Space Station Systems

A Bibliography
with Indexes

NASA SP-7056(03)
January 1987

(NASA-SP-7056(03)) SPACE STATION SYSTEMS: A CONTINUING BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 3) (National Aeronautics and Space Administration) 205 p CSCL 22A

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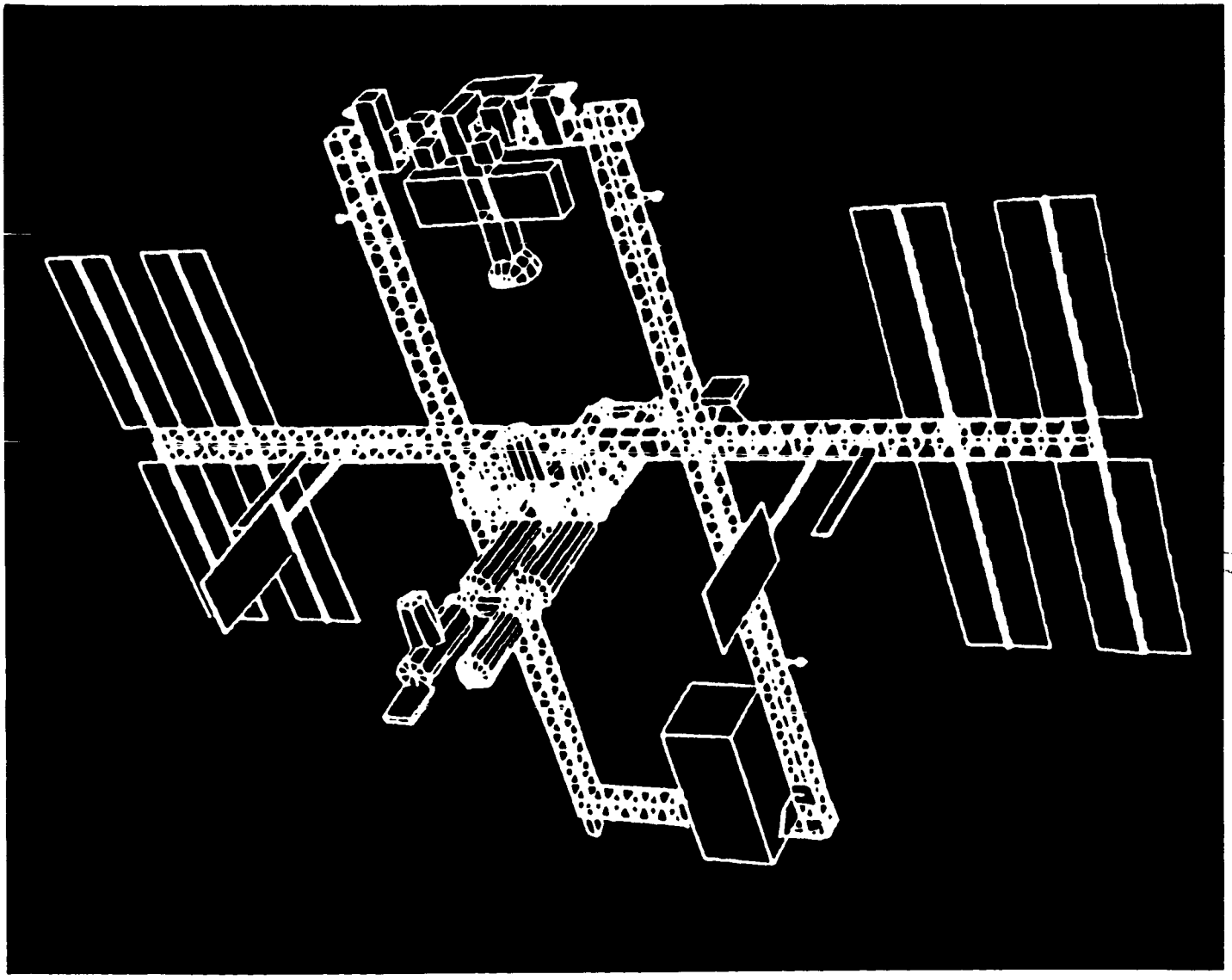

NOTE TO AUTHORS OF PROSPECTIVE ENTRIES:

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(03)

SPACE STATION SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 3

Compiled by
Technical Library Branch
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Edited by
Space Station Office
NASA Langley Research Center
Hampton, Virginia

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system between January 1 and June 30, 1986 in

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

NASA
Scientific and Technical Information Branch 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 780 reports, articles and other documents announced between January 1, 1986 and June 30, 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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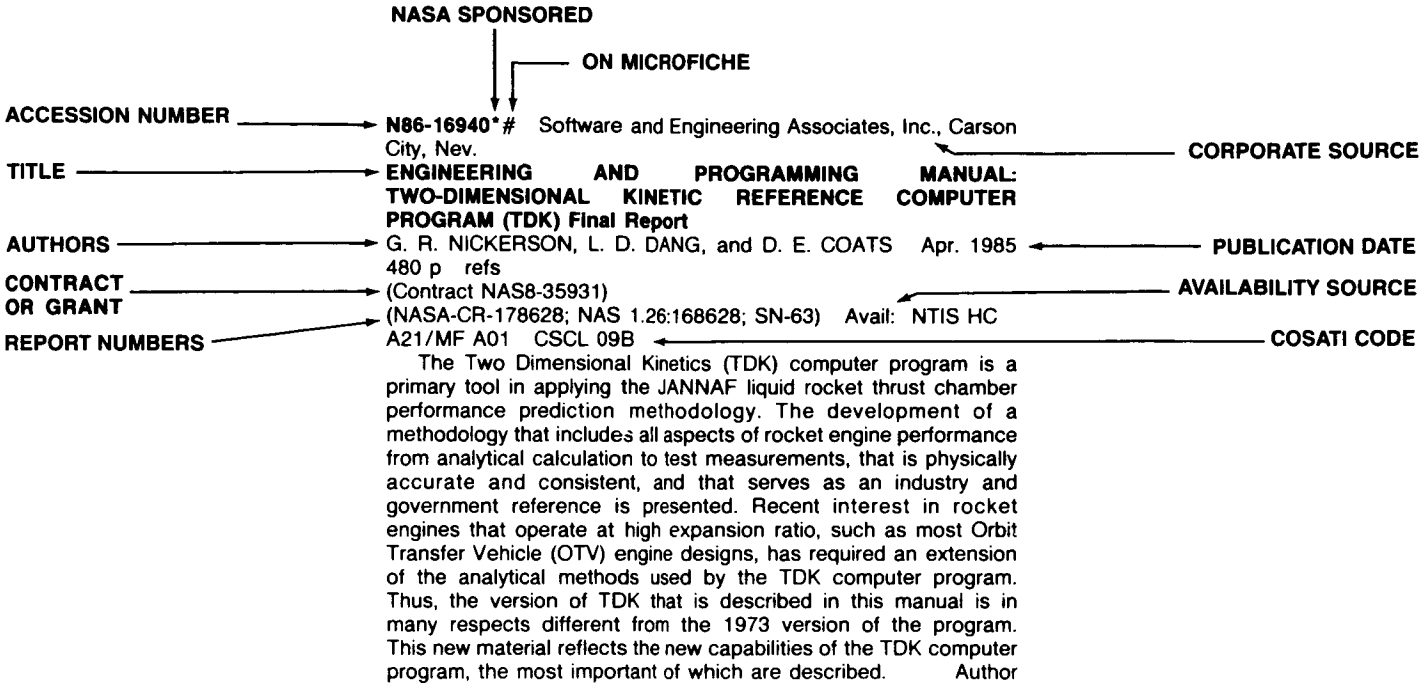
TYPICAL REPORT CITATION AND ABSTRACT



N86-16940*# Software and Engineering Associates, Inc., Carson City, Nev.

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

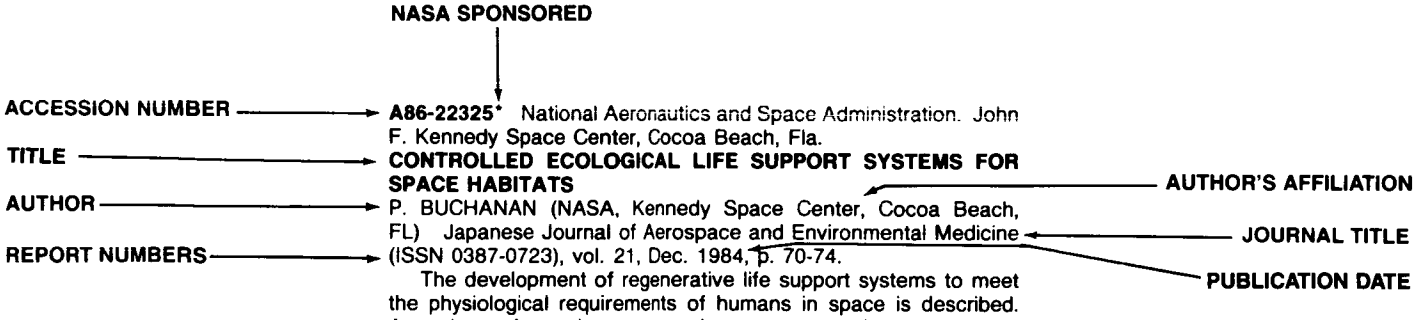
G. R. NICKERSON, L. D. DANG, and D. E. COATS Apr. 1985 480 p refs

(Contract NAS8-35931)

(NASA-CR-178628; NAS 1.26:168628; SN-63) Avail: NTIS HC A21/MF A01 CSCL 09B

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



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

CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS FOR SPACE HABITATS

P. BUCHANAN (NASA, Kennedy Space Center, Cocoa Beach, FL) 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. 3)

JANUARY 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.

A86-10936#
REQUIREMENTS, DEVELOPMENT AND PARAMETRIC ANALYSIS FOR SPACE SYSTEMS DIVISION
B. G. MORAIS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, AHS, and ASEE, Aircraft Design Systems and Operations Meeting, Colorado Springs, CO, Oct. 14-16, 1985. 7 p.
(AIAA PAPER 85-3078)

This paper presents a tutorial on requirements development and parametric analysis. It provides an overview of the System Engineering process and presents the approach and an example of parametric analysis as it relates to deriving requirements for large space systems. Author

A86-11557*
SPACE STATION PROGRAM: DESCRIPTION, APPLICATIONS AND OPPORTUNITIES
NASA-sponsored research. Park Ridge, NJ, Noyes Publications, 1985, 784 p. Previously announced in STAR as N84-33437.

The Space Station Program Description Document is summarized. The six volumes include: (1) introduction and summary; (2) mission description; (3) systems requirements and characteristics; (4) advanced development; (6) system operation, and (7) program plan. Volume 5 was deleted as a separate book.

A86-15635*# National Aeronautics and Space Administration, Washington, D.C.
PLANNING FOR SPACE STATION UTILIZATION
W. RANEY (NASA, Office of Space Station, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 5 p.
(IAF PAPER 85-48)

User requirements for the planned Space Station, and utilization planning to meet those needs, are discussed. The continual involvement of the customer in all aspects of the Space Station Program is to be achieved by identifying customers and by defining, refining, and integrating their requirements so as to stimulate the best possible design, development, and operations. Planning guidelines to be used in the Space Station definition process are shown and discussed, as is the Space Station Planning Schedule. C.D.

A86-15636*# National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION UTILIZATION FOR TECHNOLOGY PURPOSES
J. L. ANDERSON and J. ROMERO (NASA, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-50)

The role of the Space Station in in-space technology research and development is discussed. The categorizing of research and technology experiments, which is required in order to provide the proper facilities for the experiments, is described. The use of the Space Station, itself, as an experiment is studied; instrumented large space structure experiments, environmental interactions, human-machine interface, and evolutjonary technology validation can be conducted by the Space Station. The necessary conditions for the Space Station to function as a research and technology facility are analyzed. The Space Station design and planning considerations, in order to meet research and technology objectives and support requirements, are investigated. I.F.

A86-17314#
A SUMMARY OF POTENTIAL DESIGNS OF SPACE STATIONS AND PLATFORMS
R. KLINE, R. MCCAFFREY, and D. B. STEIN (Grumman Aerospace Corp., Bethpage, NY) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 267-351.

This chapter discusses the potential designs and characteristics of space stations and space platforms, and describes the ability to fulfill currently defined objectives through the year 2000. A definition of mission requirements leads to the functional requirements of the unmanned platform and manned Space Station. The chapter also describes in detail the major design issues that drive the base configuration and its respective systems for crew habitation, berthing/docking and logistics, satellite and upper-stage vehicle servicing, command, control, and communications, base resources, and platform commonality. Author

A86-17317* National Aeronautics and Space Administration, Washington, D.C.
ARCHITECTURE OF PERMANENT PRESENCE
E. E. SPEAKER (NASA, Washington, DC) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 19-29.
(AAS PAPER 84-108)

A summary of recommendations of the Concept Development Group of the NASA Space Station Task Force is given. The recommendations address the principal technical issues related to Space Station architecture, with emphasis given to design geometry. Line drawings of the four Space Station candidate geometries are provided, including: a planar geometry; a streamline geometry; a delta; and the 'power tower' concept. I.H.

A86-17319
SPACE STATION/PLATFORM CONFIGURATIONS
R. W. MCCAFFREY (Grumman Aerospace Corp., Bethpage, NY) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 45-54. refs
(AAS PAPER 84-114)

The mission requirements and potential design of the Space Station and its adjunct Space Platform are discussed. The major design issues driving the configuration shapes are considered, including: power requirements; construction costs; flight control; and adaptibility. Detailed line drawings of the principal candidate configurations for Space Station are provided. The configurations include: a planar IOC; a delta IOC; a big 'Tee' IOC; and the power tower concept. I.H.

A86-24175* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ENGINEERING AND CONFIGURATIONS OF SPACE STATIONS AND PLATFORMS
A. LOUVIERE, ED. (NASA, Johnson Space Center, Houston, TX) Research supported by NASA. Park Ridge, NJ, Noyes Publications, 1985, 791 p. No individual items are abstracted in this volume; Previously announced in STAR as N85-31146.

The data generated by the Space Station Program Skunk.Works over a period of 4 months which supports the definition of a Space Station reference configuration is documented. The data were generated to meet these objectives: (1) provide a focal point for the definition and assessment of program requirements; (2) establish a basis for estimating program cost; and (3) define a reference configuration in sufficient detail to allow its inclusion in the definition phase Request for Proposal (RFP). G.L.C.

N86-13357*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION PRELIMINARY DESIGN REPORT
Sep. 1982 252 p refs
(NASA-TM-87521; NAS 1.15:87521) Avail: NTIS HC A12/MF A01 CSCL 22B

The results of a 3 month preliminary design and analysis effort is presented. The configuration that emerged consists of a very stiff deployable truss structure with an overall triangular cross section having universal modules attached at the apexes. Sufficient analysis was performed to show feasibility of the configuration. An evaluation of the structure shows that desirable attributes of the configuration are: (1) the solar cells, radiators, and antennas will be mounted to stiff structure to minimize control problems during orbit maintenance and correction, docking, and attitude control; (2) large flat areas are available for mounting and servicing of equipment; (3) Large mass items can be mounted near the center of gravity of the system to minimize gravity gradient torques; (4) the trusses are lightweight structures and can be transported into orbit in one Shuttle flight; (5) the trusses are expandable and will require a minimum of EVA; and (6) the modules are anticipated to be structurally identical except for internal equipment to minimize cost. Author

N86-18872*# Stanford Univ., Calif. Space, Telecommunications and Radioscience Lab.
SPACE RESEARCH IN THE ERA OF THE SPACE STATION
P. M. BANKS *In* ESA The Seventh ESA Symposium On European Rocket and Balloon Programs and Related Research p 377-379 1985 Sponsored in part by ESA
(Contract NAGW-235)
Avail: NTIS HC A18/MF A01

The major elements of the NASA manned space station are described, and science activities it could be used for are suggested. The core facilities include at least two major laboratory modules with supporting utilities, including habitation accommodations, docking facilities, power and heat rejection units, and external space and support for attached payloads. A vertically oriented structure, called the Power Tower, is being studied. Scientific accommodations inside the modules include major facility instrumentation for a variety of microgravity research projects, with initial emphasis upon materials research and life sciences. The second element is composed of free-flying satellites operating in orbits near the core station. The third element consists of satellites in polar orbits. One or more large, multi-instrument platforms are planned for Earth observation and solar-terrestrial processes research. Author (ESA)

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.

A86-17443* Hughes Aircraft Co., El Segundo, Calif.
ON AN ALGORITHM FOR ANALYSIS OF THE RADIATION PATTERNS OF DUAL REFLECTOR AND SEGMENTED REFLECTOR ANTENNAS
C. G. CHRISTODOULOU (Central Florida, University, Orlando), A. B. BOTULA (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA), and J. F. KAUFFMAN (North Carolina State University, Raleigh) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. AP-33, Oct. 1985, p. 1101-1108. refs
(Contract NSG-1588)

An algorithm has been developed to calculate the radiation patterns of a large reflector antenna for space applications. The algorithm treats each panel in the reflector array as an analytic surface having n-sided polygonal boundaries. The radiation fields for individual panels are computed and stored separately, and then added to yield a uniform radiation pattern for the entire reflector. Numerical methods developed to reduce the overlap of the aperture fields of adjacent panels are described in detail. Calculations of the tangential field components of the aperture plane are carried out based on the principles of geometric optics (GO). Some radiation patterns calculated with the algorithm are compared with patterns produced by other methods, together with measured data for a classical Cassegrain antenna and the calculated patterns are illustrated. I.H.

A86-19761*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THREE-DIMENSIONAL AOTV FLOWFIELDS IN CHEMICAL NONEQUILIBRIUM
P. A. GNOFFO and R. S. MCCANDLESS (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p. refs
(AIAA PAPER 86-0230)

A technique for upwind differencing of the three-dimensional species continuity equations is presented which permits computation of steady flows in chemical equilibrium and nonequilibrium. The capabilities and shortcomings of the present approach for equilibrium and nonequilibrium flows is discussed. Modifications now being investigated to improve computational time are outlined. C.D.

A86-19954*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF PROGRAM LAURA TO THREE-DIMENSIONAL AOTV FLOWFIELDS
P. A. GNOFFO (NASA, Langley Research Center, Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs
(AIAA PAPER 86-0565)

Program LAURA (Langley Aerothermodynamic Upwind Relaxation Algorithm) is a robust, finite volume, single-level storage,

implicit upwind differencing algorithm which has been documented and tested on several three-dimensional blunt-body flows. The algorithm can run at unlimited Courant numbers (relaxing the steady-state equations) but requires the inversion of only a 5 x 5 matrix per computational cell. An alternating directional sweep Gauss-Seidel substitution strategy is used to relax the governing equations. At present, the Euler and thin-layer Navier-Stokes equations using Sutherland's law for viscosity have been modeled for a perfect gas, equilibrium air, and nonequilibrium air chemistry neglecting diffusion. The equilibrium and nonequilibrium air chemistry options have been described in a companion paper. Good comparisons with experimental data and another calculation method for pressure distributions, aerodynamic coefficients, and heat-transfer distributions have been demonstrated for three-dimensional blunt-body flows. Author

A86-22695#
MODULAR CONSTRUCTION OF SIX DEGREE-OF-FREEDOM SIMULATION FOR EVALUATION OF SPACE INTERCEPTOR DESIGN
C. A. LIN and M. M. BRIGGS (Integrated Systms, Inc., Palo Alto, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.
(AIAA PAPER 86-0357)

This paper discusses a novel approach for rapidly creating and verifying 6-DOF space interceptor simulation that replaces the usual need for using programming languages to create simulations. Instead, symbols (icons) are menu-selected to define and screen-display user-designed functional block diagrams as an expert engineer would do to automatically create the intercept simulation. The result is a substantial reduction in manpower required to evaluate an compare space interceptor concept. The 6-DOF simulation-building approach allows the user to define the interceptor to be simulated in a 'top-down' manner employing the usual process of top-down functional analysis to define functional block diagrams of the system. Subsequently, 'bottom-up' modular construction of the simulation can be accomplished, with design and verification at the I/O level of each subsystems. Author

A86-25524
A SURFACE DISCHARGE MODEL FOR SPACECRAFT DIELECTRICS
R. STETTNER (Mission Research Corp., Santa Barbara, CA) and A. B. DEWALD (Corium Industries, Inc., Atlanta, GA) (IEEE, DNA, Sandia National Laboratories, and NASA, 1985 Annual Conference on Nuclear and Space Radiation Effects, 22nd, Monterey, CA, July 22-24, 1985) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-32, Dec. 1985, p. 4079-4086. refs

A discharge propagation model which is consistent with charge conservation, energy conservation and existing data is proposed. The essential idea in the model is that ions accelerated by the large fields at the edge of the discharge cause the emission of electrons, further ion production and the consequent propagation and discharge of the surface. This paper develops the consistency arguments for three related models and compares the implications of the models with existing data. Only one of the models survives the comparison. Author

A86-26491#
INTERACTIVE COMPUTER GRAPHICS MODEL AND SIMULATE ON-ORBIT OPERATIONS
S. E. TICE (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) Mechanical Engineering (ISSN 0025-6501), vol. 108, Feb. 1986, p. 32-36.

Specialized software have been developed by means of which design, analysis, modeling and simulation efforts concerning orbital space station and EVA-related hardware can be undertaken. The software generates full color simulations employing solid and shaded object models that can be observed from multiple viewpoints at two distinct levels of complexity ('fidelity'). While high fidelity simulations involve costs an order of magnitude higher than those of low fidelity simulations, they are ideal for flight training; low fidelity simulations have as their primary advantage the ability of the operator to drive the object models in real time. The software is designated the 'Configuration Design Analysis and Simulation System'. O.C.

N86-14133# Joint Publications Research Service, Arlington, Va.
MATHEMATICAL MODELS OF NONSTATIONARY EDDY CURRENTS AND EDDY MOTIONS OF FLUID IN SPACECRAFT ORIENTATION AND STABILIZATION PROBLEMS 1 Abstract Only
B. I. RABINOVICH and V. M. ROGOVOY *In its* USSR Rept.: Space (JPRS-USP-85-005) p 41 30 Sep. 1985 Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 22, no. 5, Sep. - Oct. 1984 p 678-692 Original language document announced in IAA as A85-15255
Avail: NTIS HC A08

The paper examines the development of an adequate mathematical model for eddy currents in a conducting ferromagnetic, valid for the frequency band which characterizes spacecraft attitude and stabilization problems. The model is synthesized on the basis of the asymptotic solution of the appropriate boundary layer equations. This approach is illustrated by the model of an electromagnetic actuator for spacecraft attitude and stabilization systems. B.J.(IAA)

N86-16940*# Software and Engineering Associates, Inc., Carson City, Nev.
ENGINEERING AND PROGRAMMING MANUAL: TWO-DIMENSIONAL KINETIC REFERENCE COMPUTER PROGRAM (TDK) Final Report
G. R. NICKERSON, L. D. DANG, and D. E. COATS Apr. 1985 480 p refs
(Contract NAS8-35931)
(NASA-CR-178628; NAS 1.26:168628; SN-63) Avail: NTIS HC A21/MF A01 CSCL 09B

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

N86-17411*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
COMPUTER SIMULATION OF ENVIRONMENTAL, HAZARD SCENARIOS IN SPACE
R. H. BROWN *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 309-319 Apr. 1985 Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 09B

The development of the Advanced Computer Graphics Laboratory at NASA/JSC will enable NASA engineers to utilize state-of-the-art computer systems to simulate and analyze current and planned space missions. These systems utilize computer graphics to animate automated satellite rendezvous and docking, satellite servicing, tether operations, as well as remote manipulator activities and assembly of large space structures including the space station. These computer simulations enhance the engineering evaluation of possible hazardous scenarios in space by allowing users to view from any point in space these activities and determine if any potential problem could occur. Author

N86-18341*# Ohio State Univ., Columbus. ElectroScience Lab.
THE ROLE OF SERVICE AREAS IN THE OPTIMIZATION OF FSS ORBITAL AND FREQUENCY ASSIGNMENTS
C. A. LEVIS, C. W. WANG, Y. YAMAMURA, C. H. REILLY, and D. J. GONSALVEZ Dec. 1985 31 p refs
(Contract NAG3-159)
(NASA-CR-176488; NAS 1.26:176488; TR-716548-3) Avail: NTIS HC A03/MF A01 CSCL 17B

A relationship is derived, on a single-entry interference basis, for the minimum allowable spacing between two satellites as a function of electrical parameters and service-area geometries. For circular beams, universal curves relate the topocentric satellite spacing angle to the service-area separation angle measured at the satellite. The corresponding geocentric spacing depends only weakly on the mean longitude of the two satellites, and this is true also for alliptical antenna beams. As a consequence, if frequency channels are preassigned, the orbital assignment synthesis of a satellite system can be formulated as a mixed-integer programming (MIP) problem or approximated by a linear programming (LP) problem, with the interference protection requirements enforced by constraints while some linear function is optimized. Possible objective-function choices are discussed and explicit formulations are presented for the choice of the sum of the absolute deviations of the orbital locations from some prescribed ideal location set. A test problem is posed consisting of six service areas, each served by one satellite, all using elliptical antenna beams and the same frequency channels. Numerical results are given for the three ideal location prescriptions for both the MIP and LP formulations. The resulting scenarios also satisfy reasonable aggregate interference protection requirements. Author

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.

A86-10025*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF RANDOM MEMBER LENGTH ERRORS ON THE ACCURACY AND INTERNAL LOADS OF TRUSS ANTENNAS
W. H. GREENE (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 1, p. 697-704) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, Sept.-Oct. 1985, p. 554-559. Previously cited in issue 12, p. 1741, Accession no. A83-29801. refs

A86-10030#
CLOSE-PACK MODULES FOR MANNED SPACE STRUCTURES
W. FRISINA Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, Sept.-Oct. 1985, p. 583, 584.

Close-packable polyhedra are considered here as the basic building blocks for a manned space station. Loading in these structures is through columnar compression and tension of the frames, with no appreciable loading through seals and panels, as is the case with cylindrical modules spun to create artificial gravity. The frames can be taken apart, permitting efficient transport by booster, reuse for new orbital constructions, and panel removal. The panel seals are discussed. C.D.

A86-15064*
FRAMEWORKS FOR THE FUTURE
T. MCMAHAN, A. SHIELDS, and V. NEAL Space World (ISSN 0038-6332), vol. 5, Nov. 1985, p. 20-24. NASA-supported research.

NASA is exploring the techniques and technologies which will permit the construction of large structures in space. EASE (Experimental Assembly of Structures in Extravehicular Activity) and ACCESS (Assembly Concept for Construction of Erectable Space Structures) are structures which are carried in the Atlantis bay and are assembled in space by astronauts. The experimental structures were designed to be durable and strong, easily assembled, have removable parts, and be amenable to alterations using specially-designed tools. All space activities are first rehearsed in detail on earth, mainly in the NASA Neutral Buoyancy Facility. Thorough studies are also being done to examine the human factors of space assembly and to gather biomedical data to characterize the capabilities of humans doing construction work in space. M.S.K.

A86-15745#
NEW CONCEPTS FOR PRECISION REFLECTOR SUPPORT STRUCTURES
J. M. HEDGEPETH (Astro Aerospace Corp., Carpinteria, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(IAF PAPER 85-208)

Recent work on various approaches for providing the required dimensional accuracy to space-based reflector structures is described. The class of reflectors considered includes those with diameters in the range of 10 to 50 meters and surface tolerances of less than one-ten-thousandth of the diameter. The duality of the radiofrequency-antenna and optical-telescope approaches to assessing the effects of imperfections on performance is discussed. The implications of the two approaches on structural design requirements for the reflector surface and supporting structure are summarized. Concepts for establishing the reflector in earth orbit are described. Deployment and erection techniques are treated as well as combinations of both. Cost drivers of the various approaches are discussed and the attractiveness of simultaneous deployment, where feasible, is indicated. Author

A86-15746#
FLIGHT EXPERIMENTS INVOLVING LARGE DEPLOYABLE SPACE STRUCTURES
D. E. CHARHUT and A. R. ROBERTSON (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p. refs
(IAF PAPER 85-209)

This paper discusses why large space structures will probably be constructed using deployable components and the associated need for flight experiments to improve the ability to predict and understand the performance of these large structures in the space environment. Deployable structures concepts for both linear beams and planar surfaces are discussed. The paper concludes with discussion of the Solar Array Flight Experiment (SAFE), which was launched in 1984, and the National Aeronautics and Space Administration's Control of Flexible Structures (COFS) initiative, which involves ground tests and space flights of large deployable structures. Author

A86-17156#
DISPLACEMENT DEPENDENT FRICTION IN SPACE STRUCTURAL JOINTS
T. J. HERTZ (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and E. F. CRAWLEY (MIT, Cambridge, MA) AIAA Journal (ISSN 0001-1452), vol. 23, Dec. 1985, p. 1998-2000.

Energy dissipation due to frictional and impact losses in space structural joints was modeled for two representative types of joints: a truss/pin joint and beam/sleeve joint. It is concluded that in several common truss joints, in which the frictional forces are due

to elastic deflection, displacement-dependent friction can be used to model the damping. In sleeve-stiffened beam joints a maximum damping is obtained when the relative rotational stiffness of the joint and beam are of the same order. For pin joints in multielement trusses a maximum frictional damping occurs for trusses of low length/bay-depth ratio. The losses increase as the coefficient of friction is increased. I.S.

A86-17589
SHUTTLE MISSION EVAS TO DEMONSTRATE SPACE STATION ASSEMBLY TECHNIQUES
C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Nov. 25, 1985, p. 63-65, 67-69.

Space Shuttle Mission 61-B set aside two 6-hr EVA exercises for Space Station assembly technique demonstration, using two different types of large structures. Also demonstrated was a novel Orbiter flight control system software package applicable to any advanced spacecraft, such as the orbital maneuvering vehicle being designed to retrieve spacecraft within range of the projected Space Station. The structures assembled during EVA are of the tubular-member space frame type. O.C.

A86-24106
STRUCTURES IN SPACE - CONTRACTORS ADAPT EARTH-BASED CONSTRUCTION METHODS TO MICROGRAVITY
S. W. KANDEBO Commercial Space (ISSN 8756-4831), vol. 1, Summer 1985, p. 52, 53.

The development of construction techniques for the Space Station is briefly considered. Emphasis is given to the application of earth-based construction techniques and structural frameworks to the microgravity environment. A design concept for the modular Power Tower of the Space Station, which uses a repeating geometry network of interlocking struts and hubs, is described in detail. Color photographs of a typical hub-strut construction system are provided. I.H.

A86-29053
INSTABILITY ANALYSIS OF SPACE TRUSSES USING EXACT TANGENT-STIFFNESS MATRICES
K. TANAKA, K. KONDOH, and S. N. ATLURI (Georgia Institute of Technology, Atlanta) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 1, Dec. 1985, p. 291-311. refs
(Contract F33615-83-K-3205)

A simple (exact) expression for the tangent-stiffness matrix of a space truss undergoing arbitrarily large deformation, as well as member buckling, is given. An arc-length method is used to solve the tangent-stiffness equations in the post-buckling range of the structural deformation. Several examples to illustrate the viability of the present approaches in analyzing large space structures, simply, efficiently, and accurately, are given. Author

N86-11246*# Massachusetts Inst. of Tech., Cambridge.
FEASIBILITY OF REMOTELY MANIPULATED WELDING IN SPACE: A STEP IN THE DEVELOPMENT OF NOVEL JOINING TECHNOLOGIES
K. MASUBUCHI, J. E. AGAPAKIS, A. DEBICCARI, and C. VONALT *In* NASA. Langley Research Center Welding, Bonding and Fastening, 1984 p 271-296 Sep. 1985 refs
Avail: NTIS HC A21/MF A01 CSCL 13M

A six month research program entitled Feasibility of Remotely Manipulated Welding in Space - A Step in the Development of Novel Joining Technologies is performed at the Massachusetts Institute of Technology for the Office of Space Science and Applications, NASA, under Contract No. NASW-3740. The work is performed as a part of the Innovative Utilization of the Space Station Program. The final report from M.I.T. was issued in September 1983. This paper presents a summary of the work performed under this contract. The objective of this research program is to initiate research for the development of packaged, remotely controlled welding systems for space construction and repair. The research effort includes the following tasks: (1) identification of probable joining tasks in space; (2) identification of required levels of automation in space welding tasks; (3) development of novel space welding concepts; (4) development of recommended future studies; and (5) preparation of the final report. Author

N86-11540*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL STRUCTURAL MECHANICS: A NEW ACTIVITY AT THE NASA LANGLEY RESEARCH CENTER
N. F. KNIGHT, JR. and W. J. STROUD Sep. 1985 39 p refs Presented at 22nd Ann. Tech. Meeting of the Soc. of Eng. Sci., University Park, Pa., 7-9 Oct. 1985
(NASA-TM-87612; NAS 1.15:87612) Avail: NTIS HC A03/MF A01 CSCL 20K

Complex structures considered for the late 1980's and early 1990's include composite primary aircraft structures and the space station. These structures are much more difficult to analyze than today's structures and necessitate a major upgrade in computerized structural analysis technology. A major research activity in computational structural mechanics (CSM) was initiated. The objective of the CSM activity is develop advanced structural analysis technology that will exploit modern and emerging computers such as computers with vector and/or parallel processing capabilities. The three main research activities underway in CSM include: (1) structural analysis methods development; (2) a software testbed for evaluating the methods; and (3) numerical techniques for parallel processing computers. The motivation and objectives of the CSM activity are presented and CSM activity is described. The current CSM research thrusts, and near and long term CSM research thrusts are outlined. E.A.K.

N86-13735*# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Engineering Mechanics.
KINEMATICS OF FOLDABLE DISCRETE SPACE CRANES Final Report
A. H. NAYFEH 26 Nov. 1985 26 p
(Contract NSG-1185)
(NASA-CR-176360; NAS 1.26:176360) Avail: NTIS HC A03/MF A01 CSCL 13I

Exact kinematic description of a NASA proposed prototype foldable-deployable discrete space crane are presented. A computer program is developed which maps the geometry of the crane once controlling parameters are specified. The program uses a building block type approach in which it calculates the local coordinates of each repeating cell and then combines them with respect to a global coordinates system. Author

N86-16413*# Astro Aerospace Corp., Carpinteria, Calif.
HIGH-PERFORMANCE DEPLOYABLE STRUCTURES FOR THE SUPPORT OF HIGH-CONCENTRATION RATIO SOLAR ARRAY MODULES Final Report
M. MOBREM 31 Oct. 1985 79 p refs
(Contract NAS8-36043)
(NASA-CR-178753; NAS 1.26:178753) Avail: NTIS HC A05/MF A01 CSCL 13B

A study conducted on high-performance deployable structures for the support of high-concentration ratio solar array modules is discussed. Serious consideration is being given to the use of high-concentration ratio solar array modules or applications such as space stations. These concentrator solar array designs offer the potential of reduced cost, reduced electrical complexity, higher power per unit area, and improved survivability. Arrays of concentrators, such as the miniaturized Cassegrainian concentrator modules, present a serious challenge to the structural design because their mass per unit area (5.7 kg/square meters) is higher than that of flexible solar array blankets, and the requirement for accurate orientation towards the Sun (plus or minus 0.5 degree) requires structures with improved accuracy potentials. In addition, use on a space station requires relatively high structural natural frequencies to avoid deleterious interactions with control systems and other large structural components. The objective here is to identify and evaluate conceptual designs of structures suitable for

deploying and accurately supporting high-concentration ratio solar array modules. R.J.F.

N86-18340*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
TELESCOPING SPACE STATION MODULES
R. D. WITCOFSKI Jul. 1984 14 p
(NASA-TM-86253; NAS 1.15:86253) Avail: NTIS HC A02/MF A01 CSCL 22B

A design concept is described wherein telescoping space station modules would be utilized to nearly double the useful volume onboard a station. Methods for utilizing the concept to obtain enchanced protection from space debris and radiation are described. The amenability of the concept to variation in station configuration, assembly, and disassembly is discussed. A modification of the concept which could provide flexibility in the manner in which the Shuttle Orbiter is docked with the station and enhance collision avoidance during such maneuvers is described. Author

N86-19345# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
EQUIVALENT CONTINUUM FINITE ELEMENT MODELLING OF PLATE-LIKE SPACE LATTICE STRUCTURES Ph.D. Thesis
S. E. LAMBERSON Aug. 1985 140 p
(AD-A160879; AFIT/CI/NR-85-111D) Avail: NTIS HC A07/MF A01 CSCL 22B

A method involving finite element modelling of an equivalent continuum formulation based on matching the strain energy and kinetic energy is developed for truss type lattices with pinned joints. The method is shown to give modal results consistent with those obtained using detailed finite element modelling of the pin jointed space lattice structure, even for structures with fairly small numbers of repetitions of an identical unit cell. Feedback controllers using reduced system models derived from these modal results using Modal Cost Analysis are shown to perform as well as controllers designed using the detailed analysis results. A micropolar plate continuum model of large plate-like repetitive space lattice structures with rigid joints are derived. A plate finite element is based on this continuum model with micropolar rotations and transverse shear deformations included as nodal degrees of freedom. The natural frequencies and mode shapes are calculated using this element for a free floating hexahedral plate-like space lattice structure. These natural frequencies and mode shapes are compared to those calculated using a detailed finite element model (with every structural member modelled by a beam-column element) for several sets of frame member cross sectional properties. The static deflections of a centrally loaded and corner supported rectangular plate-like space lattice structure are also obtained and compared these two types of structural models. GRA

N86-19479* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SEQUENTIALLY DEPLOYABLE MANEUVERABLE TETRAHEDRAL BEAM Patent
M. M. MIKULAS, JR. (General Research Corp., Santa Barbara, Calif.) and R. F. CRAWFORD, inventors (to NASA) (General Research Corp., Santa Barbara, Calif.) 10 Dec. 1985 9 p Filed 8 Sep. 1983 Sponsored by NASA
(NASA-CASE-LAR-13098-1; US-PATENT-4,557,097;
US-PATENT-APPL-SN-530339; US-PATENT-CLASS-52-646;
US-PATENT-CLASS-52-632; US-PATENT-CLASS-52-637;
US-PATENT-CLASS-52-648; US-PATENT-CLASS-16-242;
US-PATENT-CLASS-16-390; US-PATENT-CLASS-403-64;
US-PATENT-CLASS-403-171) Avail: US Patent and Trademark Office CSCL 20K

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

N86-19605* National Aeronautics and Space Administration. Pasadena Office, Calif.
JOINT FOR DEPLOYABLE STRUCTURES Patent
N. D. CRAIGHEAD, II (JPL, Pasadena, Calif.), R. J. PRELIASCO (JPL, Pasadena, Calif.), and T. D. HULT, inventors (to NASA) (JPL, Pasadena, Calif.) 17 Dec. 1985 6 p Sponsored by NASA
(NASA-CASE-NPO-16038-1; US-PATENT-4,558,967;
US-PATENT-APPL-SN-469864; US-PATENT-CLASS-403-113;
US-PATENT-CLASS-403-120; US-PATENT-CLASS-16-294)
Avail: US Patent and Trademark Office

A joint is described for connecting a pair of beams to pivot them between positions in alignment or beside one another, which is of light weight and which operates in a controlled manner. The joint includes a pair of fittings and at least one center link having opposite ends pivotally connected to opposite fittings and having axes that pass through centerplates of the fittings. A control link having opposite ends pivotally connected to the different fittings controls their relative orientations, and a toggle assemly holds the fittings in the deployed configuration wherein they are aligned. The fittings have stops that lie on one side of the centerplane opposite the toggle assembly.
Official Gazette of the U.S. Patent and Trademark Office

N86-20482*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONSTRUCTION AND CONTROL OF LARGE SPACE STRUCTURES
M. F. CARD, W. L. HEARD, JR., and D. L. AKIN (MIT, Cambridge) Feb. 1986 21 p refs
(NASA-TM-87689; NAS 1.15:87689) Avail: NTIS HC A02/MF A01 CSCL 22B

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. Author

N86-20799*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DEPLOYABLE M-BRACED TRUSS STRUCTURE Patent Application
M. M. MIKULAS, JR. and M. D. RHODES, inventors (to NASA) 30 Jul. 1985 12 p
(NASA-CASE-LAR-13081-1; NAS 1.71:LAR-13081-1;
US-PATENT-APPL-SN-760378) Avail: NTIS HC A02/MF A01 CSCL 13I

A deployable M-braced truss structure, efficiently packaged into a compact stowed position and expandable to an operative position at the use site is described. The M-braced configuration effectively separates tension compression and shear in the structure and permits efficient structural design. Both diagonals and longerons telescope from an M-braced base unit and deployed either

pneumatically, mechanically by springs or cables, or by powered reciprocating mechanisms. Upon full deployment, the diagonals and longerons lock into place with a simple latch mechanism.
NASA

N86-21930# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
PASSIVELY DAMPED JOINTS FOR ADVANCED SPACE STRUCTURES
R. W. TRUDELL, L. W. REHFIELD (Georgia Inst. of Tech., Atlanta), A. D. REDDY (Georgia Inst. of Tech., Atlanta), J. PRUCZ (Georgia Inst. of Tech., Atlanta), and J. PEEBLES *In* AFWAL Vibration Damping 1984 Workshop Proceedings 28 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

The benefits to be gained by designing damping into the joints of large space structure are described. A typical joint is developed and two new nonresonant test techniques are outlined. The joints are double-lap shear joints that dissipate energy when worked in an axial direction. To better understand the relationship between structural stiffness and structural damping as a function of important physical parameters, a one-dimensional analysis of a typical joint was dveloped. Two new nonresonant forced vibration test methods (steady state and transient) were developed that are particularly well suited for obtaining the damping characteristics of joints in large space structures. The steady state method does not require measurement of relative displacements. The transient sine-pulse approach frees the specimen from fixture/joint interaction effects.
E.A.K.

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.

A86-15277
DIMENSIONAL/ANGULAR STABILITY MONITORING TECHNIQUES IN THERMAL VACUUM ENVIRONMENT
R. D. REMPT (Martin Marietta Aerospace, Test Dept., Denver, CO) IN: Optical alignment II; Proceedings of the Meeting, Arlington, VA, May 3, 4, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 96-103.

The present paper is concerned with the measurement and monitoring of two distinct varieties of thermally induced distortions experienced by space hardware subject to space environment. The first type of distortion can be represented by a change in the angle between reference lines, while the second type can be related to a change in the dimension defined by two points. A description is presented of techniques for the measurement of both types of distortion during a thermal vacuum test. The angular distortion measuring technique discussed makes use of two precision reflectors which are mounted on a space gimbal. The translational distortion measuring technique described is based on the employment of a Michelson interferometer. G.R.

A86-15749#
THERMAL DEFLECTION OF A DEPLOYABLE AND RETRACTABLE STRUCTURAL MAST
R. W. CHOLVIBUL (Fairchild Space Co., Germantown, MD) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-212)

Solar deflection and thermal performance of a deployable structural mast are discussed. The problem is unique because of the triangular geometry and unusual edge locking technique. Mechanical design is described briefly along with thermal analysis and design. Thermal distortion occurs when the temperature distribution around the cross section is unsymmetrical. Preliminary temperatures are calculated by deriving closed form solutions based on radiative heat transfer. Conduction is then evaluated through thermal vacuum testing, and a thermal math model accounting for radiation and conduction is developed for more accurate prediction of deflections. By perforating surfaces of the mast and using appropriate surface coatings, thermal distortion can be maintained within acceptable design limits. Design requirements are defined, and deflection predictions are presented in dimensionless form for a variety of configurations. Author

A86-15751#
INTERACTIVE ANALYTICAL FORMULATIONS IN THE THERMAL-STRUCTURAL CONTROL PROBLEM OF SPACE STRUCTURES
C. ARDUINI (Roma, Universita, Rome, Italy) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 32 p. Sponsorship: European Space and Technology Centre. refs
(Contract ESTEC-5485/83-NL-PB)
(IAF PAPER 85-214)

The problem of thermostructural interaction is considered using a unified analytical modelling approach. The combined actions of heat fluxes, elastic and inertial forces, and control action are taken into account. A simple application example of a rectangular, flat plate with constant thickness cantilevered at one end which carries a flat, undeformable shade at the other end is considered. C.D.

A86-15862#
SPACECRAFT THERMAL CONTROL TECHNOLOGY - DESIGN CHALLENGES INTO THE 1990'S
P. C. WISE (RCA, Astro-Electronics Div., Princeton, NJ) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 15 p. refs
(IAF PAPER 85-373)

Factors that require advanced thermal technology in the design of the projected NASA missions, such as the high heat loads, the finite number of longitude slots in the geostationary orbital positions, the requirements to minimize the weight for the extended spacecraft life and to provide close temperature control, etc., are discussed. The main elements of the thermal design of the current communication satellites and of the advanced projected thermal technology are described. The operating principles of advanced thermal control elements, such as high-capacity heat pipes (a monogroove, an advanced trapezoidal axial groove, and the variable conductance heat pipes), the radiator panel coupling concept, capillary pumped loop technology of multiple parallel evaporators, pumped two-phase flow technology, and deployable radiators, are presented and illustrated with diagrams. I.S.

A86-17324
SPACE STATION/PLATFORM THERMAL CONTROL
R. A. HASLETT (Grumman Aerospace Corp., Bethpage, NY) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 137-148. refs
(AAS PAPER 84-127)

The thermal control requirements of the Space Station are discussed. Development of the Space Station/Platform Thermal Control System is considered, with emphasis given to five key technologies: heat pipe radiators; two-phase heat transport loops; stand-alone thermal control systems; system integration; and advanced thermal control concepts. Some of the advanced thermal control concepts discussed include: a transverse variable conductance flat plate heat pipe; a liquid droplet radiator; and a space-constructible radiator concept. Line drawings of the various thermal control system components are provided. I.H.

A86-19848*# General Dynamics/Astronautics, San Diego, Calif.
EVALUATION OF ACTIVE THERMAL CONTROL OPTIONS FOR SPACE STATION
J. R. SCHUSTER, M. J. GRUSZCZYNSKI (General Dynamics Corp., Space Systems Div., San Diego, CA), and J. W. OWEN (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 15 p.
(AIAA PAPER 86-0383)

An analysis of various Space Station (MSS) active thermal control systems options under consideration because of their potential low weight, efficiency and reliability is reported. The study addressed ordinary and diode-action body mounted radiators, thermal storage, the area and pumping power requirements for single-phase cooling of cold plates, and single-phase and two-phase active cooling loops. The base configuration considered was a core MSS formed by four habitable modules on which are mounted heat pipe radiators articulated to be always edge-on to the sun. A simulation was performed which accounted for the available heat sinks, several thermal loads and the heat rejection capability. No benefits were found with diode-action radiators if the solar absorption is 0.1 or less, although diode-action heat pipes will maintain a higher level of performance in the presence of coating degradation. Thermal storage becomes important only with radiator coating degradation. Water can be up to three times as efficient as Freon as a heat transfer medium. Finally, single-phase cooling offers a lower system mass than two-phase cooling if varying temperature heat loads can be accommodated.
M.S.K.

A86-20766* MRJ, Inc., Fairfax, Va.
THERMAL MANAGEMENT OF HIGH POWER SPACE BASED SYSTEMS
H. HWANGBO and W. S. MCEVER (MRJ, Inc., Fairfax, VA) IN: Space nuclear power systems 1984; Proceedings of the First Symposium, Albuquerque, NM, January 11-13, 1984. Volume 2 . Malabar, FL, Orbit Book Co., Inc., 1985, p. 465-471. NSF-NASA-supported research. refs

Conventional techniques of using a portion of the spacecraft skin for radiation of waste heat will be inadequate for high powered payloads (50 to 100 kWe) due to the lack of sufficient area. A Shuttle type system using a pumped single phase fluid loop could be scaled up to higher power but this type of system would require excessive pump power and weight. A pumped two-phase heat transfer loop has a much lower pumping requirement due to the higher latent heat of vaporization of the fluid in comparison to the sensible heat it can absorb through a temperature change. Concepts for an evaporator and a condenser for a pumped two-phase system are described. The condenser uses capillary grooves and a separate pumped condensate return line to achieve high heat transfer coefficients and stable operation due to the separation of the vapor and liquid flows. The cold plate evaporator uses wicks to contain the liquid and transport it to the heated surface. It can also function as a condenser for warming components. Control concepts for the cold plate are discussed. Concepts for deployment or erection of large space radiators are also considered. Author

A86-23513
A HEAT PIPE QUICK DISCONNECT
J. P. ALARIO and P. J. OTTERSTEDT (Grumman Aerospace Corp., Bethpage, NY) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p.
(SAE PAPER 851323)

This paper reports the proof of concept demonstration of a heat pipe quick disconnect being developed for the space constructible radiator system. The disconnect provides a maintainable coupling between the heat pipe evaporator, which is brazed to a mating heat exchanger, and the replaceable condenser section of a monogroove heat pipe radiator element. Test results, with pressurized nitrogen gas, confirm low leakage rates in both demated and mated configurations. Comparative thermal tests in a working 3 m (10 ft) test bed heat pipe using ammonia fluid revealed a 30 percent decrease in heat transport due to the additional minor pressure losses from the quick disconnect. The bulk of this loss is attributed to the transition section that joins the two adjacent heat pipe flow channels to the separated liquid and vapor passages within the disconnect coupling. It would be possible to decrease this overall loss in heat transport to under 10 percent with a redesigned transition section. Author

A86-23514
SPACE CONSTRUCTIBLE RADIATOR SYSTEM OPTIMIZATION
R. F. BROWN and J. P. ALARIO (Grumman Aerospace Corp., Bethpage, NY) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 15 p. refs
(SAE PAPER 851324)

During the period from February 1984 to April 1985, test data have been obtained on several of the Space Constructible radiator (SCR) system components, such as the high capacity monogroove heat pipe, the contact heat exchanger, and the heat pipe disconnect. In light of both the performance data that are now available and the changes in Space Station requirements that have occurred since the inception of the SCR program in 1979, an optimization study of the entire SCR system is warranted. This paper reports the results of that study, which includes performance, weight, and reliability estimates. Author

A86-23515
THERMAL VERIFICATION FOR FUTURE LARGE TELECOMMUNICATIONS SATELLITES
D. CHALMERS (RCA, Astro-Electronics Div., Princeton, NJ) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p.
(SAE PAPER 851325)

The continued growth in demand for space-based telecommunications systems, coupled with the rapidly decreasing availability of orbital slots at geosynchronous altitude, brings closer the realization of advanced, very large communications satellites. This paper examines the impact that such large satellites will have on the thermal verification process, especially the degree to which present thermal testing and analytical modeling techniques must be adapted. In particular, the effects of satellite modularization and the use of advanced thermal technologies in the satellite's Thermal Control Subsystem are investigated. Author

A86-23536*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION THERMAL MANAGEMENT SYSTEM DEVELOPMENT STATUS AND PLANS
J. G. RANKIN (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 18 p. refs
(SAE PAPER 851350)

The manned Space Station, as currently designed, contains a baseline thermal management system (TMS) which uses components and subsystems never before employed in manned spacecraft. The basis for the technology used in the TMS design is the result of a long-term TMS Technology Development Plan which was initiated in 1979. Rankin and Marshall (1983) have discussed the history and progress of that plan from its beginnings to early 1983. The present paper is concerned with the status of activities conducted at the NASA Lyndon B. Johnson Space Center (JSC) under this plan since 1983, taking into account also a summary of activities planned for the next several years. G.R.

A86-23537
A TWO-PHASE THERMAL MANAGEMENT SYSTEM FOR LARGE SPACECRAFT
T. J. BLAND, R. S. DOWNING, and D. P. ROGERS (Sundstrand Corp., Advanced Technology Group, Rockford, IL) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 12 p.
(SAE PAPER 851351)

In the case of the NASA Space Station with its high thermal power levels and transport distances in excess of 50 meters, approaches used for thermal management in the case of low-power spacecraft or even the Space Transportation System are not feasible any longer. A novel approach to the two-phase thermal bus concept has, therefore, been developed for the Space Station. The thermal bus concept employs a two-phase fluid loop to transport heat by evaporation and condensation rather than by sensible heating and cooling. The new concept employs a rotary fluid management device (RFMD) which incorporates pitot pumps to preclude potential cavitation problems associated with centrifugal pumps. G.R.

A86-23539
HEAT PIPE TECHNOLOGY FOR CURRENT SPACECRAFT AND HIGH POWER THERMAL MANAGEMENT
E. KROLICZEK and P. BRENNAN (OAO Corp., Greenbelt, MD) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p. refs
(SAE PAPER 851353)

The application of conventional axially grooved heat pipes to the thermal control of attached shuttle payloads, instruments on free flyers, communications satellites and body mounted radiators for space station common modules is discussed. Also presented is the evolution of an advanced axially grooved design for application to the space station's space erectible radiators (SERS). Capillary Pumped Loop (CPL) development status and its application to high power thermal management for space station applications are also included. Author

A86-23548
THERMAL VACUUM TESTS OF OLYMPUS HEAT PIPE RADIATORS
D. BOGGIATTO, E. COLIZZI, V. PEROTTO, and S. TAVERA (Aeritalia S.p.A., Naples, Italy) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 10 p. Research sponsored by British Aerospace, PLC and ESA.
(SAE PAPER 851363)

The results of the thermal tests performed on the Olympus Large Telecommunication Satellite Heat Pipe Radiators are presented. The test set-up maintained the Heat Pipes horizontal, the dissipation and thermal characteristics of electronic units being simulated by thermal dummies. The tests were divided in three phases with different temperatures of the chamber cryogenic shrouds to simulate the worst steady (equinox) cold case and investigate a fictitious extreme cold case (end of eclipse steady state) and an equivalent hot case. The results testify the adequacy of the Radiator design and the agreement between analytical predictions and temperatures measured during the test. Author

A86-24837
DESIGN ASSISTANT FOR SPACECRAFT THERMAL MANAGEMENT SYSTEMS
B. R. FOX, L. T. BREWSTER, R. P. KHER, J. W. SHEFFIELD (Missouri-Rolla, University, Rolla), and V. J. VAN GRIETHUYSEN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.425-1.429. refs

This paper primarily addresses the conceptual design of spacecraft thermal management systems and their components in order to provide a basis for the development and implementation of future technologies. The components of the spacecraft thermal management system include the following: heat pipes, latent thermal energy storage materials, radiators and other thermal structures. The design problem becomes one of selecting a combination of these components subject to both spacecraft mission and launch requirements. To facilitate this design process, a knowledge based design assistant is being developed in the artificial intelligence programming language, PROLOG. The goal has been to amplify the capabilities of an experienced designer by putting significant decision making, search and retreival facilities at his or her disposal. Author

N86-13362# General Electric Co., Whetstone (England). Mechanical Engineering Lab.
STUDY OF THERMAL ANALYSIS METHODS Final Report
J. J. REBIS and P. S. WHITE Paris ESA Dec. 1984 133 p refs
(Contract ESA-5653/83/NL-PB)
(GEC-MEL12.0539; ESA-CR(P)-2045) Avail: NTIS HC A07/MF A01

Lumped parameter and finite element methods were found to be suited to spacecraft thermal analysis after a study of and spatial discretization, temporal discretization, and solution of the equations resulting from these discretizations. Advantages of finite element methods over lumped parameter are: all quantities used in the analysis are systematically derived from the geometric model and material properties (this eliminates the preliminary calculation of conduction links and capacitance values necessary for lumped parameters); the nature of the approximation is well defined and convergence to the true solution can be demonstrated under certain conditions; explicit estimates of accuracy are possible; greater accuracy for a given number of nodes; interpolation of the results can be carried out systematically; and compatibility with mainstream stress analysis programs. Disadvantages linked to its inferior robustness, greater computer resource requirement for the same number of nodes; greater software effort required to obtain the same degree of flexibility, and lack of consistent radiation modeling can be overcome. Author (ESA)

N86-16254# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
SPACECRAFT, STRAIGHT-TUBE EVAPORATOR DESIGN Final Report, 1 Jul. 1983 - 31 Mar. 1985
R. E. EASTMAN May 1985 85 p
(Contract AF PROJ. 240-2)
(AD-A158757; AFWAL-TR-85-3024) Avail: NTIS HC A05/MF A01 CSCL 13A

Two-phase (liquid-vapor) heat transfer systems are being considered for use on future spacecraft cooling systems operating at high energy levels. The design of straight-tube evaporators was studied for this application. The forced convective boiling phenomenon was examined to determine the characteristics of boiling flow and possible effects of gravitational acceleration. Experiments with straight-tube evaporators indicated that pressure fluctuations caused by slug flow may hamper efforts to build two-phase cooling systems. Upstream orifices and twisted tape inserts were investigated to overcome this problem. A method was also developed to size an evaporator based on the best available correlation equations. Some errors were corrected for flow-boiling heat transfer equations found in the literature. GRA

N86-20803*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SUN SHIELD Patent Application
A. FRANK, S. F. DERESPINIS, and J. MOCKOVCIAK, JR., inventors (to NASA) 12 Aug. 1985 12 p Prepared in cooperation with Grumann Aerospace Corp., Bethpage, N.Y.
(NASA-CASE-MSC-20162-1; NAS 1.71:MSC-20162-1; US-PATENT-APPL-SN-764805) Avail: NTIS HC A02/MF A01 CSCL 13I

A shading device which is capable of compactly storing a flexible shade on a biased, window-shade type spring roller and controlled

to deliver the shade selectively to either its operative shading or compact storage orientation. NASA

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.

A86-11833* National Aeronautics and Space Administration, Washington, D.C.
THE SKELETON IN SPACE
A. W. GOODE (London Hospital, England) and P. C. RAMBAUT (NASA, Washington, DC) Nature (ISSN 0028-0836), vol. 317, Sept. 19, 1985, p. 204, 205. refs

Calcium loss experience by astronauts under weightless conditions is discussed. I-125 photon absorption measurements on astronauts on the Apollo 14, 15, and 16 flights showed bone density decreases of 6.6 percent in one astronaut and 7.3 percent in another. The estimated total body calcium loss on Apollo 17 was 0.2 percent. The test results indicate that calcium losses occur mainly from the weight-bearing parts of the skeleton. Measures to counteract the losses include 'penguin' suits, maintenance of nutrient intakes at high levels, and extensive exercise on ergometer and treadmill. C.D.

A86-14311* Texas Univ., Houston.
COMPATIBLE ATMOSPHERES FOR A SPACE SUIT, SPACE STATION, AND SHUTTLE BASED ON PHYSIOLOGICAL PRINCIPLES
B. A. HILLS (Texas, University, Houston) Aviation, Space and Environmental Medicine (ISSN 0095-6562), vol. 56, Nov. 1985, p. 1052-1058. refs
(Contract NAG9-23)

Fundamental physiological principles have been invoked to design compatible environments for a space suit, Space Station and the spacecraft used to transport the astronauts from earth. These principles include the long-term memory of tissues for a bubble-provoking decompression, the intermittent nature of blood flow in the tight connective tissue(s) responsible for the bends whose incidence in aviators has been shown to be related to bubble volume by the Weibull distribution. In the overall design an astronaut breathing a mixture of 30 percent O2 in N2 for 4-5 h in a spacecraft at 11.9 psia can transfer to a Space Station filled with the same mix at 8.7 psia and, after a further 4-5 h, go EVA at any time without any oxygen prebreathing at any stage. The probable incidence of decompression sickness has been estimated as less than 0.5 percent using the present suit operating at 4.3 psia but the risk could be reduced to zero if the suit pressure were increased to 6.5 psia. Author

A86-14408*# San Francisco Univ., Calif.
RADIATION ENVIRONMENT OF SPACELAB-1
E. V. BENTON, A. L. FRANK (San Francisco, University, CA), T. A. PARNELL, J. W. WATTS, JR. (NASA, Marshall Space Flight Center, Huntsville, AL), and J. C. GREGORY (Alabama, University, Huntsville) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 218-227. refs
(Contract NAS8-34340; NAS9-15337)
(AIAA PAPER 85-7045)

The results of passive and active radiation measurements on Spacelab-1 are reported. Spacelab-1 was flown on the STS-9 mission, orbited at an altitude of 241 km, with an inclination of 57 deg and 240 hours of flight time. Approximately thirty passive detectors deployed inside the module, in the access tunnel, and outside on the pallet made possible the radiation measurements. The various forms of radiation measured were a low linear energy transfer component ranging from 94 to 133 mrads inside the module (average dose rate of 10.0 mrads/day; about twice the rate of earlier shuttle flights), an average mission dose-equivalent rate of about 18.5 mrem/day (six times higher than earlier flights), accumulated doses of 125 and 128 mrads and a yield of 17 and 12 mrads for passages through the South Atlantic Anomaly. Spacelab-1, because of its low altitude and short duration, was relatively benign in terms of total radiation dose. Some of the measurements such as high-LET particles and neutrons have biological significance and potential effects on future experiments. F.J.

A86-15813*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS CONCEPTUAL STUDIES
W. R. HUMPHRIES and L. E. POWELL (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-300)

It is pointed out that the establishment of a permanent manned Space Station requires the development of a comprehensive approach which combines new technologies and existing spacecraft subsystem capabilities into an optimum design. The present paper is concerned with studies which were conducted in connection with the development of the regenerative Environmental Control and Life Support Systems (ECLSS) for the Space Station. Attention is given to the current state of the ECLSS subsystems and system level analytical selection and group studies related to the integrated system conceptual design. G.R.

A86-15814*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS TEST BED PROGRAM - AN OVERVIEW
A. F. BEHREND, JR. (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-301)

The successful demonstration of the maturity of the regenerative Environmental Control and Life Support System (ECLSS) is an essential factor in the development of the Space Station. The present paper provides an overview of the Space Station ECLSS Test Bed Program, the mechanism by which the maturity of regenerative ECLSS technologies is demonstrated. Attention is given to the background regarding the ECLSS development, the purpose of the Space Station ECLSS Test Bed Program, the objectives of this program, the three facility elements of the ECLS Test Bed, the technical approach, the design support test phase, the testing of the Regenerative Life Support Equipment (RLSE) systems, advanced prototype testing, fallback testing, and the integrated test phase. The integrated test phase will provide the final demonstration of the regenerative ECLSS technology maturity. G.R.

A86-15816#
COLUMBUS LIFE SUPPORT SYSTEM CONCEPT
H. PREISS and A. I. SKOOG (Dornier System GmbH, Friedrichshafen, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. ESA-BMFT-supported research. refs
(IAF PAPER 85-303)

The compatibility of the Columbus program with the Space Station Environmental Control and Life Support System (ECLSS) is examined. The Columbus concept is reviewed, and the ECLSS design requirements are described, including system requirements and performance characteristics. The Space Station attached mode and free-flying mode of the Columbus laboratory module ECLSS are discussed. The service vehicle ECLSS is described, and the

Space Station safe haven philosophy and commonality between ECLSS subsystems are summarized. C.D.

A86-15821#
REGENERATIVE LIFE SUPPORT SYSTEM HARDWARE TESTING - A SUMMARY
R. P. REYSA (Boeing Co., Aerospace Operations, Houston, TX) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-310)

NASA recognized that the employment of regenerative Environmental Control and Life Support Systems (ECLSS) for a minimization of logistics requirements could play a key role in the growth of the American space program. The Space Station Preprototype (SSP) program was initiated in 1969, while the Regenerative Life Support Equipment (RLSE) program was started in 1976. The regenerative ECLSS primary elements of the SSP and RLSE programs were an Atmospheric Revitalization Group (ARG) and a Water and Waste Management Group (WWMG). Early testing was concerned with the SSP ARG subsystems and an integrated system. An ARG development description is presented, taking into account the Oxygen Generation Subsystem (OGS), the CO2 Collection Subsystem (CCS), the CO2 Reduction Subsystem (CRS), and the ARG Integrated System. A WWMG development description is also provided. G.R.

A86-15823*# Massachusetts Inst. of Tech., Cambridge.
SPACELAB EXPERIMENTS ON SPACE MOTION SICKNESS
C. M. OMAN (MIT, Cambridge, MA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 17 p. refs
(Contract NCC9-1; NAS9-15343)
(IAF PAPER 85-312)

Recent research results from ground and flight experiments on motion sickness and space sickness conducted by the Man Vehicle Laboratory are reviewed. New tools developed include a mathematical model for motion sickness, a method for quantitative measurement of skin pallor and blush in ambulatory subjects, and a magnitude estimation technique for ratio scaling of nausea or discomfort. These have been used to experimentally study the time course of skin pallor and subjective symptoms in laboratory motion sickness. In prolonged sickness, subjects become hypersensitive to nauseogenic stimuli. Results of a Spacelab-1 flight experiment are described in which 4 observers documented the stimulus factors for and the symptoms/signs of space sickness. The clinical character of space sickness differs somewhat from acute laboratory motion sickness. However SL-1 findings support the view that space sickness is fundamentally a motion sickness. Symptoms were subjectively alleviated by head movement restriction, maintenance of a familiar orientation with respect to the visual environment, and wedging between or strapping onto surfaces which provided broad contact cues confirming the absence of body motion. Author

A86-15826*# Texas Univ. Health Science Center, Dallas.
SPACELAB LIFE SCIENCES FLIGHT EXPERIMENTS - AN INTEGRATED APPROACH TO THE STUDY OF CARDIOVASCULAR DECONDITIONING AND ORTHOSTATIC HYPOTENSION
F. A. GAFFNEY (NASA, Johnson Space Center, Houston; Texas, University, Dallas) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p. refs
(IAF PAPER 85-316)

A Spacelab experiment to study cardiovascular deconditioning and orthostatic hypotension is proposed. Previous experiments that have attempted to explain the factors which cause alterations in cardiovascular regulation are investigated. Based on these observations a hypothesis which states cephalad fluid shift produces cardiovascular changes is studied. The testing of the hypothesis is to include the analysis of physiological and anatomical changes in humans and animals for preflight and in-flight periods. The procedures and measurement techniques for the experiment are described. I.F.

A86-15828#
PULMONARY FUNCTION IN MICROGRAVITY - SPACELAB 4 AND BEYOND
H. J. GUY, G. K. PRISK, and J. B. WEST (California, University, San Diego) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-322)

A study to observe the influence of topographic gradients on lung function and the overall function of the lung at the onset of exposure to microgravity is proposed. The experimental procedure involves the analysis of instantaneous gas concentrations and flow at the lips as a subject switches from breathing cabin air to the inhalation and exhalation of a series of test gas mixtures. The components and functions of the gas analyzer, bag-in-box assembly, and electronic controlling assembly are described. Hypotheses concerning the observed effect of uneven ventilation, perfusion, pulmonary capillary volume and blood flow, and forced expiratory spirometry are presented. I.F.

A86-15833*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
EARTH BASED APPROACHES TO ENHANCING THE HEALTH AND SAFETY OF SPACE OPERATIONS
A. M. KOLLER, JR. (NASA, Kennedy Space Center, Cocoa Beach, FL) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p. refs
(IAF PAPER 85-330)

This paper provides an overview of the current state of our earth based knowledge of space safety hazards; identification of several key areas of concern for space operations; and proposed approaches to providing technology enhancement and information needed to improve the health and safety to those conducting space operations. Included are a review of the identified hazards for space oeprations by hazard classification; a summarization of the information currently available on space experiences and an assessment of potential hazards for long duration spaceflight; a discussion of potential failure modes and their significance for Space Station work: and an assessment of current work which indicates additional research and experimentation which can only be accomplished in actual space missions. Author

A86-15834#
SYSTEM SAFETY IS AN INHERENT FUNCTION OF THE IN-LINE DISCIPLINES AND CANNOT BE SEPARATED FROM THEM
F. X. KANE (Rockwell International Corp., El Segundo, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p.
(IAF PAPER 85-331)

The safety lessons learned from Skylab and Spacelab flights and their application to the Space Station are discussed. The rescue capabilities of the Skylab and the repair tools utilized by the astronauts are described. A list of Skylab system safety program elements is given. Spacelab safety, which is assured by payload decoupling, amplified preparation of flight, training and simulations, and data transmission to ground, is examined. The safety requirements for Space Shuttle missions are provided. The incorporation of safety plans into the administration and operation of the Space Station is discussed. The development of threat strategy for all aspects of design and operation is studied. I.F.

A86-15944#
ENSURING SPACE STATION HUMAN PRODUCTIVITY
K. H. MILLER (Boeing Aerospace Co., Seattle, WA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-500)

The 'human productivity' aspect of the current NASA Space Station Program is discussed. The early development of the concept is reviewed, and its implications are considered. The approach and results of a recently completed study on human productivity are addressed. The elements that affect productivity are identified, and management plans to deal with them, including crew composition and organization, individual autonomy and

privacy, and physical amenities of the station, are briefly addressed. C.D.

A86-15945#
MULTI-CULTURAL DYNAMICS IN SPACE STATIONS
A. E. CAMPBELL (Florida, University, Gainesville) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p. refs
(IAF PAPER 85-502)

The application of knowledge from cross-cultural psychology and related fields to the issue of long-term Space-Station living is discussed. Multidimensional factors that might affect the building of community and culture include physical environment, general psychological stresses related to space living, crew heterogeneity, and culture-based individual traits. Potential issues that could prevent the successful integration of multinational groups on a Space Station are identified. Short and long-term recommendations for training and research that could facilitate the realization of large, multinational Space Stations and planetary outposts are presented. These include expanding the role of social scientists, developing positive attitudes toward stress, and developing programs in group processes and cross-cultural communication. C.D.

A86-19125
OPTIMIZING ELECTROSTATIC RADIATION SHIELDING FOR MANNED SPACE VEHICLES
W. FRISINA Acta Astronautica (ISSN 0094-5765), vol. 12, Dec. 1985, p. 995-1003. refs

An electrostatic radiation shielding for manned spacecraft in low-earth-orbit (LEO) is described. The shield consists of three concentric grids having a net charge of zero. The voltage across the outer pair was chosen to repel electrons and the voltage across the inner pair was chosen to repel nucleons. The negative grid is coated to absorb ultraviolet light and to prevent photoemission, and secondary emission is minimized using a grid/thin foil combustion. It is shown that the efficiency of the shield increases indefinitely with size. Some favorable sizes corresponding to different shield voltages are recommended. The estimated protection of the shield for large LEO habitats and small powered transport vehicles is several orders of magnitude greater than mass shielding against charged particle cosmic radiation. A line drawing of the electrode grids/support trusswork for the outer electrode pair is provided. I.H.

A86-19811*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AN EXPERT SYSTEMS APPROACH TO AUTOMATED FAULT MANAGEMENT IN A REGENERATIVE LIFE SUPPORT SUBSYSTEM
J. T. MALIN and N. LANCE, JR. (NASA, Johnson Space Center, Houston, TX) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0321)

This paper describes FIXER, a prototype expert system for automated fault management in a regenerative life support subsystem typical of Space Station applications. The development project provided an evaluation of the use of expert systems technology to enhance controller functions in space subsystems. The software development approach permitted evaluation of the effectiveness of direct involvement of the expert in design and development. The approach also permitted intensive observation of the knowledge and methods of the expert. This paper describes the development of the prototype expert system and presents results of the evaluation. Author

A86-21097
AN OVERVIEW OF SPACE PHYSIOLOGY AND RELATED EXPERIMENTS ON SPACELAB 1
L. D. CAREN (Santa Clara University, CA) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 33, Oct.-Dec. 1985, p. 331-340. refs

This paper reviews the current status of research on the physiological effects of space flight. Results from early space flights and the more recent Spacelab 1 Shuttle mission are described. Space adaptation syndrome, previously known as space motion sickness, affects at least half of those who fly in space, and countermeasures have not been totally effective. Other physiological effects of space flight include loss of muscle mass and bone mass, changes in the blood, alterations in the function of the heart and blood vessels, and some decrease in the vital capacity of the lungs. Many hormonal changes occur which are not fully understood. Although problems are described, the mechanisms underlying physiological changes are not known. We have only begun to learn whether life can successfully adapt to long periods of time in space. Author

A86-22325* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS FOR SPACE HABITATS
P. BUCHANAN (NASA, Kennedy Space Center, Cocoa Beach, FL) 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.

A86-23501* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PREPARING A HEALTH CARE DELIVERY SYSTEM FOR SPACE STATION
J. S. LOGAN (NASA, Johnson Space Center, Houston, TX) and G. R. STEWART (GE Management and Technical Services Co., Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 5 p.
(SAE PAPER 851310)

NASA's Space Station is viewed as the beginning of man's permanent presence in space. This paper presents the guidelines being developed by NASA's medical community in preparing a quality, permanent health care delivery system for Space Station. The guidelines will be driven by unique Space Station requirements such as mission duration, crew size, orbit altitude and inclination, EVA frequency and rescue capability. The approach will emphasize developing a health care system that is modular and flexible. It will also incorporate NASA's requirements for growth capability, commonality, maintainability, and advanced technology development. Goals include preventing unnecessary rescue attempts, as well as maintaining the health and safety of the crew. Proper planning will determine the levels of prevention, diagnosis, and treatment necessary to achieve these goals. Author

A86-23502* Management and Technical Services Co., Houston, Tex.
HUMAN PHYSIOLOGICAL ADAPTATION TO EXTENDED SPACE FLIGHT AND ITS IMPLICATIONS FOR SPACE STATION
F. A. KUTYNA (GE Management and Technical Services Co., Houston, TX) and W. H. SHUMATE (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 8 p. refs
(Contract NAS9-17133)
(SAE PAPER 851311)

Current work evaluating short-term space flight physiological data on the homeostatic changes due to weightlessness is presented as a means of anticipating Space Station long-term effects. An integrated systems analysis of current data shows a vestibulo-sensory adaptation within days; a loss of body mass, fluids, and electrolytes, stabilizing in a month; and a loss in red cell mass over a month. But bone demineralization which did not level off is seen as the biggest concern. Computer algorithms have been developed to simulate the human adaptation to weightlessness. So far these paradigms have been backed up by flight data and it is hoped that they will provide valuable information for future Space Station design. A series of explanatory schematics is attached. R.R.

A86-23503
HEALTH MAINTENANCE AND HUMAN PRODUCTIVITY IN THE SPACE STATION ERA
R. M. FARRELL AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 7 p. refs
(SAE PAPER 851312)

Health maintenance points for extended stays in space are presented, with emphasis on efectively and efficiently minimizing cardiovascular and musculoskeletal adaptations to weightlessness while maximizing the individual's productivity. Simulation of 1-g forces as provided by the Soviet 'penguin' constant-loading suit does not prevent the cardiovascular deconditining resulting from the shift of blood and lymph from the lower to the upper half of the body. Alleviation of such a shift of fluids is accomplished by the lower body negative pressure (LBNP) apparatus used for this purpose aboard Skylab. An ambulator LBNP suite is being developed to enable multiple use of the astronaut's time. Examples are given of devices for cardiovascular conditioning (the zero-g bicycle ergometer and the zero-g treadmill) and for larger muscle group conditioning (skiing and climbing simulators) for projected Space Station design. To minimize boredom as a negative psychological factor in conditioning, the development of zero-g sports using existing equipment is envisioned. A comprehensive diagram on Space Station elements affecting productivity is included. R.R.

A86-23504* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PHYSIOLOGICAL CONSIDERATIONS FOR EVA IN THE SPACE STATION ERA
D. J. HORRIGAN, JR., J. M. WALIGORA, and D. S. NACHTWEY (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 7 p. refs
(SAE PAPER 851313)

The physiological parameters that will affect EMU design and operational scheduling for the Space Station Program are discussed. The system must be designed to safely and effectively handle the increased frequency of extravehicular activity projected for longer flight periods than in the past. In order to minimize the risk of decompression sickness a proper combination of equilibration time to cabin pressure, suit pressure, and prebreathing denitrogenation, is necessary. Effective thermal exchange is projected to be automatically controlled and to have an 8-hr 1000 BTU/hr capability. Physiological changes due to adaptation to weightlessness must be considered in scheduling for their impact on performance/fatigue and in coping with motion sickness. Radiation protection to the limit of 80 rad/quarter must be achieved by scheduling to avoid periodic proton and solar flare exposure, and by additional EMU shielding. Additional EMU considerations are the control of microorganisms and the higher pressure requirement for emergency O2 purge. R.R.

A86-23522
EVOLUTION OF THE SHUTTLE EXTRAVEHICULAR MOBILITY UNIT'S LIFE SUPPORT SYSTEM
F. H. GREENWOOD and R. J. BALINSKAS (United Technologies Corp., Hamilton Standard Div., Windsor Locus, CT) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 11 p.
(SAE PAPER 851333)

The philosophy, design, and operation of the Shuttle Extravehicular Mobility Unit (EMU) Block I and Block II are discussed, stressing details of the life support system (LSS). Besides the need to meet performance requirements in environmental extremes, the major design considerations of the LSS were size and weight restrictions, and maintainability. The liquid cooling and ventilation garment (LCVG) contains tubes of cooling water and has ventilation ducting to return O2, CO2, and humidity to the LSS for purification, cooling, and recirculation. The primary life support subsystem (PLSS) mounted on the back of the hard upper torso (HUT) of the space suit assembly (SSA) includes the primary oxygen bottles, three storage tanks of water for heat rejection, the fan/separator/pump assembly, the heat rejection sublimator, the contaminant control cartridge, and a caution and warning system computer to monitor the LSS. A display and control module gives the computer readout and has manual control of the LCVG water temperature. Innovations in the Block II design resulted in reduced maintenance and a fourteen-fold increase in the mean time between failures. Detailed schematics are included. R.R.

A86-23526
STATIC FEED WATER ELECTROLYSIS SYSTEM FOR SPACE STATION O2 AND H2 GENERATION
J. T. LARKINS and A. J. KOVACH (Life Systems, Inc., Cleveland, OH) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 14 p. refs
(SAE PAPER 851339)

The development of a three-person O2 generation system based upon the static feed water electrolysis (SFWE) concept is analyzed. A 30-cell electrolysis module, which is capable of producing 2.50 kg/day of O2 for metabolic use, 1.18 kg/day for CO2 removal, and 0.24 kg/day to compensate for overboard leakage, is designed. The electrochemical reaction which occurs in the water electrolysis cell, and the operation of the cell are examined. The three additional components of the oxygen generation system, the coolant control assembly, the three-fluids pressure controller, and the fluid control assembly, are described. The endurance testing of the components of the SFWE system is studied. The SFWE cell size optimization based on calculating total equivalent weight in terms power penalty is investigated. A SFWE system design for the Space Station is proposed. I.F.

A86-23528* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ELECTROCHEMICAL CO2 CONCENTRATION FOR THE SPACE STATION PROGRAM
N. LANCE (NASA, Johnson Space Center, Houston, TX), M. SCHWARTZ (NASA, Ames Research Center, Moffett Field, CA), and R. B. BOYDA AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 10 p. refs
(SAE PAPER 851341)

Under the sponsorship of NASA, Electrochemical Carbon Dioxide (CO2) Concentration EDC technology has been developed that removes CO2 continuously or cyclically from low CO2 partial pressure (400 Pa) atmospheres with the performance and operating

characteristics required for Space Station applications. The most recent advancement of this technology is the development of an advanced preprototype subsystem, the CS-3A, to remove the metabolic CO2 produced by three persons from the projected Space Station atmosphere. This paper provides an overview of EDC technology, shows how it is ideally suited for Space Station application, and presents technology enhancements that will be demonstrated by the CS-3A subsystem development program. Author

A86-23530
COMPARISON OF CO2 REDUCTION PROCESS - BOSCH AND SABATIER
L. SPINA and M. C. LEE (Life Systems, Inc., Cleveland, OH) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 12 p. refs
(SAE PAPER 851343)

An essential technology for making long-term, manned space missions a reality is related to regenerative life support processes for the revitalization of the spacecraft atmosphere. A major step in such processes is concerned with the reduction of metabolically produced CO2 for subsequent recovery of oxygen. The Bosch and Sabatier processes represent two leading candidates for CO2 reduction. Both processes are being investigated by NASA with respect to their applicability to the Space Station ECLSS (Environmental Control/Life Support Systems) requirements. In the Bosch process CO2 reacts catalytically with H2 to produce water and solid carbon, while the Sabatier process involves the catalytic reaction of CO2 and H2 to produce water and methane. The Bosch CO2 reduction subsystem is discussed along with the Sabatier CO2 reduction subsystem. G.R.

A86-23531
MEMBRANE-BASED WATER- AND ENERGY-RECOVERY SYSTEMS FOR THE MANNED SPACE STATION
R. RAY (Bend Research, Inc., OR) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 16 p. refs
(SAE PAPER 851345)

This paper describes four membrane-based subsystems to use in the waste-water treatment system of the manned space station being planned by NASA. These membrane-based subsystems involve the recycle of the various wastewater streams and result in increased energy efficiency. Furthermore, in these four subsystems, the membrane acts as a barrier between the wastewater source and the wastewater treatment and consumption systems, thus increasing the reliability of these systems. Finally, the membranes are highly impermeable to the contaminants in the wastewaters and thus help to reduce the load on such expendables as post-treatment adsorption beds. Author

A86-23532* Life Systems, Inc., Cleveland, Ohio.
PHASE CHANGE WATER PROCESSING FOR SPACE STATION
E. M. ZDANKIEWICZ (Life Systems, Inc., Cleveland, OH) and D. F. PRICE (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 12 p.
(SAE PAPER 851346)

The use of a vapor compression distillation subsystem (VCDS) for water recovery on the Space Station is analyzed. The self-contained automated system can process waste water at a rate of 32.6 kg/day and requires only 115 W of electric power. The improvements in the mechanical components of VCDS are studied. The operation of VCDS in the normal mode is examined. The VCDS preprototype is evaluated based on water quality, water production rate, and specific energy. The relation between water production rate and fluids pump speed is investigated; it is concluded that a variable speed fluids pump will optimize water production. Components development and testing currently being conducted are described. The properties and operation of the proposed phase change water processing system for the Space Station, based on vapor compression distillation, are examined. I.F.

A86-23533* Astro Resources International Corp., League City, Tex.
WATER QUALITY MONITOR FOR RECOVERED SPACECRAFT WATER
E. M. EJZAK (Astro Resources International Corp., League City, TX) and D. F. PRICE (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 6 p.
(Contract NAS9-16846)
(SAE PAPER 851347)

A total organic carbon (TOC) analysis system based on ultraviolet absorption is described. The equation for measuring the intensity of the absorbed radiation of the organic substances, which is based on the Lambert-Beer law, is given; the intensity of the absorption is proportional to the concentration of the solution. The operation of the UV-Absorption analyzer, which utilizes a split beam, two wvaelength method, is studied. The influences of the cell path length and specific compounds in the solution flowing through the cell on absorbances is discussed. The performance and response of the analyzer is evaluated; good correlation is observed between the absorption value and TOC. The advantage of the UV-Absorption as compared with the UV-Oxidation are examined. I.F.

A86-23534
THERMOELECTRIC INTEGRATION MEMBRANE EVAPORATION SUBSYSTEM WATER RECOVERY - TECHNOLOGY UPDATE
G. F. DEHNER (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and R. P. REYSA (Boeing Aerospace Co., Seattle, WA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 8 p. refs
(SAE PAPER 851348)

A three-person preprototype Thermoelectric Integrated Membrane Evaporation Subsystem (TIMES I) has undergone additional wastewater processing testing in order to evaluate a redesigned evaporator assembly. The new evaporator design incorporates a number of concepts that have been selected for use in the next generation advanced preprototype subsystem design. A discussion of the operating performance of the TIMES I preprototype with the new evaporator installed is presented in this paper, as well as a more detailed description of the design changes currently being implemented in the improved water recovery subsystem (TIMES II). Special attention is given in this discussion to the improved maintenance aspects of the advanced preprototype evaporator/condenser assembly. In addition, specific advanced preprototype design information is provided in order to illustrate the end product of previous design studies. Author

A86-23535* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION NITROGEN SUPPLY SYSTEM BASED ON STORED CHEMICALS
F. T. POWELL (NASA, Ames Research Center, Cleveland, OH) and M. SCHWARTZ AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 11 p. refs
(SAE PAPER 851349)

The Space Station atmosphere is to have an 'earth-like' composition, and nitrogen is to be routinely supplied to replace losses. The required nitrogen is to be provided by an innovative method, involving a catalytic dissociation of liquid N2H4 and separation of the product nitrogen and hydrogen mixture. The considered technique of nitrogen storage and resupply has several advantages in comparison to methods using either cryogenic liquid or high pressure nitrogen. One advantage is related to savings with respect to launch weight, while a second advantage is provided

by the obtained hydrogen which is available for other uses within the Space Station. G.R.

A86-23555* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WET OXIDATION OF A SPACECRAFT MODEL WASTE
C. C. JOHNSON and T. WYDEVEN (NASA, Ames Research Center, Moffett Field, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 14 p. refs
(SAE PAPER 851372)

Wet oxidation was used to oxidize a spacecraft model waste under different oxidation conditions. The variables studied were pressure, temperature, duration of oxidation, and the use of one homogeneous and three heterogeneous catalysts. Emphasis is placed on the final oxidation state of carbon and nitrogen since these are the two major components of the spacecraft model waste and two important plant nutrients. Author

A86-23557* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
PERFORMANCE AND ENDURANCE TESTING OF A PROTOTYPE CARBON DIOXIDE AND HUMIDITY CONTROL SYSTEM FOR SPACE SHUTTLE EXTENDED MISSION CAPABILITY
C. H. LIN and R. J. CUSICK (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 10 p. refs
(SAE PAPER 851374)

An advanced flight prototype regenerable CO2 and humidity control system was delivered to NASA-JSC in February 1980. It is pointed out that this system offers substantial weight savings compared with the Shuttle Orbiter expendable lithium hydroxide CO2 removal system for extended duration missions. The present paper provides a brief description of the 4- to 10-man regenerable CO2 and humidity control system. The potential advantages which can be realized for an extended duration Shuttle mission are considered along with the results of extensive testing conducted at JSC. The performance evaluation and endurance tests show that the system is capable of long-term operation (up to 60 days) without maintenance. G.R.

A86-23558* Life Systems, Inc., Cleveland, Ohio.
SPACE STATION ENVIRONMENTAL CONTROL/LIFE SUPPORT SYSTEM ENGINEERING
C. W. MILLER and D. B. HEPPNER (Life Systems, Inc., Cleveland, OH) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p. Research supported by Life Systems, Inc. and NASA. refs
(SAE PAPER 851375)

The present paper is concerned with a systems engineering study which has provided an understanding of the overall Space Station ECLSS (Environmental Control and Life Support System). ECLSS/functional partitioning is considered along with function criticality, technology alternatives, a technology description, single thread systems, Space Station architectures, ECLSS distribution, mechanical schematics per space station, and Space Station ECLSS characteristics. Attention is given to trade studies and system synergism. The Space Station functional description had been defined by NASA. The ECLSS will utilize technologies which embody regenerative concepts to minimize the use of expendables. G.R.

A86-23559* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS TECHNOLOGY OPTIONS FOR SPACE STATION APPLICATION
J. B. HALL, JR., M. J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA), and K. H. SAGE (Kentron International, Inc., Hampton, VA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 19 p. refs
(SAE PAPER 851376)

Continuous assessments regarding the suitability of candidate technologies for manned Space Stations will be needed over the next several years to obtain a basis for recommending the optimum system for an Initial Operating Capability (IOC) Space Station which is to be launched in the early 1990's. This paper has the objective to present analysis programs, the candidate recommendations, and the recommended approach for integration these candidates into the NASA Space Station reference configuration. Attention is given to ECLSS (Environmental Control and Life Support System) technology assessment program, an analysis approach for candidate technology recommendations, mission model variables, a candidate integration program, metabolic oxygen recovery, urine/flush water and all waste water recovery, wash water and condensate water recovery, and an integration analysis. G.R.

A86-23560* Hamilton Standard, Windsor Locks, Conn.
UTILITY OF AN EMULATION AND SIMULATION COMPUTER MODEL FOR AIR REVITALIZATION SYSTEM HARDWARE DESIGN, DEVELOPMENT, AND TEST
J. L. YANOSY (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) and L. F. ROWELL (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p. refs
(SAE PAPER 851377)

Efforts to make increasingly use of suitable computer programs in the design of hardware have the potential to reduce expenditures. In this context, NASA has evaluated the benefits provided by software tools through an application to the Environmental Control and Life Support (ECLS) system. The present paper is concerned with the benefits obtained by an employment of simulation tools in the case of the Air Revitalization System (ARS) of a Space Station life support system. Attention is given to the ARS functions and components, a computer program overview, a SAND (solid amine water desorbed) bed model description, a model validation, and details regarding the simulation benefits. G.R.

A86-23569
BLSS, A EUROPEAN APPROACH TO CELSS
A. I. SKOOG (Dornier System GmbH, Friedrichshafen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p.
(SAE PAPER 851391)

The development of a biological life support system (BLSS) for space is examined. The proposed design for the BLSS is a closed loop system which supplies O2, food, and water, and maintains a balanced, stable spacecraft ecology. The terrestrial and space experiments, which focus on cultivating plants that will provide the crew with an adequate food supply, designing and testing of a terrestrial reference system, microgravity and cosmic radiation effects, and the use of PAR-radiation and high energy particle radiation protection, are studied. The functions of the Solar Plant Power Facility are investigated. The closed loop ecological life support system (ELSS) created by the ELSS technology study is analyzed. I.F.

A86-23575
WET-OXIDATION WASTE MANAGEMENT SYSTEM FOR CELSS
Y. TAKAHASHI (Niigata University, Japan) and H. OHYA (Yokohama National University, Japan) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 10 p.
(SAE PAPER 851398)

A wet oxidation system which is to treat organic wastes and redistribute inorganic compounds and elements is examined. The effect of temperature and reaction time on the solubility of carbon, nitrogen, and phosphorus in the oxidized water is investigated. The application of noble gas catalysts to the carbon and nitrogen reactions, and the need to develop catalysts which will complete oxidation and nitrification are analyzed. The behavior of metals in wet oxidation is studied. I.F.

A86-23742* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION CREW SAFETY - HUMAN FACTORS MODEL
M. M. COHEN and M. K. JUNGE (NASA, Ames Research Center, Moffett Field, CA) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1984, p. 908-912. Previously announced in STAR as N85-29540.

A model of the various human factors issues and interactions that might affect crew safety is developed. The first step addressed systematically the central question: How is this Space Station different from all other spacecraft? A wide range of possible issue was identified and researched. Five major topics of human factors issues that interacted with crew safety resulted: Protocols, Critical Habitability, Work Related Issues, Crew Incapacitation and Personal Choice. Second, an interaction model was developed that would show some degree of cause and effect between objective environmental or operational conditions and the creation of potential safety hazards. The intermediary steps between these two extremes of causality were the effects on human performance and the results of degraded performance. The model contains three milestones: stressor, human performance (degraded) and safety hazard threshold. Between these milestones are two countermeasure intervention points. The first opportunity for intervention is the countermeasure against stress. If this countermeasure fails, performance degrades. The second opportunity for intervention is the countermeasure against error. If this second countermeasure fails, the threshold of a potential safety hazard may be crossed. R.J.F.

A86-24108
AN APOLLO 11 ASTRONAUT ADDRESSES THE QUESTION OF MAN VS. MACHINE
M. COLLINS Commercial Space (ISSN 8756-4831), vol. 1, Summer 1985, p. 67-72.

The usefulness of men versus machines in space missions is discussed. Emphasis is given to the versatility of human operators in performing complex tasks in the space environment. The need for flexibility and improvisatory decision making in conducting space experiments, satellite launching, and construction of space structures is also considered. The potential utility of automated systems for maintenance and construction tasks in the installation of the Space Station is assessed. I.H.

A86-24111
LIVING IN SPACE IS POSING CHALLENGES TO DESIGNERS OF SPACE STATION CREW QUARTERS
Commercial Space (ISSN 8756-4831), vol. 1, Summer 1985, p. 88, 89, 91.

Attention is given to the main design issues governing the development of crew quarters for the Space Station. Among the design issues addressed are: command and control; airflow; nutrition; and sanitation. The design concepts currently being considered for Space Station include: hand holds and foot restraints for movement around the cabin; a closed-loop water circulation system; and exercise facilities. A color photograph of a design mock up for the Space Station habitat module is provided. I.H.

A86-28810
MASS-BALANCE MODEL FOR A CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEM ON MARS
T. R. CAUDILL (Colorado, University, Boulder) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 611-626. refs
(AAS 84-184)

The colonization of Mars is an instrumental step in the future expansion of the human race into the outer reaches of the solar system. One of the most difficult problems facing long term colonization of Mars is the supply of vital resources. This paper describes a model using a Controlled Ecological Life Support System (CELSS) which would help alleviate many logistical problems. The model outlines the usage of available Martian resources to maintain life. The results show that a closed system is theoretically feasible but there are many technical problems which must be solved before such a system can be utilized.
Author

A86-29499
CONCERNS ARE BEING RAISED ABOUT LIVING IN THE SPACE ENVIRONMENT
W. L. GIUFFRE Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 69, 70.

An evaluation is made of current understanding and outstanding problems in the field of physiological adaptation to weightless environments. The primary concerns associated with long duration space flight encompass motion sickness and disorientation, muscle atrophy, bone decalcification, and radiation exposure. Data that are currently being analyzed from the Spacelab mission D1 may show that the process of readaptation into earth gravity does not occur as rapidly as had been thought. It is noted that while space motion sickness drugs are helpful, they are not completely preventive. Future NASA planning stresses the importance of physical exercise. O.C.

N86-11220*# Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.
VIBRATIONS AND STRUCTUREBORNE NOISE IN SPACE STATION Progress Report, 1 Jan. - 30 Jun. 1985
R. VAICAITIS 30 Jun. 1985 26 p refs
(Contract NAG1-541)
(NASA-CR-176291; NAS 1.26:176291) Avail: NTIS HC A03/MF A01 CSCL 22B

The related literature was reviewed and a preliminary analytical model was developed for simplified acoustic and structural geometries for pressurized and unpressurized space station modules. In addition to the analytical work, an experimental program on structureborne noise generation and transmission was started. A brief review of those accomplishments is given. Author

N86-13900*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HUMAN FACTORS IN SPACE STATION ARCHITECTURE 1: SPACE STATION PROGRAM IMPLICATIONS FOR HUMAN FACTORS RESEARCH
M. M. COHEN Oct. 1985 13 p refs
(NASA-TM-86702; REPT-85167; NAS 1.15:86702) Avail: NTIS HC A02/MF A01 CSCL 05H

The space station program is based on a set of premises on mission requirements and the operational capabilities of the space shuttle. These premises will influence the human behavioral factors and conditions on board the space station. These include: launch in the STS Orbiter payload bay, orbital characteristics, power supply, microgravity environment, autonomy from the ground, crew make-up and organization, distributed command control, safety, and logistics resupply. The most immediate design impacts of these premises will be upon the architectural organization and internal environment of the space station. E.A.K.

N86-14091*# Missouri Univ., Columbia. Dept. of Chemical Engineering.

SOLID WASTE TREATMENT PROCESSES FOR SPACE STATION Final Report

T. R. MARRERO *In* NASA. Johnson (Lyndon B.) Space Center The 1983 NASA/ASEE Summer Faculty Fellowship Research Program Research Reports 55 p Sep. 1983 refs

Avail: NTIS HC A18/MF A01 CSCL 06K

The purpose of this study was to evaluate the state-of-the-art of solid waste(s) treatment processes applicable to a Space Station. From the review of available information a source term model for solid wastes was determined. An overall system is proposed to treat solid wastes under constraints of zero-gravity and zero-leakage. This study contains discussion of more promising potential treatment processes, including supercritical water oxidation, wet air (oxygen) oxidation, and chemical oxidation. A low pressure, batch-type treament process is recommended. Processes needed for pretreatment and post-treatment are hardware already developed for space operations. The overall solid waste management system should minimize transfer of wastes from their collection point to treatment vessel. Author

N86-15186*# Loyola Univ., Chicago, Ill.

GROUP STRUCTURE AND GROUP PROCESS FOR EFFECTIVE SPACE STATION ASTRONAUT TEAMS

J. M. NICHOLAS and R. S. KAGAN *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 330-339 1985 refs

Avail: NTIS HC A25/MF A01 CSCL 05A

Space Station crews will encounter new problems, many derived from the social interaction of groups working in space for extended durations. Solutions to these problems must focus on the structure of groups and the interaction of individuals. A model of intervention is proposed to address problems of interpersonal relationships and emotional stress, and improve the morale, cohesiveness, and productivity of astronaut teams. Author

N86-15187*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif. Man-Machine Systems.

SPACE CREW PRODUCTIVITY: A DRIVING FACTOR IN SPACE STATION DESIGN

H. L. WOLBERS *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 340-350 1985 refs

Avail: NTIS HC A25/MF A01 CSCL 05A

The criteria of performance, cost, and mission success probability (program confidence) are the principal factors that program or project managers and system engineers use in selecting the optimum design approach for meeting mission objectives. A frame of reference is discussed in which the interrelationships of these pertinent parameters can be made visible, and from which rational or informed decisions can be derived regarding the potential impact of adjustments in crew productivity on total Space Station System effectiveness. Author

N86-15188*# San Jose State Univ., Calif. Dept. of Organization and Management.

THE SPACE STATION AND HUMAN PRODUCTIVITY: AN AGENDA FOR RESEARCH

C. B. SCHOONHOVEN *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 352-367 1985 refs

Avail: NTIS HC A25/MF A01 CSCL 05A

Organizational problems in permanent organizations in outer space were analyzed. The environment of space provides substantial opportunities for organizational research. Questions about how to organize professional workers in a technologically complex setting with novel dangers and uncertainties present in the immediate environment are examined. It is suggested that knowledge from organization theory/behavior is an underutilized resource in the U.S. space program. A U.S. space station will be operable by the mid-1990's. Organizational issues will take on increasing importance, because a space station requires the long term organization of human and robotic work in the isolated and confined environment of outer space. When an organizational analysis of the space station is undertaken, there are research implications at multiple levels of analysis: for the individual, small group, organizational, and environmental levels of analysis. The research relevant to organization theory and behavior is reviewed. E.A.K.

N86-15189*# State Univ. of New York, Buffalo. School of Architecture and Environmental Design.

POST-IOC SPACE STATION: MODELS OF OPERATION AND THEIR IMPLICATIONS FOR ORGANIZATIONAL BEHAVIOR, PERFORMANCE AND EFFECTIVENESS

S. DANFORD, J. MEINDL, and R. HUNT *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 368-376 1985 refs

Avail: NTIS HC A25/MF A01 CSCL 05A

Issues of crew productivity during design work on space station are discussed. The crew productivity is defined almost exclusively in terms of human factors engineering and habitability design concerns. While such spatial environmental conditions are necessary to support crew performance and productivity, they are not sufficient to ensure high levels of crew performance and productivity on the post-Initial Operational Configurations (IOC) space station. The role of the organizational environment as a complement to the spatial environment for influencing crew performance in such isolated and confined work settings is examined. Three possible models of operation for post-IOC space station's organizational environment are identified and it is explained how they and space station's spatial environment will combine and interact to occasion patterns of crew behavior is suggested. A three phase program of research design: (1) identify patterns of crew behavior likely to be occasioned on post-IOC space station for each of the three models of operation; and (2) to determine proactive/preventative management strategies which could be adopted to maximize the emergence of preferred outcomes in crew behavior under each of the several spatial and organizational environment combinations. E.A.K.

N86-15332*# San Francisco Univ., Calif. Physics Research Lab.

RADIATION MAPPING ON SPACELAB 1: EXPERIMENT NO. INS006 Final Report

E. V. BENTON, A. FRANK, R. CASSOU, R. HENKE, and V. ROWE 1 Mar. 1985 24 p refs

(Contract NAS9-15337)

(NASA-CR-171893; NAS 1.26:171893; USF-TR-68) Avail: NTIS HC A02/MF A01 CSCL 22B

The first attempt at mapping the radiation environment inside Spacelab is described. Measurements were made by a set of passive radiation detectors distributed throughout the volume inside the Spacelab 1 module, in the access tunnel and outside on the pallet. Measurements of the low linear energy transfer (LET) component obtained from the TLD thermoluminescent detectors (TLD) ranged from 92 to 134 mrad, yielding an average low LET dose rate of 10.0 mrads/day inside the module. Because of the higher inclination orbit, substantial fluxes of highly ionizing (HZE particles) high charge and energy galactic cosmic rays were observed for the first time on an STS flight, yielding an overall average mission dose-equivalent of 295 mrem, or 29.5 mrem/day, which is about three times higher than that measured on previous STS missions. Little correlation is found between measured average dose rates or HZE fluences and the estimates shielding throughout the volume of the module. E.A.K.

N86-16903*# Economics Lab., Inc., St. Paul, Minn.
A STUDY TO DEFINE A SET OF REQUIREMENTS FOR CLEANSING AGENTS FOR USE IN THE SPACE STATION WHOLE BODY SHOWER Final Report
29 Oct. 1985 95 p
(Contract NAS9-17428)
(NASA-CR-171910; NAS 1.26:171910) Avail: NTIS HC A05/MF A01 CSCL 06K

The objective of this research is to define a set of requirements for a whole body cleansing agent to be used in the Space Station Whole Body Shower System. In addition, cleansing agent candidates are to be identified that are likely to satisfy requirements defined in the first part of the study. It is understood that the main reason for having a Whole Body Shower is to satisfy the physiological, psychological and social needs of the crew throughout the duration of duty in the Space Station. The cleansing agent must also be compatible with the vortex water/gas separator and the water reclamation system. To accomplish these goals the study was divided into six tasks. Author

N86-19906*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS: CELSS 1985 WORKSHOP
R. D. MACELROY, ed., N. V. MARTELLO, ed., and D. T. SMERNOFF, ed. Jan. 1986 624 p refs Workshop held at Moffett Field, Calif., 16-19 Jul. 1985
(NASA-TM-88215; A-86132; NAS 1.15:88215) Avail: NTIS HC A99/MF A01 CSCL 06K

Various topics related to closed ecological systems are discussed. Space habitats, vegetative growth, photosynthesis, recycling, culture techniques, waste utilization bioreactors and controlled atmospheres on space stations are among the topics covered.

N86-19907*# Massachusetts Inst. of Tech., Cambridge. Dept. of Applied Biological Sciences.
POTENTIAL FOR UTILIZATION OF ALGAL BIOMASS FOR COMPONENTS OF THE DIET IN CELSS
A. R. KAMAREI, Z. NAKHOST, and M. KAREL *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 13-22 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The major nutritional components of the green algae (Scenedesmus obliquus) grown in a Constant Cell Density Apparatus were determined. Suitable methodology to prepare proteins from which three major undesirable components of these cells (i.e., cell walls, nucleic acids, and pigments) were either removed or substantially reduced was developed. Results showed that processing of green algae to protein isolate enhances is potential nutritional and organoleptic acceptability as a diet component in controlled Ecological Life Support System. Author

N86-19908*# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
BLSS, A EUROPEAN APPROACH TO CELSS
A. I. SKOOG *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 23-33 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

Several studies have revealed the benefits of a biological life support system (BLSS) in space stations. Problem areas requiring experimental and analytical investigations necessary for the development of BLSS have been identified. The nature of these problems allows for the classification into near-term (prepilot) and long-term (pilot) studies, and into terrestrial and space research programmes. The knowledge of planned European and U.S. space experiments allows for a coordination with existing Spacelab and Shuttle programmes to avoid duplication of research efforts. The Japanese also plan biological experiments on Spacelab in 1988. Coordinating efforts should provide answers to certain BLSS relevant questions. Major areas which need immediate attention are: micorgravity effects; cosmic radiation effects; use of PAR-radiation and high energy particle radiation protection; and monitoring and control (including sensor technology). R.J.F.

N86-19913*# Niigata Univ. (Japan). Dept. of Civil Engineering.
WET-OXIDATION WASTE MANAGEMENT SYSTEM FOR CELSS
Y. TAKAHASHI and H. OHYA (Yokohama National Univ., Japan) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 77-84 Jan. 1986
Avail: NTIS HC A99/MF A01 CSCL 07B

A wet oxidation system will be useful in the Closed Ecological Life Support System (CELSS) as a facility to treat organic wastes and to redistribute inorganic compounds and elements. However at rather higher temperatures needed in this reaction, for instance, at 260 deg C, only 80% of organic in a raw material can be oxidized, and 20% of it will remain in the liquid mainly as acetic acid, which is virtually noncombustible. Furthermore, nitrogen is transformed to ammonium ions which normally cannot be absorbed by plants. To resolve these problems, it becomes necessary to use catalysts. Noble metals such as Ru, Rh and so on have proved to be partially effective as these catalysts. That is, oxidation does not occur completely, and the unexpected denitrification, instead of the expected nitrification, occurs. So, it is essential to develop the catalysts which are able to realize the complete oxidation and the nitrification. Author

N86-19914*# North Carolina State Univ., Raleigh. Dept. of Soil Science.
SIMULATION MODEL FOR PLANT GROWTH IN CONTROLLED ENVIRONMENT SYSTEMS
C. D. RAPER, JR. and M. WANN *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 85-101 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The role of the mathematical model is to relate the individual processes to environmental conditions and the behavior of the whole plant. Using the controlled-environment facilities of the phytotron at North Carolina State University for experimentation at the whole-plant level and methods for handling complex models, researchers developed a plant growth model to describe the relationships between hierarchial levels of the crop production system. The fundamental processes that are considered are: (1) interception of photosynthetically active radiation by leaves, (2) absorption of photosynthetically active radiation, (3) photosynthetic transformation of absorbed radiation into chemical energy of carbon bonding in solube carbohydrates in the leaves, (4) translocation between carbohydrate pools in leaves, stems, and roots, (5) flow of energy from carbohydrate pools for respiration, (6) flow from carbohydrate pools for growth, and (7) aging of tissues. These processes are described at the level of organ structure and of elementary function processes. The driving variables of incident photosynthetically active radiation and ambient temperature as inputs pertain to characterization at the whole-plant level. The output of the model is accumulated dry matter partitioned among leaves, stems, and roots; thus, the elementary processes clearly operate under the constraints of the plant structure which is itself the output of the model. R.J.F.

N86-19915*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
PLAN FOR CELSS TEST BED PROJECT
W. M. KNOTT *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 109-118 Jan. 1986
Avail: NTIS HC A99/MF A01 CSCL 06K

The Closed Ecological Life Support Systems (CELSS) testbed project will achieve two major goals: It will develop the knowledge and technology needed to build and test biological or combined biological physiochemical regenerative life support systems. It will fabricate, test, and operate ground based facilities to accomplish proof-of-concent testing and evaluation leading to flight experimentation. The project will combine basic research and applied research/engineering to achieve a phased, integrated development of hardware, systems, and techniques for food and

oxygen production, food processing, and waste processing in closed systems. The project will design, fabricate, and operate within three years a botanical production system scaled to a sufficient size to verify oxygen and nutrient load production (carbohydrates, fats, proteins) at a useable level. It will develop within five years a waste management system compatible with the botanical production system and a food processing system that converts available biomass into edible products. It will design, construct, and operate within ten years a ground based candidate CELSS that includes man as an active participant in the system. It will design a flight CELSS module within twelve years and construct and conduct initial flight tests within fifteen years.

R.J.F.

N86-19916*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.

PLANT GROWTH CHAMBER M DESIGN

R. P. PRINCE and W. M. KNOTT *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 119-128 Jan. 1986 refs

Avail: NTIS HC A99/MF A01 CSCL 06K

Crop production is just one of the many processes involved in establishing long term survival of man in space. The benefits of integrating higher plants into the overall plan was recognized early by NASA through the Closed Ecological Life Support System (CELSS) program. The first step is to design, construct, and operate a sealed (gas, liquid, and solid) plant growth chamber. A 3.6 m diameter by 6.7 m high closed cylinder (previously used as a hypobaric vessel during the Mercury program) is being modified for this purpose. The chamber is mounted on legs with the central axis vertical. Entrance to the chamber is through an airlock. This chamber will be devoted entirely to higher plant experimentation. Any waste treatment, food processing or product storage studies will be carried on outside of this chamber. Its primary purpose is to provide input and output data on solids, liquids, and gases for single crop species and multiple species production using different nutrient delivery systems. R.J.F.

N86-19917*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.

OPERATIONAL DEVELOPMENT OF SMALL PLANT GROWTH SYSTEMS

H. W. SCHELD (PhytoResource Research, Inc., College Station, Tex.), J. W. MAGNUSON (PhytoResource Research, Inc., College Station, Tex.), and R. L. SAUER *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 129-150 Jan. 1986 refs

Avail: NTIS HC A99/MF A01 CSCL 06K

The results of a study undertaken on the first phase of an empricial effort in the development of small plant growth chambers for production of salad type vegetables on space shuttle or space station are discussed. The overall effort is visualized as providing the underpinning of practical experience in handling of plant systems in space which will provide major support for future efforts in planning, design, and construction of plant-based (phytomechanical) systems for support of human habitation in space. The assumptions underlying the effort hold that large scale phytomechanical habitability support systems for future space stations must evolve from the simple to the complex. The highly complex final systems will be developed from the accumulated experience and data gathered from repetitive tests and trials of fragments or subsystems of the whole in an operational mode. These developing system components will, meanwhile, serve a useful operational function in providing psychological support and diversion for the crews. R.J.F.

N86-19918*# New Hampshire Univ., Durham. Complex Systems Research Center.

ELECTROCHEMICAL CONTROL OF PH IN A HYDROPONIC NUTRIENT SOLUTION

S. H. SCHWARTZKOPF *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 151-158 Jan. 1986 refs

Avail: NTIS HC A99/MF A01 CSCL 06K

The electrochemical pH control system described was found to provide a feasible alternative method of controlling nutrient solution pH for CELSS applications. The plants grown in nutrient solution in which the pH was controlled electrochemically showed no adverse effects. Further research into the design of a larger capacity electrode bridge for better control is indicated by the results of this experiment, and is currently under way. Author

N86-19919*# Battelle Columbus Labs., Ohio.

AN ENGINEERING ANALYSIS OF A CLOSED CYCLE PLANT GROWTH MODULE

G. H. STICKFORD, JR., F. E. JAKOB, and D. K. LANDSTROM *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 159-181 Jan. 1986 refs

Avail: NTIS HC A99/MF A01 CSCL 06K

The SOLGEM model is a numerical engineering model which solves the flow and energy balance equations for the air flowing through a growing environment, assuming quasi-steady state conditions within the system. SOLGEM provides a dynamic simulation of the controlled environment system in that the temperature and flow conditions of the growing environment are estimated on an hourly basis in response to the weather data and the plant growth parameters. The flow energy balance considers the incident solar flux; incoming air temperature, humidity, and flow rate; heat exchange with the roof and floor; and heat and moisture exchange with the plants. A plant transpiration subroutine was developed based plant growth research facility, intended for the study of bioregenerative life support theories. The results of a performance analysis of the plant growth module are given. The estimated energy requirements of the module components and the total energy are given. R.J.F.

N86-19922*# MODEC, Cambridge, Mass.

SUPERCRITICAL WASTE OXIDATION OF AQUEOUS WASTES

M. MODELL *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 227-251 Jan. 1986 refs

Avail: NTIS HC A99/MF A01 CSCL 07B

For aqueous wastes containing 1 to 20 wt% organics, supercritical water oxidation is less costly than controlled incineration or activated carbon treatment and far more efficient than wet oxidation. Above the critical temperature (374 C) and pressure (218 atm) of water, organic materials and gases are completely miscible with water. In supercritical water oxidation, organics, air and water are brought together in a mixture at 250 atm and temperatures above 400 C. Organic oxidation is initiated spontaneously at these conditions. The heat of combustion is released within the fluid and results in a rise in temperature 600 to 650 C. Under these conditions, organics are destroyed rapidly with efficiencies in excess of 99.999%. Heteroatoms are oxidized to acids, which can be precipitated out as salts by adding a base to the feed. Examples are given for process configurations to treat aqueous wastes with 10 and 2 wt% organics. Author

N86-19923*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

AIRBORNE TRACE CONTAMINANTS OF POSSIBLE INTEREST IN CELSS

J. S. GARAVELLI *In its* Controlled Ecological Life Support Systems p 253-262 Jan. 1986

Avail: NTIS HC A99/MF A01 CSCL 06K

One design goal of Closed Ecological Life Support Systems (CELSS) for long duration space missions is to maintain an atmosphere which is healthy for all the desirable biological species and not deleterious to any of the mechanical components in that atmosphere. CELESS design must take into account the

interactions of at least six major components; (1) humans and animals, (2) higher plants, (3) microalgae, (4) bacteria and fungi, (5) the waste processing system, and (6) other mechanical systems. Each of these major components can be both a source and a target of airborne trace contaminants in a CELSS. A range of possible airborne trace contaminants is discussed within a chemical classification scheme. These contaminants are analyzed with respect to their probable sources among the six major components and their potential effects on those components. Data on airborne chemical contaminants detected in shuttle missions is presented along with this analysis. The observed concentrations of several classes of compounds, including hydrocarbons, halocarbons, halosilanes, amines and nitrogen oxides, are considered with respect to the problems which they present to CELSS. Author

N86-19924*# New Hampshire Univ., Durham. Complex Systems Research Center.
OBSERVATIONS ON GAS EXCHANGE AND ELEMENT RECYCLE WITHIN A GAS-CLOSED ALGAL-MOUSE SYSTEM
D. T. SMERNOFF, R. A. WHARTON, JR., and M. M. AVERNER *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 263-280 Jan. 1986
Avail: NTIS HC A99/MF A01 CSCL 06K

Life support systems based on bioregeneration rely on the control and manipulation of organisms. Algae are potentially useful for a variety of Closed Ecological Life Support System (CELSS) functions including the revitalization of atmospheres, production of food and for nitrogen fixation. The results of experiments conducted with a gas-closed algal-mouse system designed to investigate gas exchange phenomena under varying algal environmental conditions, and the ability of algae to utilize oxidized mouse solid waste are reported. Inherent instabilities exist between the uptake and release of carbon dioxide (CO2) and oxygen (O2) by the mouse and algae in a gas-closed system. Variations in light intensity and cell density alter the photosynthetic rate of the algae and enable short-term steady-state concentrations of atmospheric CO2 and O2. Different nitrogen sources (urea and nitrate) result in different algal assimilatory quotients (AQ). Combinations of photosynthetic rate and AQ ratio manipulations were examined for their potential in stabilizing atmospheric gas concentrations in the gas-closed algal-mouse system. R.J.F.

N86-19925*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CELSS SCIENCE NEEDS
J. D. RUMMEL *In its* Controlled Ecological Life Support Systems p 281-284 Jan. 1986
Avail: NTIS HC A99/MF A01 CSCL 06K

Questions and areas of study that need to be persued in order to develope a Controlled Ecological Life Support System are posed. Research topics needing attention are grouped under various leadings: ecology, genetics, plant pathology, cybernetics, chemistry, computer science, fluid dynamics, optics, and solid-state physics. R.J.F.

N86-19926*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DESIGN CONCEPTS FOR BIOREACTORS IN SPACE
P. K. SESHAN, G. R. PETERSON, B. BEARD (Washington Univ., St. Louis, Mo.), and E. H. DUNLOP (Washington Univ., St. Louis, Mo.) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 287-313 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

Microbial food sources are becoming viable and more efficient alternatives to conventional food sources especially in the context of Closed Ecological Life Support Systems (CELSS) in space habitats. Since bioreactor designs for terrestrial operation will not readily apply to conditions of microgravity, there is an urgent need to learn about the differences. These differences cannot be easily estimated due to the complex nature of the mass transport and mixing mechanisms in fermenters. Therefore, a systematic and expeditious experimental program must be undertaken to obtain the engineering data necessary to lay down the foundations of designing bioreactors for microgravity. Two bioreactor design concepts presented represent two dissimilar approaches to grappling with the absence of gravity in space habitats and deserve to be tested for adoption as important components of the life support function aboard spacecrafts, space stations and other extra-terrestrial habitats. R.J.F.

N86-19927*# Martin Marietta Corp., Baltimore, Md.
AN ANALYSIS OF THE PRODUCTIVITY OF A CELSS CONTINUOUS ALGAL CULTURE SYSTEM
R. RADMER, P. BEHRENS, E. FERNANDEZ, and K. ARNETT *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 315-328 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

One of the most attractive aspects of using algal cultures as plant components for a Closed Ecological Life Support Systems (CELSS) is the efficiency with which they can be grown. Although algae are not necessarily intrinsically more efficient than higher plants, the ease which they can be handled and manipulated (more like chemical reagents than plants), and the culturing techniques available, result in much higher growth rates than are usually attainable with higher plants. Furthermore, preliminary experiments have demonstrated that algal growth and physiology is not detectable altered in a microgravity environment, (1) whereas the response of higher plants to zero gravity is unknown. In order to rationally design and operate culture systems, it is necessary to understand how the macroparameters of a culture system, e.g., productivity, are related to the physiological aspects of the algal culture. A first principles analysis of culture system is discussed, and a mathematical model that describes the relationship of culture productivity to the cell concentration of light-limited culture is derived. The predicted productivity vs cell concentration curve agrees well with the experimental data obtained to test this model, indicating that this model permits an accurate prediction of culture productivity given the growth parameters of the system. R.J.F.

N86-19928*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE DEVELOPMENT OF AN UNCONVENTIONAL FOOD REGENERATION PROCESS: QUANTIFYING THE NUTRITIONAL COMPONENTS OF A MODEL METHYLOTROPHIC YEAST
G. R. PETERSEN and B. O. STOKES (Biomass International, Ogden, Utah) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 329-338 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

A hybrid chemical/biological approach to unconventional food regeneration is discussed. Carbon dioxide and water, the major wastes of human metabolism would be converted to methanol by one of several physiochemical processes available (thermal, photocatalytic, etc.). Methanol is then used to supply carbon and energy for the culture of microorganisms which in turn produce biological useful basic food stuffs for human nutrition. Our work has focused on increasing the carbohydrate levels of a candidate methylotrophic yeast to more nearly coincide with human nutritional requirements. Yeasts were chosen due to their high carbohydrate levels compared to bacteria and their present familiarity in the human diet. The initial candidate yeast studied was a thermotolerant strain of Hansenula polymor pha, DL-1. The quantitative results that permit an evaluation of the overall efficiency in hybrid chemical/biological food production schemes are discussed. A preliminary evaluation of the overall efficiency of such schemes is also discussed. R.J.G.

N86-19929*# California Univ., Berkeley. Lawrence Berkeley Lab. Membrane Bioenergetics Group.
APPLICATION OF PHOTOSYNTHETIC N2-FIXING CYANOBACTERIA TO THE CELSS PROGRAM
L. PACKER, I. FRY, and S. BELKIN *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 339-352 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

Commercially available air lift fermentors were used to simultaneously monitor biomass production, N2-fixation,

photosynthesis, respiration, and sensitivity to oxidative damage during growth under various nutritional and light regimes, to establish a data base for the integration of these organisms into a Closed Ecological Life Support System (CELSS) program. Certain cyanobacterial species have the unique ability to reduce atmospheric N2 to organic nitrogen. These organisms combine the ease of cultivation characteristics of prokaryotes with the fully developed photosynthetic apparatus of higher plants. This, along with their ability to adapt to changes in their environment by modulation of certain biochemical pathways, make them attractive candidates for incorporation into the CELSS program. R.J.F.

N86-19930*# Cornell Univ., Ithaca, N.Y. School of Chemical Engineering.
CARBON DIOXIDE EVOLUTION RATE AS A METHOD TO MONITOR AND CONTROL AN AEROBIC BIOLOGICAL WASTE TREATMENT SYSTEM
S. S. LEE and M. L. SHULER *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 354-391 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

An experimental system was developed to study the microbial growth kinetic of an undefined mixed culture in an erobic biological waste treatment process. The experimental results were used to develop a mathematical model that can predict the performance of a bioreactor. The bioreactor will be used to regeneratively treat waste material which is expected to be generated during a long term manned space mission. Since the presence of insoluble particles in the chemically undefined complex media made estimating biomass very difficult in the real system, a clean system was devised to study the microbial growth from the soluble substrate. R.J.F.

N86-19933*# California Univ., Davis. Plant Growth Lab.
EFFECTS OF NO3(-) AND NH4(+) AND UREA ON EACH OTHER'S UPTAKE AND INCORPORATION
R. C. HUFFAKER and M. R. WARD *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 429-445 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The purpose was to determine the optimal use by wheat plants of the N sources expected from processing biological waste products, NO3(-),NO2(-)NH4(+), and urea. The approach was to determine the uptake and metabolic products of each N source (from single and multiple component solutions), inhibitory effects of each, feedback inhibition, and overall in vivo regulation of the rates of assimilation of each by wheat plants. Previously, researchers determined the interactions of NO3(-),NO2(-),NH4(+) on each other's uptake and incorporation. The assimilation and some of its effects on NO3(-) and NH4(+) assimilation which have been completed to data are discussed. R.J.F.

N86-19934*# Utah State Univ., Logan. Plant Science Dept.
STUDIES ON MAXIMUM YIELD OF WHEAT FOR THE CONTROLLED ENVIRONMENTS OF SPACE
B. G. BUGBEE and F. B. SALISBURY *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 447-485 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The economic feasibility of using food-producing crop plants in a closed ecological Life-Support System (CELSS) will ultimately depend on the energy and area (or volume) required to provide the nutritional requirements for each person. Energy and area requirements are, to some extent, inversely related; that is, an increased energy input results in a decreased area requirement and vice versa. A major goal of the research effort was to determine the controlled-environment good-production efficiency of wheat per unit area, per unit time, and per unit energy input. R.J.F.

N86-19935*# Wisconsin Univ., Madison. Dept. of Horticulture.
UTILIZATION OF POTATOES IN CELSS: PRODUCTIVITY AND GROWING SYSTEMS
T. W. TIBBITTS *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 487-498 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The potato plant (solanum tuberosum L.) is one of the basic food crops that should be studied for use in NASA's closed Ecological Life Support System (CELSS). It offers high yields per unit area and time, with most of this production in the form of highly digestible carbohydrate. Potatoes, like wheat and rice, are particularly useful in human diets because of their nutritional versatility and ease of processing and preparation. The growth of the potato was studied and it was found to be a useful species for life support systems. R.J.F.

N86-19936*# Purdue Univ., West Lafayette, Ind. Dept. of Horticulture.
OPTIMIZATION OF CONTROLLED ENVIRONMENTS FOR HYDROPONIC PRODUCTION OF LEAF LETTUCE FOR HUMAN LIFE SUPPORT IN CELSS
C. A. MITCHELL, S. L. KNIGHT, and T. L. FORD *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 499-521 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

A research project in the food production group of the Closed Ecological Life Support System (CELSS) program sought to define optimum conditions for photosynthetic productivity of a higher plant food crop. The effects of radiation and various atmospheric compositions were studied. R.J.F.

N86-19937*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CLOSED CULTURE PLANT STUDIES: IMPLICATIONS FOR CELSS
T. HOSHIZAKI *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 523-540 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

Arabidopsis plants were grown in closed cultures similar to those used in space experiments. A shift in metabolism from photosynthesis to respiration is indicated by the accumulation of CO2 in the culture atmosphere. Reproductive growth is suppressed. Plant growth and development is apparently related to the atmospheric volume available to each plant. The implications of these findings to closed ecological systems are given: (1) there is a need for an open culture having ample gas exchange, (2) CO2 levels must be maintained within prescribed limits, (3) the minimum atmospheric volume required for each plant is dependent on the precision of the gas monitors and of the subsystems used to maintain appropriate levels of various atmospheric components, and (4) volatiles such as ethylene and terpenes emanating from plants be monitored and reduced to benign concentrations. R.J.F.

N86-19938*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
A METHOD FOR SCREENING OF PLANT SPECIES FOR SPACE USE
J. D. GOESCHL (Phytokinetics, Inc., College Station, Tex.), R. L. SAUER, and H. W. SCHELD (PhytoResource Research, Inc., College Station, Tex.) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 541-554 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

A cost-effective methodology which monitors numerous dynamic aspects of carbon assimilation and allocation kinetics in live, intact plants is discussed. Analogous methods can apply to nitrogen uptake and allocation. This methodology capitalizes on the special properties of the short-lived, positron-gamma emitting isotope C-11 especially when applied as CO2-11 in a special extended square wave (ESW) pattern. The 20.4 minute half-life allows for repeated or continuous experiments on the same plant over periods of minutes, hours, days, or weeks. The steady-state isotope

equilibrium approached during the ESW experiments, and the parameters which can be analyzed by this technique are also direct results of that short half-life. Additionally, the paired .511 MeV gamma rays penetrate any amount of tissue and their 180 deg opposite orientation provides good collimation and allows coincidence counting which nearly eliminates background. R.J.F.

N86-19939*# Wisconsin Univ., Madison. Dept. of Horticulture.
POTATO LEAF EXPLANTS AS A SPACEFLIGHT PLANT TEST SYSTEM
R. M. WHEELER *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 555-564 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The use of explant tissues or organs may circumvent limitations facing whole-plant experimentation during spaceflight. In the case of potato, a crop currently being studied for application to bioregenerative life support systems, excised leaves and their subtended axillary buds can be used to test a variety of stem growth and development phases ranging from tubers through stolons (horizontal stems) to upright leafy shoots. The leaves can be fit well into small-volume test packages and sustained under relatively low irradiance levels using light-weight growing media. Tubers formed on potato leaf cuttings can yield up from 0.5 to 1.0 g fresh mass 10 days after excision and up to 2.0 g or more, 14 days from excision. Author

N86-19941*# North Carolina State Univ., Raleigh. Dept. of Soil Science.
NITROGEN UPTAKE AND UTILIZATION BY INTACT PLANTS
C. D. RAPER, JR. and L. C. TOLLEY-HENRY *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 577-594 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The results of experiments support the proposed conceptual model that relates nitrogen uptake activity by plants as a balanced interdependence between the carbon-supplying function of the shoot and the nitrogen-supplying function of the roots. The data are being used to modify a dynamic simulation of plant growth, which presently describes carbon flows through the plant, to describe nitrogen uptake and assimilation within the plant system. Although several models have been proposed to predict nitrogen uptake and partitioning, they emphasize root characteristics affecting nutrient uptake and relay on empirical methods to describe the relationship between nitrogen and carbon flows within the plant. Researchers, on the other hand, propose to continue to attempt a mechanistic solution in which the effects of environment on nitrogen (as well as carbon) assimilation are incorporated through their direct effects on photosynthesis, respiration, and aging processes. R.J.F.

N86-19942*# North Dakota State Univ., Fargo. Dept. of Plant Pathology.
THE ROLE OF PLANT DISEASE IN THE DEVELOPMENT OF CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS
B. NELSON *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 595-610 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

Plant diseases could be important factors affecting growth of higher plants in Closed Ecological Life Support Systems (CELSS). Disease control, therefore, will be needed to maintain healthy plants. The most important controls should be aimed at preventing the introduction, reproduction and spread of pathogens and preventing plant infection. An integrared ease control program will maximize that approach. In the design and operation of CELSS, plant disease should be considered an important aspect of plant growth. The effects of plant diseases are reviewed and several disease control measures are discussed. R.J.F.

N86-19943*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF SPACE TECHNOLOGY FOR ECOLOGICAL HABITATS
N. V. MARTELLO *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 613-625 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The development of closed ecological systems for space stations is discussed. Growth chambers, control systems, microgravity, ecosystem stability, lighting equipment, and waste processing systems are among the topics discussed. R.J.F.

N86-20485*# Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.
VIBRATIONS AND STRUCTUREBORNE NOISE IN SPACE STATION Progress Report, 1 Jul. - 31 Dec. 1985
R. VAICAITIS 31 Dec. 1985 119 p refs
(Contract NAG1-541)
(NASA-CR-176520; NAS 1.26:176520) Avail: NTIS HC A06/MF A01 CSCL 22B

Theoretical models were developed capable of predicting structural response and noise transmission to random point mechanical loads. Fiber reinforced composite and aluminum materials were considered. Cylindrical shells and circular plates were taken as typical representatives of structural components for space station habitability modules. Analytical formulations include double wall and single wall constructions. Pressurized and unpressurized models were considered. Parametric studies were conducted to determine the effect on structural response and noise transmission due to fiber orientation, point load location, damping in the core and the main load carrying structure, pressurization, interior acoustic absorption, etc. These analytical models could serve as preliminary tools for assessing noise related problems, for space station applications. Author

N86-20588*# National Aeronautics and Space Administration, Washington, D.C.
AEROSPACE SAFETY ADVISORY PANEL, COVERING CALENDAR YEAR 1985 Annual Report
Jan. 1986 99 p
(NASA-TM-88637; NAS 1.15:88637) Avail: NTIS HC A05/MF A01 CSCL 13B

The level of activity of the Aerospace Safety Advisory Panel was increased somewhat 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 actual flight testing of the X-29 research aircraft. Payload STS missions and NASA's overall aircraft operations were reviewed. The safety aspects of the Leasat salvage mission were assessed. The panel's 1985 work is summarized and its findings enumerated and recommendations for the attention of NASA management presented. NASA's response to the Panel's 1984 report findings and recommendations is appended. Author

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.

A86-11122* California Univ., Los Angeles.
NON-LINEAR GUIDANCE LAWS FOR AUTOMATIC ORBITAL RENDEZVOUS
P. K. C. WANG (California, University, Los Angeles) International Journal of Control (ISSN 0020-7179), vol. 42, Sept. 1985, p. 651-670. NASA-supported research. refs

In the automatic assembly of space stations or the automatic rendezvous and docking of a space-shuttle vehicle with a space station, it is of interest to determine suitable guidance laws for orbital rendezvous which are amenable to on-board implementation. In this paper, various forms of nonlinear guidance laws for automatic orbital rendezvous of two bodies represented by point masses in a central Newtonian gravitational field are derived. A basic requirement is that the approach be smooth and nonoscillatory. The global dynamic behavior of each of the resulting feedback systems is determined analytically and/or by computer simulation. Author

A86-11244#
FREQUENCY CONTROL AND ITS EFFECT ON THE DYNAMIC RESPONSE OF FLEXIBLE STRUCTURES
V. B. VENKAYYA and V. A. TISCHLER (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) (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. 431-441) AIAA Journal (ISSN 0001-1452), vol. 23, Nov. 1985, p. 1768-1774. Previously cited in issue 13, p. 1915, Accession no. A84-31731. refs

A86-11344#
SERVO-ELASTIC OSCILLATIONS - CONTROL OF TRANSIENT DYNAMIC MOTION OF A PLATE
S. N. ATLURI (Georgia Institute of Technology, Atlanta) and P. E. ODONOGHUE IN: 1984 advances in aerospace sciences and engineering: Structures, materials, dynamics, and space station propulsion; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 139-147. refs
(Contract AF-AFOSR-84-0020)

The control of the transient dynamic response of an initially stressed flat plate representing the continuum model of a large space structure (LSS) is presented using a boundary-element approach. The discretization of the equation of motion of the plate, using a singular solution approach, the control of dynamic response, and the control spillover are discussed. The implementation of algorithms for an efficient solution of Ricatti equations is accomplished. F.J.

A86-11404#
AN ACCESS CONTROL MODEL FOR A DISTRIBUTED, CAIS-CONFORMING SYSTEM
S. LEGRAND (Ford Aerospace and Communications Corp., Detroit, MI) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 18-21. refs
(AIAA PAPER 85-50441)

A 'superset' access control model for enforcing multilevel security in a distributed target environment is presented. This model contains attributes about the subjects and objects and is believed to conform to the proposed Military Standard Common APSE Interface Set (CAIS). Possible applications of such access control are subsystems of the Space Station Program and the Strategic Defense Initiative Program. B.J.

A86-11810* Howard Univ., Washington, D. C.
CONTROL OF AN ORBITING FLEXIBLE SQUARE PLATFORM IN THE PRESENCE OF SOLAR RADIATION
P. M. BAINUM and R. KRISHNA (Howard University, Washington, DC) (International Symposium on Space Technology and Science, 14th, Tokyo, Japan, May 27-June 2, 1984) Acta Astronautica (ISSN 0094-5765), vol. 12, Sept. 1985, p. 699-704. refs
(Contract NSG-1414)

An analysis is made of the dynamics of a thin, homogeneous, flexible square plate exposed to solar radiation disturbance. It is shown that only the first three flexible modes of the plate generate a first order net moment about the center of mass and that the solar radiation pressure does not influence the flexible modes of the plate for small-amplitude vibrations. In the absence of control, for a symmetrical homogeneous square platform, the solar radiation induces a steady angular drift about one of the body principal axes. For extremely flexible platforms, nominally oriented in the local horizontal plane, appreciable rigid modal amplitudes can be induced due to solar radiation, even in the presence of both active and passive control. Optimal control law and feedback gain values are obtained using linear quadratic Gaussian methods. V.L.

A86-12442
MODAL-SPACE ACTIVE DAMPING OF A BEAM-CABLE STRUCTURE - THEORY AND EXPERIMENT
G. R. SKIDMORE and W. L. HALLAUER, JR. (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Sound and Vibration (ISSN 0022-460X), vol. 101, July 22, 1985, p. 149-160. refs
(Contract AF-AFOSR-82-0217; NSF CME-80-14059)

A theory of multiple-actuator modal-space active damping (control) of individual structural vibration modes is first reviewed; then an experiment is described in which the control technique was applied to a laboratory beam-cable structure. Active damping was produced in the three lowest modes (all under 10 Hz) of the structure by a feedback control system consisting of a single velocity sensor, an analog controller, and three force actuators. Both open-loop and closed-loop frequency response functions were measured. A theoretical frequency response analysis is developed, and experimental results are compared with theoretical predictions. Author

A86-13921* California Univ., Berkeley.
ON THE DESIGN OF LARGE FLEXIBLE SPACE STRUCTURES (LFSS)
A. BHAYA and C. A. DESOER (California, University, Berkeley) IEEE Transactions on Automatic Control (ISSN 0018-9286), vol. AC-30, Nov. 1985, p. 1118-1120. refs
(Contract NAG2-243)

For a general finite-element model of an LFSS, a strictly passive compensator results in an exponentially stable feedback system when actuators and sensors are calculated. In the general case (no colocation), necessary and sufficient conditions are stated on the parameter Q for stabilizing a certain number of modes. Conditions for robust stability are given, and it is shown that feedback does not destabilize the unmodeled modes under certain conditions. Author

A86-14228#
LONGITUDINAL VIBRATION OF GRAVITY-STABILIZED, LARGE, DAMPED SPACECRAFT MODELED AS ELASTIC CONTINUA
S. K. SHRIVASTAVA and P. K. MAHARANA (Indian Institute of Science, Bangalore, India) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 689-696. Previously cited in issue 20, p. 2861, Accession no. A84-41366. refs

A86-14229#
EIGENVALUE OPTIMIZATION ALGORITHMS FOR STRUCTURE/CONTROLLER DESIGN ITERATIONS
D. S. BODDEN (Virginia Polytechnic Institute and State University, Blacksburg) and J. L. JUNKINS (Texas A&M University, College Station) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 697-706. refs
(Contract F4920-83-K-0032)

An eigenspace optimization approach is proposed and demonstrated for the design of feedback controllers for the maneuvers/vibration arrests of flexible structures. The algorithm developed is shown to be equally useful in sequential or simultaneous design iterations that modify the structural parameters, sensor/actuator locations, and control feedback gains. The approach is demonstrated using a differential equation model for the 'Draper/RPL configuration'. This model corresponds to the hardware used for experimental verification of large flexible spacecraft maneuver controls. A number of sensor/actuator configurations are studied vis-a-vis the degree of controllability. Linear output feedback gains are determined using a novel optimization strategy. The feasibility of the approach is established, but more research and numerical studies are required to extend these ideas to truly high-dimensioned systems. Author

A86-14230*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
THE IMPLEMENTATION OF MODAL FILTERS FOR CONTROL OF STRUCTURES
L. MEIROVITCH and H. BARUH (Virginia Polytechnic Institute and State University, Blacksburg) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 624-636) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 707-716. Previously cited in issue 21, p. 3105, Accession no. A84-43470. refs
(Contract NAG1-225)

A86-14231#
ROBUST NATURAL CONTROL OF DISTRIBUTED SYSTEMS
H. BARUH (Rutgers University, New Brunswick, NJ) and L. SILVERBERG (North Carolina State University, Raleigh) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 717-724. refs

The effect of having both parameter uncertainties and errors arising from spatial discretization on the performance of control systems is analyzed for distributed structures. It is shown that having errors in the system parameters, as well as errors due to a finite element type of discretization, is the equivalent to implementing the control laws by a set of admissible functions instead of by the actual eigenfunctions. It is shown that if natural control is considered in conjunction with modal filters and an adequate number of sensors, implementation of the control action by admissible functions leads to a stable closed-loop system. Using Gerschgorin's disks, the deviation of the desired closed-loop eigenvalues is determined. Author

A86-14233*# Information and Control Systems, Inc., Hampton, Va.
TWO-TIME SCALE STABILIZATION OF SYSTEMS WITH OUTPUT FEEDBACK
D. D. MOERDER (Information and Control Systems, Inc., Hampton, VA) and A. J. CALISE (Drexel University, Philadelphia, PA) (Guidance and Control Conference, Seattle, WA, August 20-22, 1984, Technical Papers, p. 554-559) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 731-736. Previously cited in issue 21, p. 3104, Accession no. A84-43462. refs
(Contract NAG1-243)

A86-14240#
COLLABORATIVE TECHNIQUES IN MODAL ANALYSIS
M. L. AMIROUCHE (Illinois, University, Chicago) and R. L. HUSTON (Cincinnati, University, OH) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 161-165) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 8, Nov.-Dec. 1985, p. 782-785. Previously cited in issue 13, p. 1854, Accession no. A85-30338. refs

A86-14381#
COMBINED VIBROACOUSTIC AND TRANSIENT INDUCED LOAD
V. N. ANDERSON and W. HENRICKS (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 38-41.
(AIAA PAPER 85-6077)

This paper presents a procedure for establishing combined acoustic/mechanically transmitted loads for subassemblies of Space Transportation System (STS) payloads. Prediction of the vibration environment is comprised of three parts: transient launch analysis, direct acoustic loading analysis, and random vibration base input analysis. Statistical combination of the loads is accomplished by the first-passage-failure criteria. The use of this procedure to determine loads for a large payload subassembly (solar array) is demonstrated. Author

A86-15750*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASUREMENT OF ORBITAL DYNAMICS OF THE OAST-1 SOLAR ARRAY USING RECORDED VIDEO IMAGES
J. B. MILLER, R. S. PAPPA, M. L. BRUMFIELD, and R. R. ADAMS (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 19 p.
(IAF PAPER 85-213)

The OAST-1 Solar Array Experiment was flown on Shuttle mission STS-41D on August 31, 1984 for NASA's Office of Aeronautics and Space Technology. It is pointed out that this was the first flight demonstration of the operation of a large solar array which was designed for multiple deployments and retractions. The array represents also a new class of very lightweight, flexible, low-frequency structures. A program was, therefore, implemented with the aim to study the structural dynamics of the array on the basis of a photogrammetric analysis of data obtained with the existing Shuttle closed circuit television (CCTV) system. The present paper has the objective to describe the experiment and its implementation, taking into account the unique process of analyzing the video data. G.R.

A86-15761#
OPTIMAL CONTINUOUS CONTROL FOR REMOTE ORBITAL CAPTURE
B. A. CONWAY (Illinois, University, Urbana) and J. W. WIDHALM (USAF, Institute of Technology, Wright-Patterson AFB, OH) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-226)

Conway et al. (1983) formulated a capture problem in which a 1000 kg target spacecraft is to be retrieved from geosynchronous orbit to low earth orbit. In a continuation of that work, this paper introduces a translational degree of freedom in the joint on the orbital maneuvering vehicle (OMV) used to retrieve the target. The capture problem is formulated as a nonsingular two-point boundary value problem (TPBVP) using optimal control theory. The TPBVP is solved by a numerical method to yield the continuous optimal, open-loop passivation controls. To size the structural requirements of the joint on the OMV and the connecting device to the target, the constraint force and torque on the joint are determined. The component of the constraint force in the direction of the joint motion gives the control requirement for moving the joint during capture. The results show that detumbling of the target

can be accomplished with control torques of very reasonable magnitudes. C.D.

A86-15763*# Howard Univ., Washington, D. C.
ON THE ACCURACY OF MODELLING THE DYNAMICS OF LARGE SPACE STRUCTURES
C. M. DIARRA and P. M. BAINUM (Howard University, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p. Previously announced in STAR as N85-29995. refs
(Contract NSG-1414)
(IAF PAPER 85-228)

Proposed space missions will require large scale, light weight, space based structural systems. Large space structure technology (LSST) systems will have to accommodate (among others): ocean data systems; electronic mail systems; large multibeam antenna systems; and, space based solar power systems. The structures are to be delivered into orbit by the Space Shuttle. Because of their inherent size, modelling techniques and scaling algorithms must be developed so that system performance can be predicted accurately prior to launch and assembly. When the size and weight-to-area ratio of proposed LSST systems dictate that the entire system be considered flexible, there are two basic modelling methods which can be used. The first is a continuum approach, a mathematical formulation for predicting the motion of a general orbiting flexible body, in which elastic deformations are considered small compared with characteristic body dimensions. This approach is based on an a priori knowledge of the frequencies and shape functions of all modes included within the system model. Alternatively, finite element techniques can be used to model the entire structure as a system of lumped masses connected by a series of (restoring) springs and possibly dampers. In addition, a computational algorithm was developed to evaluate the coefficients of the various coupling terms in the equations of motion as applied to the finite element model of the Hoop/Column. F.M.R.

A86-15765#
ON THE ORBITER BASED DEPLOYMENT OF STRUCTURAL MEMBERS
A. M. IBRAHIM and V. J. MODI (British Columbia, University, Vancouver, Canada) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(Contract NSERC-G-1547)
(IAF PAPER 85-230)

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 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. The study represents a necessary first step towards development of a suitable control strategy. Author

A86-15766#
APPLICATION OF MODEL-FOLLOWING TECHNIQUE TO THE CONTROL OF A LARGE SPACE STRUCTURE
S. C. CUI and T. C. HUANG (Wisconsin, University, Madison) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p. refs
(IAF PAPER 85-231)

The main objective of this paper is to apply the model-following method with assignable error dynamics for the control of a large flexible platform in orbit. Once the model dynamics are established for such a model-following system, the control law development is both mathematically simple and practically useful. Author

A86-17660*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
STATIC SHAPE DETERMINATION AND CONTROL FOR LARGE SPACE STRUCTURES. I - THE FLEXIBLE BEAM. II - A LARGE SPACE ANTENNA
C. J. WEEKS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) ASME, Transactions, Journal of Dynamic Systems, Measurement, and Control (ISSN 0022-0434), vol. 106, Dec. 1984, p. 261-272. NASA-supported research. refs

A method for determining and controlling the shape of large, continuous space structures by means of discrete or pointwise observations and control devices is presented. The general linear boundary value problem satisfied by a one-dimensional shape function is defined, and the existence of solutions is studied. The static shape control problems for one-dimensional systems with and without rigid body modes and the static shape estimation problem are presented and solved. Eigenfunction expansions are presented which provide approximations to the algorithm terms when the associated Green's function is not known. An integral operator approach is applied to the multidimensional static problem, and the results are illustrated with a finite element model of the disk of a large space antenna which assumes no rigid body modes. It is shown that the shape control algorithm must be modified for systems with rigid body modes. C.D.

A86-18355
STABILITY OF LARGE DAMPED FLEXIBLE SPACECRAFT WITH STORED ANGULAR MOMENTUM
P. K. MAHARANA and S. K. SHRIVASTAVA (Indian Institute of Science, Bangalore, India) Acta Astronautica (ISSN 0094-5765), vol. 12, Nov. 1985, p. 889-898. refs

The vibrational stability of large flexible structurally damped spacecraft carrying angular momentum and undergoing large rigid body rotations is studied theoretically. Analytical solutions to the motion of rigid gyrostats under torque free conditions are developed which serve as a generalization of existing solutions. Differential equations having constant or periodic coefficients for the structural vibration of the spacecraft, are obtained and Floquet theory is applied to determine the stability of the periodic differential equations. Analysis of a few beam-like and plate-like configurations indicate that the introduction of a single reaction wheel into an axisymmetric satellite does not alter the stability criterion. However, introduction of constant speed rotors deteriorates vibrational stability. I.H.

A86-18898#
PASSIVE DAMPING - HAS ITS TIME FINALLY COME?
M. L. DRAKE (Dayton, University, OH) Mechanical Engineering (ISSN 0025-6501), vol. 107, Dec. 1985, p. 20-24.

Techniques and materials being used for passive damping of dynamic structures are discussed. The goal is to dissipate resonance vibrational energy using properly designed dynamic absorbers. The methods employed can be a free-layer damping system, a constrained-layer damping system or a tuned, viscoelastic damper. Recent increases in computer power and quality control are supporting the capabilities of providing appropriate materials, analyzing the dynamic responses of structures early in the design stage, and devising the necessary damping configurations. The damping calculations are performed using finite element methods to characterize the modal strain energy in complicated structures. Damping materials, particularly polymers and ceramics, can now withstand temperatures ranging from -100 to 1600 F. Accurately designed damping systems are especially important for satellites, in which up to 40 percent of all electronic systems failures have been attributed to vibrations. The techniques are also vital to successful damping of large space structures. M.S.K.

A86-19282* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
CONTROLLER DESIGN AND PARAMETER IDENTIFIABILITY STUDIES FOR A LARGE SPACE ANTENNA
S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) Canadian Society for Mechanical Engineering, Transactions (ISSN 0315-8977), vol. 9, no. 3, 1985, p. 125-130. refs

The problem of control systems synthesis and parameter identifiability are considered for a large, space-based antenna. Two methods are considered for control system synthesis, the first of which uses torque actuators and collocated attitude and rate sensors, and the second method is based on the linear-quadratic-Gaussian (LQG) control theory. The predicted performance obtained by computing variances of pointing, surface and feed misalignment errors in the presence of sensor noise indicates that the LQG-based controller yields superior results. Since controller design requires the knowledge of the system parameters, the identifiability of the structural parameters is investigated by obtaining Cramer-Rao lower bounds. The modal frequencies are found to have the best identifiability, followed by damping ratios, and mode-slopes. Author

A86-19541* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INERTIALLY REFERENCED INSTRUMENT POINTING PLATFORM WITH MOMENTUM COMPENSATED ARTICULATION
C. E. BELL and R. H. STANTON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 165-175.

The characteristics of the Mariner Mark II Integrated Platform Pointing and Attitude Control System (IPPACS) microstep actuator with momentum compensation and the IPPACS optical reference tracker are examined, and the advantages of this new technology are identified. The momentum-compensated articulation acts to prevent platform articulation activity from disturbing the spacecaft. This guarantees dynamic stability, ensures a quiescent pointing environment, and decouples the design of the platform from the design of the spacecraft. A microstep actuator with harmonic drive provides platform angular step resolution to 0.5 arcsec for precision pointing of instruments. An optical reference tracker boresighted with scientific instruments guarantees accurate target-referenced closed-loop pointing. An IPPACS star and target tracker with 1 to 10 arcsec accuracy and wide 11 x 17 degrees field of view has been derived from Advanced Star and Target Reference Optical Sensor (ASTROS) CCD star tracker technology, greatly enhancing the optical referencing capabilities of future multimission interplanetary spacecraft. C.D.

A86-19733#
CONTINUUM MODELING OF LATTICE STRUCTURES WITH APPLICATION TO VIBRATION CONTROL
W. H. BENNETT, H. G. KWATNY, G. L. BLANKENSHIP, and N. BARKAKATI (Systems Engineering, Inc., Greenbelt, MD) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 13 p. refs
(Contract F49620-84-C-0115)
(AIAA PAPER 86-0173)

The modelling problem for control of structures and their interactions with spacecraft is considered. Continuum models for active structural control are reviewed, highlighting the nature of abstract state space models for these systems. A method for the computation of a distributed control law for continuum dynamics is briefly summarized. The theoretical basis for computing effective distributed parameter models for large truss structures with random lattice infrastructure is discussed. The method considered leads to the well-known Timoshenko model for beam dynamics. The analysis provides formulas for effective beam parameters which are quite different from those suggested by other averaging schemes. Comprehensive models are constructed by first developing subsystem models and then combining them according to interconnection rules. Basic questions of causality and well-posedness of certain standard models are reviewed, and the answers are applied to computation of hybrid state space models for an integrated space platform. C.D.

A86-19734#
EXPERIMENTS IN AUGMENTING ACTIVE CONTROL OF A FLEXIBLE STRUCTURE WITH PASSIVE DAMPING
W. J. BOOK, S. L. DICKERSON (Georgia Institute of Technology, Atlanta), and T. E. ALBERTS AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. Research supported by Georgia Institute of Technology. refs
(Contract NSF MEA-83-03539)
(AIAA PAPER 86-0176)

An experimental study of feedback control of the motion of a single-link flexible arm is presented. The constrained viscoelastic layer method of passive damping is used to control the arm in this experiment. The relation between damping and the length of the constraining layer and frequency is examined. The effect of damping on the open loop response of the system is studied; damping improves the response of the system. The configuration of the arm used in the experiment is described. The arm is tested for colocated and modal feedback conditions; graphs of the system's response with and without passive damping are provided. The benefits of damping in the colocated control case are analyzed by the root locus technique. The results of the experiments and analysis reveal that supplementing the active control of a flexible structure with a simple passive damping technique is a practical method of control. I.F.

A86-19735#
CONSIDERATIONS IN THE DESIGN OF CONTROL SYSTEMS FOR FLEXIBLE SPACECRAFT
L. SILVERBERG (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0177)

A control system design approach for flexible spacecraft is presented. The control system design is carried out in two steps. The first step consists of determining the 'ideal' control system in terms of a desirable dynamic performance. The second step consists of designing a control system using a limited number of actuators that possesses a dynamic performance that is close to the ideal dynamic performance. The effects of using a limited number of actuators is that the actual closed-loop eigenvalues differ from the ideal closed-loop eigenvalues. A method is presented to approximate the actual closed-loop eigenvalues so that the calculation of the actual closed-loop eigenvalues can be avoided. Depending on the application, it also may be desirable to apply the control forces as impulses. The effect of digitizing the control to produce the appropriate impulses is also examined. Author

A86-19736#
COMBINED STRUCTURAL AND CONTROL OPTIMIZATION FOR FLEXIBLE SYSTEMS USING GRADIENT BASED SEARCHES
D. F. MILLER and J. SHIM (Wright State University, Dayton, OH) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 16 p. refs
(Contract F33615-84-C-3217)
(AIAA PAPER 86-0178)

This paper considers the combined structural and control optimization problem for flexible systems. The sum of structural weight and controlled system energy terms is minimized simultaneously in structural and control parameters using gradient searches. The purpose of control is to effectively suppress structural vibrations due to initial excitations. Starting with a baseline structural design, the objective of the combined structural/control optimization is to produce a lighter weight structure with, when excited, reduced vibrational and control energy content. Control weighting matrix selection and dependence of optimal designs upon initial conditions are discussed. The ideas presented are illustrated through numerical simulations using a 10-bar cantilevered truss. Author

A86-20145*# Purdue Univ., West Lafayette, Ind.
MODELING GLOBAL STRUCTURAL DAMPING IN TRUSSES USING SIMPLE CONTINUUM MODELS
C. T. SUN (Purdue University, West Lafayette, IN) and J. N. JUANG (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 1, p. 722-729) AIAA Journal (ISSN 0001-1452), vol. 24, Jan. 1986, p. 144-150. Previously cited in issue 12, p. 1741, Accession no. A83-29804. refs

A86-20148*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NATURAL VIBRATION AND BUCKLING OF GENERAL PERIODIC LATTICE STRUCTURES
M. S. ANDERSON (NASA, Langley Research Center, Hampton, VA) and F. W. WILLIAMS (University of Wales Institute of Science and Technology, Cardiff) (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. 206-213) AIAA Journal (ISSN 0001-1452), vol. 24, Jan. 1986, p. 163-169. Previously cited in issue 13, p. 1914, Accession no. A84-31708. refs

A86-20223* Houston Univ., Tex.
CONTROL OF LARGE FLEXIBLE SYSTEMS VIA EIGENVALUE RELOCATION
E. D. DENMAN (Houston, University, TX) and G. J. JEON (Kyungpook National University, Taegu, Republic of Korea) Finite Elements in Analysis and Design (ISSN 0168-874X), vol. 1, Nov. 1985, p. 241-253. refs
(Contract NSG-1603; NAG1-370)

For the vibration control of large flexible systems, a control scheme by which the eigenvalues of the closed-loop systems are assigned to predetermined locations within the feasible region through velocity-only feedback is presented. Owing to the properties of second-order lambda-matrices and an efficient model decoupling technique, the control scheme makes it possible that selected modes are damped with the rest of the modes unchanged. Author

A86-20239*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ROBUSTNESS PROPERTIES OF COLLOCATED CONTROLLERS FOR FLEXIBLE SPACECRAFT
S. M. JOSHI (NASA, Langley Research Center, Hampton, VA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 85-91. Previously announced in STAR as N85-31201. refs

Robustness properties are investigated for two types of controllers for large flexible space structures, which use collocated sensors and actuators. The first type is an attitude controller which uses negative definite feedback of measured attitude and rate, while the second type is a damping enhancement controller which uses only velocity (rate) feedback. It is proved that collocated attitude controllers preserve closed loop global asymptotic stability when linear actuator/sensor dynamics satisfying certain phase conditions are present, or monotonic increasing nonlinearities are present. For velocity feedback controllers, the global asymptotic stability is proved under much weaker conditions. In particular, they have 90 phase margin and can tolerate nonlinearities belonging to the (0, infinity) sector in the actuator/sensor characteristics. The results significantly enhance the viability of both types of collocated controllers, especially when the available information about the large space structure (LSS) parameters is inadequate or inaccurate. Author

A86-20240*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
IN-FLIGHT IDENTIFICATION OF THE GALILEO SPACECRAFT FLEXIBLE MODE CHARACTERISTICS
F. C. WANG (California Institute olf Technology, Jet Propulsion Laboratory, Pasadena) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 92-98. NASA-supported research. refs
(AIAA PAPER 84-1965)

The scan platform of the Galialan spacecraft is attached to a flexible stator structure that separates the actuator from the platform-mounted inartial sensor. A scheme to identify the flexible mode characteristics (frequency, damping, and modal coefficient) of the stator using flight data is presentevd. A frequency domain analysis approach is taken and the identified mode characteristics will be used for updating the scan platform controler parameters. The influence of structural flexibility to th s can controller design is explained and the constraints in experting the identification procedure in flight are discused. Computer simulation results of the identification scheme are presented. The scheme in further verified by DISCOS simulations, in conjunction witha full spacecraft dynamics model and the scan platform controllers. Author

A86-24040*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC RESPONSE AND COLLAPSE OF SLENDER GUYED BOOMS FOR SPACE APPLICATION
J. M. HOUSNER and W. K. BELVIN (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 24th, Lake Tahoe, NV, May 2-4, 1983, Collection of Technical Papers. Part 2, p. 92-101) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Jan.-Feb. 1986, p. 88-95. Previously cited in issue 12, p. 1742, Accession no. A83-29818. refs

A86-24042#
DYNAMIC ANALYSIS OF A DEPLOYABLE SPACE STRUCTURE
G. E. WEEKS (Alabama, University, Tuscaloosa) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 43-49) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Jan.-Feb. 1986, p. 102-107. Previously cited in issue 13, p. 1854, Accession no. A85-30324. refs

A86-24806* Draper (Charles Stark) Lab., Inc., Cambridge, Mass.
ENERGY AND MOMENTUM MANAGEMENT OF THE SPACE STATION USING MAGNETICALLY SUSPENDED COMPOSITE ROTORS
D. B. EISENHAURE (Charles Stark Draper Laboratory, Inc., Cambridge, MA), R. E. OGLEVIE (Rockwell International Corp., Downey, CA), and C. R. KECKLER (NASA, Langley Research Center, Hampton, VA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.197-1.203. refs

The research addresses the feasibility of using magnetically suspended composite rotors to jointly perform the energy and momentum management functions of an advanced manned Space Station. Recent advancements in composite materials, magnetic suspensions, and power conversion electronics have given flywheel concepts the potential to simultaneously perform these functions for large, long duration spacecraft, while offering significant weight, volume, and cost savings over conventional approaches. The Space Station flywheel concept arising out of this study consists of a composite-material rotor, a large-angle magnetic suspension (LAMS) system, an ironless armature motor/generator, and high-efficiency power conversion electronics. The LAMS design permits the application of appropriate spacecraft control torques without the use of conventional mechanical gimbals. In addition, flywheel systems have the growth potential and modularity needed to play a key role in many future system developments. Author

A86-24859* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN OVERVIEW OF INTEGRATED FLYWHEEL TECHNOLOGY FOR AEROSPACE APPLICATION
C. R. KECKLER and N. J. GROOM (NASA, Langley Research Center, Hampton, VA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.331-2.336. refs

Space missions ranging from small scientific satellites to large manned spacecraft have, for many years, utilized systems of spinning flywheels to maintain vehicle attitude. These systems have included momentum and reaction wheels as well as control moment gyros. Extension of that technology to satisfy the additional tasks associated with energy storage has also been pursued. The combining of control and energy storage features into one system has been examined by NASA for space applications and demonstrated in the laboratory. The impact of technology advances in such areas as composite material rotors, magnetic suspensions, motor/generators, and electronics have prompted a re-evaluation of the viability of the flywheel storage system concept for aerospace applications. This paper summarizes the results of this re-examination and identifies shortfalls in the various technology areas. Author

A86-26512*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
CHALLENGES OF SPACE STATION NAVIGATION
P. T. PIXLEY (NASA, Johnson Space Center, Houston, TX) IN: Institute of Navigation, Annual Meeting, 41st, Annapolis, MD, June 25-27, 1985, Proceedings . Washington, DC, Institute of Navigation, 1985, p. 90-93.

A description of the main navigational challenges posed by the Space Station program is given. Among the specific navigational problems addressed are: attitude reference control for payload support applications; traffic control system requirements; navigational system for proximity operations; and the development of automated navigation systems. Navigational problems associated with solar array and radiator orientation are discussed in detail. A schematic diagram of the Space Station reference configuration is provided. I.H.

A86-26876
COMBINED EXPERIMENTAL/ANALYTICAL MODELING OF DYNAMIC STRUCTURAL SYSTEMS; PROCEEDINGS OF THE JOINT MECHANICS CONFERENCE, ALBUQUERQUE, NM, JUNE 24-26, 1985
D. R. MARTINEZ, ED. and A. K. MILLER, ED. (Sandia National Laboratories, Albuquerque, NM) Conference sponsored by ASCE and ASME. New York, American Society of Mechanical Engineers , 1985, 235 p. For individual items see A86-26877 to A86-26885.

It is pointed out that modern structural analysis involves the use of both analytical and experimental techniques. The presented papers have the objective to report the state-of-the-art in combined experimental/analytical modeling, including the substructure synthesis techniques and experimental procedures required to apply these techniques in practical applications. An overview of analytical synthesis techniques is provided, taking into account a review of the time-domain and frequency-domain component mode synthesis method. In connection with an overview of modal testing and measurement, modal test requirements for coupled structure analysis using experimentally-derived component models are examined along with excitation, measurement, and analysis methods for model testing. Hybrid experimental/analytical dynamic models of aerospace structures are considered, and structural analysis model validation using modal test data is discussed. A description of case histories and applications is also given. G.R.

A86-28399
LINEAR ACTUATOR FOR LARGE SPACE STRUCTURES
G. D. JENNEY (Dynamic Controls, Inc., Dayton, OH) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 1 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 612-617.

The success of the Space Shuttle program has provided an ability to construct large structures in space. A control of the mechanical alignment of the structures may represent a critical factor for their suitable operation. One approach for providing such a control is based on the insertion of linear actuators in selected positions within the structure. Structural control is accomplished by making the actuators extend or retract. A description is given of an actuator system which based on the use of a fluid pump to expand and contract two chambers enclosed by metal bellows. The materials used in the construction of the actuator include aluminum, stainless steel, Teflon, flurosilicone elastomers, copper, and samarium cobalt. Attention is given to the force motors used to drive the pump bellows, a pump hardware description, a controller description, actuator support bearings, and some test results. G.R.

N86-10272*# University of Southern California, Los Angeles.
EVALUATION OF A PULSE CONTROL LAW FOR FLEXIBLE SPACECRAFT Final Technical Report, 1 Jun. 1984 - 31 May 1985
Jun. 1985 40 p
(Contract NAG1-471)
(NASA-CR-176233; NAS 1.26:176233) Avail: NTIS HC A03/MF A01 CSCL 22B

The following analytical and experimental studies were conducted: (1) A simple algorithm was developed to suppress the structural vibrations of 3-dimensional distributed parameter systems, subjected to interface motion and/or directly applied forces. The algorithm is designed to cope with structural oscillations superposed on top of rigid-body motion: a situation identical to that encountered by the SCOLE components. A significant feature of the method is that only local measurements of the structural displacements and velocities relative to the moving frame of reference are needed. (2) A numerical simulation study was conducted on a simple linear finite element model of a cantilevered plate which was subjected to test excitations consisting of impulsive base motion and of nonstationary wide-band random excitation applied at its root. In each situation, the aim was to suppress the vibrations of the plate relative to the moving base. (3) A small mechanical model resembling an aircraft wing was designed and fabricated to investigate the control algorithm under realistic laboratory conditions. G.L.C.

N86-10275# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio.
NONLINEAR METHODS FOR SPACECRAFT ATTITUDE MANEUVERS Ph.D. Thesis
A. L. BATTEN 1985 152 p
(AD-A156956; AFIT/CI/NR-85-51D) Avail: NTIS HC A08/MF A01 CSCL 22A

Spacecraft attitude control is described by a nonlinear dynamic mathematical model. When Euler parameters are used to define the orientation of a spacecraft with respect to an inertial frame, the model takes a certain form where the components of one factor are quadratic or higher order functions of the state vehicles. Large-angle maneuvers have traditionally been accomplished as a succession of small-angle rotations from a sequence of defined operating points about which the model is linearized. Alternatively, a sequence of single axis rotations are performed. These processes are computationally burdensome and are unable to produce fast multi-axial rotational maneuvers. GRA

N86-10577*# Old Dominion Univ., Norfolk, Va. Dept. of Civil Engineering.
PASSIVE DAMPING CONCEPTS FOR SLENDER COLUMNS IN SPACE STRUCTURES Progress Report, 1 Feb. - 1 Jul. 1985
Z. RAZZAQ and R. K. EKHELIKAR May 1985 137 p refs
(Contract NAG1-336)
(NASA-CR-176234; NAS 1.26:176234) Avail: NTIS HC A07/MF A01 CSCL 20K

An experimental and theoretical study of three different passive damping concepts is conducted for a slender member with partial rotational end restraints. Over a hundred full-scale natural vibration experiments were conducted to evaluate the effectiveness of mass-string, polyethylene tubing, and chain damping concepts. The damping properties obtained from the experiments were used in the approximate analyses based on the partial differential equation of motion for the problem. The comparison of the experimental and the theoretical deflection-time relations shows that the velocity-dependent damping model used in the theory is adequate. From the experimental results, the effect of end connection friction and induced axial forces on damping is identified. The definition of an efficiency index is proposed based on the damping ratio and the mass of a given passive damping device. Using this definition, the efficiencies of the three damping devices are compared. The polyethylene tubing concept resulted into a low damping efficiency. B.W.

N86-10580*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THREE-DIMENSIONAL VIBRATION ANALYSIS OF A UNIFORM BEAM WITH OFFSET INERTIAL MASSES AT THE ENDS
D. K. ROBERTSON (Cincinnati Univ.) Sep. 1985 71 p refs
(NASA-TM-86393; NAS 1.15:86393) Avail: NTIS HC A04/MF A01 CSCL 20K

Analysis of a flexible beam with displaced end-located inertial masses is presented. The resulting three-dimensional mode shape is shown to consist of two one-plane bending modes and one torsional mode. These three components of the mode shapes are shown to be linear combinations of trigonometric and hyperbolic sine and cosine functions. Boundary conditions are derived to obtain nonlinear algebraic equations through kinematic coupling of the general solutions of the three governing partial differential equations. A method of solution which takes these boundary conditions into account is also presented. A computer program has been written to obtain unique solutions to the resulting nonlinear algebraic equations. This program, which calculates natural frequencies and three-dimensional mode shapes for any number of modes, is presented and discussed. Author

N86-11215*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PROBLEMS EXPERIENCED AND ENVISIONED FOR DYNAMICAL PHYSICAL SYSTEMS
R. S. RYAN Aug. 1985 148 p refs
(NASA-TP-2508; M-494; NAS 1.60:2508) Avail: NTIS HC A07/MF A01 CSCL 22B

The use of high performance systems, which is the trend of future space systems, naturally leads to lower margins and a higher sensitivity to parameter variations and, therefore, more problems of dynamical physical systems. To circumvent dynamic problems of these systems, appropriate design, verification analysis, and tests must be planned and conducted. The basic design goal is to define the problem before it occurs. The primary approach for meeting this goal is a good understanding and reviewing of the problems experienced in the past in terms of the system under design. This paper reviews many of the dynamic problems experienced in space systems design and operation, categorizes them as to causes, and envisions future program implications, developing recommendations for analysis and test approaches. Author

N86-11219 California Univ., Los Angeles.
A DIRECT MODEL REFERENCE ADAPTIVE APPROACH TO THE CONTROL OF SPACE STATIONS Ph.D. Thesis
C. H. C. IH 1985 306 p
Avail: Univ. Microfilms Order No. DA8513126

Of all large space structural systems, space stations present a unique challenge and requirement to advanced control technology. During shuttle docking the system mass may suddenly increase by more than 100% and during station assembly the mass may vary even more drastically. Large space structural systems require highly sophisticated control systems that can grow as the stations evolve and cope with the uncertainities and time-varying elements to maintain the stability and pointing of the space stations. This dissertation first deals with the aspects of space station operational properties including configurations, dynamic models, shuttle docking contact dynamics, solar panel interaction and load reduction to yield a set of system models and conditions. A model reference adaptive control algorithm along with the inner-loop plant augmentation design for controlling the space stations under severe operational conditions of shuttle docking, excessive model parameter errors, and model truncation are then investigated. DOE

N86-13358*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES USING RECURSIVE LATTICE FILTERS Final Report, period ending 31 Dec. 1985
G. L. GOGLIA Dec. 1985 80 p refs
(Contract NAG1-429)
(NASA-CR-176402; NAS 1.26:176402) Avail: NTIS HC A05/MF A01 CSCL 22B

The use of recursive lattice filters for identification and adaptive control of large space structures was studied. Lattice filters are used widely in the areas of speech and signal processing. Herein, they are used to identify the structural dynamics model of the flexible structures. This identified 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 control is engaged. This type of validation scheme prevents instability when the overall loop is closed. The results obtained from simulation were compared to those obtained from experiments. In this regard, the flexible beam and grid apparatus at the Aerospace Control Research Lab (ACRL) of NASA Langley Research Center were used as the principal candidates for carrying out the above tasks. Another important area of research, namely that of robust controller synthesis, was investigated using frequency domain multivariable controller synthesis methods. G.L.C.

N86-13587*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
DYNAMIC IDENTIFICATION FOR CONTROL OF LARGE SPACE STRUCTURES Final Report, period ending 1 May 1983
S. R. IBRAHIM Nov. 1985 64 p refs
(Contract NSG-1649)
(NASA-CR-176380; NAS 1.26:176380) Avail: NTIS HC A04/MF A01 CSCL 13B

This is a compilation of reports by the one author on one subject. It consists of the following five journal articles: (1) A Parametric Study of the Ibrahim Time Domain Modal Identification Algorithm; (2) Large Modal Survey Testing Using the Ibrahim Time Domain Identification Technique; (3) Computation of Normal Modes from Identified Complex Modes; (4) Dynamic Modeling of Structural from Measured Complex Modes; and (5) Time Domain Quasi-Linear Identification of Nonlinear Dynamic Systems.

N86-14090*# Houston Univ., Tex. Dept. of Electrical Engineering.
CONTROL OF SPACE STATIONS Final Report
K. Y. LEE *In* NASA. Johnson (Lyndon B.) Space Center The 1983 NASA/ASEE Summer Faculty Fellowship Research Program Research Reports 8 p Sep. 1983 refs
Avail: NTIS HC A18/MF A01 CSCL 22B

A study is made to develop controllers for the NASA-JSC Triangular Space Station and evaluate their performances to make recommendations for structural design and/or control alternatives. The control system design assumes the rigid body of the Space Station and developes the lumped parameter control system by using the Inverse Optimal Control Theory. In order to evaluate the performance of the control system, a Parameter Estimation algorithm is being developed which will be used in modeling an equivalent but simpler Space Station model. Finally, a scaled version of the Space Station is being built for the purpose of physical experiments to evaluate the control system performance. Author

N86-14297*# City Coll. of the City Univ. of New York. Dept. of Electrical Engineering.
AN ADAPTIVE LEARNING CONTROL SYSTEM FOR LARGE FLEXIBLE STRUCTURES Final Report, 1 Nov. 1979 - 31 Aug. 1984
F. E. THAU 1985 43 p refs
(Contract NAG1-6)
(NASA-CR-176422; NAS 1.26:176422) Avail: NTIS HC A03/MF A01 CSCL 22B

The objective of the research has been to study the design of adaptive/learning control systems for the control of large flexible structures. In the first activity an adaptive/learning control methodology for flexible space structures was investigated. The approach was based on using a modal model of the flexible structure dynamics and an output-error identification scheme to identify modal parameters. In the second activity, a least-squares identification scheme was proposed for estimating both modal parameters and modal-to-actuator and modal-to-sensor shape functions. The technique was applied to experimental data obtained from the NASA Langley beam experiment. In the third activity, a separable nonlinear least-squares approach was developed for estimating the number of excited modes, shape functions, modal parameters, and modal amplitude and velocity time functions for a flexible structure. In the final research activity, a dual-adaptive control strategy was developed for regulating the modal dynamics and identifying modal parameters of a flexible structure. A min-max approach was used for finding an input to provide modal parameter identification while not exceeding reasonable bounds on modal displacement. B.W.

N86-15338*# Rockwell International Corp., Downey, Calif.
ADVANCED INTEGRATED POWER AND ATTITUDE CONTROL SYSTEM (IPACS) STUDY Final Report
R. E. OGLEVIE and D. B. EISENHAURE (Draper (Charles Stark) Lab., Cambridge, Mass.) Washington NASA Nov. 1985 170 p refs
(Contract NAS1-17633)
(NASA-CR-3912; NAS 1.26:3912; SSS85-0025) Avail: NTIS HC A08/MF A01 CSCL 22B

Integrated Power and Attitude Control System (IPACS) studies performed over a decade ago established the feasibility of simultaneously satisfying the demands of energy storage and attitude control through the use of rotating flywheels. It was demonstrated that, for a wide spectrum of applications, such a system possessed many advantages over contemporary energy storage and attitude control approaches. More recent technology advances in composite material rotors, magnetic suspension systems, and power control electronics have triggered new optimism regarding the applicability and merits of this concept. This study is undertaken to define an advanced IPACS and to evaluate its merits for a space station application. System and component designs are developed to establish the performance of this concept and system trade studies conducted to examine the viability of this approach relative to conventional candidate systems. It is clearly demonstrated that an advanced IPACS concept is not only feasible, but also offers substantial savings in mass and life-cycle cost for the space station mission. Author

N86-16251*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DYNAMIC MODELING AND ADAPTIVE CONTROL FOR SPACE STATIONS
C. H. C. IH and S. J. WANG 15 Jul. 1985 301 p refs
(Contract NAS7-918)
(NASA-CR-176442; JPL-PUB-85-57; NAS 1.26:176442) Avail: NTIS HC A14/MF A01 CSCL 22B

Of all large space structural systems, space stations present a unique challenge and requirement to advanced control technology. Their operations require control system stability over an extremely broad range of parameter changes and high level of disturbances. During shuttle docking the system mass may suddenly increase by more than 100% and during station assembly the mass may vary even more drastically. These coupled with the inherent dynamic model uncertainties associated with large space structural systems require highly sophisticated control systems that can grow as the stations evolve and cope with the uncertainties and time-varying elements to maintain the stability and pointing of the space stations. The aspects of space station operational properties are first examined, including configurations, dynamic models, shuttle docking contact dynamics, solar panel interaction, and load reduction to yield a set of system models and conditions. A model reference adaptive control algorithm along with the inner-loop plant augmentation design for controlling the space stations under severe operational conditions of shuttle docking, excessive model parameter errors, and model truncation are then investigated. The instability problem caused by the zero-frequency rigid body modes and a proposed solution using plant augmentation are addressed. Two sets of sufficient conditions which guarantee the globablly asymptotic stability for the space station systems are obtained. Author

N86-16626# General Electric Co., Philadelphia, Pa. Space Systems Div.
DESIGN OF INTEGRALLY DAMPED SPACECRAFT PANELS
C. V. STAHLE and J. A. STALEY *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 103-107 Jun. 1985 refs
Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

The results of preliminary design and analysis studies of damped spacecraft equipment mounting panels is presented. Increased vibroacoustic reliability and reduced program development costs can be achieved by controlling spacecraft equipment vibration during launch. To reduce the significant number of anomalies which occur shortly after launch, component vibration requirements have been increased to provide larger margins. This has resulted in a large number of vibroacoustic test failures during qualification and acceptance tests. A $40 million cost saving is estimated using the OCTAVE code if the equipment vibration environment is reduced 50 percent for an operational satellite system using a NIL-STD-1540 test program. To realize this high payoff, the RELSAT project was initiated to develop and demonstrate damping control of satellite launch vibration. A typical satellite equipment panel was selected and analyzed. Author

N86-16628# Martin Marietta Aerospace, Denver, Colo.
ANALYSIS OF DAMPED TWIN TOWERS
C. W. WHITE *In* Shock and Vibration Information Center The Shock and Vibration Bulletin 55, Part 1 p 119-129 Jun. 1985 refs
(Contract F33615-83-C-3222)
Avail: SVIC, Code 5804, Naval Research Lab., Washington, D.C. 20375 CSCL 20K

The procedure used to design two viscoelastically damped 60-ft tall generic test towers is presented. How the Modal Strain Energy (MSE) approach was used to identify favorable locations in these

towers for viscoelastic structural members and for discrete viscoelastic damper mechanisms is described. The use of standard viscoelastic material (VEM) property data to design the discrete dampers is illustrated. Testing procedures and data reduction required for theoretical experimental correlation are described at both the VEM element and truss system levels. Author

N86-17373*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A CONTROL SYSTEM DESIGN APPROACH FOR FLEXIBLE SPACECRAFT
L. M. SILVERBERG (North Carolina State Univ., Raleigh) Nov. 1985 41 p refs
(NASA-TM-87599; NAS 1.15:87599) Avail: NTIS HC A03/MF A01 CSCL 22B

A control system design approach for flexible spacecraft is presented. The control system design is carried out in two steps. The first step consists of determining the ideal control system in terms of a desirable dynamic performance. The second step consists of designing a control system using a limited number of actuators that possess a dynamic performance that is close to the ideal dynamic performance. The effects of using a limited number of actuators is that the actual closed-loop eigenvalues differ from the ideal closed-loop eigenvalues. A method is presented to approximate the actual closed-loop eigenvalues so that the calculation of the actual closed-loop eigenvalues can be avoided. Depending on the application, it also may be desirable to apply the control forces as impulses. The effect of digitizing the control to produce the appropriate impulses is also examined. Author

N86-19343 Washington Univ., Seattle.
ROBUST CONTROL DESIGN METHODOLOGY WITH APPLICATION TO LARGE SPACE STRUCTURES Ph.D. Thesis
W. L. EASTMAN 1985 199 p
Avail: Univ. Microfilms Order No. DA8521582

The development of compensators for large space structures is posed as a problem in robust control system design. A methodology is developed for the design of compensators which shape the system loop gain singular values. The frequency-shaped control and estimation theory of Gupta, as reformulated by Kim for measurement frequency-shaping, has been extended to include frequency-shaping of the control law. It is shown that zeroes of the control law shaping filter become transmission zeroes of the compensator, and this result completes the duality of the frequency-shaped regulator and estimator. To design control systems with desired loop gain characteristics, a recursive eigenstructure assignment procedure was developed. By use of this algorithm, optimal regulators and estimators with assigned eigenvalues can be designed. With a modification of the usual regulator-estimator design method, the compensator can be designed with specific eigenvalues. When frequency-shaping is incorporated into the compensator, this eigenvalue assignment feature allows the compensator to retain both the poles and the zeroes of the shaping filter. Eigenstructure assignment of the compensator specifically shapes the loop gains and can be used for robustness enhancement. This capability is demonstrated for several control systems, including one for a large space structure. Dissert. Abstr.

N86-20486# Harris Corp., Melbourne, Fla. Government Aerospace Systems Div.
EXPLORATION OF THE MAXIMUM ENTROPY/OPTIMAL PROJECTION APPROACH TO CONTROL DESIGN SYNTHESIS FOR LARGE SPACE STRUCTURES Annual Report, 2 Jan. 1984 - 28 Feb. 1985
D. C. HYLAND and D. S. BERNSTEIN Feb. 1985 243 p
(Contract F49620-84-C-0015)
(AD-A161355; AFOSR-85-0966TR; AR-1) Avail: NTIS HC A11/MF A01 CSCL 13M

Increased interest in deploying large flexible spacecraft has focused attention on active structural control techniques to achieve crucial advances in vibration suppression, pointing accuracy and shape control. The extreme complexity of such systems, and the lack of accurate finite-element structural models present severe control-design challenges which were extensively documented by previous Government research Programs. Optimal Projection/Maximum Entropy Stochastic Modelling and Reduced-Order Design Synthesis is a rigorous new approach to this class of problems. Inspired by Statistical Energy Analysis, a branch of dynamic modal analysis developed for analyzing acoustic vibration problems, its present stage of development embodies a fundamental generalization of classical steady-state Kalman filter and linear-quadratic-Gaussian optimal control theory. GRA

N86-20487# Alphatech, Inc., Burlington, Mass.
ROBUST DECENTRALIZED CONTROL Final Report, 20 Jul. 1984 - 20 May 1985
D. P. LOOZE, G. C. GOODMAN, J. S. ETERNO, and M. ATHANS Aug. 1985 155 p
(Contract F33615-84-C-3618)
(AD-A161626; AFWAL-TR-85-3042) Avail: NTIS HC A08/MF A01 CSCL 22B

This report considers the problem of designing decentralized control systems for Large Space Structures to satisfy robustness and performance requirements for multiple system configurations. The problem is motivated by the fact that such structures will have to be assembled in space. A partially assembled structure will need some real-time control so that it maintains its station, performs partial functions, and damps oscillations during assembly. Completely reprogramming the control computers each time a subassembly is incorporated in the structure is likely to be impractical. A more sound engineering approach would be to require the same control system design to satisfy performance requirements for the partial assemblies and to maintain stability for the completely assembled structure. Performance can then be restored for the full assembly by applying an outer loop (hierarchical) control or adjusting the decentralized design parameters. GRA

N86-20488# WEA, Cambridge, Mass.
WAVE MEASUREMENTS ON TRUSS MODEL Technical Report, 1 Jan. 1984 - 1 Sep. 1985
J. H. WILLIAMS, JR., H. L. OU, and S. S. LEE 1 Sep. 1985 72 p
(Contract F49620-83-C-0092)
(AD-A162433; AFOSR-85-1077TR) Avail: NTIS HC A04/MF A01 CSCL 22B

Large space structures (LSS) are large periodic lattice structures being considered for space applications in Earth orbit. The vibration and wave propagation characteristics of these structures can affect their performance, integrity and the ability to nondestructively assess that integrity. In this preliminary study, the wave propagation characteristics of a tetrahedral truss model consisting of fiberglass reinforced composite rods and aluminum joints are observed experimentally. Longitudinal ultrasonic transducers are coupled to the joints of the truss model. The input signal consists of a gated sinusoid having a center frequency of 280 kHz. Because a tetrahedral truss, a commonly proposed LSS configuration can be constructed from basic repeating units of tetrahedrons and pyramids, only tetrahedrons and pyramids are considered. Tetrahedrons and pyramids are constructed by inserting fiberglass reinforced polyester rods 0.193 cm (0.076 in) in diameter and 18.72 cm (7.37 in) in length into machined 2024-T4 aluminum joints. Because a tetrahedral truss requires only two types of joints, the tetrahedrons and pyramids are constructed using the two types of joints. The cutting of the fiberglass rods, the machining of the aluminum joints and the final assembly of tetrahedrons and pyramids are done with great care to minimize structure variability. GRA

N86-20489# National Aerospace Lab., Amsterdam (Netherlands). Spaceflight Div.
TESTING OF SPACECRAFT ATTITUDE AND ORBIT CONTROL SYSTEMS Final Report
J. J. M. PRINS Paris ESA 18 May 1984 267 p refs
(Contract ESA-5262/82)
(NLR-TR-84133-L; ESA-CR(P)-2100) Avail: NTIS HC A12/MF A01

The testing of spacecraft Attitude and Orbit Control Subsystems (AOCS) from the early design up to in-flight is described. Three generic AOCS test classes, model philosophy, standardization, subsystem static test methods, subsystem dynamic test methods, generic test equipment, and test facilities are covered. It is suggested that test scheduling should aim to find problems and errors as early as possible. System level tests should be delayed in favor of detailed testing of the AOCS (unit level) and in particular subsystem level testing. Onboard AOCS software poses testing problems, especially when RAM located. There is a shift from airbearing-type dynamic tests to servotable-type dynamic tests, mainly due to increasing spacecraft size, structural flexibility, and multibody dynamics concepts. Author (ESA)

N86-21249# Lawrence Livermore National Lab., Calif.
APPROXIMATE FINITE ELEMENT MODELS FOR STRUCTURAL CONTROL
K. D. YOUNG 27 Aug. 1985 21 p Presented at the 24th IEEE Conference on Decision and Control, Fort Lauderdale, Fla., 11 Dec. 1985
(Contract W-7405-ENG-48)
(DE86-001582; UCRL-93310; CONF-851209-5) Avail: NTIS HC A02/MF A01

Approximate finite element models are developed for the purpose of preserving the tridiagonality of the mass and stiffness matrices in the state space model matrices. These approximate models are utilized in the design of active structural control laws for large flexible structures. DOE

N86-21274# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil). Space Mechanics and Control Dept.
EXACTLY SOLVING THE WEIGHTED TIME-FUEL OPTIMAL CONTROL OF AN UNDAMPED HARMONIC OSCILLATOR
M. LOPESDEOLIVEIRAESOUZA Jan. 1986 31 p refs Submitted for publication
(INPE-3750-PRE/874) Avail: NTIS HC A03/MF A01

The exact solution to weighted time/fuel optimal control of an undamped harmonic oscillator is presented. Its motivation is the possibility of improvements on the final behavior of trajectories produced by Vander Velde's design for on/off controls of large space structures, by replacing the approximate solution by the exact one. First order necessary conditions. The existence, normality, unicity, and determination of its externals and its solution were investigated. Numerical comparisons between those solutions were made according to three criteria. Author

N86-21568 Stanford Univ., Calif.
SIMULATION OF MOTIONS OF SATELLITES CARRYING A DEPLOYABLE FLEXIBLE LINKAGE Ph.D. Thesis
S. DJERASSI 1985 143 p
Avail: Univ. Microfilms Order No. DA8522130

Numerical simulations based upon equations governing the motion of a rigid body supporting a deployable flexible linkage that carries a rigid load are used to study spacecraft control. However, since existing methods for the formulation of equations of motion do not lend themselves well for this purpose, one must extend these methods in order to come into position to undertake numerical simulations. The central idea underlying the extension is that equations of motion of a system of bodies subject to constraints can be obtained by temporarily disregarding the constraints, writing expressions for generalized inertia forces and for generalized active forces associated with the unconstrained system, and then using these together with coefficients appearing in the constraint equations to generate a set of equations of motion of the original system. Certain arrays, called Z arrays, are introduced in connection with the derivation of constraint equations associated with elastic bodies arranged in closed kinematical loops. Use of these arrays makes it possible to let the linkage have any number of links. The legitimacy of modal representation of the elastic deformation of a typical link is discussed in view of the fact that the link is subjected to an unknown time-varying shear load. Several studies are performed to illustrate the behavior of the system with a variety of initial conditions, parameters, and number of modes used to describe elastic deflections. These studies indicate that in-orbit deployment can be obtained passively, and that, in certain applications, weight reduction of the links can be sustained without affecting the dynamic behavior of the system, as far as inplane motions are concerned. Dissert. Abstr.

N86-21569*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC CHARACTERISTICS OF TWO 300 KW CLASS DUAL KEEL SPACE STATION CONCEPTS
J. T. DORSEY, T. R. SUTTER, M. S. LAKE, and P. A. COOPER Feb. 1986 50 p refs
(NASA-TM-87680; NAS 1.15:87680) Avail: NTIS HC A03/MF A01 CSCL 22B

Results from an investigation of the dynamic behavior of a 300 kW class solar dynamic powered, dual kell space station are presented. The purpose of the investigation was to determine and assess the influence of space station truss bay size on station controllability during rigid body attitude adjustment and orbit reboost maneuvers. The dual keel space station concept is defined and two finite element models (one which has a truss bay size of 5m and another with a truss bay size of 9 feet) are described. Rigid and flexible body characteristics of the two space station models are also presented. Finally, results from a transient response analysis, where the stations are subjected to an orbit reboost maneuver, are summarized. Author

N86-21853 Virginia Polytechnic Inst. and State Univ., Blacksburg.
EXPERIMENTAL-THEORETICAL STUDY OF VELOCITY FEEDBACK DAMPING OF STRUCTURAL VIBRATIONS Ph.D. Thesis
G. R. SKIDMORE 1985 109 p
Avail: Univ. Microfilms Order No. DA8521353

The active damping of structural vibrations through the application of various forms of velocity feedback control is studied. Active damping will be required for large space structures which are performance-sensitive to motion or inaccurate pointing. Several control forms, including modal-space active damping and direct rate feedback are analyzed theoretically, and three laboratory models are described. A previous, unsuccessful attempt at control is reviewed and explained. The remaining control forms developed in the theoretical section were implemented successfully and the results compare favorably with theoretical predictions. Each control form is analyzed relative to its own merits and in comparison with other methods. An important point is the stability assured by a dual (colocated) configuration of velocity sensors and control force actuators. Modal-space active damping is shown to be an effective control method with predictable performance in controlled modes and beneficial spillover into residual (noncontrolled) modes. Dissert. Abstr.

N86-21915# Dayton Univ., Ohio. Research Inst.
DESIGN EVALUATION AND FIELD QUALIFICATION OF A DAMPING SYSTEM FOR AN AUXILIARY POWER UNIT
M. L. DRAKE *In* AFWAL Vibration Damping 1984 Workshop Proceedings 17 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

A turbine engine incurred resonant vibration induced fatigue failures in the inlet guide vanes (IGV). High stress levels at frequencies corresponding to the second bending and second torsional resonances were revealed. The operational environment required a damping system to be functional over the temperature range of -50 F to 150 F. The damping system had to survive the high airflow and erosion environment associated with the inlet of

the engine and also had to be field installable. A computer aided design procedure was used to develop the required damping design. The final design demonstrated an 86% stress reduction. Engine test stress reductions agreed well with the laboratory results. E.A.K.

N86-21920# Rockwell International Corp., Seal Beach, Calif.
DAMPING APPLICATION TO SPACECRAFT
T. S. NISHIMOTO *In* AFWAL Vibration Damping 1984 Workshop Proceedings 7 p Nov. 1984
Avail: NTIS HC A99/MF A01 CSCL 20K

Various cases of design application of damping technology to spacecraft development are presented. Various vibration problems for which damping was used as a design tool are illustrated. The examples of damping applications are a succession of spacecraft hardware design problems from the component level to the spacecraft system. Typical confining constraints which work to the detriment of the engineering effort are illustrated. Late fixes to equal vibration failure necessarily loads to less than desirable design solutions. The example of integrating damping into the preliminary design process for system solutions points to the technology requirements necessary. E.A.K.

N86-21926# Martin Marietta Aerospace, Denver, Colo. Guidance and Control Section.
SIZING OF DISCRETE VISCOUS DAMPERS ON A FLEXIBLE BODY IN THE PRESENCE OF A FIXED CONTROLLER
G. R. RAPACKI and R. B. RICE *In* AFWAL Vibration Damping 1984 Workshop Proceedings 27 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

The effects of discrete viscous dampers on a spacecraft's rigid body control loop were investigated. The damper's affect on the open loop gain and phase margins, the shape of the open loop gain-phase plot and the flexible body dynamics were determined as a function of the viscous damper's strength and the mass connected to the damper. The damper is sized for those configurations where the added damper improves the system robustness. E.A.K.

N86-21928# Martin Marietta Aerospace, Denver, Colo.
AN APPROACH TO THE SIZING OF DISCRETE VISCOUS STRUCTURAL DAMPERS USING AN EXTENSION OF THE FINITE ELEMENT APPROACH AND MODAL STRAIN ENERGY
R. B. RICE and E. C. DALTON (Teledyne Brown Engineering, Huntsville, Ala.) *In* AFWAL Vibration Damping 1984 Workshop Proceedings 20 p Nