (NASA, Johnson Space Center, Houston, TX) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 75-81. refs
(SAE PAPER 851803)

The features of the Space Station which permit crew members to utilize work time for payload operations are discussed. The user orientation, modular design, nonstressful flight regime, in space construction, on board control, automation and robotics, and maintenance and servicing of the Space Station are examined. The proposed crew size, skills, and functions as station operator and mission specialists are described. Mission objectives and crew functions, which include performing material processing, life science and astronomy experiments, satellite and payload equipment servicing, systems monitoring and control, maintenance and repair, Orbital Maneuvering Vehicle and Mobile Remote Manipulator System operations, on board planning, housekeeping, and health maintenance and recreation, are studied. I.F.

A86-37055#
SPACE STATION ACCOMMODATIONS FOR A PHARMACEUTICAL MANUFACTURING MODULE
F. C. RUNGE (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AAS and Japanese Rocket Society, International Symposium on Space Exploitation and Utilization, Honolulu, HI, Dec. 15-19, 1985. 15 p.
(AAS PAPER 85-651)

The proposed integration of the Electrophoresis Operation/Space (EOS) Production Facility on the Space Shuttle is discussed. The EOS facility consists of a pressurized, habitable module which houses two factories, and a supply module; a diagram of the EOS facility is presented. The location of the EOS facility and supporting equipment is studied. The on-board data and communication systems are described. The level of crew involvement and the support cycle for the EOS facility are examined. I.F.

A86-38061
OPTIMIZING ACCURACY IN TRIANGULATION FOR GEOMETRICAL VERIFICATION OF LARGE SPACE STRUCTURES
A. M. C. HOLMES (Lockheed Missiles and Space Co., Inc., Palo Alto, CA) IN: International Instrumentation Symposium, 31st, San Diego, CA, May 6-9, 1985, Proceedings . Research Triangle Park, NC, Instrumentation Society of America, 1985, p. 261-270.

The triangulation process used for geometrical verification of large space structures such as deployable antenna reflectors is analyzed. The selection and placement of the proper reference length considering the theodolite are examined. A computer program, ERNA, for optimizing the theodolite placement in relation to the measurement span is described. Utilizing the triangulation process with reference lengths which are 80 percent of the desired measurement spans, accuracies of + or - 0.013 in. and + or - 0.024 in. are achieved for spans of 100 and 200 ft, respectively. I.F.

A86-43328#
PROSPECTS FOR INTELLIGENT AEROSPACE STRUCTURES
W. J. ROWE (Lockheed-Georgia Co., Marietta) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 10 p. refs
(AIAA PAPER 86-1139)

An evaluation is made of NDE sensor and instrumentation concepts that have demonstrated promise for the future monitoring of critical structures in flight, in light of past and current efforts to implement such systems and with a view to their operational and economic advantages. Attention is given to the NDE challenges posed by advanced composite laminates, which are affected by both manufacturing and service-incurred defects. Electrical resistance strain gages in various configurations, and optical fiber-based sensors, are considered as suitable bases for composite materials' NDE systems. O.C.

A86-46948*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
VERIFICATION OF POST PERMANENTLY MANNED CONFIGURATION SPACE STATION ELEMENTS
E. J. SCULLY and M. D. EDWARDS (NASA, Kennedy Space Center; McDonnell Douglas Astronautics Co., Cocoa Beach, FL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2323)

An account is given of the techniques and ground systems designed to fulfill post permanently manned configuration (PMC) Space Station verification tasks. Consideration is given to analysis using computer math models and computer-aided interface verification systems, testing using simulators and interface mixtures, and special inspection. It is noted that an initial Space Station design that accommodates and facilitates verification is crucial to an effective verification program as well as proper instrumentation, built-in test capability, and a precise configuration management, control and record system. It is concluded that post PMC verification should be accounted for both in the initial Space Station design and in the subsequent development of initial assembly flight verification techniques and capabilities. K.K.

A86-46953#
A SPACE STATION FAULT MANAGEMENT STRATEGY
H. BASIK (TRW, Inc., Redondo Beach, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p. refs
(AIAA PAPER 86-2330)

A Space Station fault management strategy is presented with attention given to the following: (1) system engineering and fault management concepts, (2) fault management processes, and (3) operational concepts. The system engineering concepts convey the context that the fault management strategy must accommodate; together, they include such things as the use of the orbital replacement units as part of the damage repair and redundancy management schemes, and the need to achieve 'fail operational/fail safe' behaviors in all Space Station systems. The fault management process involves the mapping of the strategy onto the set of fault tolerance techniques so as to guarantee consistent process results. Strategy implementation can be illustrated via operational concepts. An example is presented which suggests a distribution of the fault management system's functionality across the levels of the system hierarchy. K.K.

A86-46958#
TRIDENT PROGRAM MAINTAINABILITY, OPERATIONS, AND MAINTENACE TECHNIQUE APPLICATION TO SPACE STATION PROGRAM
H. A. BARTLETT (Essex Corp., Alexandria, VA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 11 p.
(AIAA PAPER 86-2339)

A group of subject matter experts known to personally possess information regarding the management and execution of the TRIDENT Submarine ILS Program were queried in structured interview sessions regarding the management and technical aspects of a set of discrete logistics attributes. The interview data showed that the seven weakest areas of past submarine programs are the seven areas of greatest improvement for the TRIDENT Submarine Program. While significant improvements were made in the TRIDENT Submarine Program, opportunities for further improvement exist. Next, the Space Station operation scenario was reviewed and similarities and differences between the TRIDENT Submarine Program and the Space Station Program were identified. Three of these differences have maintenance and maintainability significance. Lastly, three top-level Space Station Program maintenance and maintainability objectives were identified and related recommendations were provided which applied TRIDENT Submarine experience to the Space Station Program and accommodated significant program differences. Author

A86-46964*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
EOS PRODUCTION ON THE SPACE STATION
F. C. RUNGE (McDonnell Douglas Astronautics Co., Huntington Beach, CA) and M. GLEASON (McDonnell Douglas Astronautics Co., St. Louis, MO) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 6 p.
(Contract NAS8-36607)
(AIAA PAPER 86-2358)

The paper discusses a conceptual integration of the equipment for EOS (Electrophoresis Operations/Space) on the Space Station in the early 1990s. Electrophoresis is a fluid-constituent separation technique which uses forces created by an electrical field. Aspects covered include EOS equipment and operations, and Space Station installations involving a pressurized module, a resupply module, utility provisions and umbilicals and crew involvement. Accommodation feasibility is generally established, and interfaces are defined. Space Station production of EOS-derived pharmaceuticals will constitute a significant increase in capability compared to precursor flights on the Shuttle in the 1980s. Author

A86-47088* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
VERIFICATION OF LARGE SPACE STRUCTURES USING SCALE MODELLING LAWS
J.-C. CHEN, J. A. GARBA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and L. A. DEMSETZ IN: International Modal Analysis Conference, 3rd, Orlando, FL, January 28-31, 1985, Proceedings. Volume 1 . Schenectady, NY, Union College, 1985, p. 31-36. NASA-supported research. refs

The feasibility of testing large space structures in 1-g environment for the purpose of verifying its performance requirement is considered. Because of the difference in test objectives as compared to the conventional structural systems, the scale modelling laws are examined. The investigation is performed on a generic structural element, a space beam. A preliminary conclusion is obtained based on the results. Author

N86-27147*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION SCIENCE LAB MODULE
D. L. DEVINCENZI *In* NASA. Lyndon B. Johnson Space Center Space Statiaon Planetology Experiments (SSPEX) 5 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The Science Lab Module (SLM), a key component of the proposed Space Station (SS) orbiting complex, is undergoing intensive study during the project design phase which is currently underway. The SLM is one of the two laboratory modules which, together with two habitation modules, comprise the core elements of the SS reference configurations. Current project emphasis is to configure the SLM as a national science laboratory module facility which would have four major functions: maximize life sciences research potential, support operations of attached payloads, provide shirtsleeve environment for other payload instrument servicing, and support other science requirements. The design

studies are focusing on outfitting a common module basic design to accommodate the four specific functions. Although design work for outfitting the SLM for life sciences research is underway, science requirements for the other sciences and functions are not as well developed. Author

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GROWTH

Includes descriptions of scenarios, analyses and system technology requirements for the evolutionary growth of the Space Station system.

A86-30118
PRELIMINARY DESIGN OF A PERMANENTLY MANNED LUNAR SURFACE RESEARCH BASE
S. J. HOFFMAN and J. C. NIEHOFF (Science Applications International Corp., Schaumburg, IL) IN: Lunar bases and space activities of the 21st century . Houston, TX, Lunar and Planetary Institute, 1985, p. 69-75.

A brief study has been performed to assess the advantages and/or disadvantages of a lunar surface space base for civilian research and development. The suitability of undertaking scientific investigations in the diverse fields of astronomy, high-energy physics, selenology, planetary exploration, earth sciences, and life sciences was considered. A lunar base was conceived to conduct the identified science, along with transportation requirements to establish and support continued operations at the base. A rough order of magnitude (ROM) estimate of the cost to deploy and operate the lunar base for a period of three years was made. Starting with the Space Station will assure performance of important low-earth-orbit science and would also set in place certain elements of the transportation infrastructure found necessary to deploy and sustain a lunar base at a reasonable cost level. It is suggested that a lunar base be given serious consideration as a longer term goal of space policy, capable of providing important direction to the Space Station initiative. Author

A86-38623
NUCLEAR POWER FOR EARTH ORBIT AND BEYOND
B. NOLLEY Space World (ISSN 0038-6332), vol. W-5-269, May 1986, p. 18-20.

The development of space-based thermoelectric nuclear power generators for such future applications as the propulsion of an Orbital Transfer Vehicle or planetary exploration is discussed. Nuclear fission reactors have a higher power/mass ratio than radioisotope or chemical generators, less atmospheric drag, and will not be dependent on attitude control. The NASA in-core thermionics SP-100 nuclear fission reactor prototype is expected in the mid-1990s. A low mass 6.4 percent efficient multimegawatt capability reactor is described with a fast spectrum reactor in the cone's apex, separate from the two silicon-germanium element thermoelectric conversion system. Liquid lithium transports heat from the 1970-C reactor to heat exchanges that convey it to the heat pipe array, and heat rejection occurs at the deployable radiator panels. R.R.

A86-46961#
AN ECONOMICS PERSPECTIVE OF THE 21ST CENTURY SPACE STATION
M. K. MACAULEY (Resources for the Future, Washington, DC) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 5 p. refs
(AIAA PAPER 86-2348)

This paper offers an admonition for effective Space Station growth in the next century. Short of ability either to forecast or influence levels of economic activity, there nonetheless remains one aspect of near-term station use that can be implemented by station planners and that has direct consequences for the longer term. This aspect is the role of pricing policy for station access and use. Pricing can be crucial in determining where technical change and new developments in station design and operation will be needed. Furthermore, if past experience with technical change in the use of nonpriced resources is a guide to the future (as with the geostationary orbit and electromagnetic spectrum), the absence of prices can invite the presence of stringent, costly technical rules to accommodate scarcity, as well as emotive debate. Given the large amount of international collaboration envisioned for the Space Station, efficient pricing established early on in the program may perpetuate the most objective long-run allocation of scarce station resources. Author

15

MISSIONS, TETHERS, AND PLATFORMS

Includes descriptions and requirements of missions and tethers onboard the Space Station and platforms that are either co-orbiting with the Space Station, in polar orbit, or in geosynchronous orbit and which are part of the Space Station system.

A86-30123
IMPACT OF LUNAR AND PLANETARY MISSIONS ON THE SPACE STATION
G. R. BABB, H. P. DAVIS, P. G. PHILLIPS, and W. R. STUMP (Eagle Engineering, Inc., Houston, TX) IN: Lunar bases and space activities of the 21st century . Houston, TX, Lunar and Planetary Institute, 1985, p. 125-139. refs

The report examines the impact of several advanced planetary missions and a populated lunar base on the growth Space Station. Planetary missions considered include a Mercury Orbiter, a Saturn Orbiter with Multiple Titan Probes, and sample return missions from Mars, the comet Kopff, and the main belt asteroid Ceres. A manned lunar base buildup scenario is defined from preliminary lunar surveys through 10 years of construction, to the establishment of a permanent 18-person facility with the capability to produce oxygen to be used as propellant. For the lunar base, the Space Station must hangar at least two OTVs, store 100 metric tons of cryogens, and support an average of 14 OTV launch, return, and refurbishment cycles per year. An average of 630 metric tons per year must be launched to the Space Station for lunar base support during the 10 years of base construction. Approximately 70 percent of this cargo from earth is OTV propellant. An Unmanned Launch Vehicle (ULV) capable of lifting 100 metric tons net useful payload is considered necessary to deliver this propellant. An average launch rate of one Shuttle every two months and one ULV every three months to the growth Space Station will provide the required 630 metric tons per year. Planetary sample return missions require a dedicated quarantine module. Author

A86-30453*# National Aeronautics and Space Administration, Washington, D.C.
EXOBIOLOGY EXPERIMENTS FOR SPACE STATION
D. L. DEVINCENZI (NASA, Washington, DC) and L. D. GRIFFITHS (GE Management and Technical Services Co., Washington DC) (International Union of Physiological Sciences, Commission on Gravitational Physiology, Annual Meeting, 7th, Niagara Falls, NY, Oct. 13-18, 1985) Physiologist, Supplement (ISSN 0031-9376), vol. 28, Dec. 1985, p. S-185, S-186.

The benefits the Space Station could provide to the study of the origin, evolution, and distribution of life throughout the universe are described. Space Station experiments relevant to the cosmic evolution of biogenic elements and compounds, prebiotic chemical evolution, early evolution of life, and the evolution of advanced life forms are examined. The application of astronomical and astrometric observations to be obtained from the Space Station to the origin of life research is discussed. I.F.

A86-32907*# Martin Marietta Aerospace, Denver, Colo.
TETHERED ORBITAL PROPELLANT DEPOT
D. A. FESTER, L. K. RUDOLPH, and E. R. KIEFEL (Martin Marietta Corp., Denver, CO) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 22 p. refs
(Contract NAS9-17059)

A planned function of the Space Station is to refurbish and refuel an advanced space-based LO2/LH2 orbit transfer vehicle. An alternative to propellant storage at the station is to use a remote facility tied to the station with a log tether. Preliminary design of such a facility is described with emphasis on fluid transfer and storage requirements. Using tether lengths of at least 300 ft, gravity gradient forces will dominate surface tension in such a system. Although gravity given transfer is difficult because of line pressure drops, fluid settling over the tank outlet greatly alleviates acquisition concerns and will facilitate vented tank fills. The major concern with a tethered orbital refueling facility is its considerable operational complexity including transport of the OTV to and from the facility. Author

A86-34574
MOTION TRAJECTORIES OF PARTICLES INSIDE AND OUTSIDE AN ORBITING SPACE SHUTTLE
H. F. BAUER (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Jan.-Feb. 1986, p. 22-33.

In connection with the conduction of space missions, certain tasks, as, for instance, the assembly of space stations in orbit, will involve the placement of objects outside the space vehicle. Such objects may be subjected to certain forces, including aerodynamic drag and lift from a residual atmosphere. The present study has the objective to assess the effect of some of the forces on the relative motion of a system outside a space laboratory in cases in which constant and time-variant forces have to be considered. Attention is given to the disturbed motion of a mass point due to an oscillatory force, disturbed motion due to a pulse, the dynamics of a mechanical mass point system, and numerical evaluations and conclusions. G.R.

A86-34976* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE STATION ADAPTABILTY TO TETHER APPLICATIONS
P. A. PENZO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 8-13 to 8-22. NASA-supported research. refs

This paper examines the Space Station configuration, requirements, and operations, and considers its adaptability to accommodate each tether application. These include power and thrust generation, rendezvous and docking, science platforms, variable gravity, and satellite boost and deboost. It attempts to uncover incompatibilities, and suggests compromises which would be required to effectively utilize each specific application. The goal is to enhance the overall understanding of the adaptability of the Space Station to tether applications. Author

A86-34990#
POWER AND THERMAL MANAGEMENT CONCEPTS FOR FREE-FLYING PLATFORMS IN THE SPACE STATION ERA
H. O. CURTIS, P. R. PIERCE, K. R. JOHNSON, and D. R. CHALMERS (RCA, Astro Electronics Div., Princeton, NJ) Canaveral Council of Technical Societies, Space Congress, 22nd, Cocoa Beach, FL, Apr. 23-26, 1985, Paper. 11 p. refs

The use of space platforms for special scientific and commercial payloads will enhance the system capability of the Space Station program and spur the exploitation of low earth orbits. These platforms will be serviceable to promote low-cost extension of platform life, as well as to provide long term payload maintenance, repair and change-out. The power and thermal subsystems of these platforms threfore will be designed to satisfy a broad and evolving range of payload resource requirements, while providing maintainability and sericeability consistent with long life. Early designs highlight the need for, and impact of, modular configurations employing advanced technologies. Author

A86-37002
THE EVOLUTION OF REMOTE SENSING SCIENCE AND APPLICATIONS
J. H. MCELROY (NOAA, National Environmental Satellite, Data, and Information Service, Washington, DC) IN: Machine processing of remotely sensed data - Quantifying global process: Models, sensor systems, and analytical methods; Proceedings of the Eleventh International Symposium, West Lafayette, IN, June 25-27, 1985 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 4-11. refs

The development of space observation systems and their applications are examined. The satellite systems that provide meteorological, oceanographic, land-science, and atmospheric data are described. The use of NASA's Polar Platform for observational missions is proposed. The need for data systems which process and distribute data quickly and accurately is discussed. I.F.

A86-37855#
LIFE SCIENCE OPPORTUNITIES IN THE SPACE STATION
L. R. YOUNG (MIT, Cambridge, MA) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 73-76.

Areas of research in the life sciences are pointed out that could benefit greatly when the facilities of the Space Station become available. Research subjects and problems meriting work include: human physiology (cardiovascular system deconditioning, loss of bone minerals, loss of muscle mass, vestibular system reaction to weightlessness); gravitational biology; and the study of the origin and evolution of life on earth. Some facilities that will be needed to conduct this research are mentioned, in particular the variable g centrifuge for use by various disciplines and capable of handling humans as well as animals and plants. D.H.

A86-37858#
THE QUESTION OF POLAR PLATFORMS
P. J. CONCHIE and I. V. FRANKLIN (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 123-130.

The potential of one of the candidate elements of the Manned Space Station Program is considered, namely the unmanned space platform. The role of the space platform in the overall complex is examined, and its use is discussed with particular reference to the polar orbit possibilities. Components would include a resource module, payload beam, propulsion module, instrument pointing module and payload module. Mission aspects would involve rendezvous and docking with the Space Station for servicing as well as deboosting and reboosting from and to operational orbit. Possibly two unmanned polar orbiting space platforms will be developed, for sun-synchronous and noon-midnight orbits. The necessity for the platform(s) to be cost-effective is emphasized. D.H.

A86-37862#
A PAYLOAD FOR UTILIZATION OF SPACE PLATFORM IN THE FIELD OF COMMUNICATION AND EARTH OBSERVATION
F. SCIARRINO (Contraves Italiana S.p.A., Rome, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 185-197.

Experiments in the field of communication and earth observation are described which can be carried out on board the Space Platform and the Shuttle Tethered Satellite. Three payloads are discussed.

SLACOM will be a space platform adaptive communication module to perform a series of experiments to investigate new K-band, C-band, and L-band techniques for improving point-to-point communications via satellite. A microwave SAR (synthetic aperture radar) will be used for high resolution imaging of land surfaces and ocean waves, monitoring earth resources, disaster assessment, navigation aids, weather and sea-state forecasting, altimetry, and subsatellite tracking. COMLINK will be an experiment using a conducting tether 10-100 km long connecting a transmitter on a subsatellite to a Space Shuttle orbiting at a higher altitude; both communications and tethering technology can be tested. D.H.

A86-40502
GEOSTATIONARY PLATFORM - AN APPLICATION OF THE SPACE STATION
K. L. ROSE (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 1-1 to 1-10.

Aggregate communication payloads developed in the NASA LeRC study are presented, and platform bus concepts currently evolving in the NASA MSFC study are described. The payloads encompass varying mixes of FSS, DBS, and maritime mobile services, WARC region 2, intraregion 2, and CONUS Intelsat traffic into the Atlantic and Pacific Ocean regions. The major features of four representative payload scenarios as developed by Ford Aerospace are described: (1) Scenario II, an FSS satellite with DBS capability, contains conventional C- and Ku-band transponders with two times frequency reuse at C-band and three times frequency at Ku-band; (2) Scenario IV is a high capacity, high power video distribution satellite; (3) Scenario V has CONUS coverage, and can be described as a high capacity CONUS, FSS satellite payload that is designed to address the distributional characteristics of CONUS traffic; and (4) Scenario VI-A, is the first of a complementary pair of satellites designed to handle all of the WARC region 2 Intelsat traffic, intraregion 2 as well as AOR and POR traffic. It is noted that Scenarios II, IV and V can be accommodated by a platform requiring a single STS launch while that accommodating Scenario VI-A requires multiple launches. K.K.

A86-40584#
THE POLAR PLATFORM OF THE SPACE STATION - A PERMANENT FACILITY FOR METEOROLOGICAL, OCEANOGRAPHIC, AND LAND OBSERVATIONS
E. L. HEACOCK, D. B. MILLER, and S. R. SCHNEIDER (NOAA, National Environmental Satellite, Data and Information Service, Washington, DC) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 49-59. refs
(AIAA PAPER 86-1174)

The design and capabilities of NASA's Space Station Polar Platform are studied. NOAA's TIROS-N (ATN) spacecraft is the current operational polar-orbiting environmental satellite and it contains sounding, imaging, data collection, and space environment monitoring equipment. The instruments from previous missions for observation of the earth's atmosphere, meteorology, oceans, and land are described. The integration of research instruments, such as the atmospheric and meteorological remote sensing assembly, solar-terrestrial environment sensing assembly, oceanic remote sensing assembly, land remote sensing assembly, data collection and platform location, and satellite-aided search and rescue, into the operational capabilities of the Polar Platform is examined. Current and proposed international contributions to the design and development of the Polar Platform are discussed. I.F.

A86-42745*# Martin Marietta Aerospace, Denver, Colo.
THE DYNAMICS OF A SPACE STATION TETHERED REFUELING FACILITY
P. ABBOTT, L. K. RUDOLPH, and D. A. FESTER (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p.
(Contract NAS9-17059)
(AIAA PAPER 86-1605)

The fluid stored in a tethered orbital refueling facility is settled at the bottom of the storage tanks by gravity-gradient forces. The fluid motions (slosh) induced by outside disturbances must be limited to ensure the tank outlet is not uncovered during a fluid transfer. The dynamics of a LO2/LH2 TORF attached to the space station have been analyzed to identify design parameters necessary to limit fluid motion. Using the worst case disturbance of a shuttle docking at the space station, the fluid motion was found to be a function of tether length and allowable facility swing angle. Acceptable fluid behavior occurs for tether lengths of at least 1000 ft. To ensure motions induced by separate disturbances do not add to unacceptable values, a slosh damping coefficient of 5 percent is recommended. Author

A86-42746*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION TETHERED REFUELING FACILITY OPERATIONS
E. R. KIEFEL, L. K. RUDOLPH, and D. A. FESTER (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. refs
(Contract NAS9-17059; NAS9-17422)
(AIAA PAPER 86-1606)

The space-based orbital transfer vehicle will require a large cryogenic fuel storage facility at the Space Station. An alternative to fuel storage onboard the Space Station, is on a tethered orbital refueling facility (TORF) which is separated from the Space Station by a sufficient distance to induce a gravity gradient to settle the propellants. Facility operations are a major concern associated with a tethered LO2/LH2 storage depot. A study was carried out to analyze these operations so as to identify the preferred TORF deployment direction (up or down) and whether the TORF should be permanently or intermittently deployed. The analyses considered safety, contamination, rendezvous, servicing, transportation rate, communication, and viewing. An upwardly, intermittently deployed facility is the preferred configuration for a tethered cryogenic fuel storage. Author

A86-43208* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A THREE-DIMENSIONAL DYNAMIC ANALYSIS AND LIBRATION STUDY OF A TETHERED SATELLITES SYSTEM
C. C. H. TANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and B. C. BARISH (California Institute of Technology, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 109-131. NASA-supported research. refs
(AAS PAPER 85-340)

By a three-dimensional Lagrangian formulation, an exact set of ten coupled nonlinear second-order differential equations has been derived for a system with an extensible tether connecting two end satellites of distributed mass. The effects of tether mass, small orbital eccentricity, central body oblateness, aerodynamic drag force, and solar radiation pressure are also included in the formulation. By linearizing the exact differential equations, the in-plane (orbital plane) differential equations are found to be decoupled from the out-of-plane ones. The characteristic equation of the in-plane differential equations is derived and some associated stability constraints are shown. Author

A86-43226* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POLAR PLATFORM SERVICING PERFORMANCE LIMITATIONS
R. W. KLEMETSON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 471-490. NASA-supported research. refs
(AAS PAPER 85-434)

The preferred service mode for space platform equipment repair, change or fluids resupply is to have manned operations via EVA and RMS. This requires that the platform achieve a rendezvous with the STS Orbiter. Because of the performance characteristics of the STS in high-inclination and high-altitude orbits, the orbit maneuvers for rendezvous must be provided by a space platform dedicated propulsion system, or by a separate Orbital Maneuvering Vehicle (OMV). An alternate service mode is to have remote operations at the platform operational altitude using an OMV. The polar platform studies examined the mass performance capability of dedicated propulsion and the OMV for both STS rendezvous and platform operational altitude service modes. Author

A86-43228* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
POLAR PLATFORM PAYLOAD REQUIREMENTS IN THE 1990'S
D. VANE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) and M. DONOHOE (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 519-528. NASA-sponsored research. refs
(AAS PAPER 85-396)

NASA's Earth Orbiting System (EOS) and NOAA's operational payloads represent two of the major users of the Space Station Polar Platform capabilities. The EOS program will be designed for Shuttle launch, servicing and on-orbit augmentation, while the NOAA's payload will be designed for the operational monitoring of the earth's atmosphere, oceans, and land masses. An overview is given of both the EOS and NOAA platform programs as well as the implied platform requirements. It is concluded that the generic platform design must be capable of operating at altitudes ranging from Shuttle altitudes to NOAA altitudes (approximately 850 km). In addition, it must be able to accommodate approximately 5000 kg of payload mass, provide 5000 W of continuous power and up to 13 kW of peak power for short durations, and store and transmit data at rates up to 300 Mbps. K.K.

A86-43231* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PLATFORM OPTIONS FOR THE SPACE STATION PROGRAM
M. J. MANGANO and R. W. ROWLEY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 569-592. NASA-supported research. refs
(AAS PAPER 85-399)

Platforms for polar and 28.5 deg orbits were studied to determine the platform requirements and characteristics necessary to support the science objectives. Large platforms supporting the Earth-Observing System (EOS) were initially studied. Co-orbiting platforms were derived from these designs. Because cost estimates indicated that the large platform approach was likely to be too expensive, require several launches, and generally be excessively complex, studies of small platforms were undertaken. Results of these studies show the small platform approach to be technically feasible at lower overall cost. All designs maximized hardware inheritance from the Space Station program to reduce costs. Science objectives as defined at the time of these studies are largely achievable. Author

A86-44002#
TROLLING THE ATMOSPHERE
Aerospace America (ISSN 0740-722X), vol. 24, June 1986, p. 16-18.

By paying out a tethered satellite to lower orbits, long term soundings of the upper atmosphere where the projected NASA aerospace plane would operate can be taken; in addition, the vehicle configuration of the aerospace plane could be investigated in scale model form. Other projects that could benefit from such research include the Aeroassisted Orbital Transfer Vehicle and the Entry Research Vehicle. The technique which constitutes a tethered wind tunnel, has been designated the Shuttle Tethered Aerodynamic Research Facility. An additional use for this system would be the verification of computer simulations employed in the design of advanced vehicles' configurations and thermal protection systems. O.C.

A86-45642
VIEWING THE EARTH FROM SPACE - TOWARDS THE SPACE STATION POLAR PLATFORM
D. L. CROOM and D. T. LLEWELLYN-JONES (SERC, Rutherford Appleton Laboratory, Didcot, England) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 97-100.

Current and proposed remote sensing techniques that may be used on the Manned Space Station (MSS) polar orbiting platforms to characterize various terrestrial phenomena are reviewed. The instruments operate in either passive or active modes, performing limb, nadir or side scanning operations to produce imagery with details ranging from 10-1000 m for high resolution to 10-100 km for low resolution. The sensor platforms are used for atmospheric, climate, ocean and ice and earthquake research, hydrology, to characterize biochemical cycles, for geophysics, etc. The polar orbits will provide access to scenes out of reach of the MSS orbit. The use of platforms will permit periodic visits, repairs, refurbishments and retrieval of the instruments. Over 12 platforms have been proposed for the initial operating configuration. The number will be significantly reduced to eliminate redundancy and to fit available launch schedules, which may permit on-station visits spaced no less than 2 yr apart. M.S.K.

A86-45708*# National Aeronautics and Space Administration, Washington, D.C.
TETHER PROPULSION
I. BEKEY (NASA, Washington, DC) and P. A. PENZO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 40-43.

The principle and applications of tethering are examined. Tethering works by momentum transfer; the center of mass of a system consisting of (for example) a Space Shuttle and a tethered payload such as the Advanced X-ray Astrophysical Facility continues to follow the original orbit. Given a slight outward velocity, the payload begins to lag behind because it has the same linear velocity as the Shuttle but is at a greater distance from the earth. Any displacement from the local vertical causes a restoring force at each end tending to restore the system to a vertical orientation. When vertically above the Shuttle, the payload has the same angular velocity but a greater linear velocity; thus momentum is transferred from the Shuttle to the payload. It is computed that a tether 32 nautical miles long could deploy AXAF into a 320-nautical mile orbit from a lower, elliptical Shuttle orbit, thus saving 5000 pounds of Shuttle propellant. Various types of tether are considered: Kevlar and steel, uniform and tapered. Numerous cases appear to be feasible for boost and deboost as well as momentum transfer, using such reaction masses as the Space Station, a lunar orbiter, the Martian moons Phobos and Deimos, various asteroids, and moons of the major planets. D.H.

A86-46853
A REPORT ON THE SUMMER STUDY OF THE SESAC TASK FORCE ON SCIENTIFIC USES OF THE SPACE STATION
J. KLARMANN (Washington University, Saint Louis, MO) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 58-61.

A86-46859* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
STUDYING ANTIPROTONS FROM BALLOONS AND SPACE STATION
J. F. ORMES, V. K. BALASUBRAHMANYAN, and R. E. STREITMATTER (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 124-133. refs

Experimental measurements are proposed to determine the existence of cosmic antiprotons and to differentiate between various hypothetical origins for them. The balloon-borne experiment proposed by Balasubrahmanyan et al. (1983) for detecting 50-220-MeV antiprotons and measuring their energy distribution is described; the astrophysical significance of antiproton measurements is considered; the antiproton/proton ratios predicted by various cosmic-ray and exotic models are presented graphically; and the performance required of a Space Station superconducting-magnet detector for the 10-1000-GeV range is discussed. It is concluded that an instrument with 0.3-sq m sr geometry could distinguish (at a 5-sigma level) between hypotheses with spectral-exponent separation of 0.1 in observing time about 1 month, assuming a spectral exponent as steep as E to the -3rd. T.K.

A86-46861
A MAGNET SPECTROMETER FACILITY - RATIONALE AND SCIENCE THEMES
D. MULLER (Chicago, University, IL) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 148-152.

The construction of a cosmic-ray facility is proposed. It consists of a large superconducting magnet spectrometer combined with interchangeable detector systems. This facility will address a number of significant topics in cosmic-ray astrophysics, such as the search for antiprotons and antimatter, measurements of electrons and positrons, precision measurements of energy spectra of cosmic-ray nuclei, determination of isotopic abundances at high energies, and observations of high-energy nucleus-nucleus interactions. The magnet-spectrometer facility will make use of the capabilities of the Space Station, such as assembly and servicing in space, and thus planning and design efforts for the facility should proceed simultaneously with the definition work for the Space Station. The importance of an ongoing program of detector development at the participating institutions is stressed. Author

A86-46862
SUPERCONDUCTING MAGNET TECHNOLOGY
R. L. GOLDEN (New Mexico State University, Las Cruces) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 153-159.

The potential for performing cosmic-ray research using superconducting magnet spectrometers on the Space Shuttle and the Space Station is reviewed. An assessment of the current technologies in magnets and cryostats is also given. Improvements in magnet construction have eliminated concerns about magnet transitions, leaving stray fields and normal cryogenics handling as the principal concerns with regard to utilizing magnets in space. Both of these problems can apparently be dealt with in a routine fashion. Improvements in spatial-detector technology which are now being employed in particle physics should allow use of ordinary NbTi superconductor to achieve measurements of antiprotons to 100 GV/c, studies of Be isotopes to 30 GV/c, and studies of iron to 6 GV/c (provided the requisite Cerenkov detector technology is available) on the Space Shuttle. On the Space Station, where observing times can be longer and stray-field problems are not so severe, an extremely wide range of experiments is possible, including antiproton observations to 1 TeV and isotopic observations to 100 GV/c using an instrument of reasonable proportions and cost. Author

A86-46869* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
NUCLEAR COMPOSITION
V. K. BALASUBRAHMANYAN (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 252-258. refs

The results of direct measurements of the energy distribution and elemental composition of cosmic rays are reviewed. Consideration is given to early calorimeter, Cerenkov-counter, and superconducting-magnet data; HEAO-3 results; balloon-borne measurements beyond 30 GeV/nucleon, and the balloon-borne emulsion-chamber data obtained in the JACEE experiments (Burnett et al., 1982 and 1983). The potential of Space Station observations to extend the data to energies as high as 10 PeV is discussed. T.K.

A86-46871* California Inst. of Tech., Pasadena.
MEASUREMENTS OF COSMIC RAY ISOTOPES FROM A SPACE PLATFORM
R. A. MEWALDT (California Institute of Technology, Pasadena) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 267-274. refs
(Contract NGR-05-002-160)

Possibilities for measuring cosmic-ray isotopes with Z = 3-30 from an earth-orbiting space platform are considered. Included are a summary of scientific objectives, a survey of current instrumentation, an examination of the effect of the geomagnetic field, and estimates of the yield of isotopes that could be realized. It is found that space-platform experiments could provide a factor-of-100 improvement in yield over currently approved future experiments. To address the objectives of cosmic-ray isotope studies most effectively, measurements should be made by several complementary instruments spanning a range of energies from less than 0.1 to about 100 GeV/nucleon. Author

A86-46876* Chicago Univ., Ill.
DETECTORS FOR HIGH ENERGY COSMIC RAYS ON SPACELAB
J. LHEUREUX, P. MEYER, D. MULLER, and S. SWORDY (Chicago, University, IL) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 310-322. refs
(Contract NAS8-32828)

Two instruments designed to determine the spectra of the individual cosmic-ray components at very high energies are described. One of these (CRNE) uses a combination of gas Cerenkov counters and transition radiation detectors for the cosmic-ray nuclei lithium to nickel; the other (TRIC) is optimized for the light cosmic rays (electrons, protons, helium) and uses a transition-radiation/ionization-calorimeter combination. The CRNE instrument, constructed at the University of Chicago, was delivered to NASA for a first Shuttle flight on Spacelab-2 in summer 1985. Some of the technical and programmatic requirements encountered during the hardware construction and integration are discussed, and the expected scientific return and the prospects of using such instrumentation on the Space Station are considered. Author

A86-46879* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
A HIGH ENERGY SPACE STATION (HESS) ARRAY FOR STUDYING EXTREMELY ENERGETIC COSMIC RAYS
J. F. ORMES and R. E. STREITMATTER (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 340-348.

The scientific aims and design concept of a High-Energy Space Station (HESS) cosmic-ray detector array are discussed. The current state of knowledge on cosmic-ray acceleration and high-energy interactions is briefly reviewed, and the need for observations yielding elemental composition and spectra in the 10-10,000-TeV/nucleon range is demonstrated. It is predicted that 2 yr of observations with a space-borne detector of geometry factor 30 sq m sr would provide adequate data to determine the acceleration mechanism (by comparing the energy level at which the spectra of He nuclei and protons break). A modular HESS array comprising W/scintillator/PM-tube calorimeter modules and Cerenkov charge-sensitive detector modules and weighing about 30 tonnes is described. The array could be assembled on orbit after transport in the Space Shuttle cargo bay, and data could be taken as soon as one or two layers of modules had been attached to the mounting-frame/support-electronics unit. T.K.

A86-46880
HIGH ENERGY COSMIC RAY OBSERVATORY
T. SAITO (Tokyo University, Japan) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 349-356. refs

Construction of a Space Station facility, the High Energy Cosmic Ray Observatory, is proposed to study high-energy gamma rays, nuclear composition and spectra, and nucleus interactions. Objectives, experimental considerations, and plans for technical and calibration studies are presented. Author

A86-46881
STUDY OF COMPOSITION AND ENERGY SPECTRA OF COSMIC RAY IONS OF Z = 6 - 28 OF E = 1 - 100 TEV/N IN SPACE STATION
S. BISWAS, R. COWSIK, N. DURGAPRASAD, P. J. KAJAREKAR, S. A. STEPHENS (Tata Institute of Fundamental Research, Bombay, India) et al. IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 357-362.

The study of cosmic-ray heavy ions (Z = 6-28) at 1-100 TeV/n can provide important clues to cosmic-ray origin and propagation in interstellar space. Characteristics of high-energy particle interaction beyond the accessible range of present-day accelerators could also be obtained. A preliminary outline of a detector system for such an experiment, which can be carried out on the proposed Space Station, is presented. It consists mainly of CR-39 and emulsion detectors interspaced with thin copper targets to facilitate fragmentation of the incident CR heavy ions. Charge resolution of Delta-Z = 0.2 can be obtained with the CR-39 plastic detector, and the opening angle of collision fragments traced in nuclear emulsions can be used to determine the particle energies. Time resolution of about 30 sec for the arrival of the relativistic particles can be achieved. The details of the proposal are discussed. Author

A86-46884
EMULSION CHAMBER EXPERIMENTS FOR THE SPACE STATION
R. J. WILKES (Washington, University, Seattle) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 380-389. refs
(Contract DE-AC06-81ER-40048)

Emulsion chambers offer several unique features for the study of ultrahigh-energy cosmic-ray interactions and spectra aboard a permanent manned Space Station. Emulsion-chamber experiments provide the highest acceptance/weight ratio of any current experimental technique, are invulnerable to mechanical shocks and temperature excursions associated with space flight, do not employ volatile or explosive components or materials, and are not dependent upon data communications or recording systems. Space-Station personnel would be employed to replace track-sensitive materials as required by background accumulation. Several emulsion-chamber designs are proposed, including both conventional passive calorimetric detectors and a hybrid superconducting-magnetic-spectrometer system. Results of preliminary simulation studies are presented. Operational logistics are discussed. Author

A86-46885* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
USE OF DIRECT ELECTRON PAIR METHOD
Y. TAKAHASHI, P. B. EBY, T. A. PARNELL (NASA, Marshall Space Flight Center, Huntsville, AL), J. C. GREGORY, and T. HAYASHI (Alabama, University, Huntsville) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 390-397. refs

A new method for energy measurement of heavy cosmic-ray nuclei in nuclear emulsion is considered: the use of Coulomb-pair production. The energy-dependent cross section for the production of direct electron pairs in nuclear emulsion is found sufficiently high to permit the energy determination of iron-group nuclei to better than +60 or -40 percent above 1 TeV/nucleon. An experimental calibration and a possible application of the method to Space Shuttle experiments are considered. Author

A86-46891* Smithsonian Astrophysical Observatory, Cambridge, Mass.
USING THE ET FOR GAMMA-RAY ASTRONOMY
D. KOCH (Smithsonian Astrophysical Observatory, Cambridge, MA) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 454-461. refs
(Contract NASW-3743)

A gamma-ray-telescope design is presented which makes use of the normally spent external tank (ET) of the Space Shuttle as the spacecraft and Cerenkov pressure vessel. The ET would be configured into the telescope once onorbit, using the Space Station as the base of operations for carrying out the assembly activities. The telescope provides a continuation to the NASA program in high-energy astrophysics, providing for follow-on observations to the survey work of the EGRET instrument on GRO. The most important features of the gamma-ray imaging telescope system are its collecting area of 250,000 sq cm per ET (40 times that of the EGRET instrument) and its ability to locate point sources to within several arc minutes. Author

A86-46893
A LARGE GAMMA-RAY TELESCOPE FOR POINT SOURCE STUDIES ABOVE 1 GEV
P. GORET (CEA, Service d'Astrophysique, Gif-sur-Yvette, France) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 469-476. refs

A large gamma-ray telescope is described which is devoted to the observation of gamma-ray point sources in the 1-100-GeV range. The principle of detection is based on imaging the Cerenkov light produced in a gas by the electron-positron conversion pair. The angular resolution for individual gamma-rays is about 5 arcmin rms at 10 GeV. With a detection area of 7 sq m and a 30 percent pair-conversion efficiency, the effective sensitive area is about 20,000 sq cm; i.e., one order of magnitude larger than GAMMA 1 or EGRET. Based on a permanent Space Station, this highly sensitive instrument would enable accurate studies of 1-100 GeV gamma-ray point sources to be performed, such as energy spectra in a range hardly accessible to present experiments, detailed analysis of gamma-ray pulsars, search for faint Galactic or extragalactic sources, studies of temporal variations in gamma-ray luminosity, and location of sources with arcmin accuracy. Author

A86-46894
LARGE ARRAY OF GAMMA-RAY DETECTORS IN SPACE STATION FOR GAMMA-RAY ASTRONOMY AND STUDYING BURSTS AND ELECTRONS ABOVE 10 TO THE 13TH EV
S. A. STEPHENS (Tata Institute of Fundamental Research, Bombay, India) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 477-484. refs

The possibility of employing an array of high-energy-gamma-ray detectors on the Space Station is discussed. It is shown that such a detector could be utilized for the study of faint extragalactic X-ray sources. It can be operated in the gamma-ray-burst mode, by which their energy spectrum can be studied from 0.1 MeV to 50 GeV, and their location determined accurately. The array can also be used for the study of cosmic-ray electrons above 10 TeV, which no other technique today can detect. Author

A86-46895
GAMMA RAYS AND NEUTRINOS DETECTIONS WITH SPACE STATION AND DUMAND
T. KITAMURA (Tokyo, University, Japan) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 485-490. refs

An observational approach to differentiate between structureless-magnetoid and black-hole models of X-ray and/or gamma-ray emission from active galactic nuclei is proposed. The theoretical basis is explained in detail, and it is shown that comparison of measurements of the gamma flux at energies above 1 GeV and the neutrino flux at energies above 1 TeV permits this differentiation. These measurements could be obtained using the Space Station calorimeter array proposed by Saito (1984) and the Deep Undersea Muon and Neutrino Detector (DUMAND), respectively. T.K.

A86-46896
A CALORIMETER FOR THE SPACE STATION
P. J. CARLSON (Stockholm, Universitet, Sweden) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 491-496. refs

It is proposed that one instrument for the Space Station should be an electromagnetic calorimeter with very high spatial resolution. Such an instrument could locate very-high-energy gamma-ray/electron-positron sources with high angular resolution. It could also serve to search for monoenergetic gamma-rays from neutron stars and also for quark matter. Author

A86-46899
A SPACE STATION FOR HIGH ENERGY ASTROPHYSICS HESSA
G. B. YODH (Maryland, University, College Park) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 528-539. refs

A proposal for designing and developing a Space Station for high-energy astrophysics is outlined. A modular structure with an overall geometrical factor of 30 sq m sr is envisioned. The components have high-precision tracking and calorimetry to be able to study elemental components from protons to iron up to 1 PeV, high-energy electrons and positrons and high-energy gamma rays (E greater than 100 GeV). Addition of a very large array of detectors surrounding the central station can extend its capabilities to measurement of ultraheavy nuclei. It is also capable of being instrumented to investigate ultrahigh-energy interactions of nuclei using emulsion chambers. Author

A86-46937*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
OVERVIEW OF SPACE STATION ATTACHED PAYLOADS IN THE AREAS OF SOLAR PHYSICS, SOLAR TERRESTRIAL PHYSICS, AND PLASMA PROCESSES
W. T. ROBERTS (NASA, Marshall Space Flight Center, Huntsville, AL), J. KROPP, and W. W. L. TAYLOR (TRW, Inc., Cleveland, OH) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p. refs
(AIAA PAPER 86-2298)

This paper outlines the currently planned utilization of the Space Station to perform investigations in solar physics, solar terrestrial physics, and plasma physics. The investigations and instrumentation planned for the Solar Terrestrial Observatory (STO) and its associated Space Station accommodation requirements are discussed as well as the planned placement of the STO instruments and typical operational scenarios. In the area of plasma physics, some preliminary plans for scientific investigations and for the accommodation of a plasma physics facility attached to the Space Station are outlined. These preliminary experiment concepts use the space environment around the Space Station as an unconfined plasma laboratory. In solar physics, the initial instrument complement and associated accommodation requirements of the Advanced Solar Observatory are described. The planned evolutionary development of this observatory is outlined, making use of the Space Station capabilities for servicing and instrument reconfiguration. Author

A86-46960#
SPACE STATION - LIFE SCIENCES
R. S. YOUNG (Management and Technical Services Co., Washington, DC) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 4 p.
(AIAA PAPER 86-2346)

The use of the Space Station for biomedical research and the study of biological cellular and subcellular processes is described. The research will require: (1) a health maintenance facility, (2) a life science research facility, and (3) instruments and platforms for automatic experiments. Experiments analyzing physiological changes induced by microgravity and the relationship between gravity, cellular and organismal physiology, and biochemistry are to be performed on the Station. The development of closed ecological life support systems is to be studied on the Space Station. The Station's facilities are also to be utilized to examine the interaction of the earth's biota with the planet environment, and the origin, evolution, and distribution of life throughout the universe. I.F.

A86-47413*# Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
A THREE-MASS TETHERED SYSTEM FOR MICRO-G/VARIABLE-G APPLICATIONS
E. C. LORENZINI (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA) IN: Guidance, Navigation and Control Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 97-105. refs
(Contract NAS8-36606)
(AIAA PAPER 86-1990)
This paper describes a Space-Station attached tethered system for micro-g/variable-g applications. The system consists of three platforms: the Space Station, an end mass anchored at the end of a 10 km long kevlar tether and a micro-g/variable-g laboratory with the capability of crawling along the tether. Control strategies are devised for performing both the deployment and the station-keeping maneuvers of the system. Effective algorithms are identified for damping out the major vibrational modes. Author

A86-47914*# Science Applications International Corp., Schaumberg, Ill.
MOTION OF A DRAG-FREE EXPERIMENT ON THE SPACE STATION
D. J. GERMAN and A. L. FRIEDLANDER (Science Applications International Corp., Schaumburg, IL) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 127-132.
(Contract NASW-4092)
(AIAA PAPER 86-2071)
This paper describes the analysis and results of a study concerning the motion of a particle in a 'drag-free experiment' (zero-gravity) performed on the Space Station. Two cases were considered: (1) motion of a particle with an at rest initial condition and (2) motion of a particle with an initial velocity. In particular, this study examined the possibility of optimal solutions in terms of displacement from the initial location relative to the station center of gravity point. These solutions were of special interest since the experiment is to be performed in a constrained volume. The results of this study indicate that the total displacement may be made smaller if the particle has an initial velocity than if the particle starts from at rest initial conditions. Author

A86-47960*# RCA Astro-Electronics Div., Princeton, N. J.
SPACE STATION POLAR ORBITING PLATFORM - MISSION ANALYSIS AND PLANNING
P. A. MILLER (RCA, Astro-Electronics Div., Princeton, NJ) AIAA and AAS, Astrodynamics Conference, Williamsburg, VA, Aug. 18-20, 1986. 8 p. refs
(Contract NAS5-29400)
(AIAA PAPER 86-2178)
The Space Station Polar Orbiting Platform will be a serviceable spacecraft supporting a range of missions. The planning and analysis of these missions is investigated. The subjects of STS compatibility, rendezvous strategy, and requisite launch windows are addressed. General, as well as, two specific cases are detailed with respect to their incremental velocity requirements. Author

A86-49479* California Univ., Santa Barbara.
SUPPORT FOR GLOBAL SCIENCE - REMOTE SENSING'S CHALLENGE
J. E. ESTES and J. L. STAR (California, University, Santa Barbara) Geocarto International, no. 1, 1986, p. 3-14. refs
(Contract NASW-455)
Advances in remote sensing techniques are discussed. The benefits possible to remote sensing with the new Earth Observing System, which is composed of the Space Station and coorbiting and polar satellite platforms, are examined. Current changes in the remote sensing field, which involve a change from an industrial society to an informational society, force technology to high technology with high touch, short term to long term, centralized to decentralized, hierarchies to networks, and either/or to multiple option systems are studied. The explanatory and objective types of analyses for investigating biophysical, geochemical, and socioeconomic processes are described; the procedures include: morphometric, cause and effect, temporal and functional and ecological system analyses, inventory, mapping, monitoring, and modeling. I.F.

A86-49554*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE SPACE REFLECTOR TECHNOLOGY ON THE SPACE STATION
J. C. MANKINS, R. M. DICKINSON, R. E. FREELAND, and N. I. MARZWELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 9 p. NASA-supported research. refs
(AIAA PAPER 86-2302)
This paper discusses the role of the Space Station in the evolutionary development of large space reflector technology and the accommodation of mission systems which will apply large space reflectors during the late 1990s and the early part of the next century. Reflectors which range from 10 to 100 meters in size and which span the electromagnetic spectrum for applications that include earth communications, earth observations, astrophysics and solar physics, and deep space communications are discussed. The role of the Space Station in large space reflector technology development and system performance demonstration is found to be critical; that role involves the accommodation of a wide variety of technology demonstrations and operational activities on the Station, including reflector deployment and/or assembly, mechanical performance verification and configuration refinement, systematic diagnostics of reflector surfaces, structural dynamics and controls research, overall system performance characterization and modification (including both radio frequency field pattern measurements and required end-to-end system demonstrations), and reflector-to-spacecraft integration and staging. A unique facility for Space Station-based, large space reflector research and development is proposed. A preliminary concept for such a Space Station-based Large Space Reflector Facility (LSRF) is described. Author

A86-49562#
SPACEHAB: A PRESSURIZED PAYLOAD-BAY SPACE STATION TEST BED MODULE - AN EARLY LOW COST DEVELOPMENT LEAD-IN FOR SPACE STATION
R. CITRON (SPACEHAB, Inc., Seattle, WA) and T. C. TAYLOR (SPACEHAB, Inc., Wrightwood, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986, Paper. 14 p. refs
The Spacehab module, a commercial pressurized research volume in the payload bay of the Space Shuttle, is designed to stimulate and support the space commercialization industry emerging in connection with Space Station. This module creates a low cost lower risk development sequence for the customers at the Space Station. Three types of modules are anticipated. The first is designed to address the middeck locker market with a three yr backlog, to maximize the cost reduction aspect of a simple existing technology shell, and to give the customer more control over the cost of orbital research operations. A later more advanced module will evolve toward greater interior complexity; this module will simulate the Space Station interior volume some five yrs before Space Station IOC. Subsequently, a deployable version of the module is expected to be attached to the Space Station to provide a commercial interface for space research and production facilities. K.K.

A86-50266*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIRTF AND THE SPACE STATION
M. W. WERNER and C. B. WILTSEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p. refs
(AIAA PAPER 86-2353)

An evaluation is made of the technical prospects and scientific goals of the Space IR Telescope Facility (SIRTF), whose telescope is of 1-m aperture and cryogenically cooled and will be able to improve on IRAS performance in such areas as wavelength coverage, spectral and spatial resolution, and sensitivity. Attention is given to the findings of an intensive review of the long-life SIRTF mission, with a view to new determinations on its orbit, scientific performance requirements, and baseline design concepts, as well as the ways in which it will employ elements of the NASA Space Station. O.C.

N86-24535*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
ANALYTICAL DETERMINATION OF SPACE STATION RESPONSE TO CREW MOTION AND DESIGN OF SUSPENSION SYSTEM FOR MICROGRAVITY EXPERIMENTS
F. C. LIU *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 36 p Jan. 1986
Avail: NTIS HC A99/MF E04

The objective of this investigation is to make analytical determination of the acceleration produced by crew motion in an orbiting space station and define design parameters for the suspension system of microgravity experiments. A simple structural model for simulation of the IOC space station is proposed. Mathematical formulation of this model provides the engineers a simple and direct tool for designing an effective suspension system. Author

N86-25403# National Environmental Satellite Service, Washington, D. C.
PLAN FOR SPACE STATION POLAR-ORBITING PLATFORM Final Report
J. H. MCELROY, S. R. SCHNEIDER, D. B. MILLER, and J. W. SHERMAN, III Jun. 1985 105 p refs
(AD-A164405) Avail: NTIS HC A06/MF A01 CSCL 22B

This ENVIROSAT-2000 Report concerns utilization of the polar platform component of NASA's Space Station program. Issues covered in the report include instrument payloads, altitudes, orbits, serviceability, communications, and data processing. A scenario is set forth for operational utilization of the platform, including issues surrounding integration of operational and research missions. The discussion is broken down by discipline: oceanography, meteorology, land sciences, atmospheric sciences, and solar-terrestrial investigations. A cost analysis shows that performing NOAA operations from the polar platforms would prove extremely beneficial by replacing the expendable two Polar-orbiting Operational Environmental Satellite (POES) system that NOAA now maintains. GRA

N86-25689*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
SYSTEM ENGINEERING STUDY OF ELECTRODYNAMIC TETHER AS A SPACEBORNE GENERATOR AND RADIATOR OF ELECTROMAGNETIC WAVES IN THE ULF/ELF FREQUENCY BAND Semiannual Report, 1 Sep. 1985 - 28 Feb. 1986
R. D. ESTES, M. D. GROSSI, and E. C. LORENZINI Mar. 1986 48 p refs
(Contract NAG8-551)
(NASA-CR-176749; NAS 1.26:176749; SAR-1) Avail: NTIS HC A03/MF A01 CSCL 20N

The transmission and generation by orbiting tethered satellite systems of information carrying electromagnetic waves in the ULF/ELF frequency band to the Earth at suitably high signal intensities was examined and the system maintaining these intensities in their orbits for long periods of time without excessive onboard power requirements was investigated. The injection quantity power into electromagnetic waves as a function of system parameters such as tether length and orbital height was estimated. The basic equations needed to evaluate alternataing current tethered systems for external energy requirements are presented. The energy equations to tethered systems with various lengths, tether resistances, and radiation resistances, operating at different current values are applied. Radiation resistance as a function of tether length and orbital height is discussed. It is found that ULF/ELF continuously radiating systems could be maintained in orbit with moderate power requirements. The effect of tether length on the power going into electromagnetic waves and whether a single or dual tether system is preferable for the self-driven mode is discussed. It is concluded that the single tether system is preferable over the dual system. E.A.K.

N86-26862*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NEW TECHNIQUES FOR THE DETECTION AND CAPTURE OF MICROMETEOROIDS
J. H. WOLFE (San Jose State Univ., Calif.), T. E. BUNCH, and G. C. CARLE *In* NASA, Washington Second Symposium on Chemical Evolution and the Origin and Evolution of Life p 59 May 1986
Avail: NTIS HC A07/MF A01 CSCL 06C

In order to understand the origin and distribution of the biogenic elements and their compounds in the solar system, it will be necessary to study material from many classes of objects. Chemical, elemental, and isotopic measurements of returned samples of comets, asteroids, and possibly extra-solar system dust clouds would provide information on a particularly important class: the primitive objects. Extraterrestrial micron-sized particles in the vicinity of earth are one source of such materials that might otherwise be inaccessible. The Space Station appears to be an eminently suitable platform from which to collect and detect these various particles. The primary challenge, however, is to collect intact, uncontaminated particles which will be encounted at tens of kilometers per seconds. A concept for a micrometeoroid detector that could be deployed at a Space Station has been developed which uses a large area detector plate implanted with acoustic transducers. When an impact event occurs, the resulting signal is subjected to spectral analysis providing positive detection, momentum information, and angle of incidence. The primary advantage of this detector is the large area which increases the probability of measuring events. Author

N86-27136*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION PLANETOLOGY EXPERIMENTS (SSPEX)
R. GREELEY, ed. (Arizona State Univ., Tempe) and R. J. WILLIAMS, ed. May 1986 97 p Workshop held in Flagstaff, Ariz., 20-22 Jun. 1985
(Contract NCC9-14; NAS9-17023)
(NASA-CP-2424; S-554; NAS 1.55:2424) Avail: NTIS HC A05/MF A01 CSCL 03A

A meeting of 50 planetary scientists considered the uses of the Space Station to support experiments in their various disciplines. Abstracts (28) present concepts for impact and aeolian processes, particle formation and interaction, and other planetary science experiments. Summaries of the rationale, hardware concepts, accomodations, and recommendations are included.

N86-27140*# National Aeronautics and Space Administration, Washington, D.C.
REPORT ON OPPORTUNITIES AND/OR TECHNIQUES FOR HIGH-CALIBER EXPERIMENTAL RESEARCH (OTHER) PROPOSALS FOR SSPEX
J. A. NUTH, III, G. CORSO (Northwestern Univ., Evanston, Ill.), D. DEVINCENZI, A. DUBA (Lawrence Livermore National Lab., Calif.), J. FREEMAN (Rice Univ., Houston, Tex.), R. LOPEZ, J. STEPHENS (Jet Propulsion Lab., California Inst. of Tech., Pasadena), I. STRONG (Los Alamos National Lab., N. Mex.), and J. WOLFE (San Jose State Univ., Calif.) *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 5 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Brief discriptions of the following 13 experiments are included: ultrahigh vacuum petrology facility; artificial comet free flyer; artificial comet (tethered); cosmic dust detector; cosmic dust collector; dust collection using tethered satellites; artificial magnetosphere; microgravity petrological studies; slitless ultraviolet spectrometer; orbital determination and capture experiment (ODACE); high velocity sputtering of amorphous silicates; particle release experiments; and calibration of gamma and X-ray remote sensingprobes. B.G.

N86-27141*# California Inst. of Tech., Pasadena. Seismological Lab.
A PLANETARY ULTRA HYPERVELOCITY IMPACT MECHANICS AND SHOCK WAVE SCIENCE FACILITY
T. J. AHRENS *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 5 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Using the concept of intercepting orbits from a pair of Space Station serviced free flyers, a class of impact and shock wave experiments pertinent to planetary science can be performed. One proposed free flying vehicle is an impactor dispensor, and the second is the impact laboratory. How collision is achieved by utilizing essentially twice orbital velocity is demonstrated. The impactor dispensor contains a series of small flyer plates or other projectiles which are launched into the trajectory of the impactor laboratory at appropriate positions. The impactor laboratory is a large impact tank similar to those in terrestrial gun laboratories, except that it contains a supply of targets and instrumentation such as high speed cameras, flash X-ray apparatus and digital recorders. Shock and isentropic pressures of up to 20 Mbar are achievable with such a system which provides 15 km/sec impact velocities for precisely oriented projectiles. B.G.

N86-27142*# California Inst. of Tech., Pasadena. Seismological Lab.
PROPOSED EARTH BASED CRATERING EXPERIMENTS AT LOW G IN HARD VACUUM
T. J. AHRENS *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

In order to address the question of whether the cratering scale which was developed can be extrapolated to low velocity (of planetesimals appropriate for conditions during accretion of the planets and the impact mechanics of encounters of both asteroids and the solid objects which comprise the rings of the outer major planets), a series of experiments at low gravity and at high vacuum are proposed. Specific issues which could be addressed include: the effect of very low gravity on cratering efficiency and final crater shape; and the dynamics of impact into a strengthless spherical and ellipsoidal liquid target. Author

N86-27145*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
LOW-GRAVITY IMPACT EXPERIMENTS: PROGRESS TOWARD A FACILITY DEFINITION
M. J. CINTALA *In its* Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Innumerable efforts were made to understand the cratering process and its ramifications in terms of planetary observations, during which the role of gravity has often come into question. Well known facilities and experiments both were devoted in many cases to unraveling the contribution of gravitational acceleration to cratering mechanisms. Included among these are the explosion experiments in low gravity aircraft, the drop platform experiments, and the high gravity centrifuge experiments. Considerable insight into the effects of gravity was gained. Most investigations were confined to terrestrial laboratories. It is in this light that the Space Station is being examined as a vehicle with the potential to support otherwise impractical impact experiments. The results of studies performed by members of the planetary cratering community are summarized. Author

N86-27146*# Indiana Univ. Northwest, Gary.
COSMIC DUST COLLECTION WITH A SUB-SATELLITE TETHERED TO A SPACE STATION
G. J. CORSO *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986
Prepared in cooperation with Northwestern Univ., Evanston, Ill.
Avail: NTIS HC A05/MF A01 CSCL 03A

The number concentration and density of 1 micron and submicron sized grains in interplanetary space, as well as their relation to the larger zodical dust particles, and the importance of the Beta meteoroid phenomenon are currently being questioned. The best approach to collecting large numbers of intact micron and submicron sized cosmic dust particles in real time while avoiding terrestrial and man made contamination would be to employ a tethered subsatellite from a space station down into the Earth's atmosphere. Such a subsatellite tied to the space shuttle by a 100 km long tether is being developed. It is also possible that a permanent space station would allow the use of a tether even longer that 100 km. It should be noted that the same tethered collectors could also be employed to study the composition and flux of man made Earth orbiting debris in any direction within 100 km or so of the space station. B.G.

N86-27148*# Lawrence Livermore National Lab., Calif.
ELECTRICAL CONDUCTIVITY OF CARBONACEOUS CHONDRITES AND ELECTRIC HEATING OF METEORITE PARENT BODIES
A. DUBA *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986 refs
Avail: NTIS HC A05/MF A01 CSCL 03A

The electrical conductivity of samples of the Murchison and Allende carbonaceous chondrites is 4 to 6 magnitudes greater than rock forming minerals such as Olivine up to 700 C. The remarkably high electrical conductivity of these meteorites is attributed to carbon at grain boundaries. The environment in the wake of the space station can be exploited to produce conditions which will allow pyrolysis of carbonaceous chondrites. An experimental package consisting of a one square meter shield attached to a 15 cm diameter by 40 cm long furnace and tied to a conductance bridge, furnace controller, and digital voltmeter inside the space station via umbilical cable could make the required measurements. Since heating rates as low as 0.1 C/hour are required to study kinetics of the pyrolysis reations which are the cause of the high conductivity of the carbonaceous chondrites, experimental times up to 3 months will be needed. B.G.

N86-27149*# Rice Univ., Houston, Tex. Dept. of Space Physics and Astronomy.

THE ORBIT PROPERTIES OF COLLIDING CO-ORBITING BODIES

J. W. FREEMAN *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986

Avail: NTIS HC A05/MF A01 CSCL 03A

It is generally assumed that an ensemble of small bodies located in similar Keplarian orbits will, because of collisions, tend to disperse into more and more dissimilar orbits. For example, it is thought that the asteroids may represent the remnants of a few larger bodies that broke up or failed to fully accrete. A proposed experiment using the space station consists of an ensemble of small bodies or particles released gently from a central location in a large chamber, much like the breaking of billiard balls. The particles would them co-orbit and occasionally collide. Their subsequent behavior could be monitored by several video recorders, their linear and angular velocities before and after collision calculated, and their general behavior studied. This experiment could yield results of fundamental importance for theories of the origin of the planets, asteroids, comets, and probably ring systems. B.G.

N86-27151*# Department of Energy, Mines, and Resources, Ottawa (Ontario). Microgravity Cratering Working Group.

IMPACT EXPERIMENTATION AND THE MICROGRAVITY ENVIRONMENT: AN OVERVIEW

R. A. F. GRIEVE *In* NASA. Lyndon B. Johnson Space Center Sapce Station Planetology Experiments (SSPEX) 2 p May 1986

Avail: NTIS HC A05/MF A01 CSCL 03A

Impact is an ubiquitous physical process in the solar system. It occurs on all solid bodies and operates over a spectrum of scales, influencing geologic processes ranging from accretion, the early evolution of planetary bodies, the petrogenetic and spatial relations of lunar samples, the surface characteristics and interpretation of spectral data of asteroidal bodies, to the nature of some meteorites. Understanding impact phenomena is therefore paramount in constraining and underpinning a large number of research efforts into fundamental planetary geology. Gravity is an important parameter in impact processes. The physical environment offered by the Space Station represents an unique opportunity to extend the experimental aspect of impact studies into the microgravity (less than 1 g) regime. Through the use of free floating targets, it may be possible to explore in detail phenomena associated with the collision of bodies. Such experiments can address questions regarding early and late accretional processes, catastrophic disruption and asteroidal evolution, as well as the effects of large impacts on the momentum and spin of the target bodies. The last question is of considerable topical interest with respect to the hypothesized origin of the moon by a Mars-sized impact on Earth. B.G.

N86-27152*# National Aeronautics and Space Administration, Washington, D.C.

EXOBIOLOGY EXPERIMENT CONCEPTS FOR SPACE STATION

L. D. GRIFFITHS (Management and Technical Services Co., Washington, D.C.) and D. L. DEVINCENZI *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 1 p May 1986

Avail: NTIS HC A05/MF A01 CSCL 03A

The exobiology discipline uses ground based and space flight resources to conduct a multidiscipline research effort dedicated to understanding fundamental questions about the origin, evolution, and distribution of life and life related molecules throughout the universe. Achievement of this understanding requires a methodical research strategy which traces the history of the biogenic elements from their origins in stellar formation processes through the chemical evolution of molecules essential for life to the origin and evolution of primitive and, ultimately, complex living species. Implementation of this strategy requires the collection and integration of data from solar system exploration spacecraft and ground based and orbiting observatories and laboratories. The Science Lab Module (SLM) of the Space Station orbiting complex may provide an ideal setting in which to perform certain classes of experiments which form the cornerstone of exobiology research. These experiments could demonstrate the pathways and processes by which biomolecules are synthesized under conditions that simulate the primitive Earth, planetary atmospheres, cometary ices, and interstellar dust grains. Exobiology experiments proposed for the Space Station generally fall into four classes: interactions among gases and grains (nucleation, accretion, gas-grain reactions), high energy chemistry for the production of biomolecules, physical and chemical processes occurring on an artificial comet, and tests of the theory of panspermia. Author

N86-27153*# Iowa State Univ. of Science and Technology, Ames. Dept. of Aerospace Engineering.

SEDIMENT-TRANSPORT EXPERIMENTS IN ZERO-GRAVITY

J. D. IVERSEN and R. GREELEY (Arizona State Univ., Tempe) *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986

Avail: NTIS HC A05/MF A01 CSCL 03A

One of the important parameters in the analysis of sediment entrainment and transport is gravitational attraction. The availability of a laboratory in Earth orbit would afford an opportunity to conduct experiments in zero and variable gravity environments. Elimination of gravitational attraction as a factor in such experiments would enable other critical parameters (such as particle cohesion and aerodynamic forces) to be evaluated much more accurately. A Carousel Wind Tunnel (CWT) is proposed for use in conducting experiments concerning sediment particle entrainment and transport in a space station. In order to test the concept of this wind tunnel design a one third scale model CWT was constructed and calibrated. Experiments were conducted in the prototype to determine the feasibility of studying various aeolian processes and the results were compared with various numerical analysis. Several types of experiments appear to be feasible utilizing the proposed apparatus. Author

N86-27155*# Rice Univ., Houston, Tex. Dept. of Space Physics and Astronomy.

A MAGNETOSPHERIC SIMULATION AT THE SPACE STATION

R. E. LOPEZ, J. W. FREEMAN, and F. C. MICHEL *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 1 p May 1986

Avail: NTIS HC A05/MF A01 CSCL 03A

It is proposed that a strong magnet (terrella) be flown at or near the Space Station to create an artificial magnetosphere in a laboratory setting. The relative flow of the ionosphere past the terrella will constitute a plasma wind that will interact with the magnetic field of the terrella to produce a localized magnetosphere. This object could then be extensively studied using diagnostic probes attached to the Space Station, or with free flyers. The space and storage requirements would be minimal, since the experiment would be conducted outside the space station. The total equipment would consist of several terrella (with varying surface conductivities), approximately 3 small magnetometer/plasma diagnostic packages, and several gas canisters for upstream seeding. Power requirements would be approximately 60 watts. Several track mounted tethers, each approximately or 200 m long in length, with track parallel to the orbital motion and 100 m long, are also needed. Astronaut time needed would be minimal in the tethered configuration (approximately 4 man hours/week). A free flying configuration, while not needing the tether track, would require much more human interaction. Author

N86-27160*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LOW GRAVITY FACILITIES FOR SPACE STATION PLANETOLOGY EXPERIMENTS
P. A. PENZO *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

For experimentation, space offers a unique environment which is unobtainable on Earth. One characteristic is a gravity force less than 1 g, where g is the mean Earth gravity acceleration of 9.8 m/sq s. The production of uniform gravity levels above zero g in space is discussed in relationship to experimental needs. For planetology experiments, providing gravity in space will make it possible to more nearly simulate conditions on natural bodies. The g-level is but one parameter involved in the design of a specific experiment. Other requirements may be: g-level range; g-level tolerance value; Coriolis tolerance value; volume requirement; g-level duration; power and materials for the experiment; and automated or man-tended operation. These requirements, and certainly others, will dictate the type of facility which should be considered. The use of the Space Station or the Tethered Satellite System configurations is discussed. B.G.

N86-27161*# Brown Univ., Providence, R. I. Dept. of Geological Sciences.
DEBRIS-CLOUD COLLISIONS: ACCRETION STUDIES IN THE SPACE STATION
P. H. SCHULTZ and D. E. GAULT (Murphys Center of Planetology, Calif.) *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The growth of planetesimals in the Solar system reflects the success of collisional aggregation over disruption. Recent experiments performed at the NASA-Ames Vertical Gun Range are discussed using the production of debris cloud impaction to model protoplanetary accretion. The impact experiment assessed the differences between clustered and single body impacts on particulate surfaces. The preliminary results would indicate that collisions between two debris clouds might produce aggregates, thereby increasing particle sizes, whereas a single particle impacting a particle results in disruption and comminution. Such an experiment could provide new insight for early planetary growth processes and for interpreting the record of this stage. The use of the microgravity environment of the Space Station to further the research is discussed. B.G.

N86-27164*# California Inst. of Tech., Pasadena. Div. of Physics, Mathematics and Astronomy.
GRAIN DYNAMICS IN ZERO GRAVITY
B. T. WERNER and P. K. HAFF *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The dynamics of granular materials has proved difficult to model, primarily because of the complications arising from inelastic losses, friction, packing, and the effect of many grains being in contact simultaneously. The kinetic model of granular systems is similar to the kinetic theory of gases, except that collisional energy losses are always present in the former and must be treated explicity. Few granular materials on Earth are describable by this limiting model, since gravity tends to collapse the grains into a high density state where Coulombic friction effects are dominant. The planned Space Station offers an unusual opportunity to test the kinetic grain model and to explore its predictions. Without gravity, the regime of low interparticle velocities (where an elastic description of the collision is still valid) can be investigated. This will allow for direct interpretation by dynamical computer simulations as well as by the kinetic theory. The dynamics of spherical grains inside a clear box would be examined. Results would be compared with the predictions of the kinetic theory and computer simulations. B.G.

N86-27165*# California Univ., Davis.
AEOLIAN PROCESSES ABOARD A SPACE STATION: SALTATION AND PARTICLE TRAJECTORY ANALYSIS
B. R. WHITE, R. GREELEY (Arizona State Univ., Tempe), J. D. IVERSEN (Iowa State Univ. of Science and Technology, Ames), and R. N. LEACH (Santa Clara Univ., Calif.) *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The Carousel wind tunnel (CWT) proposed to study aeolian processes aboard a space station consists of two concentric rotating drums. The space between the two drums comprises the wind tunnel test section. Differential rates of rotation of the two drums would provide a wind velocity with respect to either drum surface. Preliminary results of measured velocity profiles made in a CWT prototype indicate that the wall bounded boundary layer profiles are suitable to simulate flat plate turbulent boundary layer flow. The two dimensional flat plate Cartesian coordinate equations of motion of a particle moving through the air are explained. In order to assess the suitability of CWT in the analysis of the trajectories of windblown particles, a series of calculations were conducted comparing cases for gravity with those of zero gravity. Results from the calculations demonstrate that a wind tunnel of the carousel design could be fabricted to operate in a space station environment and that experiments could be conducted which would yield significant results contributing to the understanding of the physics of particle dynamics. B.G.

N86-27166*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
A SYSTEM FOR CONDUCTING IGNEOUS PETROLOGY EXPERIMENTS UNDER CONTROLLED REDOX CONDITIONS IN REDUCED GRAVITY
R. J. WILLIAMS *In its* Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The Space Shuttle and the planned Space Station will permit experimentation under conditions of reduced gravitational acceleration offering experimental petrologists the opportunity to study crystal growth, element distribution, and phase chemistry. In particular the confounding effects of macro and micro scale buoyancy-induced convection and crystal settling or floatation can be greatly reduced over those observed in experiments in the terrestrial laboratory. Also, for experiments in which detailed replication of the environment is important, the access to reduced gravity will permit a more complete simulation of processes that may have occurred on asteroids or in free space. A technique that was developed to control, measure, and manipulate oxygen fugacites with small quantities of gas which are recirculated over the sample is described. This system should be adaptable to reduced gravity space experiments requiring redox control. Experiments done conventionally and those done using this technique yield identical results done in a 1-g field. B.G.

N86-27167*# San Jose State Univ., Calif.
NEW TECHNIQUES FOR THE DETECTION AND CAPTURE OF MICROMETEOROIDS
J. H. WOLFE *In* NASA. Johnson Space Center Space Station Planetology Experiments (SSPEX) 1 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

In order to understand the origin and distribution of the biogenic elements and their compounds in the solar system, it will be necessary to study material from many classes of objects. Chemical, elemental, and isotopic measurements of returned samples of comets, asteroids, and possibly extrasolar system dust clouds would provide information on a particularly important class: the primitive objects. Extraterrestrial micron-sized particles in the vicinity of Earth are one source of such materials that might otherwise be inaccessible. The Space Station appears to be an eminently suitable platform from which to collect and detect these various particles. The primary challenge, however, is to collect intact, uncontaminated particles which will be encountered at tens of kilometers per seconds. A concept for a micrometeoroid detector

that could be deployed from the Space Station was developed which uses a large area detector plate implanted with acoustic transducers. A concept of a nondestructive micrometeoroid collector for the Space Station was also developed. Particles collected would then be returned to Earth for subsequent analysis. Author

N86-27168*# Geological Survey, Flagstaff, Ariz.
MAPPING EXPERIMENT WITH SPACE STATION
S. S. C. WU *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Mapping of the Earth from space stations can be approached in two areas. One is to collect gravity data for defining topographic datum using Earth's gravity field in terms of spherical harmonics. The other is to search and explore techniques of mapping topography using either optical or radar images with or without reference to ground central points. Without ground control points, an integrated camera system can be designed. With ground control points, the position of the space station (camera station) can be precisely determined at any instant. Therefore, terrestrial topography can be precisely mapped either by conventional photogrammetric methods or by current digital technology of image correlation. For the mapping experiment, it is proposed to establish four ground points either in North America or Africa (including the Sahara desert). If this experiment should be successfully accomplished, it may also be applied to the defense charting systems. B.G.

N86-27647*# Martin Marietta Corp., Denver, Colo.
TETHERED ORBITAL REFUELING STUDY
D. A. FESTER *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 89-123 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

Objectives are to evaluate the feasibility and limitations of fluid acquisition and transfer under an accleration induced in a tethered orbital refueling facility and to provide conceptual designs. Program tasks consist of recommendation of fluid transfer method and parameters; evaluation of disturbances, fluid motion, and damping; selection of passive devices to augment inherent fluid damping and determination of the resultant envelope of operation; assessment of the effect of tether lengths on hazards; and identification of ground and flight tests necessary to prove the tethered orbital refueling concepts. B.G.

N86-27648*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TETHERS AND GRAVITY IN SPACE
P. A. PENZO *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 125-135 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The life science objectives concerning gravitational effects in space are summarized. The use of rotation, centrifuge, and tether techniques to produce variable gravity in space are presented. The station and tether platform concept are presented for the Gravlab design. B.G.

N86-27649*# Naples Univ. (Italy). Istituto Aerodinamica U. Nobile.
TETHERED ELEVATOR: A UNIQUE OPPORTUNITY FOR SPACE PROCESSING
R. MONTI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 137-147 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The latest fluid dynamic and material science experiments in the microgravity environment have emphasized the importance of the residual gravity level and of the g-jitter on fluid physics phenomena. The tethered elevator presents the possibility of providing variable g-levels (both steady and g-jitter) around a very low steady g-level (that can be realized when the elevator is near the center of mass of the space station-tether complex). When positioning a variable periodic oscillation to the payload a clean g-jitter disturbance can be obtained that would not be otherwise obtainable by other systems. These two possibilities make the elevator a facility to help resolve a number of still open questions that are preventing wider utilization of the space environment in the microgravity area. B.G.

N86-27652*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SHUTTLE TETHERED AEROTHERMODYNAMICS RESEARCH FACILTY (STARFAC) INSTRUMENTATION REQUIREMENTS
G. M. WOOD, P. M. SIEMERS, G. M. CARLOMAGNO (Naples Univ. (Italy).), and J. HOFFMAN (Texas Univ., Dallas.) *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 251-263 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The instrumentation requirements for the Shuttle Tethered Aerothermodynamic Research Facility (STARFAC) are presented. The typical physical properties of the terrestrial atmosphere are given along with representative atmospheric daytime ion concentrations and the equilibrium and nonequilibrium gas property comparison from a point away from a wall. STARFAC science and engineering measurements are given as are the TSS free stream gas analysis. The potential nonintrusive measurement techniques for hypersonic boundary layer research are outlined along with the quantitative physical measurement methods for aerothermodynamic studies. E.R.

N86-27659*# Aeritalia S.p.A., Torino (Italy). Gruppo Sistemi Spaziali.
TETHERED ELEVATOR AND PLATFORMS AS SPACE STATION FACILITIES: SYSTEMS STUDIES AND DEMONSTRATIVE EXPERIMENTS
In NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 413-455 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

Several key concepts of the science and applications tethered platforms were studied. Some conclusions reached are herein listed. Tether elevator and platform could improve the space station scientific and applicative capabilities. The space elevator presents unique characteristics as microgravity facility and as a tethered platform servicing vehicle. Pointing platforms could represent a new kind of observation facility for large class of payloads. The dynamical, control and technological complexity of these concepts advised demonstrative experiments. The on-going tethered satellite system offers the opportunity to perform such experiments. And feasibility studies are in progress. E.R.

N86-27660*# California Univ., La Jolla. Space Inst.
ROLES FOR TETHERS ON AN EVOLVING SPACE STATION
J. A. CARROLL *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 457-472 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

A scenario was developed for evolution of space station tether capabilities. As tether imposed constaints on station developments and operations were minimized, maximum benefits were derived from a mutually compatible combination of: (1)electrodynamic tethers for power, thrust, and libration control; (2)momentum transfer operations involving the STS or upper stages; (3)aeromaneuvering devices for space station orbital plan change; and (4)tethered constellations and tether/free-flyer combinations. Some concepts determined for advance tether facilities orbiting the moon: (1)stationkeeping deltaVs to stay in precise equatorial or polar orbits; (2)ratio of facility mass to maximum payload mass (surface-orbit-escape); (3)electric-thruster power requirements and maximum rendezvous frequencies; and (4)overall capabilities and major constraints on such facilities. E.R.

N86-28115*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
APPLICATIONS OF TETHERS IN SPACE: A REVIEW OF WORKSHOP RECOMMENDATIONS
G. VONTIESENHAUSEN, ed. May 1986 24 p
(NASA-TM-86549; NAS 1.15:86549) Avail: NTIS HC A02/MF A01 CSCL 22B

Well-organized and structured efforts of considerable magnitude involving NASA, industry, and academia have explored and defined the engineering and technological requirements of the use of tethers in space and have discovered their broad range of operational and economic benefits. The results of these efforts have produced a family of extremely promising candidate applications. The extensive efforts now in progress are gaining momentum and a series of flight demonstrations are being planned and can be expected to take place in a few years. This report provides an analysis and a review of NASA's second major workshop on Applications of Tethers in Space held in October 15 to 17, 1985, in Venice, Italy. It provides a summary of an up-to-date assessment and recommendations by the NASA Tether Applications in Space Program Planning Group, consisting of representatives of seven NASA Centers and responsible for tether applications program planning implementation as recommended by the workshop panels. Author

N86-28410*# Energy Science Labs., Inc., San Diego, Calif.
TETHER FUNDAMENTALS
J. A. CARROLL *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 81-101 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

Some fundamental aspects of tethers are presented and briefly discussed. The effects of gravity gradients, dumbbell libration in circular orbits, tether control strategies and impact hazards for tethers are among those fundamentals. Also considered are aerodynamic drag, constraints in momentum transfer applications and constraints with permanently deployed tethers. The theoretical feasibility of these concepts are reviewed. E.R.

N86-28416*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
TRANSPORTATION
G. VONTIESENHAUSEN *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 185-219 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

A summary of tether transportation is given. Four steps were used over a period of time. First, theoretical engineering feasibility and technology requirements were determined. Then the survivors of that effort went into step two in the analysis of promising candidates. Those survivors went into the third phase which is engineering design and cost benefits. Survivors entered into the demonstration mission definition phase. Transportation studies have covered two kinds of deployments. First, steady state deployment was studied. Like the TSS, it's nearly vertical. It takes a long time to deploy and involves relatively high tether tension. Secondly, dynamic deployment was studied. Deployment started in an almost horizontal direction under a very shallow angle which allows a high deployment rate under very low tension. Momentum transfer here occurs by libration. Specific payloads were used to study tethered transportation benefits. Four transportation concepts were studied with regard to cost benefits. A tethered orbiter deboost from the space station, an OTV boost up from the Space Station, a science platform on a tether with a possible micro-g lab moving in between platform and station, and a tethered boost of payloads fromthe orbiter are the four concepts. These benefits are examined in detail. E.R.

N86-28418*# Martin Marietta Aerospace, Denver, Colo.
TETHER APPLICATIONS FOR SPACE STATION
W. NOBLES *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 239-267 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

A wide variety of space station applications for tethers were reviewed. Many will affect the operation of the station itself while others are in the category of research or scientific platforms. One of the most expensive aspects of operating the space station will be the continuing shuttle traffic to transport logistic supplies and payloads to the space station. If a means can be found to use tethers to improve the efficiency of that transportation operation, it will increase the operating efficiency of the system and reduce the overall cost of the space station. The concept studied consists of using a tether to lower the shuttle from the space station. This results in a transfer of angular momentum and energy from the orbiter to the space station. The consequences of this transfer is studied and how beneficial use can be made of it. E.R.

N86-28420*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TECHNOLOGY AND TEST
P. SIEMERS *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 279-283 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The chairman of the Technology Applications in Space Working Group summarizes the technology issues for each of the disciplines in Tethered Satellite Systems. The disciplines are Tether Materials and Configurations, Tether System Dynamic Simulation Capability, Tether System Instrumentation, TAS Program Related Science Instrumentation, Atmospheric/Aerothermodynamic tethered system research, and TAS Discipline Program Accomplishment. To enable these tether applications, design and development programs have been recommended and are presently underway relative to the demonstration of the hollow cathode concept which is an enabling electrodynamic tether mission technology. E.R.

N86-28424*# Naples Univ. (Italy). Inst. of Gasdynamics.
HIGH RESOLUTION REMOTE SENSING MISSIONS OF A TETHERED SATELLITE
S. VETRELLA and A. MOCCIA *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 349-363 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The application of the Tethered Satellite (TS) as an operational remote sensing platform is studied. It represents a new platform capable of covering the altitudes between airplanes and free flying satellites, offering an adequate lifetime, high geometric and radiometric resolution and improved cartographic accuracy. Two operational remote sensing missions are proposed: one using two linear array systems for along track stereoscopic observation and one using a synthetic aperture radar combined with an interferometric technique. These missions are able to improve significantly the accuracy of future real time cartographic systems from space, also allowing, in the case of active microwave systems, the Earth's observation both in adverse weather and at any time, day or night. Furthermore, a simulation program is described in which, in order to examine carefully the potentiality of the TS as a new remote sensing platform, the orbital and attitude dynamics description of the TSS is integrated with the sensor viewing geometry, the Earth's ellipsoid, the atmospheric effects, the Sun illumination and the digital elevation model. A preliminary experiment has been proposed which consist of a metric camera to be deployed downwards during the second Shuttle demonstration flight. Author

N86-29516# Stuttgart Univ. (West Germany). Abt. Bioenergetik.
A THEORETICAL CONCEPT FOR STATE CHANGES AND SHAPE CHANGES IN WEIGHTLESSNESS
R. J. STRASSER *In* DFVLR Proceedings and Program Draft in Gravitational Biology in the Federal Republic of Germany (DFVL R-Mitt-85-16) p 23-31 Oct. 1985 In GERMAN; ENGLISH summary
Avail: NTIS HC A09/MF A01; DFVLR, Cologne DM 50

A theoretical concept for state and shape changes in weightlessness based on thermodynamics principles for open systems is developed. The influence of light, temperature, pressure, and gravity on the shape and state of a biological system, and therefore on the phenotype with steady genome are studied. Experiments are carried out on leaves, chloroplasts, neurospores and mammalian cell spheroids. An experimental module for cellular biology was built for automatic optical and electrode measurements. The data are recorded, stored, and processed at a ground station. Experiments in space stations are recommended to study the influence of gravity and geomagnetism on the shape and the biochemical processes of a biological system and to obtain data on the phylogenesis of more complicated organisms. ESA

N86-30302*# National Aeronautics and Space Administration, Washington, D.C.
LIFE SCIENCES SPACE STATION PLANNING DOCUMENT: A REFERENCE PAYLOAD FOR THE LIFE SCIENCES RESEARCH FACILITY
Aug. 1986 132 p
(NASA-TM-89188; NAS 1.15:89188) Avail: NTIS HC A07/MF A01 CSCL 06B

The Space Station, projected for construction in the early 1990s, will be an orbiting, low-gravity, permanently manned facility providing unprecedented opportunities for scientific research. Facilities for Life Sciences research will include a pressurized research laboratory, attached payloads, and platforms which will allow investigators to perform experiments in the crucial areas of Space Medicine, Space Biology, Exobiology, Biospherics and Controlled Ecological Life Support System (CELSS). These studies are designed to determine the consequences of long-term exposure to space conditions, with particular emphasis on assuring the permanent presence of humans in space. The applied and basic research to be performed, using humans, animals, and plants, will increase our understanding of the effects of the space environment on basic life processes. Facilities being planned for remote observations from platforms and attached payloads of biologically important elements and compounds in space and on other planets (Exobiology) will permit exploration of the relationship between the evolution of life and the universe. Space-based, global scale observations of terrestrial biology (Biospherics) will provide data critical for understanding and ultimately managing changes in the Earth's ecosystem. The life sciences community is encouraged to participate in the research potential the Space Station facilities will make possible. This document provides the range and scope of typical life sciences experiments which could be performed within a pressurized laboratory module on Space Station. Author

N86-30589*# Northwestern Univ., Evanston, Ill. Astronomical Research Center.
THE USE OF TETHERED SATELLITES FOR THE COLLECTION OF COSMIC DUST AND THE SAMPLING OF MAN MADE ORBITAL DEBRIS FAR FROM THE SPACE STATION
G. J. CORSO *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 52-53 1986 refs Prepared in cooperation with Loyola Univ., Chicago, Ill.
Avail: NTIS HC A06/MF A01 CSCL 03B

The use of a tethered subsatellite employed downward into the earth's upper atmosphere to an altitude of about 110 km above the earth would eliminate the orbital contamination problem while at the same time affording a measure of atmospheric braking to reduce the velocities of many particles to where they may be captured intact or nearly so with properly designed collectors. The same technique could also be used to monitor the flux of all types of man-made orbital debris out to a distance of more than a hundred kilometers in any direction from the space station. In this way the build up of any debris belt orbiting earth could be determined. The actual collecting elements used for both purposes could be of several different materials and designs so as to optimize the collection of different types of particles with different densities. Stacks of foils, films, plastics, and foams, as well as simple capture cells would be mounted in clusters around the outside of a tethered satellite and protected by iris covers until the tethered had been fully deployed. If the orientation history of the satellite were known the direction of the incoming material could be infered. A chief advantage in deploying such tethered collectors from the Space Station instead of from the shuttle is the ability to maintain deployment of the tether for days instead of hours resulting in much greater yields of intact particles and impact debris. M.G.

N86-30605*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A MICROMETEOROID DECELERATION AND CAPTURE EXPERIMENT: CONCEPTUAL EXPERIMENT DESIGN DESCRIPTION
J. H. WOLFE (San Jose State Univ., Calif.), R. W. BALLARD, G. C. CARLE, and T. E. BUNCH *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 91-93 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

The preliminary conceptual design for a cosmic dust collector is described. For the case of low Earth orbit (LEO), dust particles enter the collector through the collimator at a few volts negative potential due to charging in the ionosphere, at a velocity of 1 to 50 km/sec. The particles then pass through an electron stream and are charged to about 1 KV negative (regardless of incoming polarity). The 1 KV negatively charged particle then passes through three sensing grids coupled to charge sensitive preamps (CSP). The comparison of the two pulses provided by S(1) and S(2) are utilized by the microprocessor to determine the charge, q, on the particle (pulse amplitude) and its velocity, v (by time of flight). The third sensing grid, S(3), is kept at about 20 KV negative so that the dust particle will now be decelerated in passing from S(2) (zero potential) to S(3). S(3) is capacitively coupled to its CSP and the pulse from S(3) is utilized by the microprocessor to determine the particle's energy, E, and therefore its mass, m (again by time of flight) by comparison with the pulses from S(1) and S(2). The microprocessor can now precisely program the high-voltage switching network for the proper timing in the grounding of the successive deceleration grids. As determined by the microprocessor, each successive deceleration grid is grounded just after the dust particle passes, thus reducing the particle's energy by the amount q*100 KV at each stage. The microprocessor also determines at which stage the particle will fall below a certain critical energy where all remaining grids remain unswitched so that the particle will drift to the collector. The collector is kept at about 100V positive and is covered with gold foil to eliminate contamination and is removable for subsequent return to earth for detailed analysis. Author

N86-31632*# Ball Aerospace Systems Div., Boulder, Colo.
PHASE 3 STUDY OF SELECTED TETHER APPLICATIONS IN SPACE, MID-TERM REVIEW
10 Jul. 1986 67 p
(Contract NAS8-36617)
(NASA-CR-178900; NAS 1.26:178900; DPD-665; DR-3) Avail: NTIS HC A04/MF A01 CSCL 22B

Topics addressed include: guidelines for the Space Transportation System (STS) payload deployer design; mini-orbital maneuvering vehicle (MOMV) design: shuttle tether deployer systems (STEDS); cost modeling; tethered platform analysis; fuel savings analysis; and STEDS control simulation. B.G.

N86-32863*# California Univ., Santa Barbara.
REMOTE SENSING INFORMATION SCIENCES RESEARCH GROUP, SANTA BARBARA INFORMATION SCIENCES RESEARCH GROUP, YEAR 3 Final Report
J. E. ESTES, T. SMITH, and J. L. STAR 5 Jan. 1986 87 p
(Contract NAGW-455)
(NASA-CR-179769; NAS 1.26:179769) Avail: NTIS HC A05/MF A01 CSCL 05B

Research continues to focus on improving the type, quantity, and quality of information which can be derived from remotely sensed data. The focus is on remote sensing and application for the Earth Observing System (Eos) and Space Station, including associated polar and co-orbiting platforms. The remote sensing research activities are being expanded, integrated, and extended into the areas of global science, georeferenced information systems, machine assissted information extraction from image data, and artificial intelligence. The accomplishments in these areas are examined.

N86-32864*# California Univ., Santa Barbara.
SUPPORT FOR GLOBAL SCIENCE: REMOTE SENSING'S CHALLENGE
J. E. ESTES and J. L. STAR *In its* Remote Sensing Information Sciences Research Group, Santa Barbara Information Sciences Research Group, year 3 13 p 5 Jan. 1986
Avail: NTIS HC A05/MF A01 CSCL 05B

Remote sensing uses a wide variety of techniques and methods. Resulting data are analyzed by man and machine, using both analog and digital technology. The newest and most important initiatives in the U. S. civilian space program currently revolve around the space station complex, which includes the core station as well as co-orbiting and polar satellite platforms. This proposed suite of platforms and support systems offers a unique potential for facilitating long term, multidisciplinary scientific investigations on a truly global scale. Unlike previous generations of satellites, designed for relatively limited constituencies, the space station offers the potential to provide an integrated source of information which recognizes the scientific interest in investigating the dynamic coupling between the oceans, land surface, and atmosphere. Earth scientist already face problems that are truly global in extent. Problems such as the global carbon balance, regional deforestation, and desertification require new approaches, which combine multidisciplinary, multinational research teams, employing advanced technologies to produce a type, quantity, and quality of data not previously available. The challenge before the international scientific community is to continue to develop both the infrastructure and expertise to, on the one hand, develop the science and technology of remote sensing, while on the other hand, develop an integrated understanding of global life support systems, and work toward a quantiative science of the biosphere. Author

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OPERATIONS SUPPORT

Includes descriptions of models, analyses and trade studies of maneuvers, performance, support, and EVA and/or IVA servicing requirements of Space Station systems such as the OMV and OTV, and experiments.

A86-32095*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MAINTAINABILITY PLANNING FOR THE SPACE STATION
G. R. EGAN (NASA, Johnson Space Center, Houston, TX) AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 5 p.
(AIAA PAPER 86-9754)

The planned NASA Space Station, which is expected to have many years of on-orbit operation, for the first time confronts spacecraft designers with major questions of maintainability in design. A Maintainability Guidelines Document has been distributed to all Space Station Definition and Preliminary Design personnel of the Space Station Program Office. Trade studies are being performed to determine the most economical balance between initial (reliability) cost and life cycle cost (crew time and replacement hardware) costs. O.C.

A86-32539
ON-ORBIT SERVICING - HUBBLE SPACE TELESCOPE
T. E. STYCZYNSKI (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 153-156.

The Hubble Space Telescope (HST) represents an unmanned orbiting astronomical observatory with an unparalleled scientific capability. The HST consists of three major structural elements, including appendages, System Support Module (SSM), and the Optical Telescope Assembly (OTA). HST is designed to utilize the NASA Space Shuttle for deployment, on-orbit servicing, reboost, and earth return. The on-orbit servicing plan has the objective to increase the HST scientific effectiveness by maintaining the operational systems and upgrading the science capabilities for a projected orbital life of fifteen years. Details of HST on-orbit maintenance are discussed. G.R.

A86-32550
ROBOT SPACECRAFT SURVIVABILITY USING A DECISION TREE FOR DATA PROCESSING
A. M. CHANDE and R. W. NEWCOMB (Maryland, University, College Park) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 243-249. refs

This paper deals with the survivability of robot spacecraft in hostile and congested space environments. Outlined herein is a bottom-up tree that makes navigational and stability decisions and generates a sequence of control actuations for accurate trajectories for the robot spacecraft. The approach provides the spacecraft with a sense of survivability by virtue of its tactual abilities. A path towards creating an intelligent machine and associated processing regarding its surroundings is recommended. The decision-based strategy using knowledge based heuristics is introduced to achieve autonomous and/or human assisted trajectory determination and collision avoidance, making the robot spacecraft rugged for transits in complex environments. Author

A86-32912#
ALTERNATIVE DOCKING CONCEPTS FOR APPLICATION TO THE SPACE STATION
D. S. MONITOR (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 25 p. refs

Studies of the International Space Station utilization have identified concerns relating to the rendezvous and docking operations of all space vehicles with the Space Station. Some of these concerns include contamination of the immediate environment and exposed surfaces by the Reaction Control System (RCS) exhaust products, Space Station attitude disturbances produced by the RCS exhaust plume pressure fields, and the Space Station structural response resulting from the residual velocity differences between two docking bodies. The use of remote docking facilities supported by either extensible arms or a tether combined with approaches along the orbital radius vector may attentuate these effects and satisfy the concerns. Author

A86-33829
SPEECH RECOGNITION, SPEECH SYNTHESIS AND TOUCH-PANEL TECHNOLOGY APPLIED TO THE CONTROL OF REMOTELY PILOTED SPACECRAFT
C. A. SLABY, C. S. HARTLEY, and R. PULLIAM (Martin Marietta Corp., Space Operations Simulator Laboratory, Denver, CO) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1985, p. 1140-1143. Research supported by Martin Marietta Corp. refs

The development of a prototype pilot console for remote control of spacecraft from the Space Station is examined. Speech recognition, speech synthesis, and touch-panel technology are analyzed as means of data display and control operation. The simulation tests used to evaluate speech recognition and touch-screen technologies for entering commands using a subjective workload are described. I.F.

A86-40585#
ADVANCED EVA OPERATION ON-ORBIT TASKS AND SERVICES
F. J. ABELES and R. H. SCHAEFER (Grumman Corp., Bethpage, NY) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 60-68.
(AIAA PAPER 86-1175)

Methods for improving astronauts' productivity during extravehicular activity (EVA) are described. EVA operations involve construction, servicing, and maintenance of the Space Shuttle and servicing and maintenance of the Shuttle's payloads. EVA cycle tasks must be performed in the proper sequence and it is estimated that an astronaut can perform up to 6.5 hrs of EVA productive work during one EVA and a maximum of 19.5 hrs of EVA productive work per astronaut can be accomplished in a week. The utilization of dedicated work stations, a dedicated translation system, properly designed equipment, and job performance aids, such as the helmet mounted display (HMD), to increase EVA productive time is studied. The function and advantages of the HMD are examined. The need to consider the astronaut's comfort during performance of EVA tasks is discussed. I.F.

A86-42741*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
BACKGROUND AND PROGRAMMATIC APPROACH FOR THE DEVELOPMENT OF ORBITAL FLUID RESUPPLY TANKERS
J. W. GRIFFIN (NASA, Johnson Space Center, Houston, TX) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1601)

Onorbit resupply of fluids will be essential to the evolving generation of large and long-life orbital stations and satellites. These types of services are also needed to improve the economics of space operations, and not only optimize the expenditures for government funded programs, but also pave the way for commercial development of space resources. To meet these requirements, a family of tankers must be developed to resupply a variety of fluids. Economics of flight hardware development will require that each tanker within this family be capable of satisfying a variety of functions, including not only fluid resupply from the Space Shuttle Orbiter, but also resupply from Space Station and the orbital maneuvering vehicle (OMV). This paper discusses the justification, the programmatic objectives, and the advanced planning within NASA for the development of this fleet of multifunction orbital fluid resupply tankers. Author

A86-42742#
MISSION REQUIREMENTS AND DESIGN DEFINITION FOR AN ORBITAL SPACECRAFT CONSUMABLES RESUPPLY SYSTEM (OSCRS)
B. F. GORIN (Fairchild Space Co., Germantown, MD) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p. refs
(AIAA PAPER 86-1602)

The rapidly developing capability of the Space Shuttle to repair satellites on orbit will soon be extended to include other types of service, including the replenishment of consumables. Propulsion requirements will play a major part in the definition of these fluids. The initial operational capability of the Space Station will serve to increase both the demand and the capability for such services. To fulfill these evolving requirements, an integrated system must be developed which is capable of delivering all of the necessary fluids to orbit in a safe, reliable, cost effective manner. An overview of the general requirements for such a system is presented, including a traffic model. From the traffic model, a set of detailed resupply system requirements are developed for those fluids which represent the most immediate market for on-orbit resupply. A preliminary design is described for a resupply system for monopropellant hydrazine. This design specifically considers the requirements of the Gamma Ray Observatory spacecraft refueling as well as the requirements which evolve from the traffic model. Author

A86-44532
INTELLIGENT CREW WORKSTATIONS
D. STANLEY, R. WORDEN, and R. RIVERS (Logica UK, Ltd., Cambridge, England) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 69-80.

A preliminary framework for analysis of crew workstation user interface issues is presented. The Framework attempts to map factors relating to individual users, the space station environment, tasks and the particular 'states' of the Space Station onto desirable user interface characteristics. Factors relating to the individual are discussed with respect to the provision of an adaptable user interface through the use of 'user models' derived from an intelligent training environment. Author

A86-46941#
ADVANCED SPACE SUIT DEVELOPMENT FOR FUTURE ON-ORBIT OPERATIONS
J. L. ZELON (ILC Space Systems, Houston, TX) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p. refs
(AIAA PAPER 86-2310)

This paper describes the planned space suit developments for future on-orbit operations including Shuttle, Space Station and Transatmospheric based missions. The issues driving design changes in the current Shuttle EMU for Space Station are defined. In addition, advanced development programs underway by NASA in pressure suit closure design, joint technology and glove technology are identified. Author

A86-46942#
ZERO-G SIMULATION VERIFIES EVA SERVICING OF SPACE STATION MODULES
B. N. GRIFFIN (Boeing Aerospace Co., Huntsville, AL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 6 p.
(AIAA PAPER 86-2312)

The Space Station accommodations required for on orbit zero-g maintenance and repair were evaluated during two months of neutral buoyancy testing. Boeing, in a joint effort with NASA, used Shuttle-type pressure suits and the simulated weightlessness provided by neutral buoyancy to assess four areas of hardware and operations. These included: (1) Space Station System Architecture; (2) Common Module Exterior; (3) Common Module Interior; and (4) Voice-Activated Systems. Specifically, the tests focused on servicing debris shield/body-mounted radiator panels,

replacement of thermal blankets or Multi-Layer insulation and repair techniques for debris damage. Design engineers and astronauts participated as pressure-suited test subjects in evaluation of a broad range of concept options. The significant findings for these tests are: (1) the astronaut positioning arm is one of the most useful tools for Space Station EVA operations; (2) the minimum separation between modules should be 78 inches; (3) axial debris panels were preferred over circumferential; (4) on-orbit repair techniques for debris-damaged modules were effective; and (5) voice-activated systems are ideal for EVA. Improved suit communications, however, are required for implementation.

Author

A86-46954#
SPACE STATION ON-ORBIT OPERATIONS FOR THE TWENTY FIRST CENTURY
R. H. SCHAEFER and A. C. BEARDSLEY (Grumman Corp., Bethpage, NY) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p.
(AIAA PAPER 86-2331)

The three areas of Space Station operations, mission, maintenance, and coordination, are considered. The operational activities of the Space Station consist of assembling the equipment necessary for specific missions and conducting the experiments. The maintenance operations which involve monitoring system operations and supplying resources are described. The proximity operations and ground-based support (coordination activities) are examined. The Space Station is to have a crew of 18-20 station specialists, a mobile work station, satellite servicing bays, and maneuvering vehicles for conducting orbit operations; the functions of each component are studied. I.F.

A86-46955#
MAINTAINING AND SERVICING A SPACE-BASED ORBITAL TRANSFER VEHICLE (OTV) AT THE SPACE STATION
J. W. MALONEY and L. R. PENA (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 10 p.
(AIAA PAPER 86-2332)

A candidate space-based OTV (SBOTV) is described as well as the advantages inherent to space basing, the requirements for accommodating an SBOTV, candidate hangar/support equipment, turnaround operations options, selection and definition of the most economical turnaround operations at the Space Station and maintenance of an OTV at the Space Station (SS). OTV launching, servicing/maintenance, payload integration and retrieval comprise the various space operations to be performed. Alternative methods for performing the turnaround operations (i.e. EVA with teleoperations or teleoperations only) are investigated and it is shown that the 'teleoperation only' option fulfills the need for reducing the amount of EVA manhours while simultaneously reducing the total manhours for SBOTV turnaround at the Space Station. It is concluded that modularity, accessibility, standardization of interfaces, lightweight construction, and a proper balance between EVA and teleoperations/robotics activities are key to the successful performance of an OTV at the SS in the 1990s. Man's ability to react to unexpected situations, interpret results and modify operations in real time must also be taken advantage of. K.K.

A86-46956#
SPACE STATION SERVICES PROVIDED TO COMMUNICATIONS SATELLITES
T. J. SHESKIN (Cleveland State University, OH) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 4 p. refs
(AIAA PAPER 86-2333)

The role of the Space Station in future satellite communications is discussed. Satellite communications in the 21st century are to be provided by modular geostationary platforms. The interference problems and use of fiber optics are considered. The assembly and testing of the platforms on the Space Station are described. The use of orbital transfer vehicles based on the Station to launch the platforms into geostationary earth orbit is examined. Remote servicing of the platforms is to be performed with teleoperational servicing units which will also be located on the Space Station.

I.F.

A86-46957*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
ON-ORBIT PRELAUNCH PROCESSING AND REFURBISHMENT
A. K. GLAAB, D. E. HEADLEY, and R. J. RAUCH (NASA, Kennedy Space Center; McDonnell Douglas Astronautics Co., Cocoa Beach, FL) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 9 p. refs
(AIAA PAPER 86-2334)

As the capabilities of the operational Space Station increase, emphasis will be placed on use of the Station for final development of missions, including the launch of large, complex, and reusable launch vehicles with destinations to geosynchronous orbit; lunar exploration or lunar development bases; and planetary exploration. This paper identifies and discusses the capabilities that would be needed to support the on-orbit prelaunch processing and refurbishing of a manned Mars vehicle launched from Space Station. The on-orbit launch vehicle prelaunch and refurbishment resource requirements needed to perform processing operations are projected from experience and data developed by the actual preparation of payloads for launch at the National Space Transportation System (NSTS) launch and landing site. Author

A86-49559*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
SPACE STATION USER TRAFFIC MODEL ANALYSIS FOR MISSION PAYLOAD SERVICING INTO THE TWENTY-FIRST CENTURY
G. J. GOULD (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p.
(Contract NAS5-29400)
(AIAA PAPER 86-2335)

The Space Station-based Customer Servicing Facility service bay requirements for service accommodation to the Initial Orbit Capability (IOC) and far-term Station Accommodation Test Sets (SETS) missions are analyzed using the developed mission traffic model. Analysis results are presented which indicate that one servicing bay will be sufficient to accommodate IOC customer servicing requirements. Growth servicing requirements indicate that an additional servicing bay will be needed for accommodation of the far-term SATS mission payloads. Even though the level of total mission accommodation is below 100 percent for one bay at IOC and two bays during growth operations, the levels are such that operational work-around exists so that additional servicing bays will not be required. C.D.

N86-26369*# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.
ORBIT TRANSFER ROCKET ENGINE TECHNOLOGY PROGRAM: ADVANCED ENGINE STUDY, TASK D.1/D.3 Interim Report
A. MARTINEZ, C. ERICKSON, and B. HINES Jan. 1986 237 p
(Contract NAS3-23773)
(NASA-CR-175084; NAS 1.26:175084; RI/RD86-116) Avail: NTIS HC A11/MF A01 CSCL 21H

Concepts for space maintainability of OTV engines were examined. An engine design was developed which was driven by space maintenance requirements and by a failure mode and effects (FME) analysis. Modularity within the engine was shown to offer cost benefits and improved space maintenance capabilities. Space operable disconnects were conceptualized for both engine change-out and for module replacement. Through FME mitigation the modules were conceptualized to contain the least reliable and most often replaced engine components. A preliminary space maintenance plan was developed around a controls and condition monitoring system using advanced sensors, controls, and condition monitoring concepts. A complete engine layout was prepared satisfying current vehicle requirements and utilizing projected

component advanced technologies. A technology plan for developing the required technology was assembled. Author

N86-27300*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Eng.
SPACE MANUFACTURING UTILIZING THE DIRECTIONAL ELECTROSTATIC ACCRETION PROCESS
A. MORTENSEN *In* NASA. Goddard Space Flight Center The 1985 Get Away Special Experimenter's Symposium p 19-24 May 1986
Avail: NTIS HC A13/MF A01 CSCL 22A

The Directional Electrostatic Accretion Process (DEAP) is described with respect to both the physical process and its application to manufacturing in space. This high precision portable manufacturing method will revolutionize current practices in manufacturing and repair of spacecraft and space structures. The cost effectiveness of this process will be invaluable to future space manufacturing projects. Author

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SPACE ENVIRONMENT

Includes description of the space environment and effects on Space Station subsystems. Includes requirements for Space Station to accommodate this environment.

A86-32909#
SEALING FOR LONG-TERM SPACE APPLICATION
P. B. ALLEN and H. W. BECKER (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 35 p. Research supported by the Martin Marietta Independent Research and Development Program. refs

The performances of various seals in a space environment are examined. The design and applicability of elastomeric O-rings molded from nitrile, neoprene, fluorocarbon, and silicones are analyzed. The use of nylon and teflon plastic seals for split piston rings and backup and wear rings is discussed. The advantages and disadvantages of metallic seals and gaskets are studied. Test procedures for evaluating static seals and sealants for temperature and pressure in a simulated space environment are desribed. I.F.

A86-32910#
DESIGN FOR SPACE DEBRIS PROTECTION
N. ELFER and G. KOVACEVIC (Martin Marietta Corp., New Orleans, LA) IN: Man's permanent presence in space; Proceedings of the Third Annual Aerospace Technology Symposium, New Orleans, LA, November 7, 8, 1985 . New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 14 p. Research supported by the Martin Marietta Independent Research and Development Program. refs

This paper reviews the process of designing a spacecraft to survive the space debris and meteroid environemnt. The effective exposed area, the flux and the exposure time can be used to determine the probability of impact. Due to the highly directional nature of orbiting debris, the actual surface area can be broken up and each increment should be multiplied by a flux factor according to its orientation to convert it to an effective surface area. The probability of penetration is then calculated from the probability of impact including oblique impact effects and low velocity penetration. New results are presented for the analysis of space debris shadowing effects; for the incorporation of low velocity penetration; and also for the penetration resistant properties of some composite materials. Composites have been tested as bumpers, and will be tested as intermediate shields and rear walls. Author

A86-40588#
THE IMPACT OF SPACE DEBRIS ON MANNED SPACE OPERATIONS
L. P. TEMPLE, III (DOD, Space Operations Committee, Washington, DC) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 85-90. refs
(AIAA PAPER 86-1178)

The effects of space debris on manned space activities are investigated. The probability of collisions of man-sized objects or large-scale structures with space debris is estimated; it is determined that the probability of a man-sized object receiving an impact from space debris is 1000-10000; however, for large structures the potential for impact is greater, and the structures must be designed with this consideration. The rate of debris increase which is dependent on collisions between space objects and additions due to normal operations is examined. Pit densities observed in Skylab windows and Space Shuttle flights are compared; the densities observed from Skylab are 0.1/sq cm after 84 days of exposure and 10 years later the Shuttle recorded 100-200/sq cm of debris after 7-8 days in space. It is noted that though debris is not a current problem standardized operating procedures and equipment need to be developed in order to minimize the amount of debris in space. I.F.

A86-41747*# Massachusetts Inst. of Tech., Lexington.
SATELLITE DEBRIS - RECENT MEASUREMENTS
L. G. TAFF (MIT, Lexington, MA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 342-346. NASA-sponsored research. refs
(Contract F19628-85-C-0002)

More frequent reports concerning orbital debris damage to spacecraft have prompted the design, development and testing of equipment and techniques for the observation of moving objects by passive optical means. A consolidation is presently made of hundreds of hours of space debris observation, quantifying the numbers of small bodies in space relative to the actively watched artificial satellite population and estimating the numbers of detectable objects from near-earth orbit to geostationary orbit distances. The debris reported constitutes 11 times the tracked population in near-earth orbit and between 25 and 50 percent of the deep space population. O.C.

A86-45706*#
PROTECTING SPACECRAFT FROM ATOMIC OXYGEN
L. J. LEGER and J. T. VISENTINE (NASA, Johnson Space Center, Houston, TX) Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 32-35.

Findings are reported from Space Shuttle flights STS-3, 4, 5, and 8 regarding the degradation of materials exposed to atomic oxygen in low earth orbit. Atomic oxygen, a strong oxidizing agent, is present in low concentrations at such altitudes, and a spacecraft can sweep up considerable volumes of it at orbital velocities of 5 miles/s, especially if mission lifetimes are measured in years or decades. Material loss has been found to be a function of the fluence (the number of oxygen atoms striking a unit area of surface over a given period); fluence is proportional to atmospheric density, orbital velocity, surface attitude relative to velocity vector, and duration of exposure. Atmospheric density depends first on altitude and second on the phase of the 11-year solar activity cycle. Metals, in the experiments, reacted less than nonmetals. Graphs and a table are included, permitting calculation of how far a surface of various organic materials will recede on a spacecraft in low earth orbit. The limited data base on atomic oxygen interactions with materials, using both Shuttle flight experiments and ground-based facilities must be augmented. Space Station design is imminent, and the understanding of such interactions is critical to the success of that design. D.H.

A86-46857
TESTING UNIVERSAL BARYON SYMMETRY ON THE SCALE OF GALACTIC CLUSTERS
G. TARLE (Michigan, University, Ann Arbor) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 105-111. refs

Prospects for detecting heavy antimatter from distant clusters of galaxies are examined in light of a new experimental technique for determing the sign of the charge of relativistic heavy cosmic-ray ions. For a baryon symmetric universe, it i shown that antimatter fractions of about 10 to the -6th may be expected in the local cosmic radiation, and that such small fractions can be detected using the new technique. Ideas for improving sensitivity beyond the 10 to the -7th level with a Space-Station-based instrument are discussed. Author

A86-46874
SOLAR COSMIC RAY HEAVY ION STUDIES
M. N. VAHIA, S. BISWAS, and N. DURGAPRASAD (Tata Institute of Fundamental Research, Bombay, India) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 293-300. refs

Analysis of data regarding the particles that are emitted in particle flares for the last 25 years makes it possible to identify some of the common features of solar particle emission which should be explained theoretically. It appears that the flares must be divided into large and small flares depending on the energetics and the fluxed emitted in these events. In large events it is also possible to suggest (from the fact that C, N, O, Ne, S, and Ar are never enhanced in flares) that the temperature of the plasma from which these particles are emitted must be 3 x 10 to the 6th K for all flares. The observations are a good indication regarding conditions in the particle-emitting regions of the sun. Author

A86-47336
STATUS OF CRITICAL ISSUES IN THE AREA OF SPACECRAFT CHARGING
J. E. NANEVICZ and R. C. ADAMO (SRI International, Menlo Park, CA) IN: International Aerospace and Ground Conference on Lightning and Static Electricity, 10th, and Congres International Aeronautique, 17th, Paris, France, June 10-13, 1985, Proceedings . Les Ulis, France, Les Editions de Physique, 1985, p. 475-484. refs

Attention is given to the major technical considerations important to spacecraft charging. These include the space environment, environmental interactions with satellite surfaces, discharge characteristics, coupling to systems and systems affected. The interference control problem is discussed and it is shown how its severity is dependent upon the properties of the source, the coupling path and the victim. Strategies for source elimination, coupling control and victim hardening are proposed. The engineering aspects of the spacecraft charging problem could benefit from the following: (1) identification of materials displaying susceptibility in orbit, (2) quantification of discharge characteristics in orbit and (3) characterization of internal noise pulse environments on typical satellites. It is concluded that a better understanding of the actual in-orbit discharge process and its characteristics is needed. This information could most accurately be obtained by taking advantage of payload opportunities so as to incorporate properly designed discharge detection and characterization instrumentation on present and future spacecraft programs. K.K.

A86-50357
CHARGE COMPOSITION OF THE HIGH-ENERGY ELECTRONS AND POSITRONS IN THE VAN ALLEN RADIATION BELTS
S. A. VORONOV, A. M. GALPER, V. G. KIRILLOV-UGRIUMOV, S. V. KOLDASHOV, and A. V. POPOV (Moskovskii Inzhenerno-Fizicheskii Institut, Moscow, USSR) (ZhETF Pis'ma v Redaktsiiu, vol. 43, Mar. 10, 1986, p. 240, 241) JETP Letters (ISSN 0021-3640), vol. 43, March 10, 1986, p. 306, 307. Translation. refs

An experimental observation is reported which demonstrates that the belt of high-energy electrons and positrons observed in the Van Allen radiation belt by Gal'per, Grachev, and Dmitrenko (1981) consists primarily of electrons. The experimental results also show that the proton interaction mechanisms are not the governing mechanisms of the Van Allen belt protons with the residual atmosphere. Since the electron intensity is very substantial, there appears to be an effective mechanism for the acceleration of the particles. C.D.

N86-22606# Centre d'Etudes et de Recherches, Toulouse (France). Dept. Technologie Spatiale.
CONDUCTIVITY AND SECONDARY EMISSION PROPERTIES OF DIELECTRICS AS REQUIRED BY NASCAP
L. LEVY, D. SARRAIL, and J. M. SIGUIER *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 113-123 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Spacecraft charging modeling by the computational code NASCAP is discussed. Conductivity and secondary emission are reviewed. Measurements methods and laboratory experiments are described. Results for commonly used external coatings are given. The impact of material properties on electrostatic behavior is illustrated. Author (ESA)

N86-23625# Tokyo Univ. (Japan). Institute of Space and Astronautical Science.
VACUUM-ENVIRONMENT AROUND SPACELAB-1
M. YANAGISAWA, N. KAWASHIMA, S. SASAKI, and T. OBAYASHI Aug. 1985 8 p refs
(ISAS-617; ISSN-0285-6808) Avail: NTIS HC A02/MF A01

The background pressure for the SEPAC experiments (Space Experiments with Particle Accelerators) was monitored by the vacuum gauge on the Spacelab pellet. The pressure during the whole mission shows a clear relationship with the orbiter's velocity vector. When the gauge is screened by the orbiter from the relative flow of the upper atmosphere (wake condition), the pressure is constantly low, but much higher than that of the model atmosphere. At present, it is best explained by gas leakage from Spacelab or some of its instruments. When the gauge is open to the flow (ram condition), the pressure is linearly related to the cosine of he incident angle and has a maximum at normal incidence. The maximum is more than one order of magnitude higher than the model pressure. This is interpreted as escape of incident atmosphere from the Spacelab's surface with thermal velocity. Author

N86-27063*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
OPTICAL MODEL CALCULATIONS OF HEAVY-ION TARGET FRAGMENTATION
L. W. TOWNSEND, J. W. WILSON, F. A. CUCINOTTA (Old Dominion Univ., Norfolk, Va.), and J. W. NORBURY Jul. 1986 15 p refs
(NASA-TM-87692; L-16113; NAS 1.15:87692) Avail: NTIS HC A02/MF A01 CSCL 20H

The fragmentation of target nuclei by relativistic protons and heavy ions is described within the context of a simple abrasion-ablation-final-state interaction model. Abrasion is described by a quantum mechanical formalism utilizing an optical model potential approximation. Nuclear charge distributions of the excited prefragments are calculated by both a hypergeometric distribution and a method based upon the zero-point oscillations of the giant dipole resonance. Excitation energies are estimated

from the excess surface energy resulting from the abrasion process and the additional energy deposited by frictional spectator interactions of the abraded nucleons. The ablation probabilities are obtained from the EVA-3 computer program. Isotope production cross sections for the spallation of copper targets by relativistic protons and for the fragmenting of carbon targets by relativistic carbon, neon, and iron projectiles are calculated and compared with available experimental data. Author

N86-27137*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION IMPACT EXPERIMENTS
P. SCHULTZ (Brown Univ., Providence, R. I.), T. AHRENS (California Inst. of Tech., Pasadena), W. M. ALEXANDER (Baylor Univ., Waco, Tex.), M. CINTALA, D. GAULT (Murphys Center of Planetology, Calif.), R. GREELEY (Arizona State Univ., Tempe), B. R. HAWKE (Hawaii Univ., Honolulu), K. HOUSEN (Boeing Aerospace Co., Seattle, Wash.), and R. SCHMIDT *In its* Space Station Planetology Experiments (SSPEX) 5 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Four processes serve to illustrate potential areas of study and their implications for general problems in planetary science. First, accretional processes reflect the success of collisional aggregation over collisional destruction during the early history of the solar system. Second, both catastrophic and less severe effects of impacts on planetary bodies survivng from the time of the early solar system may be expressed by asteroid/planetary spin rates, spin orientations, asteroid size distributions, and perhaps the origin of the Moon. Third, the surfaces of planetary bodies directly record the effects of impacts in the form of craters; these records have wide-ranging implications. Fourth, regoliths evolution of asteroidal surfaces is a consequence of cumulative impacts, but the absence of a significant gravity term may profoundly affect the retention of shocked fractions and agglutinate build-up, thereby biasing the correct interpretations of spectral reflectance data. An impact facility on the Space Station would provide the controlled conditions necessary to explore such processes either through direct simulation of conditions or indirect simulation of certain parameters. B.G.

N86-27139*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PARTICLE FORMATION AND INTERACTION
S. SQUYRES, G. J. CORSO (Northwestern Univ., Evanston, Ill.), L. GRIFFITHS (Management and Technical Services Co., Washington, D.C.), I. MACKINNON (New Mexico Univ., Albuquerque), J. MARSHALL, J. A. NUTH, III (National Aeronautics and Space Administration, Washington, D.C.), B. WERNER (California Inst. of Tech., Pasadena), and J. WOLFE (San Jose State Univ., Calif.) *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 4 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

A wide variety of experiments can be conducted on the Space Station that involve the physics of small particles of planetary significance. Processes of interest include nucleation and condensation of particles from a gas, aggregation of small particles into larger ones, and low velocity collisions of particles. All of these processes could be investigated with a general purpose facility on the Space Station. The microgravity environment would be necessary to perform many experiments, as they generally require that particles be suspended for periods substantially longer than are practical at 1 g. Only experiments relevant to planetary processes will be discussed in detail here, but it is important to stress that a particle facility will be useful to a wide variety of scientific disciplines, and can be used to address many scientific problems. Author

N86-27143*# Baylor Univ., Waco, Tex. Dept. of Physics.
MASS LOADING OF THE EARTH'S MAGNETOSPHERE BY MICRON SIZE LUNAR EJECTA. 1: EJECTA PRODUCTION AND ORBITAL DYNAMICS IN CISLUNAR SPACE
W. M. ALEXANDER, W. G. TANNER, P. D. ANZ, and A. L. CHEN *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Particulate matter possessing lunar escape velocity sufficient to enhance the cislunar meteroid flux was investigated. While the interplanetary flux was extensively studied, lunar ejecta created by the impact of this material on the lunar surface is only now being studied. Two recently reported flux models are employed to calculate the total mass impacting the lunar surface due to sporadic meteor flux. There is ample evidence to support the contention that the sporadic interplanetary meteoroid flux enhances the meteroid flux of cislunar space through the creation of micron and submicron lunar ejecta with lunar escape velocity. B.G.

N86-27144*# Baylor Univ., Waco, Tex. Dept. of Physics.
MASS LOADING OF THE EARTH'S MAGNETOSPHERE BY MICRON SIZE LUNAR EJECTA. 2: EJECTA DYNAMICS AND ENHANCED LIFETIMES IN THE EARTH'S MAGNETOSPHERE
W. M. ALEXANDER, W. G. TANNER, P. D. ANZ, and A. L. CHEN *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 3 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

Extensive studies were conducted concerning the indivdual mass, temporal and positional distribution of micron and submicron lunar ejecta existing in the Earth-Moon gravitational sphere of influence. Initial results show a direct correlation between the position of the Moon, relative to the Earth, and the percentage of lunar ejecta leaving the Moon and intercepting the magnetosphere of the Earth at the magnetopause surface. It is seen that the Lorentz Force dominates all other forces, thus suggesting that submicron dust particles might possibly be magnetically trapped in the well known radiation zones. B.G.

N86-27162*# Brown Univ., Providence, R. I. Dept. of Geological Sciences.
IMPACTS OF FREE-FLOATING OBJECTS: UNIQUE SPACE STATION EXPERIMENTS
P. H. SCHULTZ and D. E. GAULT (Murphys Center of Planetology, Calif.) *In* NASA. Lyndon B. Johnson Space Center Space Station Planetology Experiments (SSPEX) 2 p May 1986
Avail: NTIS HC A05/MF A01 CSCL 03A

The transfer of momentum and kinetic energy between planetary bodies forms the basis for wide ranging problems in planetary science ranging from the collective long term effects of minor perturbations to the catastrophic singular effect of a major collision. Although the collisional transfer of momentum and energy was discussed over the last two decades, major issues remain that largely reflect current limitations in Earth based experimental conditions and 3-D numerical codes. Two examples with potential applications in a Space Station laboratory, are presented: asteroid spin rates and orientations, and planetary disruption/spin rates. Asteroid spin rate and orientation experiments are needed wherein free floating nonspining and spining objects of varying strength, porosity, and volatility are impacted at varying velocities and angles. A space station platform also could provide an opportunity to test important facets of planetary disruption/spin rate models by allowing freely suspended spherical targets of varying viscosities, internal density gradients, and spin rates. Author

N86-30587*# Washington Univ., St. Louis, Mo. Dept. of Physics.
INTERPLANETARY DUST: THE INTERSTELLAR CONNECTION
W. C. CAREY and R. M. WALKER *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 47-48 1986 refs
Avail: NTIS HC A06/MF A01 CSCL 03B

Although not proven, there is the widespread belief that comets consist, at least in part, of interstellar material that was originally

present in the solar nebula. Furthermore, there are strong arguments in favor of the view that much of the interplanetary dust complex is derived from comets. The main arguments supporting this view are based on mass balance, analysis of the orbital parameters of meteors, and the long known association between meteor showers and specific comets. Laboratory measurements on interplanetary dust particles (IDPs) collected in the stratosphere have confirmed the view that many of the dust particles are primitive in the sense that they show striking enrichments of D/H relative to average solar system materials. It has also been demonstrated that the mid-infrared absorption spectra of one infrared red class of particles show strong similarities to IR sources such as the protostar W-33A. However, the laboratory studies of IDPs have shown that they represent a diverse set of objects and the measurement of the orbital parameters of specific dust particles is essential to answering the question of sources. The observation of the IRAS dust bands reopens the question of the role of asteroids in supplying a significant fraction of the dust and part of the diversity observed may be due to the fact that some of the dust is asteroidal and some cometary. In addition, some fraction of interplanetary dust must consist of an interstellar component intercepted by the solar system in its motion through the local interstellar medium. It has been shown that dust derived from nearby stars will have 75% of their orbits with eccentricities or equal to 1.1 and might be difficult to distinguish from interplanetary dust based on orbital measurements alone. M.G.

N86-30588*# Washington Univ., St. Louis, Mo. Dept. of Physics.

PROSPECTS FOR AN ORBITAL DETERMINATION AND CAPTURE CELL EXPERIMENT

W. C. CAREY and R. M. WALKER *In* Lunar and Planetary Inst. Trajectory Determinations and Collections of Micrometeoroids on the Space Station p 49-51 1986 refs

Avail: NTIS HC A06/MF A01 CSCL 03B

A dust experiment which combines measurements of the elemental and isotopic composition of individual particles with orbital information would contribute fundamental, new scientific information on the sources contributing to the micrometeoroid population. The general boundary conditions for such a system are: (1) it must be capable of measuring velocities in the range of 10 km/sec to 100 km/sec with several percent accuracy; (2) it must collect particles in such a way that the debris atoms are locally concentrated so that precise isotopic measurements are possible; (3) it should collect particles over a wide range of sizes starting with a lower limit of 10 microns; (4) it should incorporate materials that will not compromise the isotopic measurements; and (5) it should be large enough to obtain statistically meaningful results within a reasonable exposure time. Techniques which may satisfy these conditions are described. M.G.

N86-30590*# Chicago Univ., Ill. Lab. for Astrophysics and Space Research.

A NEW INSTRUMENT TO MEASURE CHARGED AND NEUTRAL COMETARY DUST PARTICLES AT LOW AND HIGH IMPACT VELOCITIES

T. ECONOMON, J. A. SIMPSON, and A. J. TUZZOLINO *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 54-55 1986 refs

Avail: NTIS HC A06/MF A01 CSCL 03B

A new class of dust particle detector, the PVDF dust detector, was designed for space missions such as the Halley Comet missions where the particle impact velocity is very high. It is demonstrated that this same PVDF detector (operating in a different mode) also has the capability of detecting dust particles having low velocity (approx. 100 m/s). This low velocity detection capability is extremely important in terms of planned missions requiring measurement of low velocity dust particles such as comet rendezvous missions. An additional detecting element (charge induction cylinder) was also developed which, when combined with a PVDF detector, yields a system which will measure the charge (magnitude and sign) carried by a cometary particle as well as the particle velocity and mass for impact velocities in the range 100 to 500 m/s. Since the cylinder-PVDF detector system has a relatively small geometry factors, an array of PVDF detectors was included having a total sensing area of 0.1 sq m for measurements in regions of space where the dust flux is expected to be low. The characteristics of the detectors in this array have been chosen to provide optimum mass sensitivity for both low-velocity cometary dust as well as high-velocity asteroid associated and interplanetary dust. Author

N86-30593*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

ORBITAL DEBRIS MEASUREMENTS

D. J. KESSLER *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micxrometeoroids on the Space Station p 61-63 1986 refs

Avail: NTIS HC A06/MF A01 CSCL 03B

What is currently known about the orbital debris flux is from a combination of ground based and in-space measurements. These measurements have revealed an increasing population with decreasing size. A summary of measurements is presented for the following sources: the North American Aerospace Defense Command Catalog, the Perimeter Acquisition and Attack Characterization System Radar, ground based optical telescopes, the Explorer 46 Meteoroid Bumper Experiment, spacecraft windows, and Solar Max surfaces. Author

N86-30594*# Technische Univ., Munich (West Germany). Institut fuer Luft-und Raumfahrt.

ACOUSTIC PENETRATION AND IMPACT DETECTOR FOR MICROMETEOROID AND SPACE DEBRIS APPLICATION

H. KUZCERA, H. IGLSEDER, U. WEISHAUPT, and E. IGENBERGS *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 64-66 1986 refs

Avail: NTIS HC A06/MF A01 CSCL 03B

The Two-Stage Acoustic Penetration and Impact Detector is a simple device for measuring the impact event time, the projectile velocity, the flight path direction and the momentum. The results of laboratory tests have shown that this detector can be used in a wide range of projectile size and velocity. According to measurement purposes the size of the detection area, the distance between the front foil and the target plate and the number of microphones as well as the evaluation procedure can easily be adjusted. The target plate area can also be replaced by another foil detector, if two penetration stages are preferred. This active detector is suitable for a variety of applications in meteoroid and space debris exploration. It can also be supplied with capture cell properties for chemical analysis of inside-deposits. Therefore, this measurement principal has been taken into consideration as a possible flight experiment for instance for a later Longer Duration Exposure Facility (LDEF) flight or future space station activities. Author

N86-30598*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

THE SOLAR MAXIMUM SATELLITE CAPTURE CELL: IMPACT FEATURES AND ORBITAL DEBRIS AND MICROMETEORITIC PROJECTILE MATERIALS

D. S. MCKAY, F. J. M. RIETMEIJER (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.), L. S. SCHRAMM, R. A. BARRETT, H. A. ZOOK, and G. E. BLANFORD (Houston Univ., Clear Lake, Tex.) *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 72-75 1986 refs

Avail: NTIS HC A06/MF A01 CSCL 03B

The physical properties of impact features observed in the Solar Max main electronics box (MEB) thermal blanket generally suggest an origin by hypervelocity impact. The chemistry of micrometeorite material suggests that a wide variety of projectile materials have survived impact with retention of varying degrees of pristinity. Impact features that contain only spacecraft paint particles are on average smaller than impact features caused by micrometeorite impacts. In case both types of materials co-occur,

it is believed that the impact feature, generally a penetration hole, was caused by a micrometeorite projectile. The typically smaller paint particles were able to penetrate though the hole in the first layer and deposit in the spray pattern on the second layer. It is suggested that paint particles have arrived with a wide range of velocities relative to the Solar Max satellite. Orbiting paint particles are an important fraction of materials in the near-Earth environment. In general, the data from the Solar Max studies are a good calibration for the design of capture cells to be flown in space and on board Space Station. The data also suggest that development of multiple layer capture cells in which the projectile may retain a large degree of pristinity is a feasible goal. Author

N86-30599*# National Aeronautics and Space Administration, Washington, D.C.
DUST COLLECTION ON SERVICEABLE SATELLITES
J. A. NUTH, III *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 76 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

One rationale for the Space Shuttle program which was dramatically realized during the repair of the Solar Maximum Mission (SMM) is the efficiency of in-orbit satellite servicing. An unexpected benefit of this repair mission was the return of parts of the Solar Max satellite which had been exposed for four years to the space environment. Studies conducted on these parts have yielded valuable data on the micrometeorite flux and composition at shuttle altitudes during this time period. The scientific results from studies of the cosmic dust component of the observed particle impacts are not yet complete but it is clear from the preliminary data available that such studies will be a valuable adjunct to the studies of cosmic dust particles collected in the atmosphere. The success of the initial studies of particles collected during repairs of the SMM spacecraft on a surface not specifically designed as a particle collector nor retrieved in a manner intended to minimize or eliminate local contamination raises the possibility that even more interesting results might be obtained if serviceable satellites were initially designed with these objectives in mind. All designs for modern satellites utilize some form of thermal blanket material in order to minimize thermal stresses inside the spacecraft. It is proposed that all future satellites be designed with standardized removeable sections of thermal blanket material which could be replaced during on-orbit servicing and returned to earth for detailed study. M.G.

N86-30606*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CAPACITOR-TYPE MICROMETEOROID DETECTORS
J. J. WORTMAN (North Carolina State Univ., Raleigh.), D. P. GRIFFIS (North Carolina Univ., Chapel Hill.), S. R. BRYAN, and W. KINARD *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 94-96 1986 refs
Avail: NTIS HC A06/MF A01 CSCL 03B

The metal oxide semiconductor (MOS) capacitor micrometeroid detector consists of a thin dielectric capacitor fabricated on a silicon wafer. In operation, the device is charged to a voltage level sufficiently near breakdown that micrometeoroid impacts will cause dielectric deformation or heating and subsequent arc-over at the point of impact. Each detector is capable of recording multiple impacts because of the self-healing characteristics of the device. Support instrumentation requirements consist of a voltage source and pulse counters that monitor the pulse of recharging current following every impact. An investigation has been conducted in which 0.5 to 5 micron diameter carbonized iron spheres traveling at velocities of 4 to 10 Km/sec were impacted on to detectors with either a dielectric thickness of 0.4 or 1.0 micron. This study demonstrated that an ion microprobe tuned to sufficiently high resolution can detect Fe remaining on the detector after the impact. Furthermore, it is also possible to resolve Fe ion images free of mass interferences from Si, for example, giving its spatial distribution after impact. Specifically this technique has shown that significant amounts of impacting particles remain in the crater and near it which can be analyzed for isotopic content. Further testing and calibration could lead to quantitive analysis. This study has shown that the capacitor type micrometeroid detector is capable of not only time and flux measurements but can also be used for isotopic analysis. M.G.

N86-30607*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PRECISION REQUIREMENTS ON COSMIC DUST TRAJECTORY MEASUREMENTS
H. A. ZOOK *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 97-100 1986 refs
Avail: NTIS HC A06/MF A01 CSCL 03B

It has been known for some time that the orbital parameters of certain major meteor streams rather closely match those of presently observed comets. There is therefore a clear parent-daughter orbital relationship between meteoroids in certain streams and the comets that they derived from. For meteoroids in the photographic meteor range, it has been estimated that from 1% to 10% of the meteoroid mass is concentrated into the major streams. However, for the smaller, more numerous meteoroids observed as radar meteors, streams are less intense but there are more of them. Sekanina (1973) has established for the radar meteors that, in addition to comets, some of the parent bodies appear to be asteroids. As noted by Grun et al. (1985), meteoroid lifetimes, due to collisional destruction or Poynting-Robertson (P-R) drag losses, range from 10(5) yr downward to less than 10(3) yr; these meteoroids therefore need to be continuously be replenished by source bodies to maintain the meteoritic complex in some sort of temporal equilibrium. It will be very important to obtain their precise trajectories when meteoroids are collected with a capture apparatus in Earth orbit, as is made apparent with the following logic: a chemical, isotopic, or other analysis of any particular meteoroid constitutes a similarly detailed analysis of a small part of the parent comet or asteroid that is orbitally associated with it. One can, consequently, do rather detailed cometary or asteroid science utilizing only an Earth-orbiting cosmic dust capturing facility. Author

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INTERNATIONAL

Includes descriptions, interfaces and requirements of international payload systems, subsystems and modules considered part of the Space Station system and other international Space Station activities such as the Soviet Salyut.

A86-32940#
DAMPING SYNTHESIS FOR A SPACECRAFT USING SUBSTRUCTURE AND COMPONENT DATA
K. W. LIPS and F. R. VIGNERON (Department of Communications, Ottawa, Canada) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 497-506) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Mar.-Apr. 1986, p. 158-164. Previously cited in issue 13, p. 1847, Accession no. A84-31739. refs

A86-33203
FLEXIBILITY CONTROL OF SOLAR BATTERY ARRAYS OF SPACECRAFTS
T. FUKUDA, H. HOSOGAI, Y. KURIBAYASHI (Tokyo, Science University, Japan), and N. YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) IN: A bridge between control science and technology. Volume 5 . Oxford and New York, Pergamon Press, 1985, p. 2933-2938. refs

The paper examines the problem of how to estimate and control the vibrational modes of flexible booms of the arrays in a reliable way even in large angle attitude maneuvers. A proposed mode estimation method, which makes use of differential outputs of instrument solar cells, gives a good estimation of the vibrational modes. Even static output maximization control in a desired direction cannot work stably without flexibility control, based on the mode estimation. The boom is controlled and implemented as a distributed parameter system by microprocessors. The dynamic control based on the feedback control theory can give good results to suppress the vibration of the arrays even in large angle attitude maneuvers. The control system has fault tolerant properties, such as dual microprocessor controlled systems with independent fault self-diagnostic software, and can degrade itself as faults go into the worse. Author

A86-33287
SPACECRAFT STRUCTURES DESIGN AND VERIFICATION
C. STAVRINIDIS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: International Symposium on Aeroelasticity and Structural Dynamics, 2nd, Aachen, West Germany, April 1-3, 1985, Collected Papers . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 669-671. refs

The scope and associated cost related with spacecraft structures design and verification depend on such factors as the weight criticality, and the degree of dynamic interaction of the payload with the launch vehicle. For large complex spacecraft which often have significant dynamic interaction with a launch vehicle, structural design and verification usually require a combination of analysis, development testing, and qualification testing. It is important when a project is initiated that the payload developer understands fully the various options, which often include specific requirements for a chosen launcher, since the selection of any of these options have a significant impact on the project cost and schedule. Author

A86-34123#
THE CANADARM - ON EARTH AS IT IS IN SPACE
C. G. TRUMP (Spar Aerospace, Ltd., Toronto, Canada) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 9 p.

Canada's contributions to space technology are reviewed. The development of the Shuttle Remote Manipulator System, which is used on manned US spacecraft and in the device used to fuel the Candu nuclear reactors, is described. Canada's satellite communication system is examined. Future Canadian space projects such as a mobile satellite system and space-based radar surveillance system are discussed. I.F.

A86-34572
MICROGRAVITY USER SUPPORT CENTRE FOR EURECA-1
H. P. SCHMIDT and K. WITTMANN (DFVLR, Institut fuer Raumsimulation, Cologne, West Germany) (DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Jan.-Feb. 1986, p. 6-12.
(DGLR PAPER 85-124)

Long duration missions like the EURECA missions with a duration of six months require new user support activities. Based on the lessons learned during the Spacelab program, DFVLR has developed a new concept for supporting the users of microgravity research. DFVLR plans the establishment of a Microgravity User Support Centre - MUSC in Koeln-Porz. User support during experiment preparation, operational support during the mission and scientific/technical support during data processing and experiment evaluation are then concentrated in one location. The user support center offers: laboratories for operating the ground models of the EURECA core payload, a user room for experiment observation and (as far as possible) experiment control, scientific/technical infrastructure and guest rooms. The proposed user support center should be regarded as a European facility. The whole European microgravity community is invited to use the center as a laboratory for the preparation and execution of their space experiments. Author

A86-34573
CONCEPTS FOR THE LIFE SUPPORT SUBSYSTEM IN THE EURECA BOTANY FACILITY
H. LOESER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) (DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 10, Jan.-Feb. 1986, p. 13-21.
(DGLR PAPER 85-126)

The Botany Facility (BF) represents one of the core experiments considered for the second Eureca launch, which is planned for 1990. A study is to be conducted regarding the ability of plants and fungi to germinate, grow, flourish, and produce seeds and spores under conditions of weightlessness. The life support subsystem requirements are discussed along with life support subsystem concepts, and the concept of water reclamation. Attention is given to BF performance data, physiological processes in plants, upper limits of physiological rates used for the design of BF life support subsystem, the basic concepts studied for the ventilation/humidification loop, an option using water reclamation with Peltier cooling, and the concept of a cuvette with internal water management. G.R.

A86-34974* National Aeronautics and Space Administration, Washington, D.C.
INTERNATIONALIZATION OF THE SPACE STATION
R. V. LOTTMANN (NASA, Office of Space Station, Washington, DC) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 8-1 to 8-9.

Attention is given to the NASA Space Station system elements whose production is under consideration by potential foreign partners. The ESA's Columbus Program declaration encompasses studies of pressurized modules, unmanned payload carriers, and ground support facilities. Canada has expressed interest in construction and servicing facilities, solar arrays, and remote sensing facilities. Japanese studies concern a multipurpose experimental module concept. Each of these foreign investments would expand Space Station capabilities and lay the groundwork for long term partnerships. O.C.

A86-35106
THE EUROPEAN OUTER SPACE PROJECT COLUMBUS - LEGAL QUESTIONS PERTAINING TO REGISTRATION [DAS EUROPAEISCHE WELTRAUMPROJEKT COLUMBUS - RECHTSFRAGEN DER REGISTRIERUNG]
UNIVERSITAET KOELN, COLOGNE, WEST GERM (Koeln, Universitaet, Cologne, West Germany) and H. BITTLINGER (Koeln, Universitaet, Cologne, West Germany) Zeitschrift fuer Luft- und Weltraumrecht (ISSN 0340-8329), vol. 35, March 1986, p. 8-30. In German. refs

The practice and problems of registering outer space projects is discussed with specific attention to the COLUMBUS project. The legal reasons for the registration requirement are summarized, and the regulatory significance of registration is discussed. The registration of the future Space Station is considered in some detail. C.D.

A86-35173#
EUROPEAN SPACE PLATFORM DEVELOPMENTS
G. ALTMANN and W. NELLESSEN (ESA, Paris, France) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 28 p. (DGLR PAPER 85-123)

The present paper is concerned with European activities related to the development of automated space platforms for low earth orbits. In the context of this paper, the term 'space platform' is used to describe 'reusable carrier systems providing basic resources and standard interfaces to temporarily attached payloads which can be replaced on orbit or on the ground'. The status of European platform developments is considered, taking into account potential platform developments based on the Spacelab pallet, the platform concept of Robus, the Spas (Shuttle-Pallet-Satellite) platform concept, the Eureca (European Retrievable Carrier) platform concept, and concepts for future space-based platforms. European developments are evaluated, taking into account efforts to establish cost effective design and operational concepts which are commercially attractive. G.R.

A86-35174#
DEVELOPMENT OF A TWO-PHASE THERMAL CYCLE FOR EUROPEAN PLATFORMS
H. KREB, P. MOELLER, and H. G. WULZ (Dornier System GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 15 p. refs
(DGLR PAPER 85-127)

The European Columbus space platform has the objective to provide a permanent facility supplying standard resources to as yet undefined payloads. It is planned to maintain the platform either in a polar orbit serviced by periodic visits of the Space Shuttle, or in an orbit in which the Columbus platform, utilizing its own propulsion system, can periodically visit the U.S. Space Station. For the long duration missions involving the Columbus space platform, the currently employed methods of thermal management are not very suited. For this reason, attention is given to a two-phase flow loop system for dissipation heat collection and transport. The system is to be interfaced with heat pipe radiators for heat rejection to space. It is expected that such an approach will provide advantages of improved reliability, operational flexibility, modular growth, and extended life with minimum maintenance, in comparison to conventional heat management systems. Details regarding the implementation of this concept are discussed. G.R.

A86-35175#
IN-ORBIT SERVICING, CRITERIA AND PROCEDURE EVALUATION [IN ORBIT SERVICING, KRITERIEN UND VERFAHRENSBEWERTUNG]
W. HALLMANN (Aachen, Fachhochschule, West Germany), J. PULS (DFVLR, Oberpfaffenhofen, West Germany), and M. KIRSCHNER (Muenchen, Technische Universitaet, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 27 p. In German. refs
(DGLR PAPER 85-128)

Future advanced spacecraft systems will require for a full cost-effective utilization 'in-orbit-servicing' (IOS) operations. The employment of IOS will make it possible to conduct space missions with improved characteristics, taking into account the implementation of a new mission type requiring periodic maintenance or other services. Other advantages are related to an enhancement of reliability by prolonging the lifetime of payloads and instrument carriers, the reduction of the cost of an individual mission, and the rescue of astronauts which suffered an accident during EVA. Attention is given to mission scenarios, the methods employed in in-orbit servicing operations, auxiliary equipment used for in-orbit servicing, and the identification of service operations. In a discussion of evaluation criteria, servicing on the platform is considered along with servicing on the Space Station or on the Shuttle, and servicing on the ground. Questions regarding the economics of various operational approaches are examined. G.R.

A86-35183#
DATA MANAGEMENT SYSTEM FOR COLUMBUS
F. PITTERMANN and F.-J. ROMBECK (Dornier System GmbH, Friedrichshafen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 12 p.
(DGLR PAPER 85-145)

Data management design and technology for Columbus are examined. The need for a data management system that is fault tolerant and has replaceable units is discussed. The requirements and implementation of computers, an interconnection link, memories, a man/machine interface, and high-speed data handling are described. The software engineering required for the management system is studied. I.F.

A86-35185#
SPACE STATION DESIGN CRITERIA FOR LONG-TERM HUMAN HABITATION [ENTWURFSKRITERIEN FUER EINE RAUMSTATION IN HINSICHT AUF LANGZEITAUFENTHALT DES MENSCHEN]
P. TETZLAFF (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985. 11 p. In German. refs
(DGLR PAPER 85-147)

The design criteria of technologies being developed to sustain human habitation aboard the Space Station for long periods are discussed. Systems aimed at maintaining life functions and to help astronauts cope with weightlessness are emphasized. Particular problem areas in these technologies are mentioned. C.D.

A86-35191#
AUTONOMOUS SPACE STATION POWER SYSTEMS
G. EGGERS (Telefunken AG, Wedel, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985, Paper. 20 p.

The design of an autonomous multichannel electrical power system (EPS) that could meet the hard requirements set for future Space Station LEO missions is discussed. Three major building blocks of the EPS functional architecture are: (1) primary power assembly (PPA), (2) the power distribution assembly (PDA), and the power system internal data bus (PINDAB). The PPA and PDA generate and handle the flow of power to the users. The PINDAB, by controlling parallel operations of the power system, performs overall control and management of PPA and PDA and provides a centralized interface to the on-board data handling system. Multiple block diagrams are included. I.S.

A86-35194#
ALTERNATIVE SPACE POWER SYSTEMS
W. WESTPAL (Telefunken AG, Frankfurt am Main, West Germany) and G. KRUELLE (DFVLR, Cologne, West Germany) DGLR, Jahrestagung, Bonn, West Germany, Sept. 30-Oct. 2, 1985, Paper. 17 p. refs

Viable alternative primary power systems which would be operational when space power growth surpasses solar array appropriability are investigated,with reference to the development of the Space Station. An operational comparison is made between photovoltaic, solar-dynamic, and nuclear dynamic concepts with regard to weight, exposed area, safety, and reliability. Energy converters under consideration include thermodynamic cycles (Brayton, Rankine, and Stirling), the thermionic converter, the combined thermionic-Brayton system, and a thermoelectric converter. It is concluded that, as compared to a photovoltaic/battery-storage system, solar- or nuclear-dynamic systems reach higher efficiencies, incorporate a more effective buffer storage for shadow phases, and drastically reduce the exposed collecting area. K.K.

A86-35320
AERITALIA'S COLUMBUS
E. VALLERANI (Aeritalia S.p.A., Naples, Italy) Space (ISSN 0267-954X), vol. 2, Mar.-May 1986, p. 16-18, 20, 28.

The Columbus system, a product of the co-operation between Europe and the USA, consists of four basic elements: (1) a

pressurized module, (2) unmanned platforms operating in polar orbit or co-orbiting with a Space Station for earth observation and microgravity experiments, (3) a resource module which supports the pressurized module in its free flyer configurations, and (4) a service vehicle, initially unmanned but later manned for pressurized module service. Three pressurized module (PM) configurations are investigated: (1) an attached PM, (2) an integral PM, and (3) a growth version of the attached PM that would become a man-tended free flying laboratory. Primary free flyer structure provides pressurized volume and mass carrying capability as well as radiation and micrometeoroid protection, while secondary structures house subsystem and payload equipment. Features such as thermal control, ECLSS, DMS and man systems are discussed in detail, together with the role of the pressurized basic module (PBM) in future applications. K.K.

A86-35562#
EUROPE AIMS FOR SPACE INDEPENDENCE
P. LANGEREUX Aerospace America (ISSN 0740-722X), vol. 24, April 1986, p. 50-54, 56 (3 ff.).

The formation of ESA in 1975 established a unified organization to direct European space efforts into the 21st century. The initial thrusts were the Ariane launcher used for communications satellites and joint programs with the U.S. The 1985-95 expenditures will be double those from 1975-85, with major programs being the Ariane 5 heavy-lift vehicle, the Hermes spaceplane and an in-orbit infrastructure which encompasses the Columbus space station segment and a DRS satellite. Controversy persists due to European plans for free-flying, pressurized, dockable Space Station modules while NASA is requiring that the Initial Operational Station be a set configuration. It is notable that the Ariane 5 is actually a new, not derivative, design, and will be powerful enough to lift space station segments, or the Hermes, into LEO. The HOTOL, a British spaceplane under study, is expected to take longer than the Hermes to develop. Cornerstone science missions will include an asteroid or cometary sample return mission, orbiting unmanned X, solar and UV observatories, and a Saturn orbiter. The Eureca is a means to perform materials science, biology, fluid physics and other basic experimentation on orbit to identify potential space industrial processes. M.S.K.

A86-36029#
ESA-SPONSORED DEVELOPMENTS IN THE FIELD OF DEPLOYABLE MASTS
M. A. AGUIRRE-MARTINEZ (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 9, no. 3, 1985, p. 313-321.

The agency is sponsoring two parallel development efforts in the field of advanced deployable masts. Both are extending tube devices capable of pushing out solar arrays and deploying such items as antennas and scientific experiments. This paper describes their current status and the present and future applications for such devices. It includes a presentation of the background to the two programmes, functional descriptions of the devices, and analyses of their performances. Author

A86-36668
CONVERSION OF SOLAR ENERGY [PREOBRAZOVANIE SOLNECHNOI ENERGII]
N. N. SEMENOV, ED. and A. E. SHILOV, ED. Moscow, Izdatel'stvo Nauka, 1985, 184 p. In Russian. For individual items see A86-36669 to A86-36673.

The papers presented in this volume provide an overview of current theoretical and experimental research related to the conversion and practical utilization of solar energy. Topics discussed include semiconductor photovoltaic cells, orbital solar power stations, chemical and biological methods of solar energy conversion, and solar energy applications. Papers are included on new theoretical models of solar cells and prospects for increasing their efficiency, metrology and optical studies of solar cells, and some problems related to the thermally induced deformations of large space structures. V.L.

A86-36671
SOLAR ENERGY CONVERSION SYSTEMS FOR POWER PLANTS IN SPACE - A COMPARATIVE ANALYSIS AND PROSPECTS FOR DEVELOPMENT [SISTEMY PREOBRAZOVANIIA SOLNECHNOI ENERGII DLIA KOSMICHESKIKH ENERGOSTANTSII - SRAVNITEL'NYI ANALIZ I PERSPEKTIVY RAZVITIIA]
V. A. GRILIKHES IN: Conversion of solar energy . Moscow, Izdatel'stvo Nauka, 1985, p. 60-74. In Russian. refs

Solar energy conversion methods and systems for orbital solar power plants are reviewed with reference to data in the literature. In particular, attention is given to general requirements for orbital solar energy conversion systems, their principal characteristics, principal types of solid-state photovoltaic cells, and thermoelectric conversion systems. A comparative analysis is made of the performance of photovoltaic and thermal systems, and directions of further research in this field are outlined. V.L.

A86-36673
SOME PROBLEMS RELATED TO THE THERMALLY INDUCED DEFORMATIONS OF LARGE SPACE STRUCTURES [NEKOTORYE VOPROSY TEMPERATURNYKH DEFORMATSII KRUPNOGABARITNYKH KOSMICHESKIKH KONSTRUKTSII]
S. K. GROMOV IN: Conversion of solar energy . Moscow, Izdatel'stvo Nauka, 1985, p. 94-99. In Russian. refs

The problem of determining the temperature fields and thermally induced deformations of large space structures consisting of rod-like elements is examined in the stationary case, i.e., for constant external heat flow and constant temperatures at all points of the structure. In particular, attention is given to the sources of external heat fluxes, consideration of radiant heat transfer and heat conduction when determining temperature distribution along a rod, thermal bending of a cylindrical structural element, and anisotropy of the thermal expansion of a rod element. V.L.

A86-37854#
COLUMBUS - THE EUROPEAN PARTICIPATION IN INTERNATIONAL SPACE STATIONS
E. VALLERANI (Aeritalia S.p.A., Gruppo Sistemi Spaziali, Turin, Italy) and H. E. W. HOFFMANN (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 29-44.

A history of the Columbus project to date is presented, beginning with the demonstration by ESA and its member States that there is a capability to take on a project of this magnitude. Columbus is intended to complement the U.S. Space Station, being (in one concept) a free-flying facility in orbit near the Space Station. It will be manned and serviced as needed from time to time by personnel who actually reside on the Space Station. The Columbus system is to consist of four elements: the pressurized module; the resource module; the payload platform; and the servicing vehicle. Anticipated to be ready by 1992 (the 500th anniversary of Columbus' discovery of America), the system will have the potential of evolving to meet future needs. D.H.

A86-37856#
THE COLUMBUS PREPARATORY PROGRAMME SUPPORTING TECHNOLOGY OF THE EUROPEAN SPACE AGENCY
H. STOEWER and R. BARBERA (ESA, Systems Engineering Dept., Noordwijk, Netherlands) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 79-96.

The status of preparation for the technical and program aspects of the European Space Agency's Columbus Preparatory Technology Research and Development activities is summarized. Technology R&D activities for the manned module, unmanned platforms including resources technologies and servicing vehicles are described. Priorities, funding allocations, and schedule aspects for industrial implementation are indicated. The Supporting Technology together with the Phase B System Definition studies

permit ESA and European industry to work together toward the 1986/87 milestone for Columbus Phase C/D implementation. The process of going from the system definition phase to supporting-technology development should provide a valuable data base and give confidence in the technical, cost and schedule predictions already derived. D.H.

A86-37860#
SOME EVALUATIONS ON THE ATTITUDE STABILITY OF A CLASS OF TETHERED SPACE STATIONS
S. BERGAMASCHI, F. LUCCHETTI (Padova, Universita, Padua, Italy), and F. BEVILACQUA (Aeritalia S.p.A., Gruppo Spazio, Turin, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 145-151. refs

Preliminary consideration is given to a tethered space station concept, examining whether the effect of the basic stabilizing force provided by gravity gradient is obscured by the action of other perturbations. The purpose is to study the attitude dynamics of a simple tethered structure, in order to find out its stable configurations. Since out-of-plane perturbations are as likely to occur as in-plane ones (at least in nonequatorial orbits), the dynamical model is three-dimensional. In most cases, the attitude of a two-dimensional rigid structure in a circular orbit in not stable against gravity gradient unless its minimum axis of inertia points to the nadir. It is shown that the addition of a rod and of a counterweight connected to it by means of a tether gives rise to other stable configurations. Certain of these configurations are studied, and it is seen that reasonable values of the parameter (m-sub-r)ld are sufficient to ensure stability, with the rod being about 10 m long. D.H.

A86-37861#
LARGE SPACE STRUCTURAL MODELS BY COMBINATION OF FINITE ELEMENTS AND TRANSFER MATRIX METHODS [MODELLI STRUTTURALI DI GRANDI STRUTTURE-SPAZIALI PER COMBINAZIONE DEI METODI AGLI ELEMENTI FINITI E DELLA MATRICE DI TRANSFERIMENTO]
L. LECCE, F. MARULO, and G. BUONO (Napoli, Universita, Naples, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 153-161. In Italian. refs

To implement a structural model able to study large space structures, a methodology is proposed based on a proper combination of the finite Element and Transfer Matrix Methods. Taking into account the repetitive aspect of such structures, it is possible to gain full advantage of the Transfer Matrix Method applied to periodic structures, without loss of the detail offered by the FEM. Some examples involving simple structures are presented, showing the characteristics and the reliability of the proposed method. Finally the implementation on already existing structural computer code (NASTRAN, SAP, etc.) is discussed and proposed to take full advantage of the method. D.H.

A86-37863#
INFLATABLE TECHNOLOGY IN ORBIT DEMONSTRATION WITHIN THE EUROPEAN SPACE AGENCY PROGRAMS
G. G. REIBALDI (ESA, Mechanical Systems Div., Noordwijk, Netherlands) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 199-205.

To support future space projects in general and the Space Station program in particular, the European Space Agency has proposed to the European countries an in-orbit technology demonstration experiment, designated 'Inflatable Space Rigidized Technology' or ISRT. ISRT has been developed within the ESA Technology Research Program, and the technology has been applied to design large size reflecting telescopes. A first in-orbit demonstration on the Space Shuttle of a 3.5-m scale model was planned for early 1986. A full-scale 14-m off-set reflector in-orbit demonstration is proposed for the middle of 1988. D.H.

A86-37870#
PRESENT AND FUTURE PROSPECTS OF MICROGRAVITY
L. G. NAPOLITANO (European Low Gravity Research Association, Munich, West Germany) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 265-309.

An overview is given of the current status of microgravity research and related disciplines, with respect to the Space Station. The broad-field list of topics with microgravity relevance includes material sciences, fluid sciences, life sciences, engineering sciences, technology and processes. Areas and disciplines with the material sciences and fluid sciences are examined in some detail, and the expected requirements and evolutionary development of the sciences aboard the Space Station are considered. The report includes a position paper covering the situation in Europe with regard to microgravity research, covering ESA's microgravity experiments and the work of the organization known as ELGRA (European Low Gravity Research Association), founded in June 1979. D.H.

A86-37872#
MISSION REQUIREMENTS FOR COORBITING AND POLAR PLATFORMS - A CRITICAL SURVEY
G. MANNARA, L. G. NAPOLITANO, and R. MONTI (Napoli, Universita, Naples, Italy) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 325-337. In Italian. refs

Missions proposed for platforms in the Space Station program are analyzed. Mission requirements are characterized for polar platforms and those coorbiting with the Space Station. It is concluded that polar platforms should satisfy different requirements from coorbiting platforms; the former should emphasize servicing operations while the latter should emphasize flexibility. B.J.

A86-38622
THE SALVAGE OF SALYUT 7
L. DORR, JR. Space World (ISSN 0038-6332), vol. W-5-269, May 1986, p. 8-12.

The salvage of the Salyut 7, launched in April 1982 and disabled some two and a half years later due to a battery sensor malfunction, is discussed. The Soyuz T-13 rescue vehicle, launched on June 6, 1985, performed a two-day tracking of the Salyut 7 before docking. Working under difficult freezing conditions, the cosmonauts Savinykh and Dzhanibekov were able in one week to restore the vehicle's power functioning, test the attitude control and main propulsion systems, and replace damaged electronics. Over the next three months the Progress 24 and Kosmos 1669 freighters brought replacement equipment including solar panels and a micrometeoroid collector, and a normal load of experiments were able to be performed. The craft was manned until November 12. R.R.

A86-38984
DESIGNING THE CONDITIONS OF LIFE AND WORK OF COSMONAUTS (2ND REVISED AND ENLARGED EDITION) [PROEKTIROVANIE USLOVII ZHIZNI I RABOTY KOSMONAVTOV /2ND REVISED AND ENLARGED EDITION/]
N. N. GUROVSKII, F. P. KOSMOLINSKII, and L. N. MELNIKOV Moscow, Izdatel'stvo Mashinostroenie, 1985, 152 p. In Russian. refs

The factors that influence cosmonauts in space are analyzed. The basic spacecraft design and work of the cosmonauts are described. The effects of cabin conditions on crew life during long space flights are investigated. The organization of the crews' cabin and methods of increasing the cosmonauts work efficiency are discussed. Psychological and physiological stresses due to space flight are studied. I.F.

A86-39490#
REDUCED ORDER MODELS FOR DISTRIBUTED SYSTEMS BASED ON HANKEL-NORM APPROXIMATIONS
R. F. CURTAIN (Groningen, Rijksuniversiteit, Netherlands), K. GLOVER, and J. LAM (Cambridge University, England) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 231-244. refs

Recently the authors have developed a mathematical theory for finite-dimensional approximations for a class of infinite-dimensional systems based on its Hankel operator. The feasibility of this approach is investigated by considering two examples which model some of the essential features of large flexible structures. Author

A86-39496#
A MATRIX APPROACH TO DYNAMICS FORMULATION OF COMPLEX SPACE STRUCTURES
Y. OHKAMI, O. OKAMOTO, T. KIDA, I. YAMAGUCHI, and K. MATSUMOTO (National Aerospace Laboratory, Tokyo, Japan) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 325-340. refs

A unified matrix approach for the formulation of complex space structure dynamical equations is proposed. The major advantage of the approach developed lies in its basic simplicity in solving constrained dynamical equations. It is essentially based on the formulation of a matrix algebraic equation of the form A X = B, to be solved for the variable X, whose elements consist of the time-derivatives of nonholonomic angular and linear momenta, followed by integration routines. The matrix A has a simple structure clarifying the characteristics of the system topology and the constraining conditions. Some examples are shown to illustrate the features of the approach, and numerical results obtained by a general-purpose computer program are presented. Author

A86-39506#
ACTIVE STRUCTURAL CONTROL WITH DECENTRALIZED AND COLOCATED CONTROL UNITS
A. ERCOLI FINZI, M. LANZ, and P. MANTEGAZZA (Milano, Politecnico, Milan, Italy) IN: Dynamics and control of large structures; Proceedings of the Fifth Symposium, Blacksburg, VA, June 12-14, 1985 . Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, p. 487-501. refs

The paper presents an approach to the active control design of large space structures that is based on the adoption of decentralized control units. These control units use colocated sensors and actuators and adopt a control law that generate forces proportional to local motions in order to emulate real structural elements, discrete tuning masses and grounding spring-damper combinations. A modal reduced order model is used to design the control law on the base of the numerical minimization of a multimodel quadratic performance index related to the response and feedback forces following a perturbation of the initial conditions and/or the application of step inputs. It is shown how the use of this type of control units allow the development of an intrinsic 'fail-safe' design. The results obtained with the application of the concepts developed in this paper are demonstrated by their application to an experiment in which a thin beam, suspended from the ceiling, is controlled by different combinations of the independent analog control units making use of a velocity transducer, an integrator and an electrodynamic actuator. Author

A86-39569#
ROBUST CONTROL OF A FLEXIBLE NON-SYMMETRICAL SPACECRAFT
J. S.-C. YUAN (Spar Aerospace, Ltd., Toronto, Canada) (CASI, Canadian Conference on Astronautics, 3rd, Ottawa, Canada, Apr. 23, 24, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 32, March 1986, p. 62-74. Sponsorship: Department of Supply and Services. refs
(Contract DSS-06ST-36001-3-2484)

This paper presents a method of simultaneous beam-pointing and attitude control of a flexible spacecraft. The latter represents a candidate concept for the next generation of large communications satellites (e.g. MSAT) which contains many flexible structural elements and are highly non-symmetrical in their overall configurations. The dynamic compensator is of the classical proportional-integral type augmented by a Kalman filter. The results demonstrate how an estimator-based compensator could be designed to retain the robustness properties with regard to parametric variation and spillover from unmodelled dynamics. Author

A86-39981
REAL FANTASY [REAL'NAIA FANTASTIKA]
S. P. UMANSKII Moscow, Izdatel'stvo Moskovskii Rabochii, 1985, 242 p. In Russian.

The need for the continual exploration of outer space is emphasized, and the ultimate benefits in store for mankind are presented in detail. The pioneers of rocket technology, the first flights into outer space, and developments in astronautics are discussed as well as the design of rockets, spacecraft, and orbital space stations. Lunar features are examined, and plans for lunar-based scientific investigation are described. Attention is given to results of investigations conducted on Mars and Venus, the design of Mars probes, and the instruments used to study Venus. Plans for flights to nearby stars are also described. K.K.

A86-39985
SPACE AND PEACE [KOSMOS I MIR]
G. P. ZHUKOV (AN SSSR, Institut Mirovoi Ekonomiki i Mezhdunarodnykh Otnoshenii, Moscow, USSR) Moscow, Izdatel'stvo Nauka, 1985, 88 p. In Russian. refs

The benefits provided to man through space exploration are described; the industrialization of space and the use of satellites to provide forecasting abilities, natural resource data, and telecommunications and television services are discussed. The dangers and methods of preventing space militarization are examined. International (bilateral and multilateral) agreements on the use of space are analyzed. The role and policies of the UN concerning the peaceful uses of space are studied. I.F.

A86-40371
CONTINUOUS FORMING OF THIN-WALLED CFRP PIPES FOR LARGE-SPACE STRUCTURE
T. WATANABE, T. SUGANO, and K. MURAYAMA (Mitsubishi Electric Co., Materials Laboratory, Sagamihara, Japan) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 505-510. Research sponsored by the Agency of Industrial Science and Technology.

A high efficiency continuous forming process for long and thin-walled CFRP pipes has been developed. The pipe will be applied to future large-scale space structures. An original manufacturing system, both process and equipment, is described. The essential working conditions of the pultrusion process through fabrication and quality evaluation of the products are presented. A useful method and the appropriate cure condition for the raw material are described. It was confirmed that the pultruded CFRP pipe had qualities equivalent to those obtained by the conventional batch method. Author

A86-40378
THE PRODUCTION AND PROPERTIES OF COMPOSITE MATERIALS WITH LIGHT ALLOY MATRICES REINFORCED WITH CONTINUOUS FIBERS (C, SIC) [ELABORATION ET PROPRIETES DE MATERIAUX COMPOSITES A MATRICES D'ALLIAGELERERS REINFORCEES DE FIBRES CONTINUES /C, SIC/]
P. MACHETO (Aerospatiale, Division Systemes Balistiques et Spatiaux, Les Mureaux, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 616-622. In French. refs

Solid phase manufacturing processes used for metal matrix composites (MMC) are briefly described, along with the mechanical properties of the resulting materials. Attention is focused on carbon-aluminum (C/Al) and silicon carbide-aluminum (SiC/Al) MMCs, wherein Al forms the matrix for the C and SiC fibers. Metallized tapes or cloths of the reinforcing fibers are laid in the mold and then hot pressed with the Al matrix material at an atmospheric pressure of 150-250 bars and a 500-600 C temperature. The materials are then quenched under pressure. The temperature-pressure-time triplet determines the quality of the resulting materials. Three-point bending tests have shown that the fatigue resistance of the C/Al MMCs have remained the same at temperatures from 20-300 C due to the high ductility of the Al matrix. Samples of SiC/Al have exhibited as high a stiffness as the C/Al materials. The C/Al MMCs eventually crack from fiber/matrix separation, while the SiC/Al MMCs fail due to fiber breakage. Finally, the low coefficients of thermal expansion of both materials commends then as candidates for tests in large space structures. M.S.K.

A86-40496
DESIGN PREPARATIONS FOR LARGE SPACE STRUCTURES
H. W. BERGMANN (DFVLR, Institut fuer Strukturmechanik, Brunswick, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 159-172.

The DFVLR has undertaken a program for the evaluation of fiber-resin systems applicable to composite space structures before and after realistic exposure to simulated space environments. Also under development are computer programs for the design and analysis of such space structures, and methodologies for the validation of these programs against test structures that are sufficiently large to exhibit behaviors characteristic of lattice structures in space. Attention is being given to the influence of thermal cycling, the influence of electron irradiation, and the weight optimization of tubular components. O.C.

A86-40498
EXPERIENCES IN FRG IN AEROSPACE APPLICATION
K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 206-228.

Attention is given to the experience gained in West Germany to date with CFRPs' fiber, matrix resin, and fiber-resin interface characteristics. Attention is given to space structures applications such as the Intelsat V series satellites' solar cell array structure, as well as the Tornado fighter aircraft's taileron, a technology development CFRP fighter cockpit, and helicopter rotor blades and driveshafts. Also noted are recent advancements in CFRP fabrication and quality assurance techniques. O.C.

A86-40597#
ELECTROSTATIC CHARGING AND ARC DISCHARGES ON SATELLITE DIELECTRICS SIMULATED BY ELECTRON BEAM
H. FUJII, Y. SHIBUYA (Mitsubishi Electric Corp., Manufacturing Development Laboratory, Amagasaki, Japan), T. ABE, R. KASAI (Mitsubishi Electric Corp., Kamakura, Japan), and H. NISHIMOTO (National Space Development Agency of Japan, Tsukuba Space Center, Sakura) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 156-163. refs
(AIAA PAPER 86-1191)

This paper describes the electrostatic charging and discharge phenomena of dielectric materials for spacecraft by electron-beam irradiation simulating the hot plasma in space. Thermal control materials were used as the dielectric materials tested. Charge accumulation in the dielectric irradiated with the partially penetrating mono-energetic electron beam causes a large potential on the surface. When the large surface potential reaches a critical value, arc discharge occurs. The rate of occurrence of the discharge increases with the electron energy and the electron beam current density. The characteristics of the discharges, however, depend on the material. Author

A86-40601#
THE PROPULSION MODULE OF THE COLUMBUS SPACE PLATFORM - TRADE OFFS AND DESIGN
G. BORRIELLO, A. FABRIZI, M. BALDUCCINI (SNIA BPD S.p.A., Colleferro, Italy), and A. BRIOIS (Aerospatiale, Cannes, France) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 190-200.
(AIAA PAPER 86-1200)

The design of the Columbus Space Platform propulsion module is described. The module design is to be cost effective and perform orbit transfer, reaction control, and orbit maintenance functions. The effect of the mechanical configuration of the module on the performance of the system is analyzed; a single modular system located at one end of the platform was chosen as the configuration for the module. The selection of the proper chemical and electrical propulsion systems for the module is examined. The mass/performance of various propellant systems are evaluated; a monomethylhydrazine and nitrogen tetroxide and a magnetoplasmadynamic electric propulsion were determined to be the most effective propellants. The pressure system, platform steering, and propulsion module servicing for the module are discussed. A configuration of 2-4-6 tanks of 0.98 cu m was chosen for the module. Central box, network, stressed box, and mixed box/network concepts are studied for the structural design of the module and the network configuration was selected. I.F.

A86-42668#
PROPULSION FOR A POLAR ORBITING SERVICEABLE SPACECRAFT FOR THE RADARSAT MISSION
B. F. GORIN (Fairchild Space Co., Germantown, MD) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1486)

The Canadian RADARSAT spacecraft is a Space Shuttle launched and serviced earth observation vehicle which will operate in a precisely maintained polar orbit with an altitude of 544 Nm (1,007 km) and an inclination of 99.52 degrees. This operational orbit combined with planned service missions and the limitations in STS performance to high inclination orbits places major demands on the RADARSAT on board propulsion system. This paper addresses the RADARSAT mission, how it drives the operational requirements for the propulsion system and the propulsion system concept which has been developed to meet those requirements. Author

A86-43230
EURECA CONCEPT AND ITS POTENTIAL EVOLUTION WITHIN THE SPACE STATION ERA
R. L. MORY (ESA, Paris, France) IN: Astrodynamics 1985; Proceedings of the Conference, Vail, CO, August 12-15, 1985. Part 1 . San Diego, CA, Univelt, Inc., 1986, p. 551-568.
(AAS PAPER 85-398)

The development and project objectives of the EURECA concept are presented as well as the design approach, system capabilities and the first mission payload. An account of EURECA's adaptation for nonmicrogravity missions is given together with its role in the Space Station and Columbus scenarios. The EURECA platform will be deployed from the Shuttle cargo bay in-orbit, will operate in a free-flying mode for about six months, and will then be retrieved, returned to earth (by a subsequent Orbiter) and prepared for the next mission. It is noted that this carrier provides all essential services so that the development of a special satellite is not necessary. Moreover, as a potential autonomous payload carrier within the future Space Station, it could accommodate and operate space instruments either in the free-flying or docked modes. It is concluded that the role EURECA will play in the Space Station scenario will be governed by the results of on-going studies and by negotiations with NASA. K.K.

A86-43336
EUROPEAN EXPERIENCE AND PERSPECTIVES [EUROPAEISCHE ERFAHRUNGEN UND PERSPEKTIVEN]
G. GREGER (BMFT, Bonn, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 17-25. In German.

The history of the cooperation between the U.S. and Europe, in particular West Germany, with respect to space-related activities is examined, taking into account the beginning of this cooperation in 1964, the cooperative satellite projects Azur and Aeros, Spacelab, and the American offer regarding a participation of other countries in the Space Station project. The form and the results of this cooperation were generally satisfactory for European partners. However, there were and are also some difficulties. One problem is related to the launching services provided by the U.S., giving attention to a complaint of an American aerospace company, claiming the violation of one of its patents. Difficulties can arise, in particular, in connection with the economic utilization of space-related activities and the competition of private firms. Attention is given to the European trend to autonomy, possible obstacles to technology transfer, problems related to U.S. laws, and the Space Station as a challenge. G.R.

A86-43341
CONTRACTS OF AND WITH PRIVATE ENTERPRISES CONCERNING THE DEVELOPMENT, THE CONSTRUCTION, AND THE ASSEMBLY OF SPACE VEHICLES [VERTRAEGE VON UND MIT PRIVATUNTERNEHMEN BETR. DIE ENTWICKLUNG, DEN BAU UND DIE MONTAGE VON RAUMFLUGKOERPERN]
E. WOLFF (Dornier System GmbH, Friedrichshafen, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 89-99. In German. refs

This paper provides a representation of some special features which characterize development contracts that governmental agencies award to industrial enterprises. Particular attention is given to conditions in West Germany. However, approaches used in connection with contracts involving ESA and NASA are also considered. The origin of the development contract is discussed along with the objective of the development contract, questions regarding the legal qualification of the development contract, regulations regarding compensation in development contracts, assurances concerning the quality of the performed work, and the rights of the party awarding the contract with respect to information, participation, and control. G.R.

A86-43345
STATE SUPERVISION AND REGISTRATION
W. VON KRIES (DFVLR, Bonn, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 129-136. refs

The basic provisions of the 1967 Outer Space Treaty dealing with state supervision, registration, and related legal issues are examined in the context of space station operations, taking into account also the 1976 Registration Convention. Three major developments considered are related to the unprecedented technical nature of future space stations, the expected intensive international participation in space station operations, and the anticipated high level private sector involvement in space station activities. The technological characterization of space stations is discussed, and questions regarding the legal characterization of space stations are examined. Attention is given to space stations as 'space objects', the registration of space stations, and space stations as launching facilities. Problems concerning the jurisdiction and control over space stations are also considered, taking into account the Space Shuttle/Spacelab precedent, the case of Columbus, and the integrated supervision and control of space station operations. G.R.

A86-43350
EXPERIENCE OF THE EUROPEAN SPACE AGENCY
G. VAN REETH and R. OOSTERLINCK (ESA, Paris, France) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 187-197. refs

The European Space Agency (ESA) has also gained experience concerning manned space flights, taking into account Spacelab and experimental satellites. A brief review is conducted of European space research, which has been conducted during a period of over twenty years. The Agency's general policy with respect to data and products is examined. Details regarding the ESA Convention are considered along with agreements between ESA and other organizations, ESA's policy on intellectual property rights, relations between ESA and non-member states, the Memorandum of Understanding between NASA and ESA on the International Solar/Polar Mission, and cooperation agreements which have certain commercial elements. Attention is also given to questions regarding the access to the technology and information needed to accomplish a cooperative program, and a distinction made between intellectual property rights of different types. G.R.

A86-43702
THE COLUMBUS SPACE PLATFORM
R. C. PARKINSON (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IN: SPACECOM '85; Space and Radiocommunications Symposium, 5th, Paris and Le Bourget, France, June 5-7, 1985, Speakers' Papers . Geneva, Switzerland, International Telecommunication Union, 1985, p. 1-5.

The requirements for a multi-user Space Platform maintained on-orbit by periodic visits by the Space Shuttle, and servicing a series of payloads, have evolved since the concept was first formulated within NASA in the mid-1970s. This paper details some of the challenges and approaches associated with the current European Space Platform concept being pursued by British Aerospace as an essential part of the program of European participation in the Manned Space Station Program (Columbus). Author

A86-43756
NONLINEAR DEFORMATION ANALYSIS OF THE OLYMPUS ASTROMAST [NICHTLINEARE VERFORMUNGSANALYSE DES OLYMPUS ASTROMAST]
O. BRUNNER (IKO Software Service GmbH, Stuttgart, West Germany), M. EIDEN, and C. STAVRINIDIS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: International FEM-Congress, 14th, Baden-Baden, West Germany, November 18, 19; 1985, Proceedings . Stuttgart, West Germany, IKOSS GmbH, 1985, p. 145, 147-159. In German.

LARSTRAN 80, a nonlinear quasi-static updated-Lagrange finite-element program developed at the Universitaet Stuttgart (1984) to treat problems with large extensions and deflections, is applied to the extension process of the Astromast for the Olympus satellite. The Astromast is a coilable continuous-longeron GFRP structure intended to support the Olympus solar arrays, and its components are subject to large deformations, material nonlinearities, and contact forces during extension. The construction of a 10-bay FEM mast model, the nonlinear computation strategy, and the techniques used to obtain experimental measurements on a 3-m demonstration model of the mast are described, and the results are presented in tables, graphs, and drawings. The FEM technique is found to give accurate predictions of the forces, deformations, and dynamic processes encountered in the deployment sequence. T.K.

A86-44402
SPACE STATION - THE NEW FRONTIER
E. VALLERANI (Aeritalia S.p.A., Turin, Italy) Space Policy (ISSN 0265-9646), vol. 2, May 1986, p. 95-98.

It is pointed out that the Space Station currently under design in the U.S. will constitute the breakthrough for a new frontier: the space environment. Developments regarding the Space Station since the U.S. decision concerning its establishment are examined, taking into account agreements between NASA and ESA to coordinate studies conducted on both sides of the Atlantic, the type of cooperation considered, a package proposed by ESA regarding Columbus, and a certain dilemma related to issues regarding 'cooperation versus autonomy'. Attention is given to the reasons which make a European participation in the development and operation of the Space Station necessary, the idea that Europe would provide an integrated pressurized module, studies performed by an Italian firm under ESA contracts, and the challenge represented by the concept of a U.S.-European cooperation in the case of the Space Station. G.R.

A86-44527
ESA AT THE CROSSROADS
R. LUEST (ESA, Paris, France) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. XIII-XXXVI.

The programs, new spacecraft and launch vehicles, long-term planning and budgetary distributions for the ESA are described. ESA is seeking significant enhancements in European space capabilities and in worldwide perceptions of those capabilities. New programs over the period 1985-2000 will include space-based stellar spectroscopy, X ray spectroscopy, probes sent to the asteroids or to retrieve cometary samples, and solar observations. Earth-directed programs will include land and ocean remote sensing, geodesy and earthquake prediction research. The science budget will increase 5 percent per year 1989 and then be re-evaluated. ESA will participate in the development of the Manned Space Station and will pursue the manufacture of co-orbiting platforms, a polar platform and other elements. Development will continue on the Ariane 5 and Hermes spaceplane vehicles. M.S.K.

A86-44530
STATUS OF ESA'S PLANNING FOR THE SPACE STATION
G. ALTMANN (ESA, Manned and Retrievable Systems Dept., Noordwijk, Netherlands) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 17-33.

The present status of preparation for the European Space Station Programme (COLUMBUS) is reviewed. A description of the COLUMBUS Programme concept placed in the context of ESA's long term space plane is presented and all facets of the COLUMBUS Preparatory Programme are outlined to provide an overview of ESA's planning for the Space Station Programme. Author

A86-44531
SPACE PLATFORM DESIGN OPTIONS - A COMPARISON, FOR COST-EFFECTIVENESS, OF EXPENDABLE, REUSABLE AND SERVICEABLE SPACECRAFT
J. A. VANDENKERCKHOVE (ESA, Paris, France) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 45-68. refs

Various operational scenarios are considered, along with their required hardware infrastructures, the associated costs, and applications for unmanned orbiting platforms in the era of the Manned Space Station (MSS). The use of unmanned platforms as part of the MSS complex will compete with expendable satellites, retrievable/reusable satellites an serviceable satellites. The selection of which capability to use for any particular purpose will be the cost-effectiveness. A polar-orbiting platform is expected to carry 5 instruments and function for a 10 yr lifetime, after which only 30 percent of the payload will have to be replaced, probably by personnel orbited by either STS or Hermes launch or by an orbiting service vehicle. Comparisons are made among the expected serviceable lifetimes relative to the costs for launch and/or retrieval by the Ariane 5, Hermes, in-orbit assembly and STS. M.S.K.

A86-44534
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS
K. THORMER (Dornier System GmbH, Friedrichshafen, West Germany) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 91-100. refs

The design of the life support and environmental control systems (ECLSS) for the ESA Columbus module of the Manned Space Station (MSS) is proceeding mainly on the basis of experience with Spacelab. One deviation will be recycle waste water and breathing air wherever possible to avoid transportation costs, closing the on-board loop where possible. CO2 will, however, initially have to be removed from the air, probably with LiOH cartridges that will be returned to earth when the cartridges reach capacity. A solid amine CO2 regenerator is being studied to eliminate the cartridges. Subsequent evolutions will move toward closing the loop with electrolytic oxygen generation, probably with water vapor electrolysis. Reliable removal of air constaminants will require basic research in the technology. A block diagram is provided of the proposed ECLSS design. M.S.K.

A86-44550
ROBOTICS IN SPACE
P. NORRIS (Logica Space and Defence Systems, Ltd., Cobham, England) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 297-305.

The scope for the use of robotics in space in the coming two decades is reviewed. Lessons from the application of robotics on ground are used to suggest the most promising space-borne applications. The technical issues associated with robotics in space are examined. Author

A86-45627
THE EUROPEAN SPACE STATION PROGRAMME
M. BIGNIER (ESA, Paris, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 3-6.

After reaching agreements at the ministerial level, ESA in 1985 began negotiations with NASA to define the European role in the MSS Phase B design effort. Prime European goals were equal access and sharing of all facilities, equitable cost-sharing, satisfactory security measures, and compatibility with future ESA space transportation systems. Configurations considered by ESA include the Columbus pressurized module, Space-Station co-orbiting and polar orbiting platforms, and a pressurized resources module. The tasks which ESA negotiators and technicians face in order to meet the MSS project schedule, to finalize the hardware plans and to ensure compatibility with other MSS systems are delineated. M.S.K.

A86-45628
THE COLUMBUS PROGRAMME CONCEPT AND ITS INITIAL IMPLEMENTATION STEPS
G. ALTMANN (ESA, Manned and Retrievable Systems Dept., Noordwijk, Netherlands) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 7-12.

The present status of the preparations for the European Space Station Programme (Columbus) is reviewed. Starting off with a description of the Columbus Programme concept and baselines, the paper then presents the major features of the Columbus preparatory programme which will be carried out in two steps, Phase B1 between June 1985 until March 1986 and Phase B2 between April 1986 and spring 1987, in cooperation with NASA. Author

A86-45629
TECHNOLOGY CHALLENGES FOR THE COLUMBUS PROGRAMME
M. TRELLA (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 17-20.

ESA participation in the NASA Manned Space Station (MSS) project is accelerating the development of indigenous European Technologies and facilities which were only partially required for the Spacelab effort. The MSS project requires hardware for extensive demonstration flights before implementation and detailed plans for future expansion. The technology programs comprise manned, platform and resources, and in-orbit operations elements. The manned element includes technologies for data management and information systems, structures and materials, environmental control and life support, electrical power management, and human factors. The platform and resources technologies cover thermal control, power generation, distribution and storage, attitude and orbit control, and data acquistion and communication. In-orbit operations comprise servicing, maneuvering and propulsion, and rendezvous and docking. Details of each of the program elements, along with their ESA funding breakdown, are provided. M.S.K.

A86-45631
MANNED PRESSURIZED ELEMENTS FOR SPACE STATION APPLICATIONS
E. VALLERANI (Aeritalia S.p.A., Turin, Italy) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 25-34.

Initial design requirements and concepts for the ESA Columbus segment of the Manned Space Station (MSS) are described. Columbus technology is an evolution of concepts developed for Spacelab, particularly the Orbiter interface, the pressurized module (PM) and the life support and instrumental capabilities. The MSS modules will each be 4 m in diam, 7-9 m long, weight about 3 tons, and encompass 100 cu m volume, providing a shirtsleeve environment to the crew. ESA is additionally proposing the manufacture of a co-orbiting free-flyer for experiments which must not be disturbed by movements within the MSS, although it could be controlled from the MSS. Proposed design concepts for the structural, thermal control, environmental control and life support, data management, airlock and man-machine interface subsystems of the pressurized module are summarized, along with design requirements to enable Columbus to be used indefinitely with proper maintenance. M.S.K.

A86-45632
SERVICE VEHICLE
P. EYMAR (Aerospatiale, Les Mureaux, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 35-45. refs

The ESA Columbus segment of the Manned Space Station (MSS) will require a service vehicle (SV) for transferring Columbus elements, payload and crew and automatic and/or manned support of the Columbus elements. The concept of an SV was first developed by NASA as an adjunct to Skylab activities, and is evolving as an Orbital Maneuvering System. The ESA SV will be based at Columbus and is to have manned and unmanned elements, the latter being the initial configuration to which a pressurized module could be added. Propulsion and power systems, avionics, docking interface, and thermal control systems are to be permanent parts of the initial SV. The manned SV, i.e., the Hermes, may become part of a Manned Space Station which is autonomous from the MSS, both to be launched on the Ariane 5 vehicle. M.S.K.

A86-45633
PLATFORMS
D. W. S. LODGE (Department of Trade and Industry, London, England) and P. J. CONCHIE (British Aerospace PLC, Weybridge, England) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 47-50. refs

The integration of man-tended platforms (MTP) into operations of the Columbus segment of the Manned Space Station (MSS) is described, along with projected applications and design features. MTPs will either co-orbit with the MSS or move to polar or other orbits, the latter two requiring dedicated launches for refurbishment. Since the MTP designs may remain fixed for up to 15 yr, it is necessary to design them for flexibility regarding payload operations, e.g., data transmission rates and orbital altitudes. A decision has been made to develop a family of MTPs in an attempt to accommodate unforeseen payload requirements. Concommitantly, efforts are being expended to project the platform costs before committing to development of any particular design option. M.S.K.

A86-45634
UTILIZATION PLANNING
H. SAX DFVLR, Cologne, West Germany) and J. COLLET (ESA, Paris, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 53-56.

The Columbus segment of the Manned Space Station (MSS) will be permanently manned, and therefore must be user-friendly and continuously powered and pressurized. Experimenters will require direct access to experiments and data. Additionally, the long lifetime intended for the MSS demands that flexibility be built into the system to allow for future experimental requirements. A 5 yr projection of utilization was devised to guide the development of Columbus capabilities and interfaces, the latter being accessed by both ESA experimenters and other participants in the MSS project. Projected timelines for the selection of initial experiments and design configurations for Columbus are provided. M.S.K.

A86-45635
ASPECTS OF IMPLEMENTATION OF THE COLUMBUS UTILIZATION TASK
N. KIEHNE and F. UNZ (DFVLR, Cologne, West Germany) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 57-59.

The preparation of European Utilization of an international Space Station is a complex task. In this early phase of the program basic aspects need investigation and definition. Some of these aspects are addressed in this paper and approaches are offered for discussion how to cope with them. The aspects covered comprise: - What does 'Utilization' mean? 'Utilization' versus 'Operations'; From Spacelab to Columbus; The role of payload astronauts; Utilization tasks in the Columbus preparatory program; User support centers; 'Commercialization'; The role of national space organizations. Author

A86-45636
ECONOMIC ASPECTS OF SPACE INDUSTRIALIZATION
G. VIRIGLIO (Aeritalia S.p.A., Gruppo Sistemi Spaziali, Turin, Italy) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 61-63.

The prospects for commercialization of space in the near-term are discussed. It is estimated that $65 billion in space ventures could be realized by the year 2000 AD, which would include $27 billion for pharmaceuticals, $15 billion for advanced space communications, and $11.5 billion for space-processed glasses. Initiatives are underway to develop semiconductor processor facilities for space to obtain, e.g., high-purity GaAs chips at a cost 25 percent lower than possible on earth. Private companies are engaging in joint projects with NASA to develop commercial space manufacturing techniques and to educate non-aerospace industries in the potential benefits of space manufacturing. Several measures can further the process, e.g., tax credits for space investments, the treatment of profits as long-term capital gains, and continual follow-ups on companies which profess interest in space manufacturing. M.S.K.

A86-45638
EUA - STATUS AND PROSPECTS
W. LEY (DFVLR, Cologne, West Germany) and K. K. REINHARTZ (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 69-77.

The results of efforts to define the technical characteristics of 17 model missions (MMs) as part of the European Utilization Aspects (EUA) study to identify potential Manned Space Station (MSS) users and their requirements are reported. The EAU study was concerned mainly with the first 3 yr of operation of the Columbus module as an input to system design, operational definition and the definition of required support systems, including a MSS user database. The 17 MMs also serve to identify requirements for payload ground processing, initialization, payload flight operations, in-orbit servicing and payload exchange, and sustaining engineering and logistics. Extensive attention is also being given to data management in terms of the user interface, data routing, house-keeping monitoring interfaces, and interrelationships between two or more payloads. Details of the 17 MMs and their impacts on the results to-date of the EUA study are delineated. M.S.K.

A86-45639
VIEW AND NEEDS OF THE MICROGRAVITY MATERIALS SCIENCE COMMUNITY
E. KALDIS (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 79, 80.

The considerations and solutions which are being examined to define suitable materials processing facilities for the Manned Space Station (MSS) are described. One major problem is the potential progress in ground-based production facilities before the MSS is operational. This concern is being offset by considering multiuser facilities which can be used for groups of materials. The Eureca platform will be the first such platform to be flown. Space-based experiments in crystal growth and metallurgy are expected to yield the greatest near-term results, and may be accompanied by discoveries in fluid physics and biotechnologies such as electrophoresis. It is emphasized that the development of many of the technologies which will lead to manufacturing operations in space will require continued basic experimentation by scientists before the machinery can be expected to perform reliably. M.S.K.

A86-45640
MICROGRAVITY FLUID SCIENCES
L. G. NAPOLITANO (Napoli, Universita, Naples, Italy) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 83-89.

The experimental apparatus which will be needed on the ESA Columbus segment of the Manned Space Station to take advantage of the unique experimental conditions afforded to microgravity fluid sciences (MFS) by long-term occupation of space are delineated. Microgravity reduces the Archimedean forces, increases the significance of other forces (Marangoni convection, Coriolis forces, etc.), and alters the relative importance of phenomena such as diffusion, unsteadiness of flows, and the production of momentum. Facilities will be necessary for thermodynamics, fluid physics, fluid chemistry and through-flow separation studies. Experimenters will need to control the atmospheric conditions of the samples, perform diagnostics and examinations of the fluids, control, separate and/or filter the waste products of experiments, and monitor or control g-forces. Specific apparatus which can be used to investigate the various phenomena are discussed. M.S.K.

A86-45643
HORIZON 2000 AND ITS RELATION TO THE COLUMBUS PROGRAMME
V. MANNO (ESA, Directorate of the Scientific Programme, Paris, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 101-104.

The ministers representing the different nation members of ESA agreed to an initial 5 percent/yr increase in the ESA science budget for the period 1985-90 as a show of support for the Horizon 200 plan. Projects started during the plan period have the flexibility for optimum utilization of all available launch facilities, including interfacing with the Columbus segment of the Manned Space Station (MSS). This interface would permit maintenance of a planned space-based submillimeter radiotelescope and the retrieval and storage of cometary samples gathered by a unmanned spacecraft. Other experiments, considered minor, could be carried on the Eureca free-flying platform, which will be launched, serviced and retrieved from the MSS base. M.S.K.

A86-45645
COLUMBUS ACTIVITIES IN THE FRAMEWORK OF THE ITALIAN SPACE PROGRAM
L. GUERRIERO (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 111, 112.

Methods are recommended for ensuring effective, cooperative, and continued funding for the user end of the Manned Space Station. It is asserted that no unnecessary duplication of experimental capabilities should be allowed among the modules being constructed by the various MSS participants; every participant must therefore be permitted access to all apparatus throughout the MSS. Joint experimentation is also viewed favorably, such as being done in the Tethered Satellite project being planned by Italy and NASA. The experiment will probe atmospheric electrodynamics and examine the possibility of tapping the space plasma as a power source for the MSS. The facilities of the MSS

may increase the quantity of possible experiments by one or two orders of magnitude, which requires the use of automated data recording and analyses capabilities, and well as mandating the development of new experimental, space transportation and manufacturing techniques which can lower the costs of space operations by an appropriate amount. M.S.K.

A86-45646
THE GERMAN PROGRAMME ON MATERIALS SCIENCE IN SPACE
W. STEINBORN (DFVLR, Cologne, West Germany) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 113-116.

Current West German experimental programs on materials processing in space are reviewed in relation to follow-on experiments in the Columbus segment of the Manned Space Station (MSS). Over 80 percent of the 78 projects active in 1985 were funded by institutions, and were in part dedicated to improving the quality and quantity of the materials processed. West Germany performed electrophoresis experiments on the Apollo-Soyuz mission, experiments with immiscible alloys on the SPAR rocket, and several experiments on the STS OSTA and Spacelab missions. All the previous experiments suffered from the short on-orbit stay and from a lack of continuous power supplies should the stays have been longer. The MSS will ameliorate these problems and access to experimental apparatus will be increased by the multi-user facility nature of the MSS. M.S.K.

A86-45647
FRENCH VIEWS ON COLUMBUS - PREPARATION OF ITS UTILIZATION RELATIONS WITH OTHER PROGRAMS
A. PERARD (CNES, Direction des Programmes, Paris, France) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 117-119.

A86-45648
U.K. UTILIZATION OF COLUMBUS
G. E. KEYTE and E. B. DAVIES (Royal Aircraft Establishment, Space Dept., Farnborough, England) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 121-126.

The development of the Columbus project will provide a major technological challenge and offer unrivalled opportunities for the exploitation of space. It offers considerable potential for a wide range of aplications and for science, with one element, the free-flying platforms being seen by the U.K. as offering especial benefits in earth resource applications and microgravity processes. This paper examines the concepts for utilization of Columbus and reviews some of the critical technology areas associated with its development. Author

A86-45649
NETHERLANDS INTEREST IN SPACE STATION UTILISATION
D. DE HOOP (Nederlands Instituut voor Vliegtuigontwikkeling en Ruimtevaart, Delft, Netherlands) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 127-130.

The Netherlands has a 4-5 percent share in the Phase B studies of the Columbus program. Work on design proposals for potential experiments and instrumentation was initiated in various national institutions in 1985, with the Netherlands Agency for Aerospace Programs guiding efforts targeted at space industrialization. The experiments other Netherlands organizations provided for the TEXUS and Spacelab-1 flights are noted. Presently, the main contribution to Columbus will be a Critical Point Facility for fluid physics experiments. Possible experiments in biology, communications, earth observation and meteorology are also being considered, as are studies of human physiological responses to weightlessness, protein crystallization and robotics. Finally, attention is given to ESA management of the Columbus design efforts and to assuring observer status from minor participants in the program. M.S.K.

A86-45650
SPANISH PLANS FOR COLUMBUS UTILIZATION
L. PUEYO and I. DA RIVA (Comision Nacional de Investigacion del Espacio, Madrid, Spain) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 131-135.

Spanish efforts in the Columbus program are presently confined to identifying users of the module, mainly for microgravity fluid physics and biology studies. The Spanish contribution in funding will amount to a 7 percent share of the project. A floating zone apparatus was flown on a Spacelab mission and the same researchers have participated in TEXUS and KC-135 flights. Additionally, a genetics experiment was carried on the Spacelab D-1 mission to study the effects of microgravity on the topological distribution of cytoplasmatic determinants in the embryo of Drosophila melanogaster. The Drosophila experiment will be continued on a Eureca flight. The current database on microgravity one- and two-phase flows is briefly summarized as the key problem area for microgravity materials processing. M.S.K.

A86-45651
LIFE SCIENCES ON COLUMBUS - GERMAN ASPECTS
J. NEUBERT and K. E. KLEIN (DFVLR, Institut fuer Flugmedizin, Cologne, West Germany) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 137-139. refs

The purpose of this paper is to summarize the utilization aspects of the planned Columbus/Space Station capabilities for the life sciences. Key problem areas of research are identified. The analysis of research items focussed in the need of the pressurized module with earth similar atmospheric conditions for study performances. It became clear that the life sciences will benefit from the permanent presence of man in space. Author

A86-46253
DETERMINATION OF MICROACCELERATIONS AT THE SALYUT-6 AND SALYUT-7 ORBITAL COMPLEXES [OPREDELENIE MIKROUSKORENII NA ORBITAL'NYKH KOMPLEKSAKH 'SALIUT-6' I 'SALIUT-7']
V. A. SARYCHEV, M. IU. BELIAEV, V. V. SAZONOV, and T. N. TIAN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 24, May-June 1986, p. 337-344. In Russian. refs

A method is presented for calculating microaccelerations generated at the Salyut-6 and Salyut-7 orbital stations during gravity-gradient stabilization. In accordance with the method, the readings of the attitude control sensors are first processed statistically to determine the motion of the station about its center of mass; for the motion thus determined, microaccelerations are then calculated for any given point of the station. The method proposed here has been implemented in a set of computer software. As an example, microaccelerations are calculated for the real motion of the Salyut-7 station. V.L.

A86-46383
QUASI-ANALYTICAL SOLUTIONS FOR THE DYNAMICS OF A CLASS OF TETHERED SATELLITES WITH DANBY'S AERODYNAMICAL DRAG
I. BONZANI and M. G. ZAVATTARO CHIADO PIAT (Torino, Politecnico, Turin, Italy) Celestial Mechanics (ISSN 0008-8714), vol. 37, Dec. 1985, p. 371-385. Research supported by the Ministero della Pubblica Istruzione. refs

An analytic solution, in terms of expansion of a small parameter, for the classical two-body tethered satellite with a specific drag model (Danby, 1962) is obtained. The time of flight as well as the solution regarding the state variable of the system are expressed in terms of quadratures of the anomaly. Author

A86-47942#
FREQUENCIES OF LONGITUDINAL OSCILLATIONS OF TETHERED SATELLITE SYSTEMS
A. K. MISRA (McGill University, Montreal, Canada) and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 386-393. refs
(Contract NSERC-A-0967; NSERC-A-2181)
(AIAA PAPER 86-2274)

Longitudinal vibrations of tethered satellite systems are investigated taking into account the role played by the undeployed part of the tether wrapped around the reel. Three cases are considered: the 'no slip' case, when the friction is sufficient to prevent any motion of the wrapped tether; the 'total slip' case, when there is no friction at all and the entire wrapped portion of the tether is free to move; and the 'partial slip' case, when a part of the undeployed tether has extensional oscillations. An analytical solution is presented for the first case, while Rayleigh-Ritz solutions are obtained for the latter two cases. The variation of the frequencies with the system parameters are studied. It is noted that even for moderate friction the frequencies of oscillation in the 'partial slip' case are quite close to those in the 'no slip' case, for which an analytical solution is available. Author

A86-48573
SPACE AND LAW
V. VERESHCHETIN, ED. and IU. KOLOSOV, ED. (Kosmos i pravo, Moscow, Institut Gosudarstva i Prava AN SSR, 1980. 140 p.) Moscow, USSR Academy of Sciences (Law: Studies by Soviet Scholars, no. 3), 1985, 192 p. Translation. Previously cited in issue 14, p. 2442, Accession no. A81-33906.

A86-49563#
SPACE STATION - THE CANADIAN CONTRIBUTION
K. H. DOETSCH (National Research Council of Canada, Space Div., Ottawa) and T. H. USSHER (Spar Aerospace Ltd., Remote Manipulator Systems Div., Toronto, Canada) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986, Paper. 17 p.

The Canadian-supplied Mobile Servicing System (MSS), a contribution to the U.S. Space Station program, is described. The flight and ground hardware elements of this system are discussed, and the expected benefits from this international cooperative endeavor are briefly examined. The Mobile Servicing Centre (MSC) functions are listed along with the role of Canada as either user or supplier of various Space Station infrastructure functions. Canadian responsibilities in the servicing and hardware on the Space Station are given, and the MSS hierarchy is shown along with MSC system elements. C.D.

A86-49564#
EUROPEAN SPACEPLANE HERMES MISSIONS TOWARDS SPACE STATIONS
P. EYMAR (Aerospatiale, Division Systemes Balistiques et Spatiaux, Paris, France) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986, Paper. 12 p.

The design and objectives of the space plane, Hermes, are described. Hermes, a 16 m long aircraft with a 10 m wingspan, is useful for scientific and commercial projects, supplying and servicing automatic platforms, satellites, and space stations, and crew and payload transport. A comparison of the capabilities of Hermes and NASA's Space Shuttle is presented. The aerodynamic control, thermal protection, and power systems for Hermes are examined. The designing of Hermes to perform specific servicing and transport functions is discussed. I.F.

A86-49565#
THE ROLE OF COLUMBUS IN A FUTURE SPACE STATION SCENARIO
W. WIENSS (ERNO Raumfahrttechnik, GmbH, Bremen, West Germany) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986, Paper. 22 p.

The possible functions and necessary space infrastructure of the European Space Station and the Columbus Program are discussed with emphasis on the Man-Tended Freeflyer (MTFF). The envisioned MTFF configuration consists of a two-segment pressurized laboratory module couple to a resource module, and Ariane 5 has been baselined as the reference launch vehicle. Maintenance, servicing, and logistics supply for the MTFF will occur via Hermes and a special logistics module. An MTFF growth scheme leading towards a permanently manned freeflyer is discussed, and the scenario for the time period of 2000 and beyond also includes the availability of an orbital infrastructure to support the transportation systems, on-orbit assembly, and servicing activities, as well as the production of materials in space. R.R.

A86-50335#
COLUMBUS - SYSTEM OVERVIEW
H. E. W. HOFFMANN and A. KUTZER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 27-44.

The Europeans have experienced a decade of progress in spacefaring capabilities, primarily through the development of the Ariane and the cooperative development of Spacelab. The off-the-shelf hardware that has resulted must now be applied wherever possible to the manned Space Station (MSS) effort. New systems and subsystems must be developed which were not required for Spacelab. The MSS effort will feature the Columbus module and the polar orbiting element. The two hardware configurations will furnish opportunities for manned intervention and automated activities. A resource module will also be developed which, if attached to the Columbus, will provide autonomy. A fourth item, a service module (SV) will contain a propulsion system and the means to move and manipulate payloads, change orbits and service the MSS. True European independence in space will then depend on the introduction of the Ariane V rocket and the Hermes as the astronaut transporter. The schedule for achieving these goals is the initial operating capability, in conjunction with the U.S. MSS, in 1993, and autonomy in 1998. Details of the schedule milestones are outlined. M.S.K.

A86-50337#
CONCEPTS ON COLUMBUS FLIGHT OPERATIONS
M. GASS (DFVLR, Oberpfaffenhofen, West Germany) and H. KUMMER (ESA, European Space Operations Centre, Darmstadt, West Germany) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 129-144.

European participation in the U.S. manned Space Station (MSS) effort is part of a long range plan for an autonomous European space station. The Columbus is the first hardware element, and is to fly either connected-to or co-orbiting the MSS. Flight operations for the Columbus will have three phases: launch/assembly, verification, and mature operations. Wherever possible, Columbus flight operations are to be controlled from Europe, although as many real-time actions as possible are to be performed by the on-board crew, assisted by expert systems and a user-friendly environment. The assignment of on-board tasks will be heavily influenced by the country and company of origin of payloads. Docking operations will be handled by the flight crew. If the Eureca is involved, then the European crew will maneuver the free-flyer into position for pick-up by the Orbiter crew. Initially, the Europeans will access the TDRSS satellite system for communications until an ESA DRS system is in place. M.S.K.

A86-50338#
COLUMBUS TECHNOLOGY - STATUS AND PLANS
H. STOEWER (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 169-206.

Current and needed technological developments are described for satisfying the requirements of the indefinite service life on-orbit design specifications of the Columbus segment of the Space Station. Phase B studies identified the flight suitability or at least the feasibility of various candidate technologies, which are to be further evaluated to arrive at a baseline design in Phase C/D studies. The criteria for the Phase C/D designs are low risk, compatibility with NASA/ESA interface standards, and fostering European development of subsystems, wherever possible. R&D efforts supporting the design studies are divided into three areas: manned elements, unmanned platforms and resources technologies, and in-orbit operations. Design options being explored for the data management and information systems, structures and materials, environmental control and life support, electrical power management, and crew systems and human factors technologies are summarized. M.S.K.

A86-50340#
A EUROPEAN VIEWPOINT - OVERVIEW OF PLANS ON COLUMBUS UTILISATION
K. K. REINHARTZ (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) and A. BALOGH (Imperial College of Science and Technology, London, England) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 237-251.

The missions thus far been defined for the Columbus segment of the Space Station are summarized. The configuration and purposes are being selected as a function of user requirements, based on the permanent presence of crew members and the experimental flexibility that allows the continuous availability of a low-gravity environment and the capability of resupplying the facility. Research on Columbus will be dominated by material and life sciences experiments, with attention given to experiments to develop a database for defining new experiments and future enhancements to Columbus capabilities. Many material science experiments will be carried out in conjunction with experiments being performed on free-flying platforms. Other experimental modes, which are briefly described, are earth remote sensing, tethered satellite applications, planetary missions support functions, robotics servicing experiments, and other planetary sciences and orbital astronomy support functions. M.S.K.

N86-22595# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials Section.
OUTGASSING AND CONTAMINATION MODEL BASED ON RESIDENCE TIME
M. VANEESBEEK and A. ZWAAL *In its* Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 25-34 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

The long duration contamination and pressure predictions for the HIPPARCOS telescope are described. Multitemperature outgassing tests were performed to accelerate the outgassing phenomena. From these tests the acceleration factors and the residence times of the outgassing species were determined. The contamination and pressure model is based upon the outgassing rates, the residence times, and geometric parameters. Author (ESA)

N86-22596# Centre National d'Etudes Spatiales, Toulouse (France).
EVALUATION OF ISOTHERMAL OUTGASSING KINETICS FOR SOME MATERIALS USED IN SPACE
J. GUILLIN *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 35-38 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Spacecraft material outgassing prediction using quartz crystal microbalances is described and data are presented. Data concern thermal control coatings, an adhesive film, an electrical wire, a carbon fiber reinforced plastic, and an adhesive. Kinetic parameters of outgassing required for modeling contamination assessment are discussed. It is assumed that the outgassing source involves several components and these are emitted according to order one of reaction. Author (ESA)

N86-22600# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials Section.
THE SUMMATION OF THE OFFGASSING CHARACTERISTICS OF A TOTAL SPACELAB PAYLOAD
P. JOLLET and M. D. JUDD *In its* Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 63-69 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

The requirement imposed on equipment to fly on board Spacelab that materials should have low offgassing characteristics (i.e., not release potentially toxic contaminants into the surrounding atmosphere) is discussed. Compliance with this requirement may be shown by tests either on materials or at black box level. In order to maintain visibility on the overall payload offgassing, a computational approach which enables specific offgassing data to be located at defined positions within a payload was developed. Full traceability through experiment facility/rack and payload is ensured together with data recall either by rack etc, or contaminant. Author (ESA)

N86-22605# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials Section.
THE DEGRADATION OF METAL SURFACES BY ATOMIC OXYGEN
A. DEROOY *In its* Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 99-108 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

The influence of atomic oxygen on erosion-corrosion of metal surfaces, especially silver, is examined. Protection schemes for silver are investigated. Bare silver samples and partly coated silver samples were exposed to low Earth orbit conditions during shuttle flights STS-8 and STS-17. The silver specimens decrease 3 to 4.5 microns in thickness depending on the relative position to the velocity vector. The examination of the coated silver samples shows that 500 nm palladium, 50 nm aluminum and silicone DC6-1104 are successful in protecting the underlying silver against atomic oxygen attack. Author (ESA)

N86-22607# United Kingdom Atomic Energy Authority, Harwell (England). Chemistry Div.
CONDUCTIVE COATINGS TO MINIMISE THE ELECTROSTATIC CHARGING OF KAPTON
D. VERDIN and M. J. DUCK *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 125-131 Nov. 1985 refs Sponsored by UK Ministry of Defence Procurement Executive
Avail: NTIS HC A13/MF A01

To reduce electrostatic charging of Kapton under electron irradiation, coatings with In2O3:polyimide ratios of up to 12:1 by weight and having a surface resistivity in the range 20,000 to 10 million ohm/sq and an alpha s/epsilon value of 0.63 were produced. These materials hold the surface below 250V during electron irradiation. The adhesion is 100% and does not deteriorate after

1100 cycles between +150 and -150 C; coatings prepared at 225 deg C exhibit negligible volatile material losses. The coatings are easily and economically prepared and may offer a practicable alternative to modified forms of Kapton when it is necessary to minimize its electrostatic charging. Author (ESA)

N86-22609# AEG-Telefunken, Frankfurt am Main (West Germany). Forschungsinst.
ON DIELECTRIC LONG TERM STABILITY OF KAPTON-FILMS STRESSED BY AC AND DC UNDER USUAL ATMOSPHERIC CONDITIONS AND IN VACUUM
W. GOELZ *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 143-148 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Voltage life curves of ac stressed polyimide films in accordance with Dakin's theory of voltage endurance were found. A first approximation of the characteristic parameters can be calculated directly from short time experiments with the threshold voltage obtained by a partial discharge detector. At ambient atmospheric pressure, as well as under vacuum, the inception of partial discharges is considered indicative for limited long term operation. Although the identification of the true threshold voltage of solar generators insulation layers may become difficult in high vacuum, and especially under dc stress, it is assumed to be well beyond the level of 1000 V. Author (ESA)

N86-22613# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
WINDING WITH THERMOPLASTIC POLYMERS
J. L. TISNE and J. BOUVARD *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 173-178 Nov. 1985 refs Sponsored by ESA
Avail: NTIS HC A13/MF A01

Thermoplastic materials properties are compared to high temperature epoxy resins. Advantages in composite material manufactured by winding of continuous fiber with thermoplastic matrix are outlined. Processing problems are pointed out. Work to be done for space applications is discussed. Author (ESA)

N86-22614# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DIMENSIONAL STABILITY OF CARBON-EPOXY COMPOSITE MATERIALS
V. BAUDINAUD and L. MASSONI *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 179-184 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

Temperature and moisture effects on the dimensional stability of carbon-epoxy composites are discussed, and test facilities to quantify the effects are described. To measure thermal expansion proper, it proved necessary to implement a laser interferometric method. Measurements can be made from minus 80 to plus 80 C. Two dilatometers placed in a programmable climatic chamber study temperature and moisture effects. Author (ESA)

N86-22615# Centre National d'Etudes Spatiales, Toulouse (France).
METAL MATRIX COMPOSITE MATERIALS FOR STRUCTURAL APPLICATIONS
P. ROY and A. MAMODE *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 185-190 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

A program to develop metal matrix composites for spacecraft structures is described. A prepeg showing adequate characteristics was made. Shaped pieces were manufactured in parallel, allowing the acquisition of the processes and characterization of the pieces. The manufacture of complex pieces such as tubes and gussets, made from C/Al and C/Mg, is envisaged. Using tubes and gussets, a structural assembly (truss) will be built and fully tested. When C/Mg elaboration is optimized, an industrial elaboration solution will be sought in order to achieve sufficient production of metal matrix composites in Europe, having quite good dimensional stability characteristics. Author (ESA)

N86-22616# Alcan International Ltd., London (England).
THE DEVELOPMENT OF ALUMINUM-LITHIUM ALLOYS FOR AEROSPACE APPLICATIONS
A. J. CORNISH, A. GRAY, W. S. MILLER, and M. A. REYNOLDS *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 195-201 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

The development of aluminum-lithium based alloys is described by considering the reasons for the rapid growth of interest in the alloy type, the property targets sought, the compositions on which the major effort is concentrated, the properties achieved, and manufacturing. The objective is to achieve a 10% reduction in density relative to standard high strength alloys, together with a 10% increase in stiffness, while matching the strength and other service properties associated with the standard alloys. Two aluminum-lithium based alloys are under development to match the service properties of alloys in the 2000 and 7000 series. One alloy is used in different tempers, either to match the properties of the medium strength alloy 2014 T6 or to give a low density replacement for the damage tolerant alloy 2024 T3. The second has a higher strength and matches the properties of 7075 T6. Author (ESA)

N86-22617# Societe Crouzet, Valence (France).
ADVANCED PRINTED WIRING BOARD (PWB) MATERIALS FOR SURFACE MOUNTED DEVICES IN AEROSPACE APPLICATIONS
G. MENOZZI *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 203-213 Nov. 1985 refs Sponsored by CNES
Avail: NTIS HC A13/MF A01

Multilayer thick film hybrid and printed wiring board technologies for leadless ceramic chip carriers (LCCC) were developed. Copper clad invar MLBs prove to be a viable solution for LCCC interconnects. The CIC core MLB offers advantages such as large size, both-side mounting, an inner thermal plane for thermal management, an easier rework process, and better vibration tolerance. One disadvantage is the weight. Thermal coefficient of expansion measurements and calculations offer a quick approach for material inspection and assembly evaluation. The thermal cycling test from minus 55 to plus 125 C widely used for evaluation programs consisting of several hundred cycles is not realistic for aerospace qualification tests. Author (ESA)

N86-22620# Selenia S.p.A., Rome (Italy).
MEASUREMENT OF THE THERMO-OPTICAL PROPERTIES OF VARYING PAINT THICKNESS ON CARBON FIBER COMPOSITES IN SPACECRAFT STRUCTURES
M. GIOMMI, M. MARCHETTI (Rome Univ., Italy), G. SALZA, and P. TESTA (Rome Univ., Italy) *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 233-238 Nov. 1985 refs Sponsored by Max-Planck Inst.
Avail: NTIS HC A13/MF A01

Diffuse spectral reflectivity for solar radiation at normal incidence, spectral normal emissivity, and integrated normal emittance for PV 100 painted samples having different paint thickness and different (carbon fiber or non) substrates were measured. Results mainly for thickness 70 microns show high spectral reflectivity or low spectral absorption coefficient while spectral emissivity has medium-high values. Limited effect (order of 10%) of the texture and thickness are pointed out. Author (ESA)

N86-22621# Centre National d'Etudes Spatiales, Toulouse (France).
NEW SPACE PAINTS
J. C. GUILLAUMON *In* ESA Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 239-243 Nov. 1985 refs
Avail: NTIS HC A13/MF A01

White conductive paint with low solar absorptance (improvement of PCB-Z) (0.16 to 0.18); black conductive paint with low outgassing (improvement of PU1); white silicone paint with low solar absorptance (0.13); epoxy primer with low outgassing; and white conductive paint for launchers and aircraft were developed. Improvements under study are outlined. Author (ESA)

N86-22624# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SCANNING LASER ACOUSTIC MICROSCOPY APPLIED TO THE EVALUATION OF MATERIAL INTERCONNECTIONS
B. D. DUNN and D. S. COLLINS *In its* Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 263-269 Nov. 1985
Avail: NTIS HC A13/MF A01

The Scanning Laser Acoustic Microscope (SLAM) for the nondestructive inspection of materials and interconnections is introduced. The operational modes of the SLAM are illustrated during the assessment of spacecraft solar cell-to-silver interconnector weldments and electronic component chip solder-attachment to a ceramic carrier. Author (ESA)

N86-22625# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
PARTICLE FALLOUT PHOTOMETER (PFO)
M. VANEESBEEK, R. BERKELJON, and H. KUIPER (URAMEC, Bilthoven, Netherlands) *In its* Proceedings of 3rd European Symposium on Spacecraft Materials in Space Environment p 271-274 Nov. 1985
Avail: NTIS HC A13/MF A01

The particle fallout photometer (PFO) for measuring particulate contamination on test surfaces is described. It is based on light scattering by settled particles when subjected to a stabilized light beam nearly parallel to a nonreflective sampling surface. Measuring range is from 0 to 1999 PPM. Particles of 5 microns can be determined. Author (ESA)

N86-22626# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
ULTRAVIOLET RADIOMETERS
G. GOURMELON, H. LYALL (IRD, Newcastle upon Tyne, England), and R. FROUD (IRD, Newcastle upon Tyne, England) *In its* Proceedings of 3rd European Symposium on Spacecraft Materials Space Environment p 275-276 Nov. 1985
Avail: NTIS HC A13/MF A01

A radiometer to measure ultraviolet radiation in a series of bands between 180nm and 450nm in a space simulation system was developed. A single channel ultraviolet detector based on the multiband ultraviolet radiometers, but featuring a more robust construction for general use, was also developed. The wavelength coverage is from 250 to 400nm with excellent rejection of visible radiation, and good temperature stability. Detectors with filters to measure a narrow band within the ultraviolet can be supplied. Author (ESA)

N86-22628# European Space Agency, Paris (France).
SPACE ENVIRONMENT SIMULATION TO TEST SATELLITE THERMAL CONTROL COATINGS. VOLUME 2, APPENDIX 1: DETAILED RESULTS OF OPTICAL MEASUREMENTS MADE AFTER THE VARIOUS STAGES OF THE FIRST TEST
Aug. 1985 139 p Transl. into ENGLISH of 'Essais de Simulation d'Environmentale Spatial sur Revetements de Controle Thermique de Satellites. Tome 2, Annexe 1: Resultats Detailles des Mesures Optiques Effectuees apres les Diverses Etapes du Premier Test" Rept. CERT-4128-Vol-2-App-1 Centre d'Etudes et de Recherche de Toulouse, France Original language document was announced as N85-17013 3 Vol.
(ESA-TT-891-VOL-2; CERT-4128-VOL-2-APP-1) Avail: NTIS HC A07/MF A01

Simultaneous irradiation of satellite thermal control coatings by electrons, protons, and ultraviolet radiation, simulating 5 yr in geostationary orbit, was carried out. A layer of contaminant, originating from adhesive RTV566 by molecular flux, was applied to samples under controlled conditions. Changes were followed by microbalances and by measurements of optical reflectance over the spectrum. Results for optical measurements before deposition and for 0.2, 0.5, and 1 yr after are presented. Author (ESA)

N86-22629# European Space Agency, Paris (France).
SPACE ENVIRONMENT SIMULATION TO TEST SATELLITE THERMAL CONTROL COATINGS. VOLUME 2: APPENDICES 2, 3, AND 4. APPENDIX 2: DETAILED RESULTS OF OPTICAL MEASUREMENTS MADE AFTER THE VARIOUS STAGES OF THE SECOND TEST. APPENDIX 3: SUMMARY OF OPTICAL RESULTS OBTAINED DURING THE FIRST TEST. APPENDIX 4: SUMMARY OF OPTICAL RESULTS OBTAINED DURING THE SECOND TEST
Aug. 1985 259 p refs Transl. into ENGLISH of 'Essais de Simulation d'Environentale Spatial sur Revetements de Controle Thermique de Satellites. Tome 2: Annexe 2: Resultats Detailles des Mesures Optiques Effectuees apres les Diverses Etapes du Deuxieme Test. Annexe 3: Recapitulatif des Essais Optiques au Cours du Premier Test. Annexe 4: Recapitulatif des Mesures Optiques Effectuees au Cours du Deuxieme Test" Rept. CERT-4128-Vol-2-App-2-App-3-App-4 Centre d'Etudes et de Recherche de Toulouse, France Original language document was announced as N85-17014 3 Vol.
(ESA-TT-891-VOL-3; CERT-4128-VOL-2-APP-2,3,4) Avail: NTIS HC A12/MF A01

Simultaneous irradiation of satellite thermal control coatings by electrons, protons, and ultraviolet radiation, simulating 5 yr in geostationary orbit, was carried out. A layer of contaminant, originating from adhesive RTV566 by molecular flux, was applied to samples under controlled conditions. Changes were followed by microbalances and by measurements of optical reflectance over the spectrum. Results at minus 35 and plus 2 C for up to 5.08 yr after deposition are presented. Author (ESA)

N86-22631# MATRA Espace, Paris-Velizy (France). Espace Produits et Technologie.
KEY DESIGN PARAMETERS FOR A VERY LOW GRAVITY IN-ORBIT FACILITY Final Report
J. C. AMIEUX, C. FOURNIER, R. STRITTMATTER (Dornier-Werke GmbH, Friedrichshafen, West Germany), M. BAIER (Dornier-Werke GmbH, Friedrichshafen, West Germany), D. SCHMITT (ONERA, Paris, France), and J. MERLET (Intespace) Paris ESA Apr. 1985 372 p refs
(Contract ESTEC-5292/82-NL-PP(SC))
(MATRA-EPT/DT/VT068/098; ESA-CR(P)-2144) Avail: NTIS HC A16/MF A01

Vibration generation and propagation in orbital platforms, including Spacelab and EURECA, were analyzed. Attitude and orbit control subsystem vibration generators; vibrations induced by thermal control subsystems; measurement techniques and experimental aspects for a microgravity environment; vibration induced by microgravity-oriented payloads; and vibration reduction techniques were studied. Dynamic synthesis of a microgravity platform is discussed. Author (ESA)

N86-23256# Joint Publications Research Service, Arlington, Va.
VACCINE PROTEINS R AND D ON SALYUT-7 Abstract Only
T. CHESANOVA *In its* USSR Report: Life Sciences. Biomedical and Behavioral Sciences (JPRS-UBB-86-002) p 107 8 Jan. 1986 Transl. into ENGLISH from Leningradskaya Pravda (Leningrad, USSR), 13 Oct. 1985 p 2
Avail: NTIS HC A06

Experiments performed on Salyut orbiting stations were aimed, at obtaining extrapure hemagglutinin and other surface proteins of the influenza virus, using the electrophoresis method. The space experiments demonstrated that such products can be obtained in conditions of zero gravity. A new-generation electrophoretic unit the EFU-Robot is used on the Salyut-7 station. The EFU-Robot can be programmed to select samples of substances purified in the course of experiments and automatically transfer the samples from the unit's working chamber to ampules, by syringes. E.A.K.

N86-23618*# National Aeronautics and Space Administration, Washington, D.C.
THE SPACE TRANSPORTATION SYSTEM AND ITS IMPACT ON LATIN AMERICAN DEVELOPMENT
F. R. C. DIAZ Nov. 1985 56 p refs Transl. into ENGLISH of El Sistema de Transporte Espacial y su Impacto en el Desarrollo de Latinoamerica (Houston, Tex.), Jun. 1984 p 1-20 Transl. by Kanner (Leo) Associates, Redwood City, Calif. Original doc. was prepared by NASA. Johnson Space Center
(Contract NASW-4005)
(NASA-TM-77684; NAS 1.15:77684) Avail: NTIS HC A04/MF A01 CSCL 22A

The three components of the Space Transportation System: the space shuttle, the permanent orbital space station and the transorbital vehicle are described. The stages of completion of the various plans are discussed and the impact of the project's implementation is discussed with particular reference to Latin America and with special emphasis on the telecommunications sector. Author

N86-23622*# National Aeronautics and Space Administration, Washington, D.C.
JAPAN'S PARTICIPATION IN SPACE STATION DESIGN: FEASIBILITY STUDY OF GAAS SOLAR CELLS FOR SPACE STATION APPLICATIONS
Mar. 1986 57 p Transl. into ENGLISH of "Bei Koku Uchu Kichi Keikaku Yobi Setsu Keisan ka GaAs Dei Tairo Denchi Seru No u Chu Kichi e No Tsuyosei No Kento" rept. ST-E-0739 National Space Development Agency of Japan, Japan, 18 Dec. 1985 p 1-44 Transl. by The Corporate Word, Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-88384; NAS 1.15:88384; ST-E-0739) Avail: NTIS HC A04/MF A01 CSCL 22B

The report gives the results of feasibility studies and a cost analysis done on GaAs solar battery cells for space stations. The studies and their results are as follows: (1) Cell size - The 2 x 4 cm cell size was found superior to the 4 x 4 cm cell; (2) Manufacturing technology - Overall, LPE crystal growth was found more suitable than MO-CVD. Current technology for post-growth processes and applying large-area cover glass can be used with few or no modifications; (3) Cell assemblies - Tests for mechanical and thermal stresses encountered from assembly through operation are recommended; (4) Procuring materials - Steps should be taken to avoid sharp price increases due to a speculative gallium market. There are no problems with arsenic materials; (5) Production facilities - The capital investment needed remains to be determined, but a working area of 4000 m2 will be required; (6) Cell costs to be determined; (7) Cell development-supply plan - Two-year lead time will be needed to develop the necessary technology and prepare for production. Author

N86-24025# AEG-Telefunken, Wedel (West Germany).
ALTERNATIVE MODULE CONFIGURATIONS FOR ADVANCED SOLAR ARRAYS ON LOW ORBIT AND EXTENDED LIFETIME MISSIONS (AMOC 1) Final Report
D. GRINGEL, J. KOCH, and W. SCHMITZ Paris ESA Jan. 1985 166 p
(Contract ESTEC-5508/83-NL-PB(SC))
(ESA-CR(P)-2129) Avail: NTIS HC A08/MF A01

The applicability and power improvement of the p-grid solar cell for low Earth orbit missions were assessed. The power improvement predicted analytically is confirmed by electrical performance measurements. Two measurement methods were used: separate illimination of front and rearside; and simultaneous illumination of front and rearside. Bifacial cells were bonded onto window type and continuous type substrates for electrical performance determination. Test samples composed of different substrate materials covered with solar cells or glass dummies were tested with respect to the expected thermal environment and mechanical behavior. Three favorable substrate designs were selected for a thermal cycling test: glass or carbon fiber reinforced Kapton modules, and treated glass cloth module. Electric performance increase is 10% to 15% after 15,000 cycles at plus or minus 100 C, compared to standard BSFR cells. Author (ESA)

N86-25398*# National Aeronautics and Space Administration, Washington, D.C.
AN OVERVIEW OF EUROPEAN SPACE TRANSPORTATION SYSTEMS
R. E. LO Nov. 1985 31 p refs Transl. into ENGLISH of conf. paper "Europaeische Raumfahrt-Transportsysteme" presented at the DGLR Annual Conference, 1985 p 1-24 Conference held in Bad Godesberg, West Germany, 30 Sep. - 2 Oct. 1985 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77683; NAS 1.15:77683; DGLR-85-100) Avail: NTIS HC A03/MF A01 CSCL 22A

With the completion of the launch rocket series Ariane 1 to 4, Europe will have reached the same capacity to transport commercial payloads as the USA has with the Space Shuttle and the kick stages which are presently operative. The near term development of these capacities would require Europe to develop a larger launch rocket, Araine 5. Further motivations for this rocket are access to manned spaceflight, the development of an European space station, and the demand for shuttle technology. Shuttle technology is the subject of research being done in France on the winged re-entry vehicle Hermes. Operation of the European space station Columbus will require development of an interorbital transport system to facilitate traffic between the various segments of the space station. All European space transportation systems will have to match their quality to that of the other countries involve in space flight. All areas of development are marked not only by possible cooperation but also by increased competition because of increasing commercialization of space flight. Author

N86-26367# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
MATHEMATICAL MODELS OF FLEXIBLE SPACECRAFT DYNAMICS: A SURVEY OF ORDER REDUCTION APPROACHES Annual Report, 1984
P. T. L. M. VANWOERKOM 21 Jan. 1985 13 p Presented at 10th IFAC Symp. on Automatic Control in Space, Toulouse, France, 25-29 Jun. 1985
(Contract NIVR-1910)
(NLR-MP-85004-U; B8578426; ETN-86-96974; AD-B098585L)
Avail: NTIS HC A02/MF A01

The usefulness of open loop model order reduction techniques for application of flexible spacecraft dynamics models was assessed. Approaches identified involve parameter optimization; aggregation; singular perturbation; modal dominance; component cost analysis; and internal balancing. The latter three approaches appear to be most meaningful, and convenient in applications. The problem of model order reduction is reviewed, and each of

the six approaches is discussed. The latter three approaches are applied to the case of a long, flexible beam in space, controlled with two line torquers. ESA

N86-26711# AEG-Telefunken, Wedel (West Germany).
GROWTH CAPABILITIES OF EUROPEAN RETRACTABLE SOLAR ARRAYS Final Report
G. BEHRENS Paris, France ESA Jun. 1985 89 p
(Contract ESTEC-5554/83-NL-PB(SC))
(ESA-CR(P)-2141; ETN-86-96870) Avail: NTIS HC A05/MF A01

The growth capabilities of the Advanced Rigid Array, Rigid Solar Generator, L-Sat solar array, SOLA solar array, Space Telescope solar array, and the Ultralight Panel array were assessed. Capabilities of up to 18kW are needed for the NASA manned space station. The assessment shows that each of the arrays can reach the required power range, but without taking economic factors into account, and given that only the existing application was considered, it is not possible to recommend any particular concept. ESA

N86-27356# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
FEATURES OF THE SOLAR ARRAY DRIVE MECHANISM FOR THE SPACE TELESCOPE
R. G. HOSTEMKAMP *In* ESA Second European and Space Mechanisms and Tribology Symposium p 13-17 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Spacecraft mechanisms; motors and actuators; tribology; space stations; and mechanism analysis and testing were discussed.

The Solar Array Drive Mechanism for the Space Telescope is described. Power and signal transfer is achieved by a flexible wire harness for which the chosen solution, consisting of 168 standard wires, is described. The torque performance data of the harness over its temperature range is presented. The off load system which protects the bearings from the launch loads is released by a trigger made from Nitinol, a memory alloy. The benefits of memory alloy and the caveats for the design are discussed. The design of the off load is outlined and test experience reported. ESA

N86-27357# British Aerospace Dynamics Group, Stevenage (England). Space and Communications Div.
HISTORICAL DEVELOPMENT OF SOLAR ARRAY DRIVE MECHANISMS BY BRITISH AEROSPACE
I. D. HENDERSON *In* ESA Second European Space Mechanisms and Tribology Symposium p 19-24 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Solar array drive mechanisms are described. Design and technical features of the Bearing and Power Transfer Assembly and the solar array drive mechanisms for Olympus and Eurostar satellites are outlined. Arrays for large space platforms are considered. ESA

N86-27358# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ANALYSIS OF IN-ORBIT PERFORMANCE OF MECHANISMS WITHIN LARGE STRUCTURES
H. BAIER *In* ESA Second European Space Mechanisms and Tribology Symposium p 29-34 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Simulating and predicting the behavior of spacecraft mechanisms especially within larger structures are discussed. Deployment kinematic analysis is outlined. Actuators and their transfer functions within an active isolation or damping system as well as investigations of the static behavior of a refocus mechanism and the dynamic behavior of a bearing and power transfer assembly are treated. For the latter case, the effects of nonlinearities and of static preloads are emphasized. Ways to verify mechanism behavior in flexible structures are summarized. ESA

N86-27359# Technische Univ., Brunswick (West Germany). Inst. fuer Angewandte Mechanik.
CONTROL OF FLEXIBLE STRUCTURES WITH RESPECT TO INFINITY
P. RUGE *In* ESA Second European Space Mechanisms and Tribology Symposium p 35-39 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The transfer matrix method is recommended for studying the stability of linear feedback controlled systems continuous in space and time. The system matrix can be assembled as it is used from finite element methods separately for each continuous member and each joint including control elements. Distributed transfer matrices for the continuous members which contain information up to infinity without poles and truncation errors are used. The calculation of as many eigenvalues as wanted is carried out by trace theorems. ESA

N86-27360# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. des Systemes Balistiques et Spatiaux.
SOLAR ARRAY DEPLOYMENT SIMULATION USING ADAMS SOFTWARE
C. ROUX and P. FLAMENT *In* ESA Second European Space Mechanisms and Tribology Symposium p 41-46 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The use of ADAMS program to predict dynamic phenomena during deployment of satellite solar arrays is reviewed. The program increases understanding of influences of constituent flexibility during deployment. The program contributes to optimization of the mechanism as to mechanical strength under deployment loads and latching shocks; motorization factor; and layout on the solar array. Prediction of all in orbit deployment cases (including possible failure cases) in order to be sure that no unexpected phenomenon perturb the space flight is also improved. The improved accuracy using ADAMS is verified by test prediction correlation. ESA

N86-27363# Technische Univ., Munich (West Germany). Lehrstuhl B fuer Mechanik.
MODELING AND CONTROL OF A LIGHTWEIGHT ROBOT
B. GEBLER *In* ESA Second European Space Mechanisms and Tribology Symposium p 59-64 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

For a lightweight industrial robot the influence of elasticity of the structural parts is studied. The system is modeled as a hybrid multibody system. It is shown that using the static deflection bending lines as shape functions yields, with only a few degrees of freedom, very good results. For control of the system, consideration of nominal deflections is proposed. This concept takes into account the elastic properties of robot arms when computing feedforward control torques. ESA

N86-27367# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
THERMAL CUTTING HOLDDOWN AND RELEASE MECHANISM
G. J. A. N. KESTER *In* ESA Second European Space Mechanisms and Tribology Symposium p 89-93 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

A restraint and release mechanism was invented and tested in the Advanced Rigid Array program. The invention degrades the mechanical properties of a restraining element like an aramid cable by means of a heat source. The performance specifications and test results are listed. The benefits of using this mechanism instead of pyrotechnic systems include higher reliability, low cost and mass, long term storage, and the possibility of prelaunch testing. ESA

N86-27369# Societe Nationale Industrielle Aerospatiale, Cannes (France).
SPEED REGULATORS FOR SPACE APPENDAGES DEPLOYMENT
J. M. LEBLANC *In* ESA Second European Space Mechanisms and Tribology Symposium p 105-111 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The requirements, design, test program, and performances of a centrifugal brake speed regulator for the deployment of spaceborne appendages are described. The regulator is qualified for the SPOT solar array, the TVSAT/TDF reflectors, and TELE-X reflectors. ESA

N86-27375# Centre National d'Etudes Spatiales, Toulouse (France).
DEFINITION AND TESTING OF GEARS FOR SPACE ROBOTICS
L. PETITJEAN and A. BORRIEN *In* ESA Second European Space Mechanisms and Tribology Symposium p 149-154 Dec. 1985
In FRENCH; ENGLISH summary
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

An automatic manipulator arm for the capture of a three-axis stabilized satellite by another satellite on the same orbit was investigated. A general design study highlighted critical technological problems, such as the design and manufacturing of the joint gear-boxes, as the joints must transmit high forces and torques (60 Nm holding torque) which induce high contact stresses on the gear teeth. The research in lubrication processes, the experimental program to prove the feasibility of the concept, and the test results under atmosphere are summarized. ESA

N86-27376# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. fuer Technische Physik.
THE PERFORMANCE OF UNBONDED MOS2 FOR SPACE APPLICATIONS
V. BUCK *In* ESA Second European Space Mechanisms and Tribology Symposium p 155-159 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The performance of MoS2 as a dry lubricant in general is outlined and the advantages and disadvantages for space applications are reviewed. Knowledge in sputtering of MoS2 is discussed and the influence of preparation conditions on impurities or disorder of the films is assessed. Results showing correlations between H2O impurities in the plasma and structural parameters of the layers are given, and the importance of these effects is outlined. Considerations relating structural properties to tribological behavior are presented. ESA

N86-27377# Centre Suisse de Documentation dans le Domaine de la Microtechnique, Neuchatel. Dept. de Recherche et Developpement.
COATINGS AGAINST FRETTING
M. MAILLAT and H. E. HINTERMANN *In* ESA Second European Space Mechanisms and Tribology Symposium p 161-166 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Coatings and lubricants to protect aerospace mechanisms from wear and microweldings caused by fretting or reciprocal sliding were investigated. From the 144 tests performed, TiC, Tiodize and Adhesoil coatings show the best results under a high specific load; the best results are obtained with Rh + MoS2 coatings under low contact pressure against Be. ESA

N86-27378# European Space Tribology Lab., Risley (England).
SURFACE-TREATED TITANIUM ALLOY GEARS FOR SPACE MECHANISMS
R. A. ROWNTREE *In* ESA Second European Space Mechanisms and Tribology Symposium p 167-171 Dec. 1985 Sponsored by ESTEC
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The performance of surface treatments against adhesive wear (galling) on the alloy IMI 318 (Ti-6Al-4V) was tested using gears unlubricated in vacuum, in a four square rig. Gear performance was determined by life or number of tooth encounters before failure of the surface treatment rather than by wear depth. Conventional treatments such as nitriding or oxidation are found to offer limited improved gear life, above that of the untreated alloy. Boronizing gives the longest gear life but causes, during treatment, dimensional growth of the gears. Sputter-deposited coatings of TiN are poorly adherent to the substrate and give short lives. Arc-evaporated coatings of TiN give improved performance until coating fracture and subsequent galling of the titanium alloy occurs. ESA

N86-27379# Societe Nationale Industrielle Aerospatiale, Cannes (France).
USE OF MOS2 APPLIED BY PHYSICAL VAPOR DEPOSITION (PVD) ON SPACE MECHANISMS
J. F. PATIN, M. MAILLAT (Centre Suisse de Documentation dans le Domaine de la Microtechnique, Neuchatel.), and H. E. HINTERMANN *In* ESA Second European Space Mechanisms and Tribology Symposium p 173-176 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Satellite mechanisms using a solid lubricant film of MoS2 applied by physical vapor deposition or RF sputtering are described. This process satisfies space requirements because MoS2 has excellent friction properties in vacuum; nevertheless it is necessary to take into account moisture effects during ground tests. Parameters likely to influence the performances of lubricated mechanisms were studied on a pin on disk tribological test rig. Sputter coated MoS2 films are successfully used in the telecommunication satellite Arabsat, the observation satellite SPOT, and the television satellite TDF. Examples of lubricated mechanisms are antennas, rigid solar array deployment mechanisms, and flexible solar array box opening mechanisms. ESA

N86-27386# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
EXPERIMENT MANIPULATORS FOR AUTOMATIC SAMPLE HANDLING
N. CABLE *In* ESA Second European Space Mechanisms and Tribology Symposium p 221-226 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The application of robotics to small scale manipulator systems for materials handling in microgravity was studied, using the single core payload of EURECA. A skeleton and an advanced concept were studied. Modularity; size and mass; joint design; sensors; reliability, safety and redundancy; orbit and ground operation; computer aided design; end effectors; grapple fixtures; storage and process interfaces; processors; software; and the use of commercially available manipulators were investigated. ESA

N86-27387# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
A DORNIER LATCH DESIGN FOR A DOCKING MECHANISM
K. PRIESETT, F. GAMPE, R. H. BENTALL, and N. CABLE *In* ESA Second European Space Mechanisms and Tribology Symposium p 227-232 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Within a technology study of a spacecraft docking mechanism subsystem, it is shown that based on the selection of a very low impact docking concept, a simple latching and connecting interface

can be applied to the coupling of two spacecraft. Structural joining is accomplished by three or four equispaced capture latches. A capture latch mechanism for this docking technique is described. Latching requirements, the standard docking interface, the latch mechanism design and analysis, and results of a predevelopment model latch test are outlined. ESA

N86-27389# Royal Netherlands Aircraft Factories Fokker, Amsterdam. Space Div.
A DEPLOYABLE AND RETRACTABLE STRONGBACK STRUCTURE
R. ZWANENBURG *In* ESA Second European Space Mechanisms and Tribology Symposium p 239-245 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

A deployable/retractable structure whose parts deploy or retract simultaneously was developed for spacecraft antennas, solar arrays, heat rejection systems, sensors, concentrators, and platforms. Its advantages include simplicity and high reliability; excellent strength and stiffness in deployed condition; high design flexibility without the need for complete redesign; low production cost due to large number of identical elements; low development effort; and simple ground testing. ESA

N86-27390# European Space Tribology Lab., Risley (England).
SOME RECENT EXPERIENCES OF MECHANISM PERFORMANCE AND COMPONENT ASSESSMENT IN THERMAL VACUUM TESTS AT ESTL
J. A. DUVALL and K. PARKER *In* ESA Second European Space Mechanisms and Tribology Symposium p 251-260 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

The spacecraft mechanism test facilities at the European Space Tribology Laboratory (ESTL) are described. Test results are reviewed on three mechanisms where, in a variety of thermal conditions, the measurement of the reaction torque which would be experienced by the spacecraft was important. Valuable performance data is obtained when it is possible to dismantle mechanisms and examine the condition of all components after the tests. This was particularly important for two ESA mechanisms subjected to seven-year real life tests, one having lead-lubricated bearings and the other oil-lubricated bearings. The ESTL experience in component examination and failure analysis, with advice on how to improve mechanism reliability, is reviewed. ESA

N86-27394# Centre National d'Etudes Spatiales, Toulouse (France).
MECHANISMS DEVELOPED IN THE FRENCH SPACE INDUSTRY
R. SALOME and L. PETITJEAN *In* ESA Second European Space Mechanisms and Tribology Symposium p 283-288 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Mechanisms developed for satellite projects such as SPOT, Giotto, TV.SAT, and TELEX-X are described. Solar Array Drives, antenna pointing mechanisms, and hinges for robot arms are presented. ESA

N86-27397# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACE MECHANISMS DEVELOPMENT IN THE ESA TECHNOLOGICAL RESEARCH PROGRAM
D. WYN-ROBERTS *In* ESA Second European Space Mechanisms and Tribology Symposium p 305-310 Dec. 1985
Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Spacecraft components, control actuators, space operation mechanisms, instrument mechanisms, deployment mechanisms, and solar array mechanisms are described. Motors, wheels (including energy storage), docking and robotics mechanisms, and masts are discussed. ESA

N86-27645*# Naples Univ. (Italy).
TETHERED CONSTELLATIONS, THEIR UTILIZATION AS MICROGRAVITY PLATFORMS AND RELEVANT FEATURES
L. G. NAPOLITANO and F. BEVILACQUA (Aeritalia S.p.A., Torino (Italy).) *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 2 p 65-77 Jun. 1986 Previously announced in IAA as A85-13279
Avail: NTIS HC A23/MF A01 CSCL 13I

The gravitational, thermal, and dynamic docking effects on tethered platforms were studied. The near-earth environment has gravitational effects such a g-jitters and intermittencies, g-noise, and frequency and amplitude features which may influence life science, materials processing, and fluid processes research and commercial activities. Artificial gravity is produced by minute accelerations imparted by tethers. The magnitudes of gravitational forces produced by tethers 100 and 100,000 m long at various altitudes from 463 to 35,786 km are calculated. Thermal analyses were performed for stainless steel and Kevlar tethers, showing the steel tether could vary 300 m in length and the polyamide 25 m during one orbit. Finally, consideration given to docking with a tethered platform revealed that the center of mass could change, which would produce, however, negligible changes in orbit and therefore gravity. M.S.K. (IAA)

N86-27654*# Aeritalia S.p.A., Torino (Italy).
TETHER POINTING PLATFORM AND SPACE ELEVATOR MECHANISMS ANALYSIS OF THE KEY CONCEPTS FOR SATP AND SCALED SATP
E. TURCI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 287-324 Jun. 1986
Avail: NTIS HC A23/MF A01 CSCL 13I

The key concepts for a scaled and full model Science and Applications Tethered Platform (SATP) are analysized. This includes a tether pointing platform and a space elevator. The mechanism concepts and technological solutions are given. The idea of the tether pointing platform mechanism is to control and stabilize the attitude of a platform by means of a movable tether. The idea of the space elevator mechanism for a scaled SATP is to drag the tether gripping it between two rotating wheels. E.R.

N86-28116# Consulenze Generali Roma (Italy).
NUMERICAL EXPERIMENTS ON A CONTROLLED FLEXIBLE STRUCTURE USING DCAF Final Report
F. GRAZIANI and C. ARDUINI Nov. 1984 264 p
(ESA-CR(P)-2159; ETN-86-96861) Avail: NTIS HC A12/MF A01

The Deficiency Corrective Action Program (DCAP) code was used to simulate analog and digital control of a flexible spacecraft for the case of only in-plane motion, without spinning. For analog control, a simple PD scheme with sensors and actuators on the main rigidbody, with control relying on separation between control bandwidth and the lowest elastic frequency, and fully flexible modal control based on LQG programs are studied. For digital control, a problem for sampled sensor signal (at constant sample interval) digital logic and actuation is formulated by a zero order sample and hold device (at constant sample rate). ESA

N86-28117# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
COMPUTATION OF TETHERED SATELLITE POTENTIAL, CURRENT, AND AMBIENT MAGNETIC FIELD
M. CANDIDI Aug. 1985 18 p
(IFSI-85-8; ETN-86-97092) Avail: NTIS HC A02/MF A01

A tethered satellite magnetic field, tether current timeline, and induced potential timeline were calculated. The total magnetic field is modulated between 21,000 nT and 48,000 nT: the minimum in the total field is due to the South Atlantic anomaly. In upward deployment of the tethered satellite (for a westward motion of the system) the natural polarity is such that the satellite is positively charged with respect to the ambient plasma (while the Shuttle termination of the tether tends to go negative with respect to the plasma); vice versa for a downward deployment. Tether current is 20 to 70 times above the undisturbed plasma thermal current,

i.e., 30 mA for a satellite with a radius of 80 cm, for an applied voltage of 4 kV. ESA

N86-28118# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France). Lab. des Materiaux.
DESIGN OF BONDED STRUCTURAL JOINTS FOR SPACECRAFT [CALCUL DES LIASONS COLLEES STRUCTURALES DANS LES VEHICULES SPATIAUX]
J. P. MAIGRET and M. MARTIN 1986 20 p In FRENCH Presented at Colloq. sur les Tendances en Calcul des Struct., Bastia, France, 6-8 Nov. 1985
(SNIAS-861-430-105; ETN-86-97167) Avail: NTIS HC A02/MF A01

It is shown that for designing bonded joints, computer programs must include joint geometry, stress, environment, tolerances, and adhesive characteristics. The results of the experimental evaluation of characterization methods are presented and the most important unsolved problems are indicated. ESA

N86-28411*# Padua Univ. (Italy). Inst. of Applied Mechanics.
A REVIEW OF TETHER INDUCED DYNAMICAL FEATURES
S. BERGAMASCHI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 103-116 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The simplest mathematical model used for the simulation of TSS motion is considered in order to review the dynamics of tethers. This model is discussed. Also reviewed are elasticity effects, perturbation sources, orbit eccentricity and natural frequencies. Tethered systems provide a unique opportunity for skilled measurement activities in space. Some of the experiments envisaged require the measurement of very small mechanical quantities. This implies that the level of dynamical noise on instruments output be low or that system response to excitation, either external or internal, be sufficiently known. In this respect, the first TSS flights will be very useful, but much work will be needed in order to have reliable estimates of structural damping in different future systems. E.R.

N86-28414*# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. Fisica Spazio Interplanetario.
ELECTRODYNAMIC INTERACTIONS
M. DOBROWOLNY *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 153-160 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

The electrodynamic interaction of long metallic tethers with the ionosphere is introduced. Due to the tether's motion across the Earth's field, a polarization electric field is generated along the tether. In a system like the Tethered Satellite System (TSS) where the tether is coated with dielectric and the electrical contact is between its two terminations and the ionosphere, the upper end termination will collect electrons and, in a passive system, the lower end termination will collect ions. Space charge regions will develop around the two terminations of the system, which can be at considerable potential with respect to the unperturbed ionospheric plasma and the current in the tether will be most significantly determined by local processes in such space charge regions. A qualitative view of the global perturbation induced by TSS in the ionosphere is outlined. One of the applications of electrodynamic tethers is that of using them as low frequency wave generators to communicate to the Earth. This application is briefly discussed. An equivalent circuit of the tether system is described. The basic equation of the circuit is given. E.R.

N86-28425*# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
LABORATORY SIMULATION OF THE ELECTRODYNAMIC INTERACTIONS OF A TETHERED SATELLITE WITH AN IONOSPHERIC PLASMA
C. BONIFAZI, J. P. LEBRETON (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk, Netherlands), G. VANNARONI, C. COSMOVICI, R. DEBRIE (Centre National de la Recherche Scientifique, Orleans, France), M. HAMELIN, L. POMATHIOD, and H. ARENDS (European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands) *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 401-420 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

An improved experimental set-up in the Orleans Plasma Chamber allowed investigations of the I-V characteristics of a conductive spherical body (10 cm diameter) in a plasma environment. Moreover, the influence of a transversal magnetic field at 0.6 and 1.2 G was investigated, for the first time, both on the sheath potential profile and current collection. Floating potential profiles were measured at 16 different radial distances from the test body up to 9 body radii in 8 different angular positions. The test body potential could be increased in the range from -200 V up to +100 V. Preliminary results are shown and discussed. Author

N86-28427*# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. Fisica Spazio Interplanetario.
SPONTANEOUS RADIATION EMITTED BY MOVING TETHERED SYSTEMS
M. DOBROWOLNY *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 431-439 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

Some concepts related to radiation emitted by a large conductor moving through a magnetoplasma are outlined and referred to the case of long tethers. Some recent results of a theoretical calculation of Alfven wings, their structure and the power associated with are shown. How the problem of radiation from TSS or for any large conductor moving through a magnetoplasma should be approached is presented. The approach is that of the theory of antennas in plasmas. E.R.

N86-28428*# Consiglio Nazionale delle Ricerche, Frascati (Italy). Piano Spaziale Nazionale.
TETHERED SATELLITE SYSTEM (TSS) CORE EQUIPMENT
C. BONIFAZI *In* NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Volume 1 p 441-469 Jun. 1986
Avail: NTIS HC A25/MF A01 CSCL 13I

To date, three Tethered Satellite System (TSS) missions of the Italian provided scientific satellite orbiting in the ionosphere connected to U.S. Space Shuttle is foreseen. The first mission will use an electrically conductive tether of 20 km deployed upward from the orbiter flying at 300 km altitude. This mission will allow investigation of the TSS electrodynamic interaction with the ionosphere due to the high voltage induced across the two terminators of the system during its motion throughout the geomagnetic field. The second mission will use a dielectric tether of 100 km deployed downward from the Orbiter flying at 230 km altitude. Tethered-vehicle access to altitude as low as 120 to 150 km from the Orbiter would permit direct long term observation of phenomena in the lower thermosphere and determination of other dynamical physical processes. The third mission would use the same configuration of the first electrodynamic mission with the complete Core Equipment. Study of power generation by tethered systems would be possible by operating the Core Equipment in the inverted current mode. This mode of operation would allow ion current collection upon the TSS satellite by controlling its potential with respect to the ambient ionospheric plasma. The main requirements of the Core Equipment configuration to date foreseen for the first TSS electrodynamic mission is described.

Besides the Core Equipment purposes, its hardware and operational sub-modes of operation are described. E.R.

N86-28979# Joint Publications Research Service, Arlington, Va.
EUROPE LOOKS TO TWENTY-FIRST CENTURY WITH HERMES
In its West Europe report: Science and Technology (JPRS-WST-85-021) 4 p 12 Jul. 1985 Transl. into ENGLISH from Revue Aerospatiale (Paris, France), Jun. 1985 p 9; 11; 15
Avail: NTIS HC A04/MF A01

Hermes, a manned spacecraft launched by Ariane 5, is described. Requirements for composite materials are discussed for use in the structural design. The docking mechanism is designed to be compatible with the US space station, with Columbus, and with the Soviet station. The reentry, approach, and landing are also discussed. B.G.

N86-29876*# National Aeronautics and Space Administration, Washington, D.C.
AN OVERVIEW OF THE KALININGRAD SPACEFLIGHT CONTROL CENTER
May 1986 35 p Transl. into ENGLISH of the mono. "Tsentr Upravleniya Poletom" Moscow, USSR, Mashinostroyeniye, 1985 p 1-33 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-87980; NAS 1.15:87980) Avail: NTIS HC A03/MF A01 CSCL 14B

A general description is given of the Kaliningrad Spaceflight Center near Moscow, where Soviet orbiting and interplanetary spacecraft are monitored and controlled. Brief descriptions of the equipment used and the scope of work done at the center are included. Author

N86-30604*# Technische Univ., Munich (West Germany). Lehrstuhl fuer Raumfahrttechnik.
COSMIC DUST DETECTION WITH LARGE SURFACE PIEZOCERAMICS
U. WEISHAUPT *In* Lunar and Planetary Inst. Trajectory Determinations and Collection of Micrometeoroids on the Space Station p 88-90 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

Piezoelectric transducers mounted on targets made out of metal plates or plastic foils have been used in many former space missions to detect impacting dust particles and to determine some of their parameters (e.g., momentum). The proposed detector is based on a large disc made out of piezoceramic material. Dust particles impacting on the detector will cause electrical charge pulses due to the piezoelectric nature of the target material. These charge pulses are measured on the electrodes of the disc and transformed with a charge sensitive amplifier (CSA) to voltage pulses. Counting the number of pulses leads to the dust-flux impacting on the detector. Additionally the amplitude and the rise time of the pulse slopes are determinated to evaluate the momentum and the size of the dust particles. Due to the high charge production rate per force unit of piezoceramics and momentum transfer without loss the sensivity of this acoustic sensor is very high. A method to derive size and momentum from the rising slope of an acoustic signal is described. M.G.

N86-30658# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
STRUCTURAL OPTIMIZATION WITH CONSTRAINTS IN DYNAMICS
H. J. BAIER *In* DGLR The 2nd International Symposium on Elasticity and Structural Dynamics p 426-433 1985
Avail: NTIS HC A99/MF E03

Application of mathematical programming for spacecraft optimum structural design, especially weight minimization under static constraints is discussed. Since optimization under dynamic response in general leads to highly nonconvex problems, special care has to be taken for considering local optima. Whatever solution strategy is applied, availability of derivatives of the response is highly desirable. The control force approach is an interesting alternative to the classical mathematical optimization approaches. Since it usually leads to linear problems it is very efficient and circumvents problems related with nonconvexity. Examples to outline the findings are given. ESA

N86-30684# Technische Hochschule, Aachen (West Germany). Inst. fuer Leichtbau.
RECONSTRUCTION OF FORCING FUNCTIONS BASED ON MEASURED STRUCTURAL RESPONSES
H. OERY, H. GLASER, and D. HOLZDEPPE *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 656-668 1985 Sponsored by Deutsche Forschungsgemeinschaft, ESA, and MBB/Erno G.m.b.H.
Avail: NTIS HC A99/MF E03

A structural analysis procedure to reconstruct the significant parts of the forcing function time-histories based on a restricted number of test records is presented. Use of the inverse application of the phase-plane method and Williams' method is proposed. The procedure is based on the fact that very slowly varying loads induce deformations, which can be determined using the stiffness matrix only. It can be applied to aerospace structures and to earthquake engineering. ESA

N86-30685# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACECRAFT STRUCTURES DESIGN AND VERIFICATION
C. STAVRINIDIS *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 669-671 1985
Avail: NTIS HC A99/MF E03

Definition of spacecraft design loads, design and development of spacecraft structures, and qualification and acceptance of spacecraft structures are discussed. State of the art structural engineering; maturity of methodologies; sequence of events as they arise in spacecraft projects; trends; and future requirements are described. ESA

N86-30686# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
LOW FREQUENCY DESIGN VERIFICATION OF LARGE SPACECRAFT STRUCTURES
E. ERBEN and K. ECKHARDT *In* DGLR The 2nd International Symposium on Aeroelasticity and Structural Dynamics p 672-682 1985 Sponsored by INTELSAT and ESTEC
Avail: NTIS HC A99/MF E03

Multiaxis vibration system (MAVIS) testing of large spacecraft structures is described. Specified acceleration time histories are compared with the realized time histories measured at base point of test item. For the uniaxial excitation compliance is very good. During two axis excitation the differences between specified and measured input time histories are significant. The deviations are associated with strong frequency and amplitude changes in the transient motion. However, these results are achieved with an open loop control configuration of test facility and improvements are possible. Simulations of antenna reactions suggest deviations between applied and specified forces but resulting acceleration responses on different structure points are comparable with results achieved in test with complete S/C (same order of maximum acceleration peaks). ESA

N86-30759# Fulmer Research Inst. Ltd., Stoke Poges (England).
THE APPLICATION OF COMPOSITES TO SPACE STRUCTURES: GUIDELINES ON IMPORTANT ASPECTS FOR THE DESIGNER
D. P. BASHFORD *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 9-16 Feb. 1986
Avail: NTIS HC A16/MF A01

Guidelines and surveys on the state of composites as structural aerospace materials were produced. The guidelines give a detailed background on composites for spacecraft and are intended for designers and engineers unfamiliar with composites. Topics covered include: selection of composite materials; aramid composites; prepreg and resin procurement specifications;

nondestructive tests polymeric matrices; mechanical test methods for composites; joining techniques; and moisture absorption/thermal cycling response. ESA

N86-30762# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
THERMAL RESIDUAL STRESSES IN SYMMETRIC AND UNSYMMETRIC CARBON FIBER REINFORCED PLASTICS: SOME TENTATIVE WAYS OF EVALUATION
J. P. FAVRE *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 31-38 Feb. 1986
Avail: NTIS HC A16/MF A01

Effects of thermal stresses which develop during fabrication on the integrity of composites used in spacecraft are discussed. For an unsymmetric material, the result is a modification of the shape. In the simple case of a long and thin cross-ply specimen, residual stresses in the transverse plies can be deduced from reading the curvature. For a plate, the existence of several stable shapes according to the aspect ratio is verified. For the symmetric material, in-situ estimation of residual stress magnitude by X-ray diffraction using a metallic powder embedded between the plies is described. ESA

N86-30763# Atomic Energy Research Establishment, Harwell (England). Materials Development Div.
DYNAMIC MECHANICAL ANALYSIS AS AN AID TO THE CHARACTERIZATION OF COMPOSITE MATERIALS
D. H. BOWEN, R. DAVIDSON, R. J. LEE, and M. AGUIRRE *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 39-46 Feb. 1986
Avail: NTIS HC A16/MF A01

Dynamic mechanical analysis (DMA) was used to assess the thermal properties of polymeric materials and resin matrix carbon fiber composites. By considering the storage and loss moduli and damping as a function of temperature, information relating to the nature, state of cure, and hysteretic characteristics of the matrix can be obtained. This information assists in the interpretation of the impact strengths and creep resistance of polymers and composites. Examples of the use of DMA in research and development programs with composite materials based on heat resistant thermoplastic (PES, PEI, PEEK) and thermosetting polymers (phenolics, bismaleimides and epoxides) are given. The factors and limitations affecting the quantitative stiffness measurements of orthotropic composite materials by DMA are discussed, specifically measurements on unidirectional carbon fiber reinforced polyether ether ketone. ESA

N86-30765# Imperial Coll. of Science and Technology, London (England). Center for Composite Materials.
THE STRENGTH OF BOLTED JOINTS IN KEVLAR RP
J. M. HODGKINSON, D. L. DEBEER, and F. L. MATTHEWS *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 53-61 Feb. 1986 Sponsored by ESA
Avail: NTIS HC A16/MF A01

Failure data for single and multibolt joints in woven Kevlar reinforced epoxy resin are presented. The results are relevant to 6-ply, 0.5 mm thick, symmetrical laminates of different fiber orientation. Bolts used were M4 diameter (d) with standard washers. Lay-up, bolt tensile load, and hence washer pressure, end (e) and width (w) effects were explored in single and double lap joint configurations. Quasi-isotropic lay-ups fail at higher stresses than orthotropic laminates, and, for sufficiently large e/d and w/d ratios, failure is in bearing with no observable edge effects. Multiple bolt tests concerned lines and rows of bolts, the pitch being varied to determine the effects of bolt interaction. These tests were performed on the preferred quasi-isotropic lay-up. ESA

N86-30766# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
ORTHOTROPIC PROPERTIES OF LAYERED FIBER COMPOSITES
G. R. KRESS *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 65-70 Feb. 1986
Avail: NTIS HC A16/MF A01

A mathematical method to replace orthotropic and symmetric laminates by a homogeneous material whose mechanical properties are defined in all three spatial directions is presented. A very good agreement between the out-of-plane properties calculated with the method and those obtained using a finite element approach is shown. The values for the in-plane properties are identical to those obtained by the classical lamination theory. ESA

N86-30767# Waldrich Siegen Werkzeugmaschinen G.m.b.H., Burbach (West Germany).
THEORETICAL AND EXPERIMENTAL BEHAVIOR OF CARBON FIBER REINFORCED PLASTICS UNDER MECHANICAL AND THERMAL LOAD
U. BIELING *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 71-78 Feb. 1986
Avail: NTIS HC A16/MF A01

Based on a fiber resin system for aerospace components, the linear and nonlinear stress-strain behavior of CRP laminates is investigated. Theoretical and experimental results correlate very well up to high loads by entering strain-dependent coefficients into the stiffness matrix. Approaches for tracking the initiation of microcracks and crack propagation by acoustic emission and dissipation of energy are presented. By measuring the coefficients of thermal expansion (CTE) of a basic lamina and the equations of classical lamination theory, CTE's of any laminate can be calculated. ESA

N86-30768# Politecnico di Milano (Italy). Dept. of Aerospace Engineering.
ANALYTICAL AND EXPERIMENTAL RESULTS OF ADVANCED COMPOSITE STIFFENED PANELS UNDER COMBINED LOADS
G. ROMEO *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 79-86 Feb. 1986 Sponsored by Italian Ministry of Education
Avail: NTIS HC A16/MF A01

A theoretical analysis to design advanced composite hat and blade-stiffened panels under uni and biaxial compression and/or shear is reported. The analysis is based on the buckling equation of the simply-supported orthotropic plate to predict the overall buckling of the panel and the local buckling of each cross-section element, and on the torsional instability theory for the blade-stiffened panels. A computer program to evaluate the minimum-mass optimization of the panels was designed. Tests on graphite/epoxy hat and blade-stiffened panels under uniaxial compression and unstiffened panels under shear were conducted. Adequate correlation between theoretical analysis and experimental results is obtained. ESA

N86-30771# Brussels Univ. (Belgium).
NEW PREDICTION METHODS FOR COMPOSITES HYGROTHERMAL BEHAVIOR
C. C. HIEL *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 101-107 Feb. 1986 Sponsored by NAS-NRC and NATO
Avail: NTIS HC A16/MF A01

A method to predict the thermal expansion and swelling of a composite material due to temperature and moisture variations which typically occur in a launch environment is presented. It is demonstrated that constitutive equations for moisture absorption and moisture-induced dimensional changes can be obtained with an internal variable method rooted in the theory of irreversible thermodynamics. Realism is injected into the model through the concept of free volume. ESA

N86-30772# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany).
DESIGN AND MANUFACTURING ASPECTS OF SPACE TRUSSES
H. W. BERGMANN *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 109-115 Feb. 1986
Avail: NTIS HC A16/MF A01

The dimensional stability of fiber reinforced composites for large space structure trusses is discussed. Temperature and moisture effects cannot be accurately assessed by extrapolation from the response of small test coupons. The buckling strength of hollow filament-wound struts depends very sensitively on the angular directions of the individual plies. Optimal configurations can be derived by a computerized program. An alternative approach to filament-wound strut construction by surrounding a prefabricated foam core by carbon fiber rovings or fabrics is viable. The interconnection of struts in rigid three-dimensional trusses is possible by filament-wound joints with the advantages of low cost, low weight, and improved thermal compatibility. ESA

N86-30777# California Univ., Berkeley. Dept. of Mechanical Engineering and Center for Advanced Materials.
DELAMINATION FRACTURE TOUGHNESS OF COMPOSITE SPACECRAFT STRUCTURES
C. K. H. DHARAN *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 159-167 Feb. 1986
(Contract DE-AC03-76SF-00098)
Avail: NTIS HC A16/MF A01

Opening mode (mode 1) delamination fracture behavior of graphite and aramid-epoxy composites was investigated. The effect of loading rate and reinforcement geometry (unidirectional vs woven) on fracture toughness was determined, and observation of the fracture surface was used to derive microfailure modes. A micromechanical delamination model to estimate the relative contributions of the matrix and the fiber-matrix interface to the overall delamination fracture toughness is proposed. Results show that the mode 1 delamination fracture toughness of graphite composites is small relative to glass composites. Woven graphite composites exhibit opening mode delamination crack energy release rates 2.5 times those of the unidirectionally reinforced material. The fracture surface of the graphite-epoxy laminates is characterized by clean exposed fiber surfaces indicating poor interfacial fracture toughness. ESA

N86-30778# Royal Inst. of Tech., Stockholm (Sweden). Dept. of Aeronautical Structures and Materials.
DAMAGE ZONE FRACTURE ANALYSIS OF FIBROUS COMPOSITES
K. HOLLMANN, P. CLARIN, C. G. ARONSSON, and J. BAECKLUND *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 169-174 Feb. 1986
Avail: NTIS HC A16/MF A01

Excellent results were achieved using the Damage Zone Model (DZM) to predict mode 1 fracture loads of notched composites. A computer program of high computational efficiency, called FRACOM, was developed. Computations are performed in a few minutes on a personal computer and result in an estimated load-displacement behavior and damage zone characteristics under quasi-static loading. ESA

N86-30779# Engineering System International, Rungis (France).
INDUSTRIAL CALCULATION OF DAMAGE TOLERANCE AND STRESS ALLOWABLES IN COMPONENTS MADE OF COMPOSITE MATERIALS USING THE PAM-FISS/BIPHASE MATERIAL MODEL
A. DEROUVRAY and E. HAUG *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 175-185 Feb. 1986 Sponsored by ESA/ESTEC
Avail: NTIS HC A16/MF A01

A finite element code to simulate the heterogeneous constitution of composite materials during the damage process was developed. The code simulates the basic damage mechanisms; matrix micro and macrocracking, fiber ruptures, layer delamination. It is used to calculate initial, tangent, and residual rheological properties, as well as damage (or defect) initiation and stable/unstable growth, in the critical zones of arbitrary composite structures. It provides realistic equivalent homogeneous properties (moduli; stress/strain allowables) compatible with an efficient damage tolerant design. ESA

N86-30780# Paderborn Univ. (West Germany). Fachgebeit Technische Mechanik.
ON CORRELATION BETWEEN THERMAL STRESSES, ELASTIC STRAIN ENERGY AND DEBONDING IN THERMALLY LOADED FIBER-REINFORCED COMPOSITE MATERIALS
F. G. BUCHHOLZ *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 187-196 Feb. 1986
Avail: NTIS HC A16/MF A01

Correlations between thermal stresses, elastic strain energy, and the energy release rate during debonding of unidirectionally fiber reinforced composite materials are investigated numerically. It is shown that the strain energy caused by thermal loads in a single circular unit cell of such a material is directly correlated with the energy spent by the compound on debonding of fiber and matrix. For a corresponding hexagonal unit cell within a compound two additional influences are effective, resulting in an interferred correlation and distinctly lower energy release rates during the process of debonding. ESA

N86-30781# Strathclyde Univ., Glasgow (Scotland). Dept. of Mechanics of Materials.
ASSESSING THE EFFECTS OF DELAMINATIONS ON THE POSTBUCKLING STRENGTH OF CRFP PANELS
W. M. BANKS, J. RHODES, and G. B. CHAI *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 197-202 Feb. 1986 Sponsored by UK Ministry of Defense and ESA
Avail: NTIS HC A16/MF A01

The effect of deliberately inbuilt delaminations on the postbuckling strength of carbon fiber composite panels with a b/t ratio of 70 and 50 was tested. The panels are fabricated from 14 layers of unidirectional carbon fiber using an autoclave process. The delamination positions were chosen to coincide with the position of highest interlaminar shear stress, the position of highest direct strain, the central buckle peak, and the inflection points on the panel. The control panel for a b/t ratio of 68.57 failed prematurely due to unforeseen edge effects. However it is clear that the worst position for delamination is when it coincides with the highest interlaminar shear stress at the edge of the panel. There appears to be little effect with the delamination at the buckle peak. ESA

N86-30782# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
ON THE DEFECT SENSITIVITY OF SPACECRAFT TYPICAL THIN CFRP LAMINATES
J. BISCHOFF *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 203-209 Feb. 1986
Avail: NTIS HC A16/MF A01

The brittleness of high modulus CFRP laminates used in spacecraft was investigated. It is shown that small defects can cause a crucial reduction of loading capacity. The dependence of this reduction on fiber orientation and the laminate stacking sequence is discussed. Fiber-matrix-bonding is identified as an essential factor affecting the notch sensitivity. ESA

N86-30783# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
INTEGRITY OF CARBON FIBER REINFORCED PLASTICS. STRUCTURAL ELEMENTS, SCREENING PROCEDURES, OPPORTUNITIES AND OPEN ISSUES
W. H. PAUL *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 211-215 Feb. 1986
Avail: NTIS HC A16/MF A01

Activities (of the standard design procedure) necessary to prevent catastrophic failures of CFRP manufactured items in manned spaceflight due to global or local deficiencies are discussed. Criteria which CFRP structural elements must meet in order to be used in STS are given. ESA

N86-30784# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
NONDESTRUCTIVE TESTING OF FIBER REINFORCED COMPOSITES USING X-RAY FINE STRUCTURE PROCEDURES
J. WALTER and HENSCHEL (Bundesanstalt fuer Materialpruefung, Berlin, West Germany) *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 217-229 Feb. 1986
Avail: NTIS HC A16/MF A01

Nondestructive inspection (NDI) of fiber reinforced composites is introduced. Nondestructive testing with the X-ray fine structure procedure is based on the fact that the paracrystalline microstructure of the fibers diffracts the X-rays at the lattice planes. The long chain molecules are arranged in a nearly crystalline (paracrystalline) configuration; the chains have a high degree of orientation parallel to the fiber axis, so that the X-ray pattern produced by a bundle of fibers irradiated in a directional normal to their long axis is typical for the specific type. This property can be used as NDI-criterion and thickness layer measurement method. ESA

N86-30785# Fulmer Research Inst. Ltd., Stoke Poges (England).
DEVELOPMENTS IN THE NONDESTRUCTIVE EVALUATION (NDE) OF COMPOSITE MATERIALS
R. L. CROCKER *In its* Proceedings of a Workshop on Composites Design for Space Applications (ESA-SP-243) p 231-235 Feb. 1986
Avail: NTIS HC A16/MF A01

The effects on composites inspection of digital techniques of computing and data storage, robotics, and image processing made possible by digitizing raw data are assessed. Ultrasonics, X-radiography, thermography, mechanical impedance, vibrothermography, and laser holography are discussed. In many cases the actual defect detection capability is not changed by introducing these techniques; it is the integrity of the inspection or evaluation which is improved. ESA

N86-30794# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
STRENGTH OF CARBON FIBER COMPOSITE/TITANIUM BONDED JOINTS AS USED FOR SPAS-TYPE STRUCTURES
J. FRANZ and H. LAUBE *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 301-308 Feb. 1986
Avail: NTIS HC A16/MF A01

The analytical and experimental verification of bonded tubes used for SPAS strut assemblies is described. The strut elements consist of a carbon fiber tube and two titanium mounting elements, connected by tapered, double-shear bonded joints. The analysis of the geometric design minimized the shear stress peaks at the ends of the overlapping section under external and temperature loadings. The load capability is verified by a destructive qualification test program (static load and fatigue) and each individual strut is acceptance tested before integration into a satellite structure. Data can be used for load capability estimations for similar strut components, i.e., with increased or decreased tube diameter, or with modified overlapping length of the bonding section. ESA

N86-30796# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
DESIGN AND DEVELOPMENT OF THE ADVANCED RIGID ARRAY (ARA) SOLAR PANEL
R. W. H. HORSSELENBERG *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 319-328 Feb. 1986
Avail: NTIS HC A16/MF A01

The Advanced Rigid Array panel technologies are summarized: specific weight is less than 1.2 kg/sqm; can survive extreme thermal cycling (plus 80 to minus 180 C); excellent flatness and dimensional stability; extremely high stiffness properties due to application of GY-70 carbon fiber; high satellite interface flexibility; high panel sizing flexibility; and simple and low cost production. Developments include the establishment of panel technologies to obtain specific weights below 0.8 kg/sqm via open lay-up CFRP facesheet technology. ESA

N86-30799# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany).
A STEP TOWARDS AN ESA COMPOSITES DESIGN HANDBOOK FOR SPACE STRUCTURE APPLICATIONS
J. BOLZ *In* ESA Proceedings of a Workshop on Composites Design for Space Applications p 351-355 Feb. 1986
Avail: NTIS HC A16/MF A01

The European Space Agency initiated a Composites Design Handbook for Space Structure Applications, because the increasing application of composite materials in space structures requires harmonization. Establishment of a Handbook structure and the compilation of information on as many topics as possible is described. ESA

N86-30804# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
WINDING WITH THERMOPLASTIC POLYMERS
J. L. TISNE and J. BOUVARD 1986 8 p Presented at 3rd European Symposium on Spacecraft Materials in Space Environment, Noordwijk, Netherlands, 3 Oct. 1985 Previously announced as N86-22613
(SNIAS-861-430-106; ETN-86-97168) Avail: NTIS HC A02/MF A01

Filament winding of continuous fibers impregnated with thermoplastic resins for spacecraft structure manufacturing is described. The mandrel is at ambient temperature, or is maintained below the fusion temperature, which enables winding unstable trajectories by means of the under layer/strand sticking. Another method consists in having the material and the mandrel at the fusion temperature while winding. This process simplifies the machine but presents two drawbacks, with respect to the thermoset resins: it is impossible to wind other than stable trajectories, close to geodetic ones; and the curing on the thermoset epoxy (maximum 180 C) is replaced by a fusion in an oven (from 250 to 400 C). This poses a problem of resistance of the enclosed parts and tools. ESA

N86-31629 Centre National d'Etudes Spatiales, Toulouse (France).
DESIGN OF SPACECRAFT
D. MARTY and F. DALLEST 1986 669 p In FRENCH; ENGLISH summary
(ISBN-2-225-80732-9; ETN-86-97643) Avail: CEPADUES, Toulouse, France

Satellite orbit calculation, orbit perturbations, structural design, thermal control, satellite tests, interplanetary vehicles, conventional launchers, space shuttles, avionics, propulsion, stability and optimization are covered in this textbook. ESA

N86-31636# National Aerospace Lab., Amsterdam (Netherlands). Spaceflight Div.
ATTITUDE CONTROL OF SPACECRAFT: AN OVERVIEW OF RECENT DEVELOPMENTS AND RESEARCH
T. ZWARTBOL 27 Jun. 1985 24 p In DUTCH; ENGLISH summary Submitted for publication
(NLR-MP-85055-U; B8664362; ETN-86-97681; AD-B101030L)
Avail: NTIS HC A02/MF A01

The application of modern control techniques for the development of spacecraft attitude estimation and control algorithms is reviewed. Control theories, and the mathematical modeling of the systems such as optical systems, flexible spacecraft, and liquid sloshing in microgravity are treated. The Modular Attitude Control System (MACS) is presented. The MACS test and simulation assembly, built for ESA, is described. ESA

N86-31639# Societe Nationale Industrielle Aerospatiale, Cannes (France).
USE OF MOS2 APPLIED BY PHYSICAL VAPOR DEPOSITION (PVD) ON SPACE MECHANISMS
J. F. PATIN, M. MAILLAT, and H. E. HINTERMANN 1986 6 p Presented at Second ESA European Symposium on Space Mechanisms and Tribology, Schloss Meersburg, West Germany, 9-11 Oct. 1985
(SNIAS-861-440-101; ETN-86-97610) Avail: NTIS HC A02/MF A01

The laboratory test results of sputter coatings of MoS2 are described. The lubricating film, produced using a physical vapor deposition technique was used in the Arabsat, SPOT and TDF satellites. The test program includes the study of the influence of many parameters, including speed, vacuum, temperature, load, and air humidity in the case of ground tests. The tests show that MoS2 is an excellent lubricant for space mechanisms. The only remaining problem is its high sensitivity to moisture when performing ground tests. ESA

N86-31640# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DESIGN AND TEST OF A SPACE DEPLOYABLE RADIATOR
B. MOSCHETTI, M. AMIDIEU, and B. TATRY 1986 8 p
(SNIAS-861-440-103; ETN-86-97612) Avail: NTIS HC A02/MF A01

A deployable panel of hinged type where the power is spread over the surface by means of embedded heat pipes and the thermal rotating joints are coaxial with the panel hinge is described. The prototype model has a radiation panel of 800 x 600 mm with 5 embedded heat pipes and 2 radiative faces capability. In the hot case the capability is 160 W to maintain 30 C. Thermal performance test results are given. ESA

N86-31643# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
DYNAMICS OF FLEXIBLE SPACECRAFT: AN ANALYSIS OF APPROACHES TOWARDS MATHEMATICAL MODEL ORDER REDUCT ION
P. T. L. M. VANWOERKOM 16 Apr. 1985 202 p
(Contract NIVR-1910)
(NLR-TR-85068-U; B8665500; ETN-86-98038) Avail: NTIS HC A10/MF A01

Reduction of the mathematical order (i.e., of the mathematical complexity) of the open loop spacecraft dynamics model with minimal loss of model accuracy is discussed. Approaches to open loop model order reduction were analyzed regarding application to dynamic models of flexible spacecraft. Parameter optimization, aggregation, singular perturbation, modal dominance, and component cost analysis were compared. The latter two approaches appear to be most meaningful and convenient amongst the five. ESA

N86-31993# Societe Nationale Industrielle Aerospatiale, Cannes (France). Dept. Generateurs Solaires.
PHOTOVOLTAIC SOLAR GENERATORS: FROM SATELLITES TO A SPACE STATION [LES GENERATEURS SOLAIRES PHOTOVOLTAIQUES: DU SATELLITE A LA STATION SPATIALE]
M. A. ZILIANI 17 Feb. 1986 21 p In FRENCH
(SNIAS-861-440-112; ETN-86-97620) Avail: NTIS HC A02/MF A01

Ways to generate power for spacecraft operation are presented and the design of a 30 kW solar generator for the Columbus platform is described. The generator is specified for 10 yr life, 30 kW continuous power, low atmospheric drag, H shape deployment and 1992 launching target. A GaAs option is included, as the anticipated performance is better that of silicon cells. It is shown that the generator design is characterized by high reliability, low cost, and good adaptability (15 to 60 kW). ESA

N86-31997# Societe Nationale Industrielle Aerospatiale, Cannes (France).
HIGH POWER RIGID SOLAR ARRAY
M. A. ZILIANI and L. PELENC 1986 7 p
(SNIAS-861-440-110; ETN-86-97618) Avail: NTIS HC A02/MF A01

The design of a solar array providing 30 kW is described. Main specifications are compatibility with the European Columbus platform and resource module, low life cycle cost, reliability, multideployment-retraction ability and low development risk. The design is based on interchangeable rigid panels with silicon cells and proved pantograph mechanisms. The advantages of this concept include modularity at elementary panel (0.5 kW) level, capability of providing power while partially retracted, and of withstanding high levels of in-orbit loads. ESA

N86-32106# National Aerospace Lab., Amsterdam (Netherlands). Flight Div.
CONTROL THEORETIC ANALYSIS OF HUMAN OPERATOR MEDIATED RENDEZVOUS AND DOCKING
P. MILGRAM and P. H. WEWERINKE 26 Feb. 1985 10 p Presented at 2nd IFAC/IFIP/IFORS/IEA Conf. on Analysis, Design and Evaluation of Man-Machine Systems, Varese, Italy, 10-12 Sep. 1985
(NLR-MP-85020-U; B8661085; ETN-86-97669) Avail: NTIS HC A02/MF A01

A model based analysis of manual control of space rendezvous and docking in the presence of transmission time delays (nominal case: human operator (HO) on the ground) is presented. The variables studied are time delay, human induced motor noise levels, rotational and translational control and the effect of display prediction. An envelope of performance is estimated, bounded by performance with optimal prediction and performance with no prediction at all. Nominal performance for a simple second order Taylor predictor display is estimated. An HO imperfect internal representation of the system is used to model the no-predictor and predictor display cases. ESA

N86-32107# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 1: HUMAN ENGINEERING ANALYSIS, SYNTHESIS AND EVALUATION TECHNIQUES Final Report
P. MILGRAM, R. C. VANDEGRAAFF, and P. H. WEWERINKE Paris ESA 17 May 1985 280 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-1; ESA-CR(P)-2190-PT-1; ETN-86-97787)
Avail: NTIS HC A13/MF A01

Human engineering approaches and methodologies applicable for analysis of performance of human-machine systems, particularly space teleoperator applications, are reviewed. Motivated by the presumed active role of the human operator in future space teleoperation missions, the application of human engineering within the various stages of system development is discussed, emphasizing the impact on the development cycle of being able

to analyze various aspects of human-in-the-loop system performance. Experimental and theoretical approaches to human performance analysis are identified. Fundamental and practical aspects of each approach are outlined. A modeling approach for the analysis of a specific class of supervisory space teleoperator missions is proposed. Human-computer task allocation for such missions is considered. ESA

N86-32108# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 3: RENDEZVOUS AND DOCKING OPERATIONS AND MODEL ANALYSIS OF PERFORMANCE WITH HUMAN-IN-THE-LOOP Final Report
P. MILGRAM, P. T. L. M. VANWOERKOM, and P. H. WEWERINKE Paris ESA 7 Dec. 1984 192 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-3; ESA-CR(P)-2190-PT-3; ETN-86-97789)
Avail: NTIS HC A09/MF A01

Human-in-the-loop rendezvous and docking (RVD) performance was analyzed to demonstrate the practicality of applying engineering methods and techniques to the analysis of control loops with human operators in space operations. The RVD space segment and the related autonomous operations are described. Model analyses of RVD performance in the final approach phase, for the case in which the human operator is involved in manual control of RVD, and for the case in which the human operator is monitoring an automated RVD for the occurrence of failures are given. ESA

N86-32109# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 4: RESEARCH REQUIREMENTS FOR HUMAN-IN-THE-LOOP SPACE TELEOPERATOR DEVELOPMENT Final Report
P. MILGRAM Paris ESA 17 May 1985 62 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-4; ESA-CR(P)-2190-PT-4; ETN-86-97790)
Avail: NTIS HC A04/MF A01

Short-term human engineering research requirements for developing rendezvous and docking and space telemanipulation capabilities are presented. A catalog of research topics related to human-in-the-loop teleoperation performance is given. Available resources for model analytical investigation of these research topics and resources for the establishment of an initial human performance research laboratory for carrying out such investigations and for testing proposed design concepts by ESA are reviewed. ESA

N86-32110# National Aerospace Lab., Amsterdam (Netherlands). Space Flight Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 5: EXECUTIVE SUMMARY Final Report
P. MILGRAM Paris ESA 17 May 1985 157 p
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-5; ESA-CR(P)-2190-PT-5; ETN-86-97791)
Avail: NTIS HC A08/MF A01

Human engineering analysis, synthesis, and evaluation techniques; robotics operations and manual control experiments; spacecraft rendezvous and docking operations and model analysis of performance with human-in-the-loop; and ESA research requirements for human-in-the-loop space teleoperator development are discussed. ESA

N86-32347# European Space Agency, Paris (France).
PREPARING FOR THE FUTURE: THE ESA TECHNOLOGICAL RESEARCH AND DEVELOPMENT PROGRAM 1986-1988 Executive Summary
N. LONGDON, ed. Dec. 1985 55 p Original document contains color illustrations
(ESA-SP-1079; ISSN-0250-1589; ETN-86-97566) Avail: NTIS HC A04/MF A01

European Space Agency work on Earth-space telematics; space communications; infrastructure; global Earth monitoring; deep space and observatory facilities; microgravity utilization; space platforms; in-orbit operations; and maintenance of European competitiveness is outlined. ESA

N86-32516# Societe Nationale Industrielle Aerospatiale, Cannes (France).
INFLUENCE OF STRUCTURAL PARAMETER UNCERTAINTIES ON FLEXIBLE SPACE STRUCTURAL CONTROL PERFORMANCES
L. PASSERON 1986 29 p Presented at American Control Conference Workshop on Identification and Control of Flexible Space Structures, San Diego, Calif., 4-8 Jun. 1984
(SNIAS-861-440-104; ETN-86-97613) Avail: NTIS HC A03/MF A01

A geometric approach to check controllability and observability properties of light flexible space structures is presented. A matrix model of general autonomous linear systems is described. The system properties are decoupled on each characteristic subspace of the respective matrices. Straightforward criteria expressions are given. A quantitative analysis of the system properties versus parametric uncertainties is given. The results are applied to large flexible space structures. It is shown that the method enables a thorough investigation of structural parameter uncertainties on observability and controllability properties. ESA

N86-32517# MATRA Espace, Toulouse (France). Direction Etudes Systemes Spatiaux et Charges Utiles.
ESABASE EXTENSION TO SPACECRAFT CHARGING Final Report
M. FREZET Paris ESA 17 Jun. 1986 125 p
(Contract ESTEC-3-5632/83-NL-PP)
(MATRA-CMT-TS101/RT/16.85; ESA-CR(P)-2191; ETN-86-97792)
Avail: NTIS HC A06/MF A01

A system level tool, ESABASE/CHARGING, to simulate spacecraft charging in space conditions (geosynchronous) and test tank environment is described. The software results from the coupling of NASCAP with ESABASE/MATVIEW. It offers an integrated framework with automatic file management. Up to 30 different files are generated during a typical simulation. A high-level input langauge is automatically interpreted to generate the rigid NASCAP inputs. A 3-D preprocessor sets up the NASCAP model. A fully 3-D postprocessor allows the visualization of user-defined parameters for a selected cycle on the spacecraft. The 3-D postprocessor is easy to use and fast. Improved NASCAP auxiliary codes plot colored equipotentials or various graphics with UDISP. ESA

N86-32584# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Product Assurance Div.
DATA FOR SELECTION OF SPACE MATERIALS
Nov. 1985 211 p
(ESA-PSS-01-701-ISSUE-1; ISSN-0379-4059; ETN-86-97796)
Avail: NTIS HC A10/MF A01

Data on adhesives, adhesive tapes, coatings and varnishes, glasses, lubricants, metals, paints, plastic films, potting compounds, reinforced and thermosetting resins, rubbers, and thermoplastics for space applications are presented. The materials were used by ESA. ESA

N86-33024# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
CONTROL LOOPS WITH HUMAN OPERATORS IN SPACE OPERATIONS. PART 2: ROBOTICS OPERATIONS AND MANUAL CONTROL EXPERIMENT Final Report
C. M. VANSWIETEN and S. KAMPEN Paris ESA 5 Sep. 1985 140 p Prepared in cooperation with Royal Netherlands Aircraft Factories Fokker, Amsterdam
(Contract ESA-5594/83)
(NLR-TR-84116-L-PT-2; FOK-TR-R-84-CHO-131-PT-2; ESA-CR(P)-2190-PT-2; ETN-86-97788-PT-2) Avail: NTIS HC A07/MF A01

Servicing of satellites and assembly of space structures via robotic operations controlled from the ground by human operators are discussed. Five operational modes for the combined space and ground segment are defined: high level manipulation; manual augmented; preprogrammed; single joint (emergency mode); and direct drive (emergency mode). The main difficulty in the manual modes is the presence of time delay in the control loop and the way the operator can cope with it. Human operator performance was assessed for the direct drive mode, in which the system provides the least support. A simple model for this mode shows essentially nonlinear actuator behavior, which makes results from the literature not applicable. Therefore experiments were done. The experiments show that the operator can control the system, but a lot of overshooting responses are observed. Possibly, these overshoots can be eliminated by different instructions to the operator, who was instructed in the experiments to be as fast as possible. ESA

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SUPPORT SPACECRAFT

Includes design, analysis, requirements, trade studies and simulations of Space Station support spacecraft including the orbital transfer vehicle (OTV) and the orbital maneuvering vehicle (OMV).

A86-37041
THERMAL DESIGN OF AEROASSISTED ORBITAL TRANSFER VEHICLES
H. F. NELSON, ED. (Missouri-Rolla, University, Rolla) New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 96), 1985, 578 p. No individual items are abstracted in this volume.

Recent studies concerning the design of the aeroassisted orbital transfer vehicle (AOTVs) are presented. The basic equations for the flight regimes of AOTVs and numerical calculations of flowfields over AOTVs are reviewed, and trajectories of AOTVs are addressed. The thermal protection of AOTVs and phenomena occurring at the surface of an AOTV are examined. Some individual topics discussed include: relaxation algorithm for AOTV bluff body flow, performance aerodynamics of AOTVS, multiple pass trajectories for an AOTV, and AOTV aeroheating and thermal protection study, thermal response of an AOTV with a conical brake drag, design and performance analysis of a conical aerobrake OTV concept, temperature-dependent reaction rate expressions for oxygen recombination, surface-slip equations for low Reynolds number multicomponent air flow, rate chemistry problems in the flight regimes of AOTVs, and progress in noncatalytic surfaces for metallic heat shields. C.D.

A86-37135*# PEDA Corp., Palo Alto, Calif.
AOTV BLUFF BODY FLOW - RELAXATION ALGORITHM
C. K. LOMBARD, J. BARDINA, and E. VENKATAPATHY (PEDA Corp., Palo Alto, CA) IN: Thermal design of aeroassisted orbital transfer vehicles. New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 96), 1985, p. 85-112. refs
(Contract NAS2-11920; F49620-83-C-0084; DAAG29-84-C-0002)
(AIAA PAPER 84-1699)

Preliminary investigations have led to the consideration of two classes of energy efficient aeroassisted orbital transfer vehicle (AOTV) concepts, with high and low L/D. The AOTV represent reentry space vehicles which are to fly hypersonically in the continuum upper reaches of the atmosphere. Problems arise in connection with convective and nonequilibrium radiative heating. As the possibilities for obtaining needed information by experimentation are limited, reliance must be placed on computational techniques to simulate testing of design concepts. A new relaxation algorithm for the compressible Navier-Stokes equations has been developed in the context of recent work with a conservative flux difference eigenvector split implicit upwind scheme CSCM (conservative supracharacteristics method). Attention is given to the CSCM implicit method, and early results for axisymmetric bluff body flow including complete forebody and base flow for a free flight range model drag brake AOTV. G.R.

A86-39913*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CALCULATION OF CONVECTIVE HEATING ON PROPOSED AEROASSIST FLIGHT EXPERIMENT VEHICLE
H. H. HAMILTON, II and K. J. WEILMUENSTER (NASA, Langley Research Center, Hampton, VA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 8 p. refs
(AIAA PAPER 86-1308)

Convective heating calculations of a NASA aeroassist flight experiment (AFE) configuration consisting of a blunted, elliptic cone raked off at the base, and fitted with a skirt-type afterbody with a generous corner radius, are presented. The HALIS inviscid flowfield code is used to supply edge properties to an approximate three-dimensional boundary-layer method to calculate the surface heating. Calculations at Mach number 9.86 and approximate Reynolds number of 500,000, for angles of attack from -10 to 10 degrees, are in general good agreement with Langley 31-inch Mach 10 Tunnel experimental data. The results validate the application of the present overall AFE configuration heating pattern heating contours to aeroassist orbital transfer vehicle heating distribution determinations. R.R.

A86-39915*# Sydney Univ. (Australia).
DIRECT SIMULATION OF TYPICAL AOTV ENTRY FLOWS
G. A. BIRD (Sydney, University, Australia) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 10 p. refs
(Contract NAGW-728)
(AIAA PAPER 86-1310)

The direct simulation Monte Carlo method is applied to two flows that are relevant to the projected aeroassisted orbital transfer vehicle. The first is the axially symmetric flow about a 70 degree blunted cone shield with a cylindrical afterbody, and the second is the one-dimensional flow along the stagnation streamline of the first flow. The shock standoff distance for the stagnation streamline study is obtained from the full axially symmetric calculation. Advantage is then taken of the speed of the one-dimensional calculation to study the sensitivity of the stagnation point heat transfer to a number of physical variables. These include the chemical reaction rate coefficients, the surface catalycity, the electric field associated with ambipolar diffusion, and the nonequilibrium thermal radiation from the shock front. Author

A86-39936*# Martin Marietta Corp., Denver, Colo.
ORBITAL MANEUVERING VEHICLE THERMAL DESIGN AND ANALYSIS TECHNIQUES
J. CHAPTER (Martin Marietta Corp., Denver, CO) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 15 p. refs
(Contract NAS8-36115)
(AIAA PAPER 86-1337)

This paper describes the OMV thermal design that is required to maintain components within temperature limits for all mission phases. A key element in the OMV thermal design is the application of a motorized thermal shade assembly that is a replacement for the more conventional variable conductance heat pipes or louvers. The thermal shade assembly covers equipment module radiator areas, and based upon the radiator temperature input to onboard computer, opens and closes the shade, varying the effective radiator area. Thermal design verification thermal analyses results are presented. Selected thermal analyses methods, including several unique subroutines, are discussed. A representation of enclosure Script F equations, in matrix form, is also included. Personal computer application to the development of the OMV thermal design is summarized. Author

A86-40504* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
REENTRY GUIDANCE AND CONTROL FOR AN AEROASSIST FLIGHT
L. B. BRANDON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 3-1 to 3-18.

An Aeroassist Flight Experiment (AFE) is proposed to show how the use of an atmospheric braking device can reduce the perigee velocity of a vehicle upon its return from a mission to geosynchronous orbit. This braking device would be used to attain low earth orbit comparable with the STS Orbiter. The basic design of the AFE is presented and the guidance and control aspects of the design are discussed. The lifting-brake design selected for the AFE is a raked cone with a coefficient of drag of 1.5 and a lift to drag ratio of 0.3. The potential second flight of the AFE would have a ballute aerobraking device with a predictor/corrector guidance scheme. It is concluded that the approach described to implement the AFE is a feasible one and minimizes risk by having adequate margins wherever needed, by reducing error sources in sensitive areas, and by conducting an extensive simulation activity to verify the design. K.K.

A86-40515* Alabama Univ., Huntsville.
AN ORBITAL MANEUVERING VEHICLE SIMULATOR
W. TEOH, J. WALLS (Alabama, University, Huntsville), T. BRYAN, F. ROE (NASA, Marshall Space Flight Center, Huntsville, AL), and N. SHIELDS (Essex Corp., Huntsville, AL) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 6-14 to 6-23.

The Orbital Maneuvering Vehicle (OMV) is a teleoperated vehicle designed to dock with a target vehicle in space to peform certain tasks. This vehicle is not yet in production, but a simulator of the OMV is located at Marshall Space Flight Center (MSFC). The MSFC facility provides a realistic simulation of the OMV. Various docking maneuvers can be studied in some detail. A special robot has been constructed that provides a moving target for the simulator to dock with. This facility is valuable for conducting studies on the OMV; it also is excellent for personnel training. Author

A86-42236
DEVELOPING THE FINAL FRONTIER: INTERNATIONAL COOPERATION IN THE PEACEFUL USES OF OUTER SPACE
A. FLORINI Research supported by the James S. McDonnell Foundation, Armand Hammer Foundation, and Carnegie Corp. New York, United Nations Association of the United States of America, Inc., 1985, 79 p.

This history and law of human activity in outer space is examined, current space programs are reviewed, and the major policy issues facing the U.S. and the world are outlined. The launching of Sputnik is discussed as well as the formation of NASA, the race to the moon, the Apollo-Soyuz Test Project, the Outer Space Treaty and the Moon Treaty. NASA's Space Shuttles are considered as well as U.S. scientific aspirations in space; the Salyut space stations; ESA's Ariane, Spacelab, and EURECA projects; and the space programs of Japan, China, India, and Canada. A treatment is provided of the Space Station from the point of view of international cooperation and the military. The militarization of outer space is discussed, with particular emphasis on antisatellite systems and 'SDI'. Multilateral initiatives are also outlined. K.K.

A86-42623*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TWO-STAGE EARTH-TO-ORBIT VEHICLES WITH SERIES AND PARALLEL BURN
J. A. MARTIN (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1413)

Recent studies have indicated that a fully reusable earth-to-orbit vehicle system will be needed near the beginning of the next century. One likely concept is a two-stage, vertical takeoff system with liquid rocket propulsion. Such vehicles have been examined with series burn and parallel burn of the engines of each stage. The results indicate that the preferred concept will have parallel burn with crossfeed, the booster will have hydrocarbon engines, the Orbiter will have both hydrocarbon and hydrogen engines, and the staging velocity will be low enough to allow the booster to glide back to the launch site. Author

A86-42808#
SLOSH DYNAMICS IN A TOROIDAL TANK
J. S. MESEROLE and A. FORTINI (Boeing Aerospace Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 13 p. refs
(AIAA PAPER 86-1717)

An investigation is described of fluid slosh dynamics in a 1/4-scale model of a toroidal liquid oxygen tank for a minimum-length orbit transfer vehicle. Experimentally and analytically derived equivalent mechanical models for the slosh modes under a one-g acceleration are compared, and measurements of the reductions in slosh forces obtained with slosh baffles are presented, as are equivalent mechanical models for the slosh modes with baffles installed. A methodology is given for efficient measurement of slosh dynamics by digital spectral analysis. Observations of nonlinear effects in the slosh motions are described. Author

A86-46949#
A SPACE BASED ORBITAL TRANSFER VEHICLE OPERATING FROM THE SPACE STATION
R. J. GORSKI (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 12 p.
(AIAA PAPER 86-2325)

Previous Orbital Transfer Vehicle (OTV) and Space Station studies have shown that a space-based OTV offers potential economic and operational advantages over ground-based systems. This paper describes a candidate space-based OTV and the unique benefits it offers as compared to a ground based orbital transfer system. The first part of the paper describes the requirements for operating the space based OTV at the Space Station and how

the OTV is designed to meet these requirements in an efficient manner. This includes all phases of the OTV mission, including initial delivery to the Station, OTV proximity operations in vicinity of the Space Station, and OTV maintenance and turnaround operations. Alternative approaches in OTV design and operations will be compared and the rationale for the recommended approach delineated. The selected space-based OTV concept will be described, including features which are unique in comparison to those of a ground-based OTV. Examples of features that will be discussed include the modular propellant tank approach, which allows the spacebased OTV to handle a variety of payload weights in an efficient manner, and the potential for a lightweight OTV structure due to its being launched in the Shuttle empty of propellants. The second part of the paper will discuss the benefits derived from operating the OTV from the Space Station. The preceding data will show that an OTV can be operated efficiently at the Space Station starting in the 1990's. Author

A86-46967#
GAS/SURFACE SCATTERING MODELS FOR SATELLITE APPLICATIONS
F. C. HURLBUT (California, University, Berkeley) IN: Thermophysical aspects of re-entry flows . New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 97-119. refs

The utility of molecular dynamic simulation of flowfields and aerothermodynamic effects upon the vehicle depends in part upon accurate knowledge of gas scattering at the surface for conditions of very high relative velocity. In this paper, a limited field of experimental work is reviewed and the trajectory approach to the modeling of gas/surface interactions is considered. The computational results of several investigators are discussed in light of the experimental information. Two major conclusions are advanced: neither the hard-sphere lattice model nor the harmonic oscillator lattice model are appropriate for applications in models of the gas/surface interactions involving the relative velocities of orbital order. The basis for these conclusions is developed and support is given through trajectory modeling conducted by the author. Author

A86-46968*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RATE CONSTANTS FOR CHEMICAL REACTIONS IN HIGH-TEMPERATURE NONEQUILIBRIUM AIR
R. L. JAFFE (NASA, Ames Research Center, Moffett Field, CA) IN: Thermophysical aspects of re-entry flows . New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 123-151. refs

In the nonequilibrium atmospheric chemistry regime that will be encountered by the proposed Aeroassisted Orbital Transfer Vehicle in the upper atmosphere, where air density is too low for thermal and chemical equilibrium to be maintained, the detailed high temperature air chemistry plays a critical role in defining radiative and convective heating loads. Although vibrational and electronic temperatures remain low (less than 15,000 K), rotational and translational temperatures may reach 50,000 K. Attention is presently given to the effects of multiple temperatures on the magnitudes of various chemical reaction rate constants, for the cases of both bimolecular exchange reactions and collisional excitation and dissociation reactions. O.C.

A86-46969*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ELECTRON-NITROGEN MOLECULAR COLLISIONS IN HIGH-TEMPERATURE NONEQUILIBRIUM AIR
W. M. HUO (NASA, Ames Research Center, Moffett Field, CA; Notre Dame, University, IN), V. MCKOY, T. L. GIBSON (California Institute of Technology, Pasadena), and M. A. P. LIMA IN: Thermophysical aspects of re-entry flows . New York, American Institute of Aeronautics and Astronautics, Inc., 1986, p. 152-196. refs
(Contract NCC2-147; NCC2-319)

Ab initio calculation of vibrational excitation and deexcitation cross sections of N2 by low energy resonant electron impact have been carried out. The calculation includes initial target state in v = 0-12 and final target state in v = 0-17. The calculated cross sections are found to agree with available experimental data to within reported experimental error. Effect of target rotation has been investigated. Comparison of vibrational excitation cross sections at J = 0, 50, and 150 shows that the major effect of target rotation is to lower the resonance energy. Vibrational excitation and deexcitation rate coefficients are tabulated for electron temperatures of 1100-55,000 K. The present tabulation supercedes an earlier compilation by the Naval Research Laboratory that was derived from experimental data with a factor-of-two error. The tabulated rate coefficients are suited for flowfield modeling of aeroassisted orbital transfer vehicles. Author

A86-47678#
EFFECT OF ROTATING EARTH FOR AOTV ANALYSIS
H. IKAWA IN: Atmospheric Flight Mechanics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 239-247. refs
(AIAA PAPER 86-2133)

The Aeroassisted Orbit Transfer Vehicle (AOTV) operates in the endo/exoatmosphere. Exoatmospheric flight phase is dictated only by the inertial properties. In endoatmospheric flight phase, the trajectory is also shaped by the inertial velocity. However, the aerodynamic maneuver that causes the trajectory perturbation is controlled by the relative velocity. For example, along the equatorial flight path: (1) the velocity difference between the inertial and the relative reference frames represents 5 to 7 percent of the entry velocity; (2) the dynamic pressure difference becomes 10 to 14 percent, which is significant in evaluating the proper atmospheric flight maneuver; (3) in consequence, exit errors that are induced at the edge of the sensible atmosphere produce significant deviation in the final orbit transfer. The possible errors affecting AOTV analyses conducted by neglecting the earth's rotation are discussed. The control laws using the shallow glide path ascent and the constant altitude glide trajectories in the atmosphere, with the required pull-up maneuver, are also demonstrated. Conclusions are: (1) AOTV analyses using the stationary earth assumption tend to underpredict the final LEO altitude and to overpredict the orbital inclination change, and (2) effects of the rotating earth cannot be ignored for realistic AOTV simulations. Author

A86-47906#
OPTIMUM BURN SCHEDULING FOR LOW-THRUST ORBITAL TRANSFERS
R. G. MELTON (Pennsylvania State University, University Park), K. M. LAJOIE, and J. W. WOODBURN IN: Astrodynamics Conference, Williamsburg, VA, August 18-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 44-51. Research supported by the Pennsylvania State University. refs
(AIAA PAPER 86-2010)

This paper describes a method for optimizing the point at which thrust should be initiated on each passage of a multiple, low-thrust, finite duration perigee burn ascent trajectory. The quantity being minimized is the rotation of the line of apsides. The method is semianalytic, requiring only a simple root-finding routine for the numerical portion of the solution is used to model the flight path

during the burn, yielding a 'burn-on' position with a maximum error of approximately 2 percent. Author

A86-49598*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SIMULATING AOTV HEATING ENVIRONMENT IN AN ARC JET
J. BALBONI, W. WINOVICH (NASA, Ames Research Center, Moffett Field, CA), and A. BALAKRISHNAN (Eloret Institute, Sunnyvale, CA) AIAA and ASME, Joint Thermophysics and Heat Transfer Conference, 4th, Boston, MA, June 2-4, 1986. 11 p. refs
(AIAA PAPER 86-1312)

The application of arc-jet facilities to the simulation of the combined radiative and convective heating environments calculated for AOTV return missions is presented. The AOTV mission requirement and design configuration determine the magnitude of the radiative and convective heating rates. This paper considers methods for obtaining radiation from the high temperature plasma in arc-jet flows. A computer code that predicts arc-heater performance was used to determine the effect of gas mixtures on arc-heater performance, with the intent of increasing the gas temperature and resultant radiative emission. Numerical radiation solutions were compared with direct measurements of the radiative intensity from the gas cap. Convective heating measurements were made as well. The arc-jet was operated at AOTV enthalpy and pressure levels for these measurements to assess the simulation capabilities for AOTV material development/testing. A parametric study is presented that defines the capability of the Interaction Heating Facility arc jet at Ames to simulate both the radiative and the convective heating for current AOTV configurations. Author

N86-24217*# Essex Corp., Huntsville, Ala. Space Systems Group.
THE SYSTEM INTEGRATION AND VERIFICATION TESTING OF AN ORBITAL MANEUVERING VEHICLE FOR AN AIR BEARING FLOOR Final Report
N. L. SHIELDS, JR., M. F. MARTIN, K. R. PAULUKAITIS, J. W. HASLAM, JR., and D. E. HENDERSON 22 Feb. 1986 125 p refs
(Contract NAS8-35636)
(NASA-CR-178350; NAS 1.26:178350; H-86-02) Avail: NTIS HC A06/MF A01 CSCL 05H

The teleoperator and Robotics Evaluation Facility (TOREF) is composed of a 4,000 square foot precision air bearing floor, the Teleoperator Motion Base, the Target Motion and Support Simulator, the mock-ups of the Hubble Space Telescope, Multi-mission Modular Spacecraft, and the Orbital Maneuvering Vehicle (OMV). The TOREF and its general capabilities to support the OMV and other remote system simulations; the facility operating procedures and requirements; and the results of generic OMV investigations are summarized. B.G.

N86-24536*# Alabama Univ., Birmingham. Dept. of Computer and Information Science.
MACHINE VISION AND THE OMV
M. A. MCANULTY *In* NASA. Marshall Space Flight Center Research Reports: 1985 NASA/ASEE Summer Faculty Fellowship Program 24 p Jan. 1986 refs
Avail: NTIS HC A99/MF E04 CSCL 09B

The orbital Maneuvering Vehicle (OMV) is intended to close with orbiting targets for relocation or servicing. It will be controlled via video signals and thruster activation based upon Earth or space station directives. A human operator is squarely in the middle of the control loop for close work. Without directly addressing future, more autonomous versions of a remote servicer, several techniques that will doubtless be important in a future increase of autonomy also have some direct application to the current situation, particularly in the area of image enhancement and predictive analysis. Several techniques are presentet, and some few have been implemented, which support a machine vision capability proposed to be adequate for detection, recognition, and tracking. Once feasibly implemented, they must then be further modified to operate together in real time. This may be achieved by two courses, the use of an array processor and some initial steps toward data reduction. The methodology or adapting to a vector architecture is discussed in preliminary form, and a highly tentative rationale for data reduction at the front end is also discussed. As a by-product, a working implementation of the most advanced graphic display technique, ray-casting, is described. Author

N86-26735*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
KINEMATICS, COMPOSITION AND THERMODYNAMICS OF THE MESOPAUSE, TURBOPAUSE, REGION OF THE ATMOSPHERE (BETWEEN 80 AND 120 KM) RELATED TO THE AEROASSISTED ORBIT TRANSFER VEHICLE (AOTV) OPERATIONS
M. SUSKO Apr. 1986 21 p refs
(NASA-TM-86545; NAS 1.15:86545) Avail: NTIS HC 02/MF A01 CSCL 04A

The mesopause-turbopause region (80 to 120 km) of the atmosphere which is frequently used as a boundary between the thermosphere and mesosphere for models of the atmosphere is discussed. The initialization of models is important since uncertainties may lead to significant changes in the computations of total density at greater altitudes. In this transition region, the experimental data base for the total gas density and the constituents of smaller abundance is very limited. The turbopause height (h sub t) may vary from 90 to 120 km and no pronounced dependence of (h sub t) on season, local time, or solar activity is determined. The importance of atmospheric turbulence is discussed and its important role in the mesosphere and lower atmosphere by influencing the thermal balance of the upper atmosphere, as well as the distribution of different atmospheric constituents, is presented. The number of measurements of turbulence at these altitudes is small. Data from radio meteors, noble gas ratio analysis, and luminescent cloud analysis reveal no definite conclusion or systematic variation of the turbulence region. The heat input by gravity waves is a dominant term in the energy balance equation. Also gravity waves, either directly or through a mechanism of turbulence generation, enhance the mixing ability of the atmosphere. Internal gravity waves produce variations in the density as well as concentration of atomic oxygen. The uncertainty in the atmospheric density variation leads to control system design problems for the AOTV relative to the control authority required to deal with the unpredictable variation in density. Author

N86-26932*# Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
A LATERAL GUIDANCE ALGORITHM TO REDUCE THE POST-AEROBRAKING BURN REQUIREMENTS FOR A LIFT-MODULATED ORBITAL TRANSFER VEHICLE M.S. Thesis
G. C. HERMAN Jun. 1986 155 p
(Contract NAS9-17560)
(NASA-CR-177295; NAS 1.26:177295; CSDL-T-912) Avail: NTIS HC A08/MF A01 CSCL 09B

A lateral guidance algorithm which controls the location of the line of intersection between the actual and desired orbital planes (the hinge line) is developed for the aerobraking phase of a lift-modulated orbital transfer vehicle. The on-board targeting algorithm associated with this lateral guidance algorithm is simple and concise which is very desirable since computation time and space are limited on an on-board flight computer. A variational equation which describes the movement of the hinge line is derived. Simple relationships between the plane error, the desired hinge line position, the position out-of-plane error, and the velocity out-of-plane error are found. A computer simulation is developed to test the lateral guidance algorithm for a variety of operating conditions. The algorithm does reduce the total burn magnitude needed to achieve the desired orbit by allowing the plane correction and perigee-raising burn to be combined in a single maneuver. The algorithm performs well under vacuum perigee dispersions, pot-hole density disturbance, and thick atmospheres. The results for many different operating conditions are presented. Author

N86-30373*# Eloret Corp., Sunnyvale, Calif.
THEORETICAL RESEARCH PROGRAM TO STUDY CHEMICAL REACTIONS IN AOTV BOW SHOCK TUBES Technical Progress Report, 1 Nov. 1985 - 30 Jun. 1986
P. TAYLOR 30 Jun. 1986 69 p
(Contract NCC2-371)
(NASA-CR-176992; NAS 1.26:176992) Avail: NTIS HC A04/MF A01 CSCL 09B

Progress in the development of computational methods for the characterization of chemical reactions in aerobraking orbit transfer vehicle (AOTV) propulsive flows is reported. Two main areas of code development were undertaken: (1) the implementation of CASSCF (complete active space self-consistent field) and SCF (self-consistent field) analytical first derivatives on the CRAY X-MP; and (2) the installation of the complete set of electronic structure codes on the CRAY 2. In the area of application calculations the main effort was devoted to performing full configuration-interaction calculations and using these results to benchmark other methods. Preprints describing some of the systems studied are included.

N86-30375*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BENCHMARK FULL CONFIGURATION-INTERACTION CALCULATIONS ON H2O, F- AND F
C. W. BAUSCHLICHER, JR. and P. R. TAYLOR (Eloret Corp., Sunnyvale, Calif.) *In* Eloret Corp. Theoretical Research Program to Study Chemical Reactions in AOTV Bow Shock Tubes 15 p 30 Jun. 1986
Avail: NTIS HC A04/MF A01 CSCL 09B

Full configuration-interaction calculations are reported, and compared to other methods, for H2O at its equilibrium geometry and at two geometries with the H-O bonds stretched. Since the percentage of the self-consistent field (SCF) reference in the full configuration-interaction (FCI) wave function decreases greatly with the bond elongation, the accuracy of techniques based on a single reference do not compare well with the FCI results. However, the results from a complete active space SCF/multireference configuration-interaction (CASSCF/MRCI) treatment are in good agreement with the FCI. Correlation effects in F compared to Ne are far more similar than for F- compared to Ne, despite F- and Ne being isoelectronic. Since the importance of higher than double excitations is more important for F- than F, a very high percentage of the correlation must be obtained to accurately compute the electron affinity. In a CASSCF/MRCI treatment the higher than quadruple excitations contribute 0.02 eV to the electron affinity (EA), even for modest basis sets. M.G.

N86-30376*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
BENCHMARK FULL CONFIGURATION-INTERACTION CALCULATIONS ON HF AND NH2
C. W. BAUSCHLICHER, JR., S. R. LANGHOFF, P. R. TAYLOR (Eloret Corp., Sunnyvale, Calif.), N. C. HANDY (Cambridge Univ. (England).), and P. J. KNOWLES (University of Western Ontario, London.) *In* Eloret Corp. Theoretical Research Program to Study Chemical Reactions in AOTV Bow Shock Tubes 16 p 30 Jun. 1986
Avail: NTIS HC A04/MF A01 CSCL 09B

Full configuration-interaction (FCI) calculations are performed at selected geometries for the 1-sigma(+) state of HF and the 2-B(1) and 2-A(1) states of NH2 using both DZ and DZP gaussian basis sets. Higher excitations become more important when the bonds are stretched and the self-consistent field (SCF) reference becomes a poorer zeroth-order description of the wave function. The complete active space SCF - multireference configuration-interaction (CASSCF-MRCI) procedure gives excellent agreement with the FCI potentials, especially when corrected with a multi-reference analog of the Davidson correction. M.G.

N86-31068# British Library Lending Div., Boston Spa (England).
EXPERIMENTAL AND ANALYTICAL RESULTS OF LARGE-SCALE PRESSURIZED THERMAL SHOCK TESTING
A. SAUTER, H. HUBER, and T. NGUYEN-HUY 1986 33 p
Transl. into ENGLISH from "Experimentelle und Analytische Ergebnisse eines Grossversuchs zur Notkuehlsimulation" Stuttgart, West Germany 33 p Presented at the 11th MPA Seminar, Stuttgart, WestWest Germany, 10-11 Oct. 1985
(BLL-RISLEY-TR-5282-(9091.9F)) Avail: British Library Lending Div., Boston Spa, England

The systems engineering activity concentrated on evaluation of emission model characteristics and the requirements they impose on the Orbit Transfer Vehicles (OTV), establishing debris/meteoroid shielding criteria, and updating Mission and Systems Requirements document. The Macintosh based computer system was expanded to encompass performance calculations coupled with the mission model. Two configuraton updates were indicated for the baseline vechicles: the ground based vehicle will have debris/meteoroid shielding added to the propellant tanks; the space based vehicle will be resized to accommodate the new driving manned GEO sortie mission (probably to the vicinity of 75,000 pounds propellant load). The optimum cargo bay appears to be tending towards the shortest possible configuration, the torous LOX tank version. The definition of the aeroassist trade vehicles is progressing, but conclusions are not yet available. The trajectory control evaluations were conducted for all 14 STS upper atmosphere profiles, and the guidance algorithm performs accurately in all cases. B.G.

N86-32489 Michigan Univ., Ann Arbor.
OPTIMAL AEROASSISTED ORBITAL TRANSFER INVOLVING ELLIPTICAL ORBITS Ph.D. Thesis
J. R. F. JOHANNESEN 1985 168 p
Avail: Univ. Microfilms Order No. DA8600465

Minimum-fuel orbital transfer between elliptical orbits is studied by first analyzing separately the three phases of aeroassisted orbital transfer (deorbit, atmospheric fly-through and post atmospheric maneuvers). For the atmospheric fly-through of a ballistic vehicle, second-order analytical solutions for the altitude and flight path angle are obtained using Poincare's method of small parameters. Expressions for the speed, time of flight, longitudinal deceleration, and critical entry angle are also derived. For a vehicle whose coefficient of drag can be modulated between a maximum and a minimum value, an explicit self-correcting guidance law is derived to achieve the targeted exit speed with small flight path angle. For a vehicle with lifting capability, a near optimal control with constant normalized lift coefficient and explicit bank modulation is obtained to maximize the atmospheric plane change. The influence of maximum lift-to-drag ratio on the atmospheric plane change is also assessed. Regions of optimality for deorbit to a prescribed entry angle are obtained and the post atmospheric maneuvers necessary to achieve the target final orbit are derived. The problem of transfer between coplanar elliptic orbits is studied. The two impulse transfer is obtained by solving three equations for three unknowns. Dissert. Abstr.

N86-32504*# Boeing Aerospace Co., Kennedy Space Center, Fla.
ORBITAL TRANSFER VEHICLE LAUNCH OPERATIONS STUDY: MANPOWER SUMMARY AND FACILITY REQUIREMENTS, VOLUME 5 Final Report
7 Mar. 1986 36 p
(Contract NAS10-11165)
(NASA-CR-179705; NAS 1.26:179705) Avail: NTIS HC A03/MF A01 CSCL 22D

All manpower numbers, number of heads (by skill), serial time and manhours have been accumulated and compiled on a per subtask basis in spreadsheet format for both the ground based and the space based data flows. To aid in identifying the facility resources required to process the Ground Based Orbital Transfer Vehicle (GBOTV) and/or the space based orbital transfer vehicle (SBOTV) through the ground facilities at Kennedy Space Center (KSC), a software application package was developed using a general purpose data base management system known as Data

Flex. The facility requirements are used as the basic input to this software application. The resources of the KSC facility that could be used by orbital transfer vehicle program were digitized in the same format used to identify facility requirements. The facility capabilities were digitized in this format for subsequent, automated comparative analyses. Composite facility requirements are compared to each of the baseline facility capabilities and the system generates a relative score that indicates how each facility weighs against the composite requirements in relation to the other facilities in the set. Author

N86-32505*# Boeing Aerospace Co., Kennedy Space Center, Fla.
ORBITAL TRANSFER VEHICLE LAUNCH OPERATIONS STUDY. PROCESSING FLOWS. VOLUME 3 Final Report
7 Mar. 1986 230 p
(Contract NAS10-11165)
(NASA-CR-179766; NAS 1.26:179766) Avail: NTIS HC A11/MF A01 CSCL 22D

The Orbit Transfer Vehicle (OTV) processing flow and Resource Identification Sheets (RISs) for the ground based orbit transfer vehicle and for the space based orbit transfer vehicle are the primary source of information for the rest of the Kennedy Space Center (KSC) OTV Launch Operations Study. Work is presented which identifies KSC facility requirements for the OTV Program, simplifies or automates either flow though the application technology, revises test practices and identifies crew sizes or skills used. These flows were used as the primary point of departure from current operations and practices. Analyses results were documented by revising the appropriate RIS page. B.G.

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LIFE SCIENCES/HUMAN FACTORS/SAFETY

Includes studies, models, planning, analyses and simulations for biological and medical laboratories, habitability issues for the performance and well-being of the crew, and crew rescue.

A86-30441*# Lockheed Missiles and Space Co., Sunnyvale, Calif.
CONSIDERATIONS IN THE DESIGN OF LIFE SCIENCES RESEARCH FACILITIES FOR THE SPACE STATION
M. HEINRICH and C. E. RUDIGER (Lockheed Missiles and Space Co., Inc., Bioastronautics Div., Sunnyvale, CA) (International Union of Physiological Sciences, Commission on Gravitational Physiology, Annual Meeting, 7th, Niagara Falls, NY, Oct. 13-18, 1985) Physiologist, Supplement (ISSN 0031-9376), vol. 28, Dec. 1985, p. S-161, S-162.
(Contract NAS5-20400)

The facilities required for life science research on a permanent Space Station are examined. Specifications important to the designing of facilities and planning of activities on the Space Shuttle are: (1) the species to be tested, (2) the number and procedure for testing, (3) the number of specimens at each sampling time, (4) the analyses required, (5) the methods of preserving samples, instruments, and supplies, and (6) the amount of crew time required. Experiments which are relevant to understanding the effects of microgravity on living systems are to be performed on the Space Station. The design and instruments of a Space Station laboratory and specimen centrifuge are described. I.F.

A86-30443#
VIVARIA REQUIREMENTS FOR ANIMAL LIFE CYCLE STUDIES ON SPACE STATION
R. C. MAINS (Mains Associates, Berkeley, CA) and J. R. ALBERTS (Star Enterprises, Bloomington, IN) (International Union of Physiological Sciences, Commission on Gravitational Physiology, Annual Meeting, 7th, Niagara Falls, NY, Oct. 13-18, 1985) Physiologist, Supplement (ISSN 0031-9376), vol. 28, Dec. 1985, p. S-165, S-166.

The application of animal vivaria to life cycle research is discussed. The requirements for the reproduction/growth, maintenance, and measurement of amphibians and rodents in space are described. The development of systems capable of reproduction and growth, and life support of animals is examined. I.F.

A86-30444*# Phytoresource Research, Inc., College Station, Tex.
TISSUE CULTURE APPARATUS FOR FLIGHT EXPERIMENTATION
H. W. SCHELD, J. W. MAGNUSON (PhytoResource Research, Inc., College Station, TX), and A. D. KRIKORIAN (New York, State University, Stony Brook) (International Union of Physiological Sciences, Commission on Gravitational Physiology, Annual Meeting, 7th, Niagara Falls, NY, Oct. 13-18, 1985) Physiologist, Supplement (ISSN 0031-9376), vol. 28, Dec. 1985, p. S-167, S-168.
(Contract NAS9-17292; NAS9-17291)

The development of an apparatus for in-flight treatment of cells, tissues, or small organisms for microscopic and chemical analyses is discussed. The hardware for the apparatus is to have: (1) automated functions, (2) the capability to interface with ground-based facilities, (3) independently controlled chambers, (4) variable chamber configurations and volumes, and (4) the capabilities for processing the materials. The components of the equipment used on Skylab 3 for the study of animal cells are described. The design of an apparatus which incorporates all the required capabilities is proposed. I.F.

A86-30449*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION LIFE SCIENCE RESEARCH FACILITY - THE VIVARIUM/LABORATORY
J. D. HILCHEY (NASA, Marshall Space Flight Center, Huntsville, AL) and R. D. ARNO (NASA, Ames Research Center, Moffett Field, CA) (International Union of Physiological Sciences, Commission on Gravitational Physiology, Annual Meeting, 7th, Niagara Falls, NY, Oct. 13-18, 1985) Physiologist, Supplement (ISSN 0031-9376), vol. 28, Dec. 1985, p. S-177, S-178.

Research opportunities possible with the Space Station are discussed. The objective of the research program will be study gravity relationships for animal and plant species. The equipment necessary for space experiments including vivarium facilities are described. The cost of the development of research facilities such as the vivarium/laboratory and a bioresearch centrifuge is examined. I.F.

A86-30451*# California Univ., Davis.
LIFE SCIENCE RESEARCH ON THE SPACE STATION
C. A. FULLER (California, University, Davis) (International Union of Physiological Sciences, Commission on Gravitational Physiology, Annual Meeting, 7th, Niagara Falls, NY, Oct. 13-18, 1985) Physiologist, Supplement (ISSN 0031-9376), vol. 28, Dec. 1985, p. S-181, S-182. refs
(Contract NAG2-349)

The requirements for studying the mechanisms of response and adaptation to the microgravity environment are examined. The necessary facilities, equipments, and technologies for the use of animals in space research are discussed. The application of a centrifuge to the analysis of the effects of microgravity on physiological adaptation is described. I.F.

A86-33813* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
HUMAN PRODUCTIVITY OF SPACE STATION
K. F. WILLSHIRE (NASA, Langley Research Center, Hampton, VA) IN: Human Factors Society, Annual Meeting, 29th, Baltimore, MD, September 29-October 3, 1985, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1985, p. 843-845.

The objectives of NASA's Space Station Human Productivity Program are examined. The design and functions of the Space Station are described. The effects of the interior architecture, crew support, crew activities, intravehicular activity (IVA) systems, and extravehicular/IVA interfaces on the productivity of the Space Station are investigated. It is estimated that crew productivity should be sustained for a 90-day tour at levels above 90 percent of the initial mission performance level. I.F.

A86-34980
SPACE STATION HUMAN PRODUCTIVITY STUDY
W. R. GONZALEZ (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 9-7 to 9-10.

A study which is to develop design and operation requirements that will maximize the productiveness of crew performance in space is described. The analysis procedures utilized in this study are examined. Space Station designs and operations that could affect crew performance include: interior architecture, crew support, crew activities, and IVA/EVA interface. The development of a data base and management plans for establishing requirements is discussed. I.F.

A86-35433* Boeing Aerospace Co., Seattle, Wash.
SPACE STATION CREW INTERFACE SPECIFICATIONS AND STANDARDS
C. W. GEER, K. H. MILLER (Boeing Aerospace Co., Seattle, WA), and J. L. LEWIS (NASA, Johnson Space Center, Houston, TX) IN: Aerospace Behavioral Engineering Technology Conference, 4th, Long Beach, CA, October 14-17, 1985, Proceedings . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 57-70.
(SAE PAPER 851801)

NASA's Space Station Human Productivity and Man/System Integration Standards programs are described. The data collection methodologies and analyses utilized in the productivity study are examined. The study reveals that attention to habitability is required in order to maximize human productivity for on-orbit operations. The nine program tasks used to develop standards for man/system integration are discussed. I.F.

A86-37037* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE HUMAN ROLE IN SPACE: TECHNOLOGY, ECONOMICS AND OPTIMIZATION
S. B. HALL, ED. (NASA, Marshall Space Flight Center, Huntsville, AL) Park Ridge, NJ, Noyes Publications, 1985, 398 p. No individual items are abstracted in this volume.

Man-machine interactions in space are explored in detail. The role and the degree of direct involvement of humans that will be required in future space missions are investigated. An attempt is made to establish valid criteria for allocating functional activities between humans and machines and to provide insight into the technological requirements, economics, and benefits of the human presence in space. Six basic categories of man-machine interactions are considered: manual, supported, augmented, teleoperated, supervised, and independent. Appendices are included which provide human capability data, project analyses, activity timeline profiles and data sheets for 37 generic activities, support equipment and human capabilities required in these activities, and cumulative costs as a function of activity for seven man-machine modes. C.D.

A86-41033#
SAFETY IN THE SPACE STATION
R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 26-29.

The task of assuring crew safety aboard the Space Station is examined, considering the recent change in the baseline configuration from the so-called 'power tower' to the 'double keel'. For the new baseline, the manned portion of the station is placed between the two main structural keels near the center of gravity. This reduces the influence of crew activity on station motion, which disturbs microgravity experiments and processing and earth and space observations. The base of the structure was freed for grouping Orbital Transfer Vehicle servicing hangars. The rearrangement improved safety by connecting the module ends by intermediate airlocks. Research on the two greatest threats to safety - onboard fire and a disabled environmental control and life-support system - is described. Zero-g combustion and means of dealing with it must be understood. 'Critical equipment in life-support systems must be designed', according to Hamilton Standard's Robert Breeding, 'to fail operational and then fail safe. Noncritical equipment . . . must be designed to fail safe'. Centralized life support functions must continue for 28 days after complete failure of the compartment in which they are housed. Repairs have to be easy because service calls from earth will take time. D.H.

A86-44326
SPACE SAFETY AND RESCUE 1984-1985
G. W. HEATH, ED. (SAR-assist, Inc., Greenwich, CT) San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 64), 1986, 400 p. For individual items see A86-44327 to A86-44333.

The present conference on spacecraft crew safety and rescue technologies and operations considers safety aspects of Space Shuttle ground processing, the Inmarsat and COSPAS/SARSAT emergency location satellite systems, emergency location and rescue communications using Geosat, the use of the Manned Maneuvering Unit for on-orbit rescue operations, NASA Space Station safety design and operational considerations, and the medico-legal implications of space station operation. Also discussed are the operational and environmental aspects of EPIRBS, mobile satellites for safety and disaster response, Inmarsat's role in the Future Global Maritime Distress and Safety System, and test results of the L-band satellite's EPIRB system. O.C.

A86-44330
SPACE STATION SAFETY DESIGN AND OPERATIONAL CONSIDERATIONS
R. E. BREEDING and P. G. TREMBLAY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) IN: Space safety and rescue 1984-1985 . San Diego, CA, Univelt, Inc., 1986, p. 207-218.

The Space Station is a closed and isolated environment. Emergency rescue of the crew with the Shuttle can take as long as 28 days following a request. This constraint increases the criticality of the inherent reliability and safety of the life support functions. This paper evaluates the impact of these two parameters on a typical space station life suppoort system. It assesses various approaches to enhancing the mission success probability through equipment redundancy and inflight maintenance; and discusses the safety considerations inherent in life support process equipment, the methods of analysis available to identify critical failure modes, and the approaches used to reduce their criticality. Author

A86-45424*# Columbia Univ., New York.
VIBRO-ACOUSTICS FOR SPACE STATION APPLICATIONS
R. VAICAITIS (Columbia University, New York) and D. A. BOFILIOS (San Diego University, CA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 10 p. refs
(Contract NAG1-541)
(AIAA PAPER 86-1937)

An analytical procedure has been developed to study noise generation in a double wall and single wall cylindrical shell due to mechanical point loads. The objective of this study is to develop theoretical procedures for parametetric evaluation of noise generation andd noise transmission for the habitability modules of the proposed Space Station operation. The solutions of the governing acoustic-structural equations are obtained utilizing modal decomposition. The numerical results include modal frequencies, deflection response spectral densities and interior noise sound pressure levels. Author

A86-45482*# Comtek, Grafton, Va.
A FEASIBILITY STUDY ON THE NUMERICAL MODELING OF INTERIOR NOISE FIELDS
A. L. ABRAHAMSON (COMTEK, Grafton, VA) and C. A. POWELL (NASA, Langley Research Center, Hampton, VA) AIAA, Aeroacoustics Conference, 10th, Seattle, WA, July 9-11, 1986. 11 p.
(AIAA PAPER 86-1862)

New developments in electronics and computer control have made active methods of noise suppression feasible. To date, however, active methods of noise control have been applied principally in geometrically uniform spaces with localized sound sources. The purpose of this paper is to demonstrate how finite element techniques may be used to model sound fields and active control inside geometrically complex spaces with non-uniform acoustic boundaries and multiple spatially separated sources. A closed-form solution is derived for the case of a one-dimensional tube with a vibrating piston at each end. Results are compared with finite element solutions and the problem is then generalized to two-dimensions with non-uniform geometry and non-uniform acoustic boundaries. Author

A86-46938#
AN UPDATED MODEL FOR A SPACE STATION HEALTH MAINTENANCE FACILITY
W. T. HARVEY, S. M. FARRELL, A. J. HOWARD, and F. C. PEARLMAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 7 p.
(AIAA PAPER 86-2303)

The Space Station Health Maintenance Facility (HMF) is required to provide 'critical care' capability for one crew-member for 28 days. The HMF must also provide routine monitoring and care for the Space Station crew for the duration of the mission. The equipment necessary to meet these requirements has been defined and an estimate of the physical characteristics of each piece of equipment has been completed. The equipment has been integrated into two Space Station standard outfitting packages, one which contains the laboratory and data management equipment and one which holds the critical care equipment and X-ray reader. The front panel configuration has been designed for optimum crew interface. The total system weight, volume and power requirements have been estimated at 1500 lbs, 140 cubic feet, and 0.5/2 kilowatts (routine/ critical care). The HMF Medical Data Management System hardware and architecture has been designed to complement the Space Station Data Management System. Author

A86-49560#
OPERATIONAL MEDICAL PLANNING FOR SPACE STATION
R. J. LUCIANI and E. PIERCE (Lovelace Medical Foundation, Albuquerque, NM) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 11 p.
(AIAA PAPER 86-2337)

The requirements for the Health Maintenance Facility of the Space Shuttle are examined using ground-based models. Data collected from the Antarctic station and Polaris submarines are studied with consideration given to habitability, human adaptation, and isolation. Remote rural clinics provide information on the incidence of clinical problems, and equipment and training for the care of the illness. The specific space-related difficulties of radiation, bends, hypoxia, nephrolithiasis, muscle and cardiovascular deconditioning, skeletal calcium loss, and propellant toxic hazards are considered in terms of screening, diagnosis, and therapy. I.F.

A86-50265*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION IN THE 21ST CENTURY - A SOCIAL PERSPECTIVE
B. J. BLUTH (NASA, Space Station Program Office, Washington, DC) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 9 p. refs
(AIAA PAPER 86-2349)

A human factors and sociological consideration of Space Station crew facilities and interactions is presented which attempts to place the experiences of astronaut communities in the larger context of late 20th century industrial, economic, and cultural trends. Attention is given to the relationship of Space Station communities to 'Information Society' - related historical developments. O.C.

N86-24736*# National Aeronautics and Space Administration, Washington, D.C.
SPACECRAFT ARCHITECTURE
V. V. ZEFELD Mar. 1986 9 p refs Transl. into ENGLISH from Arkhitektura Kosmicheskikh Obyektov (Moscow, USSR), Nauka, 1977 p 187-191 Original language doc. was announced in IAA as A78-13592 Transl. by SCITRAN, Inc., Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77908; NAS 1.15:77908) Avail: NTIS HC A02/MF A01 CSCL 22B

Three requirements for a spacecraft interior are considered. Adequate motor activity in the anatomical-physiological sense results from attention to the anthropometric characteristics of humans. Analysis of work requirements is a prerequisite for the planning of adequate performance space. The requirements for cognitive activity are also elucidated. The importance of a well-designed interior during a long space flight is discussed. Author

N86-24741# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A PROPOSED DESIGN FOR AN INTERIM SPACE RESCUE FERRY VEHICLE M.S. Thesis
J. D. HALSELL, JR. Dec. 1985 211 p refs
(AD-A164039; AFIT/GSO/ENY/85D-2) Avail: NTIS HC A10/MF A01 CSCL 22B

This investigation proposed a method of connecting the Personnel Rescue Enclosure to the Manned Maneuvering Unit using a modified flight-qualified hardware item the Apogee Kick Motor Capture Device. The resulting configuration is an immediately available but non-optimum vehicle for transferring stranded astronauts housed within Personnel Rescue Enclosures from a rotating stranded spacecraft to a nearby rescue spacecraft. The flying qualities of this Interim Rescue Vehicle (IRV) were simulated using an existing NASA spaceflight simulation computer program. The results showed that the Manned Maneuvering Unit's control system was capable of limiting uncommanded IRV rotations to within the control law deadbands during all simulated maneuvers and in all control modes except during transverse translations in

the backup control mode. The IRV's increased mass and increased center-of-mass/center-of-thrust offset significantly degraded acceleration capability and specific propellant consumption. Plume impingement however was found to be of minor importance. The satellite stabilization mode was found to have significant rotational-to-translational coupling which made it undesirable for IRV use. Finally procedures were outlined for using the IRV in an orbiter-to-orbiter rescue scenario. Author (GRA)

N86-25118# Air Force Academy, Colo.
BEHAVIORAL CONSIDERATIONS FOR SPACE STATION DESIGN Final Report, Oct. 1984 - Dec. 1985
F. R. WOOD and K. O. DUNIVIN Jan. 1986 69 p refs
(AD-A163478; USAFA-TR-86-3) Avail: NTIS HC A04/MF A01 CSCL 05J

Flight crews are more than just the sum of the members' individual technical skills. They are dynamic and constantly changing systems of interacting units. The critical factor in this system is the interaction process. Factors which affect this interaction process are design considerations critical to the successful operation of the human system in space. Future space missions will be longer and will involve more routine tasks. Crews will be larger and more heterogeneous. These conditions make proper consideration of group dynamics principles imperative. Formal design of future space missions should consider critical design factors which promote the group process. The real change to current NASA mission design suggested by this report is that greater consideration be given to the informal processes characteristic of the human system. Consideration of these factors will pay large dividends in terms of human system performance and neglect of these factors will incur costs. GRA

N86-28982*# California Univ., Davis. Dept. of Psychology.
IMPLICATIONS OF PRIVACY NEEDS AND INTERPERSONAL DISTANCING MECHANISMS FOR SPACE STATION DESIGN Final Report, 1 Jun. - 31 Dec. 1985
A. A. HARRISON, R. SOMMER, N. STRUTHERS, and K. HOYT 3 Jan. 1986 51 p
(Contract NAG2-357)
(NASA-CR-177097; NAS 1.26:177097) Avail: NTIS HC A04/MF A01 CSCL 22B

The literature on privacy needs, personal space, interpersonal distancing, and crowding is reveiwed with special reference to spaceflight and spaceflight analogous conditions. A quantitative model is proposed for understanding privacy, interpersonal distancing, and performance. The implications for space station design is described. Author

N86-29495*# Stanford Univ., Calif. Div. of Cardiology.
EFFECTS OF SIMULATED WEIGHTLESSNESS ON REGIONAL BLOOD FLOW SPECIFICALLY DURING CARDIOVASCULAR STRESS Final Report
D. C. HARRISON 1986 15 p
(Contract NCC2-126)
(NASA-CR-177117; NAS 1.26:177117) Avail: NTIS HC A02/MF A01 CSCL 06S

Significant changes in the cardiovasular system of humans and animals have been observed following exposure to prolonged periods of weightlessness during space flight. Although adaption to weightlessness is relatively uncomplicated, marked changes in cardiovascular deconditioning become evident upon return to normal gravity, including orthostatic hypotension and tachycardia. Some evidence that myocardial degeneration occurs has been demonstrated in animals who have been immobilized for two months. Also, evidence of possible loss of myocardial mass following manned space flight has been obtained by means of echocardiographic studies. These findings have serious implications in light of the increasing frequency and duration of Space Shuttle missions and the prospect of extended space station missions in the future. A number of both military and civilian investigators, including middle-aged scientists, will probably encounter prolonged periods of weightlessness. It has been imperative, therefore, to determine the effects of prolonged weightlessness on cardiovascular deconditioning and whether such effects are cumulative or reversible. The research project conducted under NASA Cooperative Agreement NCC 2-126 was undertaken to determine the effects of prolonged simulated weightlessness on regional blood flow. Research results are reported in the three appended publications. Author

N86-29879*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
AEROSPACE SAFETY ADVISORY PANEL REPORT TO THE NASA ACTING ADMINISTRATOR Annual Report, Calendar Year 1985
Jan. 1986 118 p The Panel's annual report, findings and recommendations were completed prior to the STS-51L accident
(NASA-TM-89226; NAS 1.15:89226) Avail: NTIS HC A06/MF A01 CSCL 22B

The level of activity of the Aerospace Safety Advisory Panel was increased smewhat during 1985 in concert with the increased mission rate of the National Space Transportation System, the evolutionary changes in management and operation of that program, and the preparation of the Vandenberg Launch Site; the implementation of the Program Definition Phase of the Space Station Program; and the actual flight testing of the X-29 research aircraft. Impending payload STS missions and NASA's overall aircraft operations are reviewed. The safety aspects of the LEASAT salvage mission were assessed. The findings and recommendation of the committee are summerized. Author

N86-30338*# California Univ., Davis. Dept. of Psychology.
IMPLICATIONS OF PRIVACY NEEDS AND INTERPERSONAL DISTANCING MECHANISMS FOR SPACE STATION DESIGN Progress Report, Jul. - Aug. 1985
A. A. HARRISON, R. SOMMER, N. STRUTHERS, and K. HOYT 30 Aug. 1985 26 p
(Contract NAG2-357)
(NASA-CR-176938; NAS 1.26:176938) Avail: NTIS HC A03/MF A01 CSCL 05H

Privacy needs, or the need of people to regulate their degree of contact with one another, and interpersonal distancing mechanisms, which serve to satisfy these needs, are common in all cultures. Isolation, confinement, and other conditions accociated with space flight may at once accentuate privacy needs and limit the availability of certain common interpersonal contact. Loneliness occurs when people have less contact with one another than they desire. Crowding occurs when people have more contact with one another than they desire. Crowding, which is considered the greater threat to members of isolated and confined groups, can contribute to stress, a low quality of life, and poor performance. Drawing on the general literature on privacy, personal space, and interpersonal distancing, and on specialized literature on life aboard spacecraft and in spacecraft-analogous environments, a quantitative model for understanding privacy, interpersonal distancing, loneliness, and crowding was developed and the practical implications of this model for space station design were traced. Author

N86-31431*# Texas Univ., Houston. Dept. of Environmental Sciences.
CYTOGENETIC ANALYSES OF PERIPHERAL LYMPHOCYTES SUBJECTED TO SIMULATED SOLAR FLARE RADIATION
H. M. PRICHARD *In* NASA. Johnson Space Center NASA/American Society for Engineering Education (ASEE) Summer Faculty Fellowship Program, 1985 9 p Jul. 1986
Avail: NTIS HC A99/MF E03 CSCL 06R

Solar flare protons share many radiological health characteristics of the inner Van Allen Belt protons, and both types of radiation pose serious dangers to a number of missions planned. It is appropriate to evaluate crew dose determination procedures in terms of the type of radiation responsible for the major part of the projected exposure, i.e., protons in the neighborhood of 100 MeV. Monitoring chromosome abnormalities in peripheral lymphocytes is one method to determine an individual's accumulated radiation dosage. Cell culture and harvest is a

relatively simple procedure and is well within the capabilities of a station health facility, but the evaluation of prepared microscopic slides is a time consuming and subjective procedure. This project is part of an effort to demonstrate the utility of automated image processing and evaluation procedures in expediting dose evaluation. The initial goal of this project is to produce a set of reference chromosome spreads produced from control lymphocytes and from lymphocytes exposed in whole blood to protons or gamma rays. The results of manual and automated aberration scoring will ultimately be compared to test for systematic differences between the two evaluation procedures and between the two radiation qualities. Proton irradiations are performed at the University of Texas Health Science Center at Houston Cyclotron Facility. Proton dosimetry is supplemented by TLD packets from and by assay of short-lived proton activation products in the irradiation blood samples. Author

N86-33210*# Washington Univ., Seattle. Coll. of Architecture and Urban Planning.
THE QUANTITATIVE MODELLING OF HUMAN SPATIAL HABITABILITY Final Report, Feb. - Dec. 1985
J. A. WISE 1985 154 p
(Contract NAG2-346)
(NASA-CR-179716; NAS 1.26:179716) Avail: NTIS HC A08/MF A01 CSCL 05K

A model for the quantitative assessment of human spatial habitability is presented in the space station context. The visual aspect assesses how interior spaces appear to the inhabitants. This aspect concerns criteria such as sensed spaciousness and the affective (emotional) connotations of settings' appearances. The kinesthetic aspect evaluates the available space in terms of its suitability to accommodate human movement patterns, as well as the postural and anthrometric changes due to microgravity. Finally, social logic concerns how the volume and geometry of available space either affirms or contravenes established social and organizational expectations for spatial arrangements. Here, the criteria include privacy, status, social power, and proxemics (the uses of space as a medium of social communication). B.G.

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GENERAL

Includes descriptions, analyses, trade studies, commercial opportunities, published proceedings, seminars, hearings, historical summaries, policy speeches and statements that have not previously been included.

A86-30122
MISSION AND OPERATIONS MODES FOR LUNAR BASING
G. R. WOODCOCK (Boeing Aerospace Co., Huntsville, AL) IN: Lunar bases and space activities of the 21st century . Houston, TX, Lunar and Planetary Institute, 1985, p. 111-124.

Future lunar operations may be directed to permanent or long-term presence on the moon and supported by a Space Station as an intermodal transportation complex. Flight mechanics constraints on station-supported lunar operations are described and analyzed, and the implications for the Space Station are presented. Mission modes supportable by the NSTS and its derivatives, and by the Space Station, are described and compared. Sensitivities of the modes and their uses for lunar operations are described. Author

A86-31259
SECTAM XII - PROCEEDINGS OF THE TWELFTH SOUTHEASTERN CONFERENCE ON THEORETICAL AND APPLIED MECHANICS, PINE MOUNTAIN, GA, MAY 10, 11, 1984. VOLUME 2
Auburn, AL, Auburn University, 1984, 586 p. No individual items are abstracted in this volume.

Subjects in the area of fluid mechanics are discussed, taking into account heat-up flows of a contained fluid, an analytical solution for natural convection in a vertical oriented porous annulus, the Weissenberg effect generated by a torsionally oscillating rod in a layered medium, a system analysis for a model of bluff body base flow, steady solutions of the shallow water equations, and the subsonic near-wake of an axisymmetric body with a slanted base. Computational methods are considered along with structural vibrations, structural stability, experimental methods, coastal hydrodynamics, dynamical systems, large space structural systems, the hydraulics of sediment transport, localization of deformation, wave propagation, vibrations of plates and shells, composite materials, and design studies. Attention is given to damage tolerance studies in operational aircraft, design verification testing of advanced prototype structures, continuous filament wound grid stiffened composite structures for aircraft fuselages, and Navier-Stokes solutions for two-dimensional subsonic base flow. G.R.

A86-31260
CONFERENCE ON DECISION AND CONTROL, 23RD, LAS VEGAS, NV, DECEMBER 12-14, 1984, PROCEEDINGS. VOLUME 1
Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1984, 688 p. No individual items are abstracted in this volume.

Various papers on decision and control in engineering are presented. The general topics addressed include: estimation and filtering, stochastic adaptive control nonlinear systems, model order reduction, new approaches to stability problems of electric power systems, reliable/robust control and some applications to large-space structures, production planning and control of manufacturing systems, control systems governed by nonlinear partial differential equations, generalized state-space systems, and frequency-domain design of multivariable control systems. Also discussed are: identification, implementation issues and applications of adaptive control, analysis and synthesis of nonlinear input-output responses, signal processing, voltage VAR modeling and control for power systems, optimal control and filtering algorithms, analysis of queueing networks and related systems, control of distributed parameter systems, computer-aided technology, control of linear systems, and failure detection and fault-tolerant systems. C.D.

A86-31776
GUIDANCE AND CONTROL 1985; PROCEEDINGS OF THE EIGHTH ANNUAL ROCKY MOUNTAIN CONFERENCE, KEYSTONE, CO, FEBRUARY 2-6, 1985
R. D. CULP, ED. (Colorado, University, Boulder), E. J. BAUMAN, ED. (Colorado, University, Colorado Springs), and C. A. CULLIAN, ED. (Ball Corp., Ball Aerospace Systems Div., Boulder, CO) Conference sponsored by AAS. San Diego, CA, Univelt, Inc. , 1985, 616 p. For individual items see A86-31777 to A86-31808.

Consideration is given to the history of classical control theory and the current guidance and control theory taught at universities. Papers are presented on payload isolation, precision pointing spacecraft experiments, the evaluation of spacecraft disturbances, the performance of a laser communications pointing and tracking system, and the hardware and working models of control-related components and subsystems. Topics discussed include spacecraft attitude control, new guidance, navigation and control components, space repair mission activities, and on-orbit control systems. I.F.

A86-32526
EASCON '85: NATIONAL SPACE STRATEGY - A PROGRESS REPORT; PROCEEDINGS OF THE EIGHTEENTH ANNUAL ELECTRONICS AND AEROSPACE SYSTEMS CONFERENCE, WASHINGTON, DC, OCTOBER 28-30, 1985
Conference sponsored by IEEE, Boeing Electronics, Inc., General Electric Co., et al. New York, Institute of Electrical and Electronics Engineers, Inc., 1985, 387 p. For individual items see A86-32527 to A86-32566.

Aspects of the Space Transportation System technology are discussed, taking into account a review of high payoff technologies, structures and materials technology issues for reusable launch vehicles, advanced rocket propulsion system technology required to reduce LEO payload costs, advanced airbreathing propulsion as an enabling key to affordable aerospace transportation, a hypersonic aerothermodynamics status report, avionics and automation, and strategies to minimize Delta V costs of extraterrestrial resources. Other subjects studied are related to the Space Transportation System policy/programs, civil space program technology, civil space program policy, the common space support program, and the control of unclassified technology with military and space applications. Topics concerning the commercial space program are considered, giving attention to processing and services, policy, and boosters and transfer vehicles. G.R.

A86-32543*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION ADVANCED DEVELOPMENT PROGRAM
R. F. CARLISLE (NASA, Office of Space Station, Washington, DC) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 183-191.

The Space Station Advanced Development Program has the objective to transform promising new techniques into mature proven concepts to enable design options for the initial Space Station. It is pointed out that the options should improve system performance and reduce operational costs. Attention is given to the approach employed in the implementation of the program, the technology issues, aspects of Space Station evolution and growth, a Space Station technology overview, and subsystem technologies. The Advanced Development Power Program is considered along with the advanced development of auxiliary propulsion, the program dealing with attitude control and stabilization, and developments related to data management. Other developments are concerned with communication, system operation, manned systems technology, structures, and environmental control and life support. G.R.

A86-32548*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
MARS MISSIONS AND BASES - A RECENT LOOK
J. M. BUTLER, JR. (NASA, Marshall Space Flight Center, Huntsville, AL) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 211-222. refs

This paper discusses some of the key options for Mars programs, missions, bases, elements, and systems. Program and mission options include Mars flyby, orbiting, and landing missions; they include near-term 'sortie' missions, and later, longer-duration Mars-base missions. Key program and mission parameters include the mix of manned/unmanned elements, the number and types of space vehicles used, types of science done, trajectory options and implications launch timing and schedules, etc. The key mission parameters strongly affect the nature, sizing, and quantity of earth-to-orbit (ETO) vehicles. On-orbit assembly of space vehicles (SVs) is also an important related consideration. The potential degree of utilization of the Space Station (SS) and other then-existing elements is a key question, and several possibilities are discussed in this paper. Several configurations of SVs are provided. Several options are identified for the Mars base infra-structure, and parametric data is shown for buildup of bases as a function of mission and vehicle type. Technologies required for the missions are also discussed. Author

A86-32553
ENVIRONMENTAL CRITERIA GUIDELINES FOR SPACE VEHICLE AND SPACE DESIGN
R. E. TURNER and W. FROST (FWG Associates, Inc., Tullahoma, TN) IN: EASCON '85: National space strategy - A progress report; Proceedings of the Eighteenth Annual Electronics and Aerospace Systems Conference, Washington, DC, October 28-30, 1985 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 273-279.

The natural environment plays an important role in the design of space vehicles and systems to ensure the operational capabilities are met in an efficient and economical manner. It is necessary that the criteria be specified to agree with the operational requirements for the system under development. This paper discusses the philosophy used in the development of natural environment criteria and describes the two major criteria guidelines documents prepared to support the criteria development activities. Author

A86-32904
MAN'S PERMANENT PRESENCE IN SPACE; PROCEEDINGS OF THE THIRD ANNUAL AEROSPACE TECHNOLOGY SYMPOSIUM, UNIVERSITY OF NEW ORLEANS, LA, NOVEMBER 7, 8, 1985
Symposium sponsored by AIAA. New Orleans, LA, American Institute of Aeronautics and Astronautics, 1985, 813 p. For individual items see A86-32905 to A86-32934.

Papers are presented on the need, and capabilities of the Space Station, managing fluids in space, propellant supply for space operations, and the effect of the space environment on spacecraft materials. Topics discussed include docking concepts, a launch system, the designs and planning of a lunar base/lunar city, space applications of composite structures, and the fabrication of composite tooling. Consideration is given to FAA air traffic control program management technology applications, the application of thermal analysis to polyurethane prepolymeric materials, surface sensitive techniques for the analysis of ET polymers, nondestructive measurements of residual stress, integrated logistics support, and mobile gantry robots for large structures. I.F.

A86-33226
INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS, 2ND, RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE, AACHEN, WEST GERMANY, APRIL 1-3, 1985, COLLECTED PAPERS
Symposium organized by DGLR; Supported by BMFT. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, 713 p. For individual items see A86-33227 to A86-33261, A86-33263 to A86-33291.
(DGLR BERICHT 85-02)

The present conference considers topics in the unsteady aerodynamics and aeroelastic characteristics of aircraft structures, active structural control technologies, structural modeling and optimization methods, structural system identification, and the structural dynamics design verification of space structures. Specific attention is given to the transonic equivalent strip method for aeroelastic applications, transonic unsteady methods for the calculation of flutter airloads, experimental and analytical buffeting investigations of a delta wing, the application of unsteady wing collocation methods to subsonic flow cascades, a static aeroelastic analysis employing aircraft vibration modes, and a general theory for the finite state modeling of aeroelastic systems for active control applications. Also discussed are the use of control law synthesis for gust load alleviation using linear quadratic Gaussian theory, the stiffness control of large space structures, the variation of isotropic behavior in structural optimization, the dynamic analysis of structures with flexible rotors, modal parameter estimation from driven-base tests, rapid vibration mode analysis of aircraft with

external stores, and low frequency design verification of large spacecraft structures. O.C.

A86-34110
U.S. OPPORTUNITIES IN SPACE CONFERENCE; PROCEEDINGS OF THE SECOND ANNUAL SPACE BUSINESS CONFERENCE, WASHINGTON, DC, OCTOBER 30-NOVEMBER 1, 1985
Conference organized by Space Consultants International, Ltd. London, Space Consultants International, Ltd., 1985, 264 p. For individual items see A86-34111 to A86-34123.

Papers are presented on the capabilities and commercial opportunities for materials processings in space, remote sensing systems, and the application of space technologies to terrestrial projects. Topics discussed include the privatization of Expendable Launch Vehicles and the legal issues related to commercialization. Consideration is given to the Leasecraft system, 'Canadarm', and the Space Station. I.F.

A86-34113#
OPPORTUNITIES FOR SPACE SERVICE BUSINESS
P. E. GLASER (Arthur D. Little, Inc., Cambridge, MA) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 17 p.

The development of space industrial infrastructure is discussed. The services required for the evolution of space infrastructure include: (1) earth-based support, (2) on-orbit facilites, (3) satelliites, (4) power supplies, (5) life support, (6) propellants, (7) medical care, and (8) trained personnel. Technologies that are applicable to the development of these services are examined. The economic benefits of space services are studied. The roles of the government, institutions, such as NASA, and private industry in the formation of space services are described. I.F.

A86-34114*# Teledyne Brown Engineering, Huntsville, Ala.
FUTURE CAPABILITIES AND COMMERCIAL OPPORTUNITIES FOR MATERIALS PROCESSING IN SPACE
D. M. HAMMOCK (Teledyne Brown Engineering, Huntsville, AL) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 24 p. refs
(Contract NAS8-36122)

The development of the Space Station and its application to materials processing are studied. The proposed components and capabilities of the Space Station are described. The advantages the modular Space Station configuration will provide to its users are discussed. The functions of the laboratory module and free flying platforms of the Microgravity and Materials Processing Facility (MMPF) are examined; microgravity science research and the development of commercial materials processing technologies are conducted in the MMPF. The equipment of the Commercial Materials Processing Support Facility and the designs of attached- and free-flying platforms are analyzed. I.F.

A86-34117#
THE CHALLENGE OF EMERGING TECHNOLOGIES
P. W. WOOD (Booz, Allen and Hamilton, Inc., Bethesda, MD) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 21 p.

Technological developments required to increase the commercialization of space are discussed. The need for continuing research in space materials processing and its application to terrestrial processing are examined. Advances in automation, robotics, and intelligent systems, which relate to the development of the Space Station, are described. Research in human physiology, life support, data transmission and storage, and reducing transportation costs is required in order to commercialize space. The social benefits that are possible with continued space research are studied. I.F.

A86-34121#
ADJUSTING LEGAL REGIMES TO NEW COMMERCIAL REALITIES
D. J. BURNETT (Benner, Burnett and Coleman, Washington, DC) IN: U.S. Opportunities in Space Conference; Proceedings of the Second Annual Space Business Conference, Washington, DC, October 30-November 1, 1985 . London, Space Consultants International, Ltd., 1985, 19 p.

Legal issues regarding multinational commercial space activities are discussed. The formation of international laws or agreements concerning financial and technical support for multinational space activities, the intellectual property rights for technologies developed as part of a multinational space project, and the protection of national security and state sovereignty is examined. The intergovernmental agreements need to be multilateral and issued from the highest government official. I.F.

A86-34594* National Aeronautics and Space Administration, Washington, D.C.
NASA SPACE PLANS AND SCENARIOS TO 2000 AND BEYOND
Park Ridge, NJ, Noyes Publications, 1986, 252 p.

NASA's research and development plans, as reflected in its missions, goals, and objectives to the year 2000 and beyond, are presented. New starts for the next decade and space program activities are highlighted, including space science and applications, space flight, space stations, space tracking and data systems, and space research and technology. Space programs for the 21st century are also covered. C.D.

A86-34951
SPACE AND SOCIETY - PROGRESS AND PROMISE; PROCEEDINGS OF THE TWENTY-SECOND SPACE CONGRESS, COCOA BEACH, FL, APRIL 23-26, 1985
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, 411 p. For individual items see A86-34952 to A86-34989.

A collection of papers is presented which examines improvements in space systems operations, new initiatives in the procurement process for space technology, and technological developments supporting future initiatives. The reporting of mission results and plans for the future by worldwide sources is addressed. The general topics covered include: operational efficiency in STS, remote operation in space and robotics, contracting and management, space systems technology, Spacelab mission results, advanced missions and transportation, Space Station technology, international programs, productivity in space activities, Getaway spacial program, and energy. C.D.

A86-34962* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INITIATION OF THE NEXT STEP - THE ACQUISITION OF A SPACE STATION PROGRAM
T. G. MANCUSO (NASA, Johnson Space Center, Houston, TX) IN: Space and society - Progress and promise; Proceedings of the Twenty-second Space Congress, Cocoa Beach, FL, April 23-26, 1985 . Cape Canaveral, FL, Canaveral Council of Technical Societies, 1985, p. 3-1 to 3-4.

Attention is given to NASA's Space Station Program acquisition strategy, as well as the internal implementation of the strategy and the nature of NASA's relations with industry. While the acquisition strategy addresses phased procurement, design-to-cost, and advanced development emphasis, internal implementation concerns itself with 'skunk works' activities and the exploitation of the Technical and Management Information System. NASA's relationship to contractors will stress competition, extensive commercial and international involvement, and design/development phase competition flexibility. O.C.

A86-35216
SPACE STATION DESIGN-TO-COST - A MASSIVE ENGINEERING CHALLENGE
M. C. SIMON (General Dynamics Corp., Space Systems Div., San Diego, CA) Society of Allied Weight Engineers, Annual Conference, 44th, Arlington, TX, May 20-22, 1985. 11 p. refs
(SAWE PAPER 1673)

The Space Station, NASA's first major test of design-to-cost concepts, must include: (1) pressurized modules with habitat provisions for six crewpersons as well as space for laboratory and logistics functions; (2) a power system capable of generating 75 kilowatts of continuous power; and (3) unmanned platforms for conducting experiments that cannot be accommodated on the core facility. Beyond the implementation of these basic necessities, NASA and its contractors must adhere to a rigorous design-to-cost approach to SS design, development and production. Ultimately, size, shape and function of the SS will be determined by cost more than any single evaluation criterion. K.K.

A86-35426
AEROSPACE BEHAVIORAL ENGINEERING TECHNOLOGY CONFERENCE, 4TH, LONG BEACH, CA, OCTOBER 14-17, 1985, PROCEEDINGS
Conference sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc., 1985, 444 p. For individual items see A86-35427 to A86-35458.
(SAE P-168)

Papers are presented on assessing human fitness and performance; the use of simulation as a cockpit design tool; the man-machine interface; the Space Station; and human performance. Consideration is given to advanced transport aircraft technology; operator workload analysis; rotorcraft missions; the pilot in the operational loop; and flight crew training. Topics also discussed include cockpit communications; color displays; commercial air transport and general aviation operations; and space and military operations. I.F.

A86-37051*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION TECHNOLOGY EXPERIMENTS AND USES
R. A. BRECKENRIDGE and R. A. RUSSELL (NASA, Langley Research Center, Hampton, VA) American Vacuum Society, National Symposium, 32nd, Houston, TX, Nov. 18-22, 1985, Paper. 33 p. refs

With the advent of the Space Station will come significant opportunities to perform experiments in the near-earth space environment. It is anticipation that the Space Station will be an in-space facility where long duration missions can be conducted. A large number of experiments are expected to b e performed in science and applications, technology, and commercial ventures. NASA is working very actively to establish the experimental requirements from each experiment category. This paper addresses the in-space technology experiments and uses of the Space Station as presently envisioned for this next step in space. Author

A86-37176
AEROSPACE SIMULATION II; PROCEEDINGS OF THE SECOND CONFERENCE, SAN DIEGO, CA, JANUARY 23-25, 1986
M. UNG, ED. (Southern California, University, Los Angeles, CA) San Diego, CA, Society for Computer Simulation (Simulation Series. Volume 16, No. 2, 1986), 1986, 304 p. For individual items see A86-37177 to A86-37195.

Papers are presented on techniques for optimizing computer performance in real-time flight simulation; the effects of simulator variation on the fidelity of a UH-60 Black Hawk simulation; a real-time simulation for helicopter rotor wind-tunnel operations; simulation support software in a real-time environment; simulation of auto-rendezvous and docking; a generic missile weapon system model for war-gaming; and the optimal missile nonlinear multiloop controller design principle. Topics discussed include the modeling of a tethered two-body system in space; the testing of a spacecraft attitude control system; Space Station dynamic modeling; interactive mission planning for a Space Shuttle flight experiment; hybrid simulation of ejection seat dynamics, adaptive autoregressive target modes' identification; and optimal control of air-launched homing missiles using realistic performance indices. Consideration is given to flow separation and dynamic stall research, transonic trailing edge flow, fluid dynamics, man/machine interface, computer generated image time delays, the simulation of a satellite attitude control system, and the application of flight simulators to the development of advanced fighter flight control. I.F.

A86-37852
INTERNATIONAL CONFERENCE ON SPACE, 25TH, ROME, ITALY, MARCH 26-28, 1985, PROCEEDINGS [CONVEGNO INTERNAZIONALE SULLO SPAZIO, 25TH, ROME, ITALY, MARCH 26-28, 1985, ATTI]
Conference sponsored by the Ministero per il Coordinamento delle Iniziative per la Ricerca Scientifica e Tecnologica, Ministero degli Affari Esteri, FAO, and ESA. Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, 487 p. In Italian and English. For individual items see A86-37853 to A86-37881.

Various papers are presented on space station missions and programs, utilization, configuration, subsystems, services, as well as miscellaneous topics concerning space stations. Individual subjects addressed include: the U.S. Space Station program, European participation in international space stations, the views of the U.S. scientific community on the Space Station, prospects for the life sciences and microgravitational experiments in the Space Station, data and communications infrastructure for the Space Station, polar platforms, and the Ariane 5 space transportation system. Also discussed are: attitude stability of a class of tethered space stations, large space structural models combining finite elements and transfer matrix methods, inflatable technology in orbit demonstration, design of the ESA thematic mapper processing chains, and an energy balance study by satellite imagery. Several papers are also presented on the Italian Space Agency and on the Italian-Chinese SIRIO program. C.D.

A86-37853*# National Aeronautics and Space Administration, Washington, D.C.
THE U.S. SPACE STATION PROGRAM
P. E. CULBERTSON (NASA, Office of Space Station, Washington, DC) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 11-22.

An overview is given of the U.S. Space Station program, beginning with President Reagan's directive to NASA 'to develop a permanently manned Space Station and to do it within a decade'. The international aspects of the project are emphasized, and fruitful cooperation between Italy and the U.S. in past and present space research is noted. The Station is to serve diverse functions, including that of a laboratory in space, a permanent observatory, a servicing facility, a transportation node, and assembly and manufacturing facility, a storage depot, and a staging base for future endeavors. Management-related and engineering-related guidelines are laid out. The plan is to make the Space Station a legacy from this century to the next, with the help of and to the benefit of all who share our goals. D.H.

A86-37868*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION UTILIZATION
W. P. RANEY (NASA, Office of Space Station, Washington, DC) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 251-256.

The essential requirement of the Space Station that the customer be continually involved in all aspects of the program is considered. Potential users of the Space Station need both formal and informal channels into the program at an early stage of the definition process to secure their influence and participation in the development process. Only with this participation can users' needs and requirements be integrated into the design phase to produce 'user friendliness' in the Space Station. A Space Station that is easy and economical to use will generate more users that can

take advantage of the available resources. The Space Station must be: a research facility; a satellite servicing and assembly facility; an observatory for terrestrial, solar, and astronomical viewing; and a transportation node for orbit transfer vehicles. NASA intends to see that the Space Station is developed and operated so as to serve its users. D.H.

A86-37869#
UNITED STATES SCIENTIFIC COMMUNITY VIEWS OF THE SPACE STATION
B. LICHTENBERG (Payload Systems, Inc., Wellesley, MA) IN: International Conference on Space, 25th, Rome, Italy, March 26-28, 1985, Proceedings . Rome, Rassegna Internazionale Elettronica Nucleare ed Aerospaziale, 1985, p. 257-264.

Results are presented from a summer (1983) study conducted by the Task Force on the Scientific Uses of the Space Station. The charter of the committee is: (1) to assist NASA in planning for the scientific utility of the space station; (2) to assist NASA in understanding the relationship between the existing and new parts of the space program; (3) to periodically update scientific requirements on Space Station hardware and operations; and (4) to act as a focal point for the U.S. science community and to interact as needed with contractors during the definition phase of the program. Science discipline teams included: astronomy and astrophysics; solar system exploration and planetary science; solar-terrestrial processes; earth observations; life sciences; microgravity sciences and applications; and physics and chemistry in space. Major concerns are flexibility, adequate resources, and easy access. Strong emphasis was put on a continuing Shuttle experiment program, including a request for additional power resources to enable the Shuttle to remain in orbit for up to 15 days. D.H.

A86-38051
INTERNATIONAL INSTRUMENTATION SYMPOSIUM, 31ST, SAN DIEGO, CA, MAY 6-9, 1985, PROCEEDINGS
Symposium sponsored by ISA. Research Triangle Park, NC, Instrumentation Society of America (Instrumentation in the Aerospace Industry. Volume 31; Advances in Test Measurement. Volume 22), 1985, 808 p. For individual items see A86-38052 to A86-38084.

Consideration is given to techniques for measuring pressure, temperature, and solid mechanics, blast and shock instrumentation, flow measurements, measurement errors, and uncertainty analyses. Topics discussed include the applications of mini/microcomputers, data acquisition, processing, and analysis techniques and systems, and real-time control and display systems. Papers are presented on weighing instruments for space, special test facilities and data reduction procedures, flow applications, and wind tunnel instrumentation and control. Emphasis is given to the study of electrooptic and fiber optic instrumentation, NDT and acoustic emissions, software development for instrumentation, and science policies and the role of the government concerning scientific developments. I.F.

A86-38100
PIONEERING THE SPACE FRONTIER
New York, Bantam Books, 1986, 221 p. No individual items are abstracted in this volume.

The goals and plans of the program for exploration and development of the space frontier recommended by the National Commission on Space for the next 50 years are described. The topics discussed include civilian space goals for 21st-century America, low-cost access to the solar system, opening the space frontier, and American leadership on the space frontier. Papers are presented on advancing science; exploring, prospecting, and settling the solar system; space enterprise and building the technology base; and on an economical, phased approach. In addition, consideration is given to the aspects of conducting an effective science program, government policy and the private sector, international cooperation and competition, 21st-century America, and to what the recommended program will do. I.S.

A86-38540
STRUCTURAL DYNAMIC TESTING AND ANALYSIS; AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985, TECHNICAL PAPERS
Conference and Exposition sponsored by SAE. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-635), 1986, 115 p. For individual items see A86-38541 to A86-38548.
(SAE SP-635)

Papers are presented on a normal mode identification test using multiple inputs; a global technique for estimation of modal parameters from measured data; and a comparison of experimental and analytical structural dynamics using a modal assurance criterion. Topics discussed include the design of an optimal seismic isolation system; modal randomness induced by boundary conditions; and eigenvector relations for natural vibrations of damped systems. Consideration is given to the constrained adjustment of analytical stiffness matrices; the multiple boundary condition test; smoothing errors in Fourier transform-based modal data analysis; and the synthesis of discrete passive vibration dampers. I.F.

A86-38551
SPACECRAFT DESIGN AND OPERATIONAL PROBLEMS: PROCEEDINGS OF THE AEROSPACE TECHNOLOGY CONFERENCE AND EXPOSITION, LONG BEACH, CA, OCTOBER 14-17, 1985
Conference and Exposition sponsored by SAE, Martin Marietta Corp., McDonnell Douglas Corp., et al. Warrendale, PA, Society of Automotive Engineers, Inc. (SAE SP-636), 1985, 58 p. For individual items see A86-38552 to A86-38556.
(SAE SP-636)

Papers are presented on space and launch vehicle designs and flight operations. Topics discussed include flight planning with the NASA Flight Design System and flight planning techniques for mixing deployable payloads on the Space Shuttle. Consideration is given to health and safety in the Shuttle environment and spacecraft software costs. I.F.

A86-38801
STRUCTURES, STRUCTURAL DYNAMICS AND MATERIALS CONFERENCE, 27TH, SAN ANTONIO, TX, MAY 19-21, 1986, TECHNICAL PAPERS. PARTS 1 & 2
Conference sponsored by AIAA, ASME, ASCE, and AHS. New York, American Institute of Aeronautics and Astronautics, 1986. Pt. 1, 788 p.; pt. 2, 706 p. For individual items see A86-38802 to A86-38950.

Among the topics discussed are finite nodal point methods, the Advanced Software Environment for Automated Design, verification methods for large beam-type space structures, a nonlinear optimization expert system, a transfinite element methodology for unified thermal/structural analysis, hysteresis and energy dissipation in metallic tubes, ingot metallurgy Al-Li alloys for aircraft, a cryogenic tank design for the Orbital Transfer Vehicle, a structural analysis of the controlled impact demonstration of a jet transport aircraft, and the mechanical property degradation of advanced composites in aircraft service. Also treated are the thermostructural behavior of composite sandwich structures, the synthesis of structures with multiple frequency constraints, the aeroelastic behavior of forward-swept graphite/epoxy wings with rigid body freedoms, the buckling of viscoelastic beam columns, and the effect of crack growth rate variations on life predictions. Finally, attention is given to cracking in military transport pressure bulkheads, a modular approach to three-dimensional structural shape optimization, the aeroelastic tailoring of composite wings with external stores, and the effect of load history on cumulative damage in a composite solid propellant. O.C.

A86-39476
DYNAMICS AND CONTROL OF LARGE STRUCTURES; PROCEEDINGS OF THE FIFTH SYMPOSIUM, BLACKSBURG, VA, JUNE 12-14, 1985
L. MEIROVITCH, ED. (Virginia Polytechnic Institute and State University, Blacksburg) Symposium sponsored by the Virginia Polytechnic Institute and State University and AIAA. Blacksburg, VA, Virginia Polytechnic Institute and State University, 1985, 605 p. For individual items see A86-39477 to A86-39511.

Papers are presented on Space Station on-orbit parameter and disturbance identification, the identification of a damping matrix from model data, structural parameter identification using modal response data, a Neumann series approach to random vibrations, and the evaluation of performance characteristics for a space antenna system subjected to stochastic disturbances. Also considered are spacecraft uniform damping control, the control of traveling waves in flexible structures, the control of civil engineering structures, balanced augmented controller reduction, and closed-loop stability of large space structures with reduced-order controllers. Other topics include dynamics of gyroelastic vehicles, a matrix approach to dynamics formulation of complex space structures, linear regulator control of the hoop-column antenna, and a robust nonlinear attitude control law for space stations with flexible structural components. Papers are also presented on experiments in optimal control of a flexible arm with passive damping, the effects of sensor and actuator errors on static shape control for large space structures, maneuvering of flexible spacecraft with application to SCOLE, a slewing control experiment for flexible structures, and single step optimization strategies for constrained retargeting maneuvers. R.R.

A86-40501
SPACE TECH; PROCEEDINGS OF THE CONFERENCE AND EXPOSITION, ANAHEIM, CA, SEPTEMBER 23-25, 1985
Conference and Exposition sponsored by ASM, ASME, IEEE, et al. Dearborn, MI, Society of Manufacturing Engineers, 1985, 413 p. For individual items see A86-40502 to A86-40529.

The conference presents papers on the geostationary platform as an application of the Space Station, and continuous fiber composite hoops as well as guidance, controls and sensors, artificial intelligence and robotics, material applications, simulation and software, space structures, habitation, manufacturing for and in space, propulsion and communications. Attention is focused on reentry guidance and control for an Aeroassist Flight Experiment, a two-dimensional near-infrared tracking system, robotic nondestructive inspection of aerospace structures, the cost of materials in space, an orbital maneuvering vehicle simulator and the effect of pressurization on natural frequencies and modes of vibration of orthotropic cylindrical shells. Also considered are concepts for a permanent human lunar colony, Mars survival kit engineering, automation requirements derived from space manufacturing concepts, optimizing cutting tool performance in high tensile strength materials, and communications and tracking as the keys to Space Station utilization. K.K.

A86-40522* Worcester Polytechnic Inst., Mass.
THE WPI SPACE GLOVE DESIGN PROJECT
W. W. DURGIN, A. H. HOFFMAN, H. K. AULT, and F. C. LUTZ (Worcester Polytechnic Institute, MA) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 8-26 to 8-41. NASA-supported research.

Worcester Polytechnic Institute (WPI) was one of four colleges and universities awarded NASA grants for student design and development of an improved glove for space suits. This paper traces the design, development and testing of the WPI prototype glove. Test results showed that the glove did not significantly limit hand and finger motion when pressurized at 8 psi, except in the spherical grip mode. This project demonstrated that problems originating from space technology provide excellent vehicles for student learning and can generate creative solutions. Author

A86-40576
SPACE SYSTEMS TECHNOLOGY CONFERENCE, SAN DIEGO, CA, JUNE 9-12, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 259 p. For individual items see A86-40577 to A86-40608.

Papers are presented on liquid droplet radiator thermal characteristics, battery designs, mobile satellite communications, space-based air traffic surveillance, the Italsat regenerative downlink performance, nondisruptive group delay and amplitude measurement, the Polar Platform of the Space Shuttle, EVA tasks and services, fault diagnosis, and an autonomous power system test bed. Topics discussed include space debris and manned space operations, data transport and command management services for the Space Station, a thermodynamic approach to data processor analysis, anomaly detection and resolution system, the Telemetry, Timing, Command, and Control system, the Space Construction Shuttle Flight experiment, and structural analysis of the Space Shuttle propulsion components. Consideration is given to electrostatic charging and arc discharges on satellite dielectrics, the attitude control system of the IUE, orbital acceleration, spaceborne distributed aperture/coherent array processing, the propulsion module for the Columbus Space Platform, the next-generation STS, trajectory performance evaluation, the Hubble Space Telescope, a linear quadratic tracker for control moment gyro based attitude control of the Space Station, and existing satellite systems and networks. I.F.

A86-40577#
FUTURE CIVIL SPACE MISSION OPPORTUNITIES AS PERCEIVED BY THE AIAA
R. A. DAVIS (AIAA, New York) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 1-3.
(AIAA PAPER 86-1155)

The AIAA's report to the National Commission on Space notes several emerging themes that could influence greatly the mix of mission opportunities that the U.S. may want to pursue in its civil space program over the next half-century. The themes range in scope from the Strategic Defense Initiative to Global Habitability. The mission opportunities range from a host of beneficial earth-oriented applications to the eventual exploration and exploitation of Mars via a user friendly field test center on the Moon. In the long run, however, the reality of those opportunities depends on how well the U.S fosters its space technology base, including education in science and engineering. Author

A86-41154* Alabama Univ., Huntsville
COMMERCIAL USE OF SPACE - STATUS AND PROSPECTS
C. A. LUNDQUIST (Alabama, University, Huntsville) and W. C. SNODDY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Winter National Design Engineering Show and Conference, Anaheim, CA, December 11-13, 1985, Conference Talks . Stamford, CT, Cahners Exposition Group, 1985, p. 225-239. refs

The development of commercial enterprises in space is discussed. The convenience and cost-effectiveness of satellites for communications are examined; satellite communications is an established industry and continues to grow. Meteorological satellites and remote sensing satellite systems (Landsat and SPOT) are being utilized to collect earth resources data. The development of materials processing facilities in space is studied. Current and proposed systems for transporting payloads to space and space lab facilities are investigated. The advantages a space station will provide to communications, earth resources, and materials processing are analyzed. The role of governments in the commercialization of space is described. I.F.

A86-41678
BUDGET CONSTRAINTS FORCE NASA TO SCALE BACK SPACE STATION PLAN
Commercial Space (ISSN 8756-4831), vol. 2, Spring 1986, p. 49-52.

The final baseline Space Station configuration, based on budget cuts expected in 1987, is described. The design incorporates one European, one Japanese, and two U.S. modules, 5-m long struts, and two U.S. and two European free-flying platforms. Program reductions include only one major bay for satellite servicing, nine ports down to five for major instrument utilities and mounting positions, and operation at 250 nautical miles, down from the originally planned 270. Other decisions include hydrazine for attitude control and altitude reboost, a hybrid 25-kilowatt solar voltaic cell 50-kilowatt dynamic solar power system, and the first U.S. closed-loop environmental control and life support system. An advanced suit design and orbital maneuvering vehicle are projected, and the Station will accommodate 6-8 astronauts at initial operating capability for missions of 45-180 days. Division versus consolidation of Station responsibilities is discussed. Operation is to begin in 1994. R.R.

A86-41679
NASA FINDS THE WAY TOWARD BUILDING A STATION FRAUGHT WITH LEGAL HURDLES
J. W. ANDERSON (Wilson, Elser, Moskowitz, Edelman, and Dicker, New York) Commercial Space (ISSN 8756-4831), vol. 2, Spring 1986, p. 57, 59-61.

Political and legal questions concerning the financing, design, and use of the Space Station by the Europeans, Japanese, Canadians, NASA, and the Defense Department are addressed. Disagreements include the Europeans' desire for a free-flying material processing module, and the Japanese wish for 70 percent of their on-board activities to be proprietary. The development of 'astrolaw' to determine a space criminal code, and the need for the presence of an astrolawyer to arbitrate conflicts among the various groups and individuals, are discussed. Though the Defense Department maintains that it has no use for the Space Station, its increasing role in U.S. space activities, as evidenced by the announcement of the X-31 spaceplane, and its space budget of twice that of NASA, suggest its possible involvement in the future. Final agreement on the Station is not expected before the spring of 1987. R.R.

A86-41978* National Aeronautics and Space Administration, Washington, D.C.
BUSINESS IN ORBIT - THE COMMERCIAL USE OF SPACE
I. T. GILLAM, IV (NASA, Washington, DC) Journal of International Affairs (ISSN 0022-197X), vol. 39, Summer 1985, p. 115-120.

Current and proposed business opportunities in space are discussed. The advantages offered by the zero gravity environment of space are examined. The roles of the Space Shuttle and the Space Station in space commercialization are described. International development and use of the Space Station is proposed. It is observed that the communications satellite industry is a successful space venture, and opportunities for materials processing and pharmaceuticals production in space are considered. The relationship between NASA's Office of Commercial Programs, which assists businesses in space commercialization, and industry is studied. The impact of space commercialization on the national economy and international trade is analyzed. I.F.

A86-41982
EXPECTATIONS IN SPACE LAW - A PEEK INTO THE FUTURE
S. GOROVE (Mississippi, University, University) Journal of International Affairs (ISSN 0022-197X), vol. 39, Summer 1985, p. 167-174. refs

Legal concerns related to the Space Station and human settlements in free space and celestial bodies, solar power satellites, the geostationary orbit, direct broadcast satellites, and remote sensing are discussed. The issues of interparty and third party liability, the registration of the Space Station, and jurisdiction, supervision, and control of the Space Station are examined. The need for laws for human conduct in space and the prohibiting of space resources exploitation is described. Questions related to national versus international authority are considered. The proposed use of solar power satellites to generate energy will result in problems related to the impact of the transmission on the earth's environment, potential interference with other radio transmissions, and access to GEO for power transfer. Problems with the free dissemination of remote sensing data and prior consent for direct satellite broadcasting are studied. I.F.

A86-43201
ASTRODYNAMICS 1985; PROCEEDINGS OF THE CONFERENCE, VAIL, CO, AUGUST 12-15, 1985. PARTS 1 & 2
B. KAUFMAN, ED. (U.S. Navy, Naval Research Laboratory, Washington, DC), J. J. F. LIU, ED., F. R. HOOTS, ED. (USAF, Space Command, Peterson AFB, CO), and R. A. CALICO, ED. (USAF, Institute of Technology, Wright-Patterson AFB, OH) Conference sponsored by AAS and AIAA. San Diego, CA, Univelt, Inc. , 1986. Pt. 1, 785 p.; pt. 2, 745 p. For individual items see A86-43202 to A86-43253, A86-43255 to A86-43278.

Papers are presented on the age and stability of the solar system, orbit dynamics, transfer dynamics, attitude dynamics and control, optimal control, and control and identification of large space structures. Topics discussed include platform servicing, mission design, and control for the 1990's, platform configurations, mission designs and applications, and atmospheric density at satellite altitudes. Consideration is given to estimating the Extreme Ultraviolet Explorer sky survey exposure, a fiber-optic laser velocimeter for studying unsteady rotating flows in spinning rocket motors, nonlinear feedback control for remote orbital capture, orbit evolution and ion cloud releases, collision-induced and explosion-induced satellite breakups, and the transfer of asteroidal material to earth orbit by means of gravity assist trajectories. Emphasis is placed on celestial mechanics, geosynchronous satellite orbits, orbit determination and maneuvers, orbit determination using TDRSS and the GPS, interplanetary exploration, and planetary exploration. I.F.

A86-43335
SPACE STATIONS: LEGAL ASPECTS OF SCIENTIFIC AND COMMERCIAL USE IN A FRAMEWORK OF TRANSATLANTIC COOPERATION; PROCEEDINGS OF THE INTERNATIONAL COLLOQUIUM, HAMBURG, WEST GERMANY, OCTOBER 3, 4, 1984
K.-H. BOECKSTIEGEL, ED. (Koeln, Universitaet, Cologne, West Germany) Colloquium organized by the Universitaet Koeln and DGLR; Supported by BMFT. Cologne, West Germany, Carl Heymanns Verlag (Schriften zum Luft- und Weltraumrecht. Volume 5), 1985, 262 p. In English and German. For individual items see A86-43336 to A86-43350.

Amerian experiences and perspectives regarding an international coperation on a permanently manned space station are considered along with European experience and perspectives, the relevance of general multilateral space conventions to space stations, possible models for specific space agreements, agreements between States and with International Organizations, and contracts of and with private enterprises concerning the development, the construction, and the assembly of space vehicles. Attention is given to contractual and related agreements required for a satellite launch, applicable law and dispute settlement, forms of coverage and current market situation in the case of insurance, state supervision and registration, and legal questions which need to be addressed in the case of the Space Station. Other questions explored are related to legal aspects of stations in space, space stations and the law concerning intellectual property, aspects of law and practice in the U.S., and the experience of the European Space Agency. G.R.

A86-43337* National Aeronautics and Space Administration, Washington, D.C.
AMERICAN EXPERIENCES AND PERSPECTIVES - INTERNATIONAL COOPERATION ON A PERMANENTLY MANNED SPACE STATION
K. S. PEDERSEN (NASA, Washington, DC) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 27-32.

In the late 1960s, NASA contemplated the establishment of a permanently manned Space Station along with the development of the Space Shuttle. After a temporary postponement of the Space Station project, it was finally decided to develop a Space Station and to have it operating by the early 1990s. This station is to serve in a variety of functions which are important for further advances with respect to the utilization of space. The Space Station could even serve as a staging base for trips to the moon and visits to Mars. An international approach is to be taken regarding the development and utilization of the Space Station, giving attention to a cooperation of the U.S. with Canada, Europe, and Japan. The implementation of such a cooperation requires that a number of problems are solved. Basic approaches suitable for achieving such a solution are discussed, taking into account the development of operational schemes which provide for efficient management, while permitting the exercise of diverse 'ownership' rights. G.R.

A86-43338
THE RELEVANCE OF GENERAL MULTILATERAL SPACE CONVENTIONS TO SPACE STATIONS
E. GALLOWAY (International Institute of Space Law, Washington, DC) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 33-57. refs

In connection with the formulation of plans for the establishment of a space station, it is important to take into consideration legal arrangements which are relevant for such planning activities. Such arrangements can be related to outer space treaties, conventions which have been expanded to include outer space activities, and agreements formulated to establish international intergovernmental organizations to carry on technical space operations. Attention is given to space station planning, basic tenets which have to be kept in mind in evaluating applicable international space law, the relevance of space treaties formulated within the United Nations, the International Telecommunication Convention and radio regulations, and international intergovernmental space organizations established outside the United Nations. G.R.

A86-43339
POSSIBLE MODELS FOR SPECIFIC SPACE AGREEMENTS
P. P. C. HAANAPPEL (McGill University, Montreal, Canada) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 59-68. refs

At the present time, space stations are in the developmental and experimental stages, while the operational stage will only be reached in the 1990s. Questions are, therefore, considered regarding the advisability of the development of rules and regulations for space stations ahead of impending technical and economic developments. It appears that the answer to these questions can be put in the broader framework of the relationships between law and technology and between law and economics. It is pointed out that the law does not precede technological developments. Rather it reacts to them ex post facto, once they have taken place. It is recommended that caution should be exercised in the legislative process so as not to hamper technological and economic developments regarding space stations. Attention is given to participants in space station activities, government regulation of space station activities by private enterprises, prolonged human presence in outer space, conflicts of law, and contractual and extra-contractual relations. G.R.

A86-43340
AGREEMENTS BETWEEN STATES AND WITH INTERNATIONAL ORGANIZATIONS
M. G. BOURELY IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 71-87. refs

The present paper is concerned with the form and the contents of agreements governing international cooperation in the construction, transport, and assembly in space of space stations within the framework of the American program. Attention is given to agreements to be drawn up in the future, taking into account the absence of precedents for such agreements. It is pointed out, however, that there are a number of international cooperative activities, both past and present, which have points in common with the space station project. In a review of such past arrangements, elements which have already formed part of an international cooperative program are considered. These elements are related to the construction of hardware, the transport of hardware, the use of hardware in orbit, man's participation in the use of space, and in-orbit rendezvous. The American offer is discussed along with international agreements between European partners, and transatlantic international agreements. G.R.

A86-43343
APPLICABLE LAW AND DISPUTE SETTLEMENT
K.-H. BOECKSTIEGEL (Koeln, Universitaet, Cologne, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 109-116. refs

The development, construction, and operation of space stations will require the cooperation of many institutions, bodies, and persons. A formal settlement procedure will be required in cases in which agreement by negotiation cannot be reached, and questions regarding the applicable law arise. Treaties relating to space stations are discussed, taking into account the applicable law, and dispute settlement. Problems concerning contracts are also investigated, giving attention to questions regarding the substantive law applicable to a contract, the assurance of mandatory dispute settlement with regard to commercial contracts, the inclusion of arbitration clauses in the contract, and the choice of arbitration as the exclusive dispute settlement machinery even in cases in which a state or state institution is one of the contractual partners. G.R.

A86-43344
INSURANCE - FORMS OF COVERAGE AND CURRENT MARKET SITUATION
A. BAUER (Deutscher Luftpool, Munich, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 117-126.

The present paper provides a look at insurance aspects of space risks, taking into account the approaches used to deal with these risks. Various types of risks arising in connection with space-related material are mainly concerned with four principal stages, including the construction phase, the prelaunch phase, the launch phase, and the in-orbit phase. An outline is presented of the basic forms of insurance coverage in the considered cases. Certain risks which remain are related to the loss of direct revenues, incentive payments, and indirect losses. Indirect losses, for instance, can be incurred by satellite systems users when, resulting from failures of any kind or even only late delivery by the manufacturer, the commissioning of a satellite system will be

delayed. Attention is also given to Third Party Legal Liability insurance. G.R.

A86-43346* National Aeronautics and Space Administration, Washington, D.C.
THE SPACE STATION - PAST, PRESENT AND FUTURE WITH SOME THOUGHTS ON SOME LEGAL QUESTIONS THAT NEED TO BE ADDRESSED
S. N. HOSENBALL (NASA, Washington, DC) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 137-142.

The history of the concept of a space station is briefly considered, taking into account a story written by Hale (1869), quantitative work provided by Oberth and Tsiolkovsky, von Braun, and the U.S. decision regarding the establishment of a space station. Arguments in favor of constructing a space station are related to the utility of a laboratory in earth orbit, the importance of a repair and maintenance base for satellites, the provision of capabilities for the commercial utilization of space, and the employment of a space station as a staging base for missions to the moon, Mars, and, possibly, the asteroids. Plans for the implementation of the Space Station concept are discussed, taking into account also legal issues involved in such an implementation. Attention is given to questions regarding the applicability of the Liability convention, U.S. domestic law, the domestic law of other countries, and four treaties. G.R.

A86-43347
LEGAL ASPECTS OF STATIONS IN SPACE
S. GOROVE (Mississippi, University, University) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 143-152. refs

Advances related to the exploration and utilization of space, and the evolution of space-related technology have now led to the U.S. Space Station project. In connection with this development, it will be necessary to study scientific, technical, and legal issues along with aspects of policy. A brief review is provided of applicable treaty law and attendant legal issues. The meaning and the characteristics of a space station are examined, taking into account the terms 'space station' and 'space object', objects originating from the earth, objects not originating from the earth, functional characteristics and purposes, durability, size, and manned or ummanned stations. Attention is also given to the Outer Space Treaty, the Moon Agreement, other provisions in space treaties, expectations, and an assessment. G.R.

A86-43348
ASPECTS OF LAWS AND PRACTICE IN WESTERN EUROPE - SPACE STATIONS AND THE LAW CONCERNING INTELLECTUAL PROPERTY [WELTRAUMSTATIONEN UND DAS RECHT DES GEISTIGEN EIGENTUMS]
F.-K. BEIER and D. STAUDER (Max-Planck-Institut fuer auslaendisches und internationales Patent- , Urheber- und Wettbewerbsrecht, Munich, West Germany) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 155-173. In German. refs

In connection with the possibilities of a commercial utilization of space, questions have arisen regarding the property rights which exist with respect to scientific-technological results obtained as a consequence of space activities. Saragowitz (1975) has discussed such questions. The present study attempts to make a contribution to the further clarification of the involved issues. The principles of international law are examined, taking into account the unique status of outer space, the Outer Space Treaty of 1967, questions regarding an application of patent law with respect to developments in space, aspects of sovereignty and control in the case of space objects, and the territoriality principle. Attention is also given to the acquisition of intellectual property rights by activities in outer space, the utilization of patents in outer space and problems of infringement, and cases in which patent protection might represent an obstruction in the conduction of space activities. G.R.

A86-43349
ASPECTS OF LAW AND PRACTICE IN THE UNITED STATES
B. LUXENBERG (DOC, Washington, DC) IN: Space stations: Legal aspects of scientific and commercial use in a framework of transatlantic cooperation; Proceedings of the International Colloquium, Hamburg, West Germany, October 3, 4, 1984 . Cologne, West Germany, Carl Heymanns Verlag, 1985, p. 175-185. refs

The establishment of a permanently orbiting space station will usher in a new era, in which a significant shift will occur toward private entrepreneurial activity in space. However, in order to provide an incentive to private entities to engage in such ventures, the protection of intellectual property resulting from space station activities must be assured. The international law of outer space is considered along with developments regarding intellectual property rights in the case of NASA, commercial activities in space, national policy on space commercialization, and issues for the future. It is pointed out that NASA has developed flexible legal arrangements for companies pursuing commercial space ventures in the shuttle era and that this policy will undoubtedly carry over into the space station. G.R.

A86-43650
THE EXPLOITATION OF SPACE: POLICY TRENDS IN THE MILITARY AND COMMERCIAL USES OF OUTER SPACE
M. SCHWARZ, ED. and P. STARES, ED. London and Stoneham, MA, Butterworth, 1985, 182 p. No individual items are abstracted in this volume.

Current developments and planning for the military and commercial exploitation of near-earth and outer space are examined critically from a global perspective in contributions to a revised and updated version of the survey of Schwarz and Stares (1982). Chapters are devoted to the evolution of space flight from Sputnik to the present, the transition from passive support to active weapons systems in the military use of space, civilian space exploitation, space industrialization, telecommunications, space as a potential future battlefield, problems of and prospects for the U.S. Strategic Defense Initiative, space stations, the relatively low availability of space exploitation to third-world nations, and alternative space futures. Maps, drawings, diagrams, and tables of numerical data are provided. T.K.

A86-43701
SPACECOM '85; SPACE AND RADIOCOMMUNICATIONS SYMPOSIUM, 5TH, PARIS AND LE BOURGET, FRANCE, JUNE 5-7, 1985, SPEAKERS' PAPERS
Symposium organized by ITU and Direction Generale des Telecommunications. Geneva, Switzerland, International Telecommunication Union, 1985, 232 p. In English and French. For individual items see A86-43702 to A86-43718.

Papers are presented on future space transportation systems, space platforms and launchers, telecommunications satellite designs, and the Olympus spacecraft. The application of direct television satellite broadcasting, advanced satellite communication systems, Telecom 1, and radio determination satellite service to aeronautical and land functions is discussed. Consideration given to orbit utilization by different services, the effect of earth stations on orbit utilization, and access for satellites of the fixed-satellite service to orbit and spectrum. Topics related to technology transfer and training, the cost and benefits of international space meteorology programs, the use of the global distress system to provide for sea safety, remote sensing, and collaboration and cooperation between governments and industry on a regional level are examined. I.F.

A86-44329
MEDICO-LEGAL IMPLICATIONS OF SPACE STATIONS
J. DVORAK (Central Institute of the Railway Health Services, Prague, Czechoslovakia) IN: Space safety and rescue 1984-1985 . San Diego, CA, Univelt, Inc., 1986, p. 199-205.

Medical-legal implications arise in manned space station operations because a number of parties can be held liable for damages resulting from insufficient knowledge of onboard conditions. Occasionally, experiments entailing a certain amount of crew risk will be conducted during space station operations. It will for some time be difficult, however, to furnish a suficiently high level of medical support for space station crews. From the legal viewpoint, it is important to determine the extent to which the terrestrial precedents from which space station conditions are to be extrapolated are really comparable. O.C.

A86-44403
INTERNATIONAL PARTICIPATION AND THE SPACE STATION
G. W. KEYES (Boeing Aerospace Corp., Seattle, WA) Space Policy (ISSN 0265-9646), vol. 2, May 1986, p. 99-102.

Questions related to an international cooperation on the Space Station project are discussed from the point of view of an American aerospace company which is deeply involved in this project, taking into account the benefits of cooperation as well as some concerns about cooperation. It is pointed out that international cooperation will foster the objective of peaceful exploitation of space. Thus, international cooperation may provide a larger technology base for utilization, which could in turn provide greater overall benefits. Such a cooperation might also lead to an increase in investment, and, consequently, to a more capable Space Station. It is also throught that Government commitments to participate in development and utilization of the Space Station should have a stabilizing and strengthening effect on continued support by all participants. One of the concerns considered is related to a situation in which demand for space experiment and production capability would lead to damaging international competition. G.R.

A86-44405* National Aeronautics and Space Administration, Washington, D.C.
THE CHANGING FACE OF INTERNATIONAL SPACE COOPERATION - ONE VIEW OF NASA
K. S. PEDERSEN (NASA; Georgetown University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 2, May 1986, p. 120-137. refs

It is pointed out that from its earliest years NASA has incorporated international participation into many of its programs. Guidelines were developed with the objective to maximize the benefits of international cooperation. The cooperative guidelines were accepted because they reflected conditions which applied during much or all of the 1960-1980 period. There existed a clear technology and experience gap between the U.S. and even its largest cooperative partners. Thus, the U.S. enjoyed a virtual Free World monopoly on launching large satellites, especially those destined for geostationary or interplanetary orbits. However, on the basis of new developments, NASA faces now a modified international operating environment, in which the U.S. technological lead has been significantly reduced. The results of this situation are examined, taking into account the equalization of capabilities, the rise of commercial competition, Soviet competition, multinational patterns, and reduced cooperative opportunities. G.R.

A86-44526
SPACE - TECHNOLOGY AND OPPORTUNITY; PROCEEDINGS OF THE CONFERENCE, GENEVA, SWITZERLAND, MAY 28-30, 1985
Pinner, England, Online Publications, 1985, 356 p. For individual items see A86-44527 to A86-44551.

The technologies, organizations, hardware and plans for the commercialization of space activities in the near future are detailed. Financing schemes for manufacturing, leasing, sharing, or owning all or part of a spacecraft or a potential space-based industrial process are delineated, along with the problems facing the space insurance business. Although emphasis is placed on ESA and other European programs, the NASA Manned Space Station plays a pivotal role in the space development plans of most western nations, experimenters, and corporations. Attention is also devoted to unmanned platforms, their potential commercial applications, and to the necessary hardware infrastructure to support their operations. The capabilities of the Ariane 5 launch vehicle, the Hermes space plane, and a series of Chinese launch vehicles are described. Comparisons are made of the economics of various types of partially and fully reusable launch vehicles with diverse payload capabilities, of which the STS has the largest capacity. M.S.K.

A86-44528* National Aeronautics and Space Administration, Washington, D.C.
JOINING FORCES IN SPACE - NASA'S VIEW
K. S. PEDERSEN (NASA, Washington, DC) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 1-4.

The NASA history of international cooperation is briefly reviewed. The evolving nature of the international space environment is discussed. The proposed international Space Station is described as an example of the continuing cooperative spirit and of the need to adapt to changed circumstances as they arise. Author

A86-44529* National Aeronautics and Space Administration, Washington, D.C.
NASA'S SPACE STATION PLANNING - AN UPDATE
F. T. HOBAN (NASA, Office of Space Station, Washington, DC) IN: Space - Technology and opportunity; Proceedings of the Conference, Geneva, Switzerland, May 28-30, 1985 . Pinner, England, Online Publications, 1985, p. 5-15.

The Manned Space Station (MSS) program is summarized, along with the program guidelines, activities, plans, management approach, international involvement and the present and future private sector role in space. The MSS, the first continually-manned facility in space, will be configured to grow modularly to meet future needs. Comprising both manned and unattached unmanned elements, the program is to advance the state of robotics and automation. Numerous uses of the MSS have been defined in support of and as the primary platform for astronomical observations, experimentation on prototype space-based industrial processes, and as a staging area for the launch and refurbishment of spacecraft. Current studies are targeted at defining the final design of the initial operating configuration, the hardware to be developed by the nations and organizations which are sharing in the work, and developing interest among potential commercial users of the MSS capabilities. M.S.K.

A86-45626
COLUMBUS I; PROCEEDINGS OF THE FIRST COLUMBUS WORKSHOP UTILIZATION ASPECTS, CAPRI, ITALY, JUNE 17-21, 1985
Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, 156 p. For individual items see A86-45627 to A86-45651.

The directions being taken in the development of the European Columbus pressurized module for the NASA Manned Space Station (MSS) are explored. Attention is given to the distribution of work among the participating nations on the basis of funding contributions, and to previous space research by the same countries, particularly in the Spacelab missions. The Phase B studies will lead to a final definition of the module design, its interfaces with the rest of the MSS, the instrumental and experimental payloads, and avenues for future expansion. ESA plans for a parallel development of an autonomous capability, including another pressurized module, the Hermes space plane, an unmanned service vehicle and a data relay satellite, are described. Details of the experimental goals and hardware prototypes for future experiments in fluid physics, biology, materials processing, and tethered satellite applications are presented. Finally, possible configurations of the polar and co-orbiting

unmanned platform elements of the MSS program are discussed. M.S.K.

A86-45630
US STATUS OF SPACE STATIONS PHASE B ACTIVITIES
J. AARON (JSP, Houston, TX) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 21-23.

Phase B efforts for the Manned Space Station (MSS) project in mid-1985 are described, along with activities to follow in the succeeding 9 mos. Phase B is formal systems definition and is projected to require 21 mos of work comprising the identification of options, evaluations and selections, carried out by NASA centers and internationally. An Engineering Master Schedule has been defined on the basis of trends that emerged in analyses of proposed configurations, operations and missions. The Schedule is intended in part to force convergence of the various proposed configurations. The design options thus far adopted are a solar power tower and a minimum of 37.5 kW power for a crew of four, increasing to 105 kW for a crew of 12. Cost estimates are also to be determined in Phase B. M.S.K.

A86-45637* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION UTILIZATION
W. RANEY (NASA, Office of Space Station, Washington, DC) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 65-68.

Progress in the definition of Manned Space Station (MSS) capabilities and operations as of June 1985 is assessed in terms of the user requirements and engineering decisions. Input for making design and performance envelope decisions has come from various NASA offices, the NOAA, ESA and Japan. NASA, in coordinating the planning, is incorporating as much flexibility as possible to accommodate unforeseen requirements of the various participants. The decisions extend to the co-orbiting and polar orbiting platforms that are actually integral parts of the MSS concept. The rapid identification of uses of the MSS and man-tended platforms has defined sufficient uses to surpass the STS launch capabilities in the late 1990s and projected data recording capabilities. Other activity requests to-date have included 400 hr of EVA, 120 kW solar power input and six Orbital Maneuvering Vehicle missions the first year of operation. M.S.K.

A86-45641* National Aeronautics and Space Administration, Washington, D.C.
POINT OF VIEW OF THE U.S. SCIENCE COMMUNITY
D. C. BLACK (NASA, Washington, DC) (Columbus Workshop, 1st, Capri, Italy, June 17-21, 1985) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 6, no. 1, 1986, p. 91-93.

A special task force was formed by the National Academy of Sciences to examine the applications of Manned Space Station (MSS) platforms, communications and information systems, MSS operations and satellite assembly and repair capabilities on seven areas of space research. The task force reached several conclusions, including comprehensive space science planning by NASA with the MSS being one element of the plan. The STS is to provide a test bed for space research technologies and its basic design should be studied for conversion to an extended duration flight vehicle. The MSS could be categorized as a national facility, and payloads should be developed which specifically take advantage of its capabilities. The repair and maintenance capabilities which the MSS will furnish are concluded to be a significant asset to any future space science activities, and participation in those activities by the international science community is to be encouraged. M.S.K.

A86-45709#
TECHNOLOGY BASE FOR THE FUTURE OF SPACE
R. A. DAVIS Aerospace America (ISSN 0740-722X), vol. 24, July 1986, p. 44-47.

A summary is given of the detailed report of the AIAA's Ad Hoc Technical Committee on Space Systems, presented in November 1985 to the National Commission on Space. Among the key technologies detailed in the AIAA report that were highlighted by the Commission are high-performance electric propulsion systems, processing of lunar and other nonterrestrial materials, autonomous fault-tolerant machinery, aerospaceplane propulsion, advanced rocketry, aerobraking, long-duration closed ecosystems, nuclear-electric power plants, space tethers, and high-performance materials. Themes for civil space agendas are considered: cooperative international ventures, space commercialization, manned space stations leading to the protocolony, a Moon base, a Mars base during the third decade of the next century, and development and refinement of all the necessary support technologies. Author

A86-46808
DISTRIBUTED PARAMETER SYSTEMS; PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE ON CONTROL THEORY FOR DISTRIBUTED PARAMETER SYSTEMS AND APPLICATIONS, VORAU, AUSTRIA, JULY 9-14, 1984
F. KAPPEL, ED., W. SCHAPPACHER, ED. (Graz, Universitaet, Austria), and K. KUNISCH, ED. (Graz, Technische Universitaet, Austria) Conference sponsored by BMFWF. Berlin and New York, Springer-Verlag (Lecture Notes in Control and Information Sciences, Volume 75), 1985, 470 p. For individual items see A86-46809 to A86-46816.

Papers are presented on a variational approach to parameter estimation; fixed point methods in nonlinear control; an initial value control problem for Burgers' equation; control of retarded Lienard equations; the identification of a spatially varying coefficient in a parabolic partial differential equation; disturbance decoupling for distributed systems; the Riccati equation with unbounded coefficients; shape optimal designs for communications satellites; and distributed parameters in porous media flow. Topics discussed include the maximum principle for nonlinear, nonconvex systems and of distributed parameter systems with time lags; the optimal control of non-well-posed systems; the Legendre-Tau approximation for functional differential equations; time-minimal control problems; the approximation of Riccati equations corresponding to hyperbolic boundary control problems; an interconnected distributed parameter system; the tandem connection of systems with delays; distributed vibratory systems; and an infinite dimensional system with unbounded control and observation. Consideration is given to coefficient identification for a parabolic problem, theorems for a stochastic system with Poisson jumps; the differential stability of control-constrained optimal control problem; the stability properties of a hyperbolic damped wave equation; continuous time programming without differentiability; and shape stabilization of flexible structures. I.F.

A86-46851* Louisiana State Univ., Baton Rouge.
WORKSHOP ON COSMIC RAY AND HIGH ENERGY GAMMA RAY EXPERIMENTS FOR THE SPACE STATION ERA, LOUISIANA STATE UNIVERSITY, BATON ROUGE, OCTOBER 17-20, 1984, PROCEEDINGS
W. V. JONES, ED. and J. P. WEFEL, ED. (Louisiana State University, Baton Rouge) Workshop sponsored by the Louisiana State University, Martin Marietta Corp., NASA, and NSF. Baton Rouge, LA, Louisiana State University, 1985, 575 p. For individual items see A86-46852 to A86-46899.

The potential of the Space Station as a platform for cosmic-ray and high-energy gamma-ray astronomy is discussed in reviews, reports, and specific proposals. Topics examined include antiparticles and electrons, science facilities and new technology, high-energy nuclear interactions, nuclear composition and energy spectra, Space Shuttle experiments, Space Station facilities and detectors, high-energy gamma rays, and gamma-ray facilities and techniques. Consideration is given to universal-baryon-symmetry

testing on the scale of galactic clusters, particle studies in a high-inclination orbit, balloon-borne emulsion-chamber results on ultrarelativistic nucleus-nucleus interactions, ionization states of low-energy cosmic rays, a large gamma-ray telescope for point-source studies above 1 GeV, and the possible existence of stable quark matter. T.K.

A86-46854* National Aeronautics and Space Administration, Washington, D.C.
ASTROPHYSICS AND THE SPACE STATION - EXECUTIVE SUMMARY OF THE NASA WORKING GROUP
C. J. PELLERIN, D. GILMAN, and F. O. VON BUN (NASA, Washington, DC) IN: Workshop on Cosmic Ray and High Energy Gamma Ray Experiments for the Space Station Era, Baton Rouge, LA, October 17-20, 1984, Proceedings . Baton Rouge, LA, Louisiana State University, 1985, p. 62-82.

Current plans for astrophysics experiments using the Space Station are summarized. The planning history is briefly traced; the fundamental roles of the Station as observatory, assembly plant, and service point for free-flying astrophysics platforms are considered; the NASA astrophysics programs are described; the chief outstanding problems are listed; and the need for smaller experiments is stressed. Lists of desired Station performance parameters and charts showing projected completion dates for Station components are provided. T.K.

A86-46951#
SPACE STATION OPERATIONS IN THE TWENTY-FIRST CENTURY
G. R. BENNETT (McDonnell Douglas Astronautics Co., Houston, TX) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NY, Sept. 3-5, 1986. 10 p. refs
(AIAA PAPER 86-2328)

A model outlining the requirements for achieving manned space operations is presented. Several Space Stations, each serving specific functions are proposed for effective use of space. The components of the Stations are to be designed for modularity and flexibility. The advantages of a multi-Space-Station system are discussed. The transportation system necessary for accomplishing the proposed space operations is described. The implementations of robotics to assist in operations, due to a limit on crew size, and of a computer system to schedule the use of limited resources are examined. The effect of the National Aerospace Plane on Space Station operations is investigated. The participation of industry in Space Station operations is considered. I.F.

A86-46963#
GROWTH OF ELECTRONIC MATERIALS IN MICROGRAVITY
B. L. HOEKSTRA (USAF, Materials Laboratory, Wright-Patterson AFB, OH) and W. R. WILCOX (Clarkson University, Potsdam, NY) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 6 p.
(AIAA PAPER 86-2356)

This paper reviews the advantages of processing electronic materials in the microgravity environment. Emphasis is placed on commercially viable processes for high value-added crystals and the development of scientific knowledge for improving crystals growth on earth. This will be done by reviewing past flight experiments as well as ground-based experiments and theory. This will all be discussed in the context of future electronic materials research needs as well as the potential for commercial production on the Space Station in the 21st century. Author

A86-47055* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION TECHNOLOGY EXPERIMENTS AND USES
R. A. BRECKENRIDGE and R. A. RUSSELL (NASA, Langley Research Center, Hampton, VA) Journal of Vacuum Science and Technology A (ISSN 0734-2101), vol. 4, May-June 1986, pt. I, p. 281-285. refs

The use of the proposed Space Station for technological experimentation is discussed. The general objectives and capabilities of the Station and the status of planning are reviewed; the external and internal environmental conditions at the 500-km 28.5-deg-inclination Station orbit are described; and six conceptual Technology Development Missions designed by NASA and included in the Mission Requirements Data Base are briefly characterized and illustrated with drawings. The missions considered concern spacecraft-materials performance, solar dynamic power, data transfer and processing microelectronics, long-term cryogenic-fluid storage, active-optics technology, and cryogenic-propellant transfer, storage, and reliquefaction. T.K.

A86-47401
GUIDANCE, NAVIGATION AND CONTROL CONFERENCE, WILLIAMSBURG, VA, AUGUST 18-20, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA. New York, American Institute of Aeronautics and Astronautics, 1986, 983 p. For individual items see A86-47402 to A86-47509.

Recent developments in navigation, guidance, and control technology are discussed in reviews and reports, with an emphasis on aeronautical and space applications. Topics examined include flight-management systems for commercial jets, nonlinear adaptive control of an elastic robotic arm, the Space Telescope precision-pointing control system, spin-axis controllers for GEO satellites, dynamics and control of slew maneuvers of a large flexible spacecraft, and multicriterion approaches to optimization of linear regulators. Consideration is given to the effect of time delay on flying qualities, laser feedback controls for passive ring-laser gyros, eigensystem synthesis for active flutter suppression on an oblique-wing aircraft, terminal control factors for the carrier landing task, and a linear-quadratic guidance law for solid-fuel space-based interceptors. T.K.

A86-47648#
THE U.S. CIVIL SPACE PROGRAM: A REVIEW OF THE MAJOR ISSUES REPORT OF AN AIAA WORKSHOP, ALEXANDRIA, VA, JULY 22, 23, 1986
New York, American Institute of Aeronautics and Astronautics, 1986, 85 p. refs

Urgent and long-term issues affecting the U.S. civil space program are defined and recommendations are made. These issues include: (1) access to space (i.e., Shuttle redesign and requalification, launch and spacecraft insurance, and new launcher development); (2) space program management (ie., budget rationale and implementation, NASA's relation to other agencies, and military-civil interaction); (3) international involvement (ie., interactional civil space leadership, international cooperation and competition and international space year 1992); and (4) human motivations, resources and perceptions. It is noted that U.S. leadership in space can be restored only by vigorous action backed by firm commitments. The first requirement is a unified national policy which sets along terms objectives, and the second is a civil space budget which is approximately double what it is at the present time. K.K.

A86-47901
ASTRODYNAMICS CONFERENCE, WILLIAMSBURG, VA, AUGUST 18-20, 1986, TECHNICAL PAPERS
Conference sponsored by AIAA and AAS. New York, American Institute of Aeronautics and Astronautics, 1986, 413 p. For individual items see A86-47902 to A86-47944.

Various papers on satellite and planetary mission dynamics are presented. Individual topics discussed include: orbital motion in the frequency domain, the Galileo orbital tour for the 1986 launch opportunity, circulating transportation orbits between earth and Mars, optimum burn scheduling for low-thrust orbital transfers, comparison of nonlinear filters for orbit determination, common period four-satellite continuous global coverage, motion of a drag-free experiment on the Space Station, and engineering improvements, sequencing and orbital determination for Voyager 2 Uranus encounter. Also considered are: approach strategy for rendezvous with Comet Tempel 2, maneuver strategies for Magellan Mission, Jupiter Polar Orbiter Mission concepts, modelling

and simulation of Spacecraft Solar Array deployment, sensitivity analysis for lunar trajectories, maximum likelihood estimation for orbit determination, adaptive estimation for an accelerating spacecraft, Slinger in-orbit booster facility, simulation of satellite breakups, missile launch windows of avoiding collisions with satellites, linear-quadratic stationkeeping for the STS Orbiter. C.D.

A86-48373
SPACE STATION EVOLUTION - THE UNCERTAINTY PRINCIPLE PREVAILS
C. BULLOCH Interavia (ISSN 0020-5168), July 1986, p. 779-782.

NASA planners have repeatedly reduced the scope of initial Space Station design concepts in order to realistically respond to financial stringencies. The number of U.S.-operated pressurized modules has been reduced to two, not counting the Space Station's logistics module. A decision has been made to rely on a solar dynamic electrical generation system based on a closed thermodynamic cycle that is powered by a solar concentrator-reflector. Attention is given to Canadian, European and Japanese plans for participation, and the ownership/legal status consequences that various collaborative arrangements can have. O.C.

A86-48451#
PROJECTIONS OF SPACE SYSTEMS OPPORTUNITIES AND TECHNOLOGIES FOR THE 2000 TO 2030 TIME PERIOD
New York, American Institute of Aeronautics and Astronautics, 1985, 101 p. refs

The present work is a report compiled by an Ad Hoc Committee of AIAA and subsequently presented to AIAA for submittal to the National Commission on Space. Particular emphasis is placed on the establishment of a technology base which would be crucial to civil space endeavors in the 2000-2030 time period. It considers the impact of technologically relevant events of the last five years, discusses future space system missions and opportunities, highlights critical technology developments, and outlines the steps necessary to the enhancement of the technology base over the next few decades. Space system technologies for the following areas are discussed in detail: information processing; guidance navigation and control; autonomy and automation; sensors; communications; materials; propulsion, power and energy; atmospheric flight; thermal management; environment; human support manufacturing; test and evaluation; and economics. K.K.

A86-49551*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION AND TECHNOLOGY EXPERIMENTS
R. A. BRECKENRIDGE, R. A. RUSSELL, and L. G. CLARK (NASA, Langley Research Center, Hampton, VA) AIAA, Space Station in the Twenty-first Century, Meeting, Reno, NV, Sept. 3-5, 1986. 8 p. refs
(AIAA PAPER 86-2299)

The space technology experiments to be performed on the Space Station are discussed. The characteristics of the dual keel Station, which contains modules for habitation, logistics, and laboratories, applicable to technology experiments are described. Experiments utilizing the initial Space Station design include: (1) assessing the instrumented Space Station, (2) the testing of spacecraft materials and coatings, and (3) a microelectronics data system experiment; the objectives and procedures for these studies are examined. With increases in the number of modules, and electrical power and OTV capabilities, the evaluation of teleoperated techniques, the development and testing of a diversified antenna near- and far-field measurement facility, the study of cryogenic propellant transfer, and storage, and the implementation of a large concentrator in space are possible; descriptions of these proposed experiments are provided. I.F.

A86-50334
TOWARDS COLUMBUS AND SPACE STATION; PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM, BONN, WEST GERMANY, OCTOBER 2-4, 1985
Symposium organized by DGLR; Sponsored by AAS, AIAA, BMFT, et al. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, 384 p. For individual items see A86-50335 to A86-50340.
(DGLR BERICHT 85-03)

The progress made in ESA design and other work on the development of the Columbus segment and other ESA contributions to the NASA Space Station project as of October 1985 is summarized. The discussions are performed from technology synthesis, utilization, program and schedule, and user requirements points of view. Design decisions and technological developments necessary to realize the attached Columbus module and the associated free-flying platforms, either co- or polar-orbiting, are delineated. Attention is given to power system, data management system and other hardware systems which have been selected for Columbus, along with possible evolutions to meet future Space Station or autonomous European space station requirements. Finally, design schedules and project milestones which have been or must still be met are described. M.S.K.

A86-50339*# National Aeronautics and Space Administration, Washington, D.C.
A SCIENCE PERSPECTIVE OF THE SPACE STATION
D. C. BLACK (NASA, Space Station Office, Washington, DC) IN: Towards Columbus and Space Station; Proceedings of the International Symposium, Bonn, West Germany, October 2-4, 1985 . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1985, p. 229-236.

On-orbit scientific research involving the presence of humans has been hampered during Shuttle flights due to the brevity of the missions and the limited power supplies and data management facilities. The solutions to these limitations are the Space Station and extended duration Orbiter, the latter offering 2.5 weeks on-orbit operations. The Space Station configuration is to include polar orbiting and co-orbiting unmanned platforms serviced, initially, by the Shuttle. The longer duration operations on the Space Station will permit lowering the amount of on-the-ground training in favor of on-orbit experience, thereby enhancing the flexibility of experimental opportunities and expanding the breadth of investigations. The goal of all the developments is to furnish groundside experimenters access to space, along with minimized adaptation of experimental procedures to exploit the space environment. M.S.K.

N86-22593# European Space Agency, Paris (France).
PROCEEDINGS OF THIRD EUROPEAN SYMPOSIUM ON SPACECRAFT MATERIALS IN SPACE ENVIRONMENT
T. D. GUYENNE, comp. and J. J. HUNT, comp. Nov. 1985 293 p refs Symposium held in Noordwijk, Netherlands, 1-4 Oct. 1985; sponsored by ESA, CNES, and Centre d'Etudes et de Recherches de Toulouse
(ESA-SP-232; ISSN-0379-6566) Avail: NTIS HC A13/MF A01

Spacecraft contamination; material behavior in low orbit; spacecraft charging; composite materials; and thermal control materials were discussed.

N86-23620*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SPACE STATION WORKSTATION TECHNOLOGY WORKSHOP REPORT
K. L. MOE, C. M. EMERSON, D. R. EIKE (Carlow Associates, Fairfax, Va.), and T. B. MALONE (Carlow Associates, Fairfax, Va.) Mar. 1985 135 p
(Contract NAS5-28597)
(NASA-CP-2414; 4033-85-1DRE; NAS 1.55:2414) Avail: NTIS HC A07/MF A01 CSCL 22B

This report describes the results of a workshop conducted at Goddard Space Flight Center (GSFC) to identify current and anticipated trends in human-computer interface technology that may influence the design or operation of a space station

workstation. The workshop was attended by approximately 40 persons from government and academia who were selected for their expertise in some aspect of human-machine interaction research. The focus of the workshop was a 1 1/2 brainstorming/forecasting session in which the attendees were assigned to interdisciplinary working groups and instructed to develop predictions for each of the following technology areas: (1) user interface, (2) resource management, (3) control language, (4) data base systems, (5) automatic software development, (6) communications, (7) training, and (8) simulation. This report is significant in that it provides a unique perspective on workstation design for the space station. This perspective, which is characterized by a major emphasis on user requirements, should be most valuable to Phase B contractors involved in design development of the space station workstation. One of the more compelling results of the workshop is the recognition that no major technological breakthroughs are required to implement the current workstation concept. What is required is the creative application of existing knowledge and technology. Author

N86-24507*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
RESEARCH REPORTS: 1985 NASA/ASEE SUMMER FACULTY FELLOWSHIP PROGRAM Final Report
G. R. KARR, ed. (Alabama Univ., Huntsville), T. L. OSBORN, ed., J. B. DOZIER, ed., and L. M. FREEMAN, ed. (Alabama Univ., Tuscaloosa) Jan. 1986 966 p refs Program held in Huntsville, Ala., 2-16 August 1985
(Contract NGT-01-008-021)
(NASA-CR-178709; NAS 1.26:178709) Avail: NTIS HC A99/MF E04 CSCL 05I

A compilation of 40 technical reports on research conducted by participants in the 1985 NASA/ASEE Summer Faculty Fellowship Program at Marshall Space Flight Center (MSFC) is given. Weibull density functions, reliability analysis, directional solidification, space stations, jet stream, fracture mechanics, composite materials, orbital maneuvering vehicles, stellar winds and gamma ray bursts are among the topics discussed.

N86-24588# Space Command, Peterson AFB, Colo. Cost and Economic Analysis Div.
PRIMER ON OPERATING AND SUPPORT (O AND S) COSTS FOR SPACE SYSTEMS
R. H. LAMONTAGNE Sep. 1985 16 p Presented at the 19th Annual Department of Defense Cost Analysis Symposium, Leesburg, Va., 17-20 Sep. 1985
(AD-A162381) Avail: NTIS HC A02/MF A01 CSCL 14A

Currently, the most common space system is the satellite with its associated ground-based support facilities. However, other systems are currently being developed such as the Strategic Defense Initiative (SDI), Space Station, space based radar, anti-satellite weapon, and others. Our difficulty in the cost community is in developing O&S cost estimates for all these systems. As a result HQ Space Command/ACM is in the process of developing a primer on O&S costs for Space Systems. It is intended to provide some guidelines and fundamentals for estimating the O&S cost for space systems; to address the O&S costs associated with space systems; and to present methodologies and factors to estimate the O&S costs. An O&S cost element structure will be developed for space systems. The primer will result in providing cost visibility for space systems for developing budget and life cycle cost estimates and analyses. GRA

N86-24729* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SHUTTLE-LAUNCH TRIANGULAR SPACE STATION Patent
W. C. SCHNEIDER, inventor (to NASA), R. B. BERKA, inventor (to NASA), C. KAVANAUGH, inventor (to NASA), K. NAGY, inventor (to NASA), R. C. PARISH, inventor (to NASA), J. A. SCHLIESING, inventor (to NASA), P. D. SMITH, inventor (to NASA), F. J. STEBBINS, inventor (to NASA), and C. J. WESSELSKI, inventor (to NASA) 1 Apr. 1986 9 p Filed 9 Mar. 1984 Sponsored by NASA
(NASA-CASE-MSC-20676-1; US-PATENT-4,579,302; US-PATENT-APPL-SN-587764; US-PATENT-CLASS-244-159)
Avail: US Patent and Trademark Office CSCL 22B

A triangular space station deployable in orbit is described. The framework is comprized of three trusses, formed of a pair of generally planar faces consistine of foldable struts. The struts expand and lock into rigid structural engagement forming a repetition of equilater triangles and nonfolding diagonal struts interconnecting the two faces. The struts are joined together by node fittings. The framework can be packaged into a size and configuration transportable by a space shuttle. When deployed, the framework provides a large work/construction area and ample planar surface area for solar panels and thermal radiators. A plurity of modules are secured to the framework and then joined by tunnels to make an interconnected modular display. Thruster units for the space station orientation and altitude maintenance are provided.

Official Gazette of the U.S. Patent and Trademark Office

N86-24732*# Rockwell International Corp., Huntsville, Ala.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY Final Report, Jan. - Oct. 1985
Dec. 1985 116 p
(Contract NAS8-35618)
(NASA-CR-178819; NAS 1.26:178819; STS85-0174-ADD) Avail: NTIS HC A06/MF A01 CSCL 22B

NASA has recognized that the capability for remote resupply of space platform expendable fluids will help transition space utilization into a new era of operational efficiency and cost/effectiveness. The emerging Orbital Maneuvering System (OMV) in conjunction with an expendables resupply module will introduce the capability for fluid resupply enabling satellite lifetime extension at locations beyond the range of the Orbiter. This report summarizes a supplemental study to the original Phase A study and is presented as addenda to that study. Author

N86-24733*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY. VOLUME 1: EXECUTIVE SUMMARY Report, Mar. - Dec. 1984
Dec. 1984 36 p 4 Vol.
(Contract NAS8-35618)
(NASA-CR-178820; NAS 1.26:178820; STS-85-0174-VOL-1)
Avail: NTIS HC A03/MF A01 CSCL 22B

NASA has recognized that the capability for remote resupply of space platform expendable fluids will help transition space utilization into a new era of operational efficiency and cost/effectiveness. The emerging Orbital Maneuvering System (OMV) in conjunction with an expendables resupply module will introduce the capability for fluid resupply enabling satellite lifetime extension at locations beyond the range of the Orbiter. This report summarizes a Phase A study of a remote resupply module for the OMV. Volume 1 is the executive summary. Author

N86-24734*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY, VOLUME 2 Technical Report, Mar. - Dec. 1984
Dec. 1984 295 p 4 Vol.
(Contract NAS8-35618)
(NASA-CR-178821; NAS 1.26:178821; STS-85-0174-VOL-2)
Avail: NTIS HC A13/MF A01 CSCL 22B

NASA has recognized that the capability for remote resupply of space platform expendable fluids will help transition space utilization into a new era of operational efficiency and cost/effectiveness. The emerging Orbital Maneuvering System (OMV) in conjunction with an expendables resupply module will introduce the capability for fluid resupply enabling satellite lifetime extension at locations beyond the range of the Orbiter. This report summarizes a Phase A study of a remote resupply module for the OMV. Volume 2 represents study results. Author

N86-24735*# Rockwell International Corp., Downey, Calif.
SPACE PLATFORM EXPENDABLES RESUPPLY CONCEPT DEFINITION STUDY. VOLUME 3: WORK BREAKDOWN STRUCTURE AND WORK BREAKDOWN STRUCTURE DICTIONARY Technical Report, Mar. 1984 - Dec. 1984
Dec. 1984 13 p 4 Vol.
(Contract NAS8-35618)
(NASA-CR-178822; NAS 1.26:178822; STS-85-0174-VOL-3)
Avail: NTIS HC A02/MF A01 CSCL 22B

The work breakdown structure (WBS) for the Space Platform Expendables Resupply Concept Definition Study is described. The WBS consists of a list of WBS elements, a dictionary of element definitions, and an element logic diagram. The list and logic diagram identify the interrelationships of the elements. The dictionary defines the types of work that may be represented by or be classified under each specific element. The Space Platform Expendable Resupply WBS was selected mainly to support the program planning, scheduling, and costing performed in the programmatics task (task 3). The WBS is neither a statement-of-work nor a work authorization document. Rather, it is a framework around which to define requirements, plan effort, assign responsibilities, allocate and control resources, and report progress, expenditures, technical performance, and schedule performance. The WBS element definitions are independent of make-or-buy decisions, organizational structure, and activity locations unless exceptions are specifically stated. Author

N86-25794*# National Aeronautics and Space Administration, Washington, D.C.
PROCEEDINGS OF A WORKSHOP ON APPLICATIONS OF TETHERS IN SPACE: EXECUTIVE SUMMARY
W. A. BARACAT, Compiler 1986 43 p Proc. held in Venice, Italy, 15-17 Oct. 1985
(Contract NASW-3921)
(NASA-CP-2422; NAS 1.55:2422) Avail: NTIS HC A03/MF A01 CSCL 13I

The workshop was attended by persons from government, industry, and academic institutions to discuss the rapidly evolving area of tether applications in space. Many new applications were presented at the workshop, and existing applications were revised, refined, and prioritized as to which applications should be implemented and when. The workshop concluded with summaries developed individually and jointly by each of the applications panels. Author

N86-26650*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
INDEX OF AEROSPACE MECHANISMS SYMPOSIA PROCEEDINGS 1-19
A. RINALDO (Lockheed Missiles and Space Co., Sunnyvale, Calif.) and J. WILSON Apr. 1986 281 p
(NASA-TM-88205; A-86076; NAS 1.15:88205) Avail: NTIS HC A13/MF A01 CSCL 13I

This index, organized in five sections (by symposium, by title, by author, by subject, and by project), brings together information on the first 19 Aerospace Mechanisms symposia. Key words are included, cross-referencing all the symposia, and the eighteenth and nineteenth symposia are cross-indexed by project. The Aerospace Mechanisms symposia are devoted to discussions of design, fabrication, test, and operational use of aerospace mechanisms; this is the first index that compiles information on symposia held from 1966 through 1985. Author

N86-27353# European Space Agency, Paris (France).
SECOND EUROPEAN SPACE MECHANISMS AND TRIBOLOGY SYMPOSIUM
T. D. GUYENNE, comp. and J. HUNT, comp. Dec. 1985 327 p In ENGLISH and FRENCH Symposium held in Schloss Meersburg, West Germany, 9-11 Oct. 1985; sponsored by ESA, Dornier-Werke GmbH, and DFVLR
(ESA-SP-231; ETN-86-96851) Avail: NTIS HC A15/MF A01; ESA, Paris FF 150 or $18 Member States, AU, CN, NO (+20% others)

Spacecraft mechanisms; motors and actuators; tribology; space stations; and mechanism analysis and testing were discussed. ESA

N86-27409*# National Aeronautics and Space Administration, Washington, D.C.
THE SUITABILITY OF VARIOUS SPACECRAFT FOR FUTURE SPACE APPLICATIONS MISSIONS
C. W. MATHEWS, R. BERNSTEIN (International Business Machines Corp., Palo Alto, Calif.), and D. C. MACLELLAN (Massachusetts Inst. of Tech., Cambridge.) Jul. 1986 18 p
(NASA-TM-88986; NAS 1.15:88986) Avail: NTIS HC A02/MF A01 CSCL 22B

The Space Applications Advisory Committee (SAAC) of NASA's Advisory Council was asked by the Associate Administrator for Space Science and Applications to consider the most suitable future means for accomplishing space application missions. To comply with this request, SAAC formed a Task Force whose report is contained in this document. In their considerations, the Task Force looked into the suitability of likely future spacecraft options for supporting various types of application mission payloads. These options encompass a permanent manned space station, the Space Shuttle operating in a sortie mode, unmanned platforms that integrate a wide variety of instruments or other devices, and smaller free fliers that accommodate at most a few functions. The Task Force also recognized that the various elements could be combined to form a larger space infrastructure. This report summarizes the results obtained by the Task Force. It describes the approach utilized, the findings and their analysis, and the conclusions. Author

N86-27644*# National Aeronautics and Space Administration, Washington, D.C.
APPLICATIONS OF TETHERS IN SPACE: WORKSHOP PROCEEDINGS, VOLUME 2
W. A. BARACAT, comp. (General Research Corp., McLean, Va.) Jun. 1986 502 p Workshop held in Venice, Italy, 15-17 Oct. 1985; sponsored by NASA, the Italian National Space Plan and CNR
(Contract NASW-3921)
(NASA-CP-2422-VOL-2; NAS 1.55:2422-VOL-2) Avail: NTIS HC A23/MF A01 CSCL 13I

Topics addressed include: tethered orbital transfer vehicle operations, Centaur and Shuttle tether technology; tethered constellations, gravitational effects; Shuttle continuous open wind tunnel; optimal control laws, electrodynamic tether technology; and space station facilities.

N86-28016# National Oceanic and Atmospheric Administration, Washington, D. C.
INTERNATIONAL COORDINATION OF AND CONTRIBUTIONS TO ENVIRONMENTAL SATELLITE PROGRAMS Final Report
P. UHLIR and L. SHAFFER Jun. 1985 65 p
(AD-A165142) Avail: NTIS HC A04/MF A01 CSCL 22B

The paper begins with an overview of U.S. policy on remote sensing. Next, the extensive international cooperation in U.S. Polar-orbiting Operational Environmental Satellites (POES) is described. This includes participation in the POES direct readout services program, and existing instrument contributions and commitments to the POES system. The opportunities and mechanisms for future contributions to POES, or to the polar platform component of the U.S. Space Station, are also examined. Geostationary environmental satellites are operated by the United States, the European Space Agency, Japan, and India. These systems are described, and the Coordination on Geostationary Meteorological Satellites is discussed. Other international organizations used for cooperation and coordination in remote-sensing activities are outlined. These include the World Meteorological Organization, the Intergovernmental Oceanographic Commission, the International Council of Scientific Unions, and the Committee on Earth Observations Satellites. Contributions by the United States to planned foreign remote-sensing programs are addressed as well. Finally, the report identifies and discusses three trends in remote sensing, and makes some concluding observations about the future of international remote-sensing ac tivities. Appendix A lists the dates of all relevant documents, such as Memoranda of Understanding, Terms of Reference for international committees, and Minutes of Meetings. GRA

N86-28407*# National Aeronautics and Space Administration, Washington, D.C.
APPLICATIONS OF TETHERS IN SPACE: WORKSHOP PROCEEDINGS, VOLUME 1
W. A. BARACAT, comp. (General Research Corp., McLean, Va.) Jun. 1986 585 p Workshop held in Venice, Italy, 15-17 Oct. 1985; sponsored by NASA, the Italian National Space Plan and CNR
(Contract NASW-3921)
(NASA-CP-2422-VOL-1; NAS 1.55:2422-VOL-1) Avail: NTIS HC A25/MF A01 CSCL 13I

The complete documentation of the workshop including all addresses, panel reports, charts, and summaries are presented. This volume presents all the reports on the fundamentals of applications of tethers in space. These applications include electrodynamic interactions, transportation, gravity utilization, constellations, technology and test, and science applications.

N86-29888*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
PROCEEDINGS OF THE 2ND ANNUAL CONFERENCE ON NASA/UNIVERSITY ADVANCED SPACE DESIGN PROGRAM
Jun. 1986 31 p Conference held at Cocoa Beach, Fla., 18-20 Jun. 1986
(Contract NGT21-002-080)
(NASA-TM-89399; NAS 1.15:89399) Avail: NTIS HC A03/MF A01 CSCL 22B

Topics discussed include: lunar transportation system, Mars rover, lunar fiberglass production, geosynchronous space stations, regenerative system for growing plants, lunar mining devices, lunar oxygen transporation system, mobile remote manipulator system, Mars exploration, launch/landing facility for a lunar base, and multi-megawatt nuclear power system. B.G.

N86-30584*# Lunar and Planetary Inst., Houston, Tex.
TRAJECTORY DETERMINATIONS AND COLLECTION OF MICROMETEOROIDS ON THE SPACE STATION. REPORT OF THE WORKSHOP ON MICROMETEORITE CAPTURE EXPERIMENTS
F. HOERZ, ed. 1986 105 p refs Workshop held in Houston, Tex., 16-18 Dec. 1985
(Contract NASW-4066)
(NASA-CR-177303; NAS 1.26:177303; LPI-TR-86-05) Avail: NTIS HC A06/MF A01 CSCL 03B

Summaries of papers presented at the Workshop on Micrometeorite Capture Experiments are compiled. The goals of the workshop were to define the scientific objectives and the resulting performance requirements of a potential Space Station facility and to identify the major elements of a coherent development program that would generate the desired capabilities within the next decade. Specific topics include cosmic dust and space debris collection techniques, particle trajectory and source determination, and specimen analysis methods.

N86-30602*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION
D. R. THOMPSON *In* Lunar and Planetary Inst. IN Trajectory Determination and Collection of Micrometeoroids on the Space Station p 83-84 1986
Avail: NTIS HC A06/MF A01 CSCL 03B

The Space Station is being defined as a multi-purpose facility with emphasis in the following areas: scientific and technology research laboratory; permanent observatory; spacecraft servicing facility; construction and assembly facility; manufacturing facility; transportation node; and staging base for future space endeavors. The Station complex, in its initial operating capability configuration, includes a continuously habitable manned element, a polar orbiting unmanned platform, and a second unmanned platform co-orbiting with the manned element. All elements are dependent on the Space Transportation System (STS) for initial placement on-orbit and for subsequent logistical services. The manned element will be designed for long duration operations with systems maintainable on-orbit and operationally autonomous from ground control. A major feature of the Station will be its adaptability to evolutionary technology upgrades; and the Space Station, as a system, is to be designed for maximum ease of use by its users. Author

N86-30627# Deutsche Gesellschaft fuer Luft- und Raumfahrt, Bonn (West Germany).
THE SECOND INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS
1985 713 p Symposium held in Aachen, West Germany, 1-3 Apr. 1985; sponsored in cooperation with DFVLR, NLR and ONERA
(DGLR-85-02; ISBN-3-922010-28-8; ETN-86-97411) Avail: NTIS HC A99/MF E03

Unsteady aerodynamics and aeroelastic characteristics; active control technology; structural modeling and optimization; structural system identification; and structural dynamics design verification of space structures were discussed. ESA

N86-30744*# Colorado Univ., Boulder. Center for Space Law and Policy.
A STUDY OF FACTORS RELATED TO COMMERCIAL SPACE PLATFORM SERVICES
S. N. HOSENBALL Aug. 1986 254 p
(Contract NAGW-884)
(NASA-CR-176881; NAS 1.26:176881) Avail: NTIS HC A12/MF A01 CSCL 22A

In the past four years, the issue of the commercial development of space has come to the forefront of the U. S. national space policy. Though the Administration, Congress and NASA have all shown strong support for encouraging the private sector to become more actively involved in the commercial utilization of space, the question remains whether they must do more to foster the creation

and development of a viable U. S. commercial space industry. Marketing aspects, insurance and risk loss, tax related factors, space transportation, termination liability, institutional barriers, and procurement laws and regulations are discussed. B.G.

N86-30758# European Space Agency, Paris (France).
PROCEEDINGS OF A WORKSHOP ON COMPOSITES DESIGN FOR SPACE APPLICATIONS
W. R. BURKE, comp. Feb. 1986 375 p Workshop held in Noordwijk, Netherlands, 15-18 Oct. 1985
(ESA-SP-243; ISSN-0379-6566; ETN-86-97217) Avail: NTIS HC A16/MF A01

The choice and characteristics of composite materials for space applications, calculation and design methods, and dimensional stability were some areas of discussion in this workshop. Also discussed was integrity control, Ariane applications of composites, load carrying structures in satellites, and satellite antenna and solar array applications.

ESA

N86-31409*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
NASA/AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE) SUMMER FACULTY FELLOWSHIP PROGRAM, 1985
R. G. CHILTON, ed. (Texas A&M Univ., College Station.) and C. E. WILLIAMS, ed. Jul. 1986 733 p Program held in Houston, Tex., 1985
(Contract NGT-44-001-800)
(NASA-CR-171931; NAS 1.26:171931) Avail: NTIS HC A99/MF E03 CSCL 05I

The 1985 NASA/ASEE Summer Faculty Fellowship Research Program was conducted by Texas A&M University and the Johnson Space Center. The ten week program was operated under the auspices of the American Society for Engineering Education (ASEE). The faculty fellows spent the time at JSC engaged in research projects commensurate with their interests and background and worked in collaboration with NASA/JSC colleagues. This document is a compilation of the final reports of their research during the summer of 1985.

N86-31450# Committee on Appropriations (U. S. House).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Department of Housing and Urban Development-Independent Agecies Appropriations Bill, 1987 p 42-49 1986
Avail: US Capitol, House Document Room

Budget allocations for the orbital space station, space flight control and data communications, space shuttles, construction of new facilities, research and project management, Advanced Communications Technology Satellite (ACTS) program, space commercialization, and the shuttle infrared telescope facility (SIRTF) are discussed. B.G.

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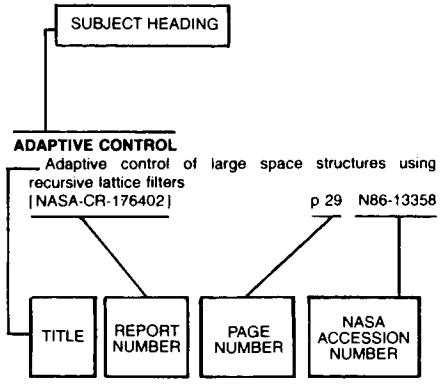

The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession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

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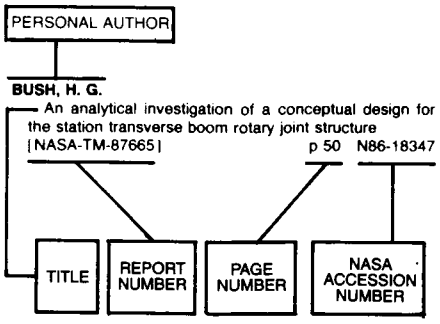

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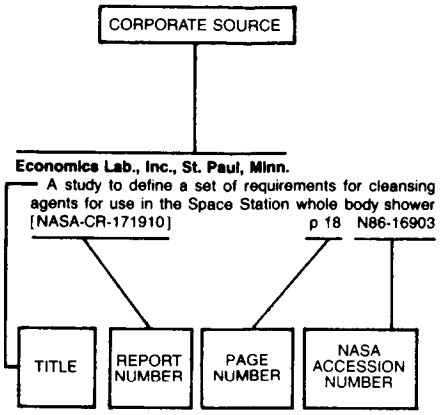

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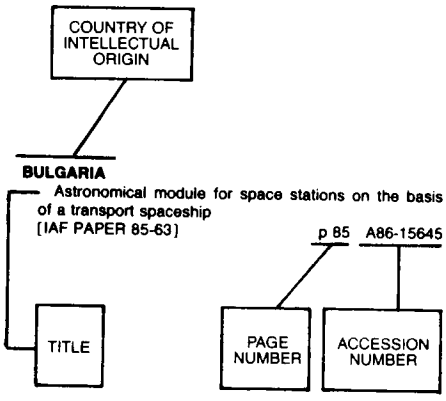

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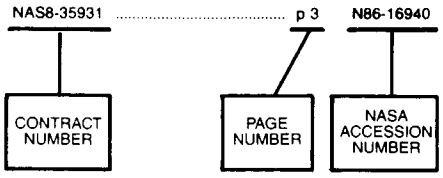

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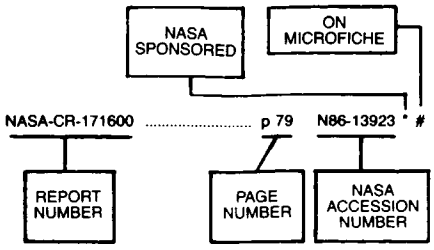

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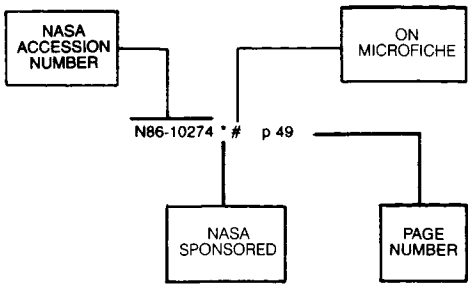

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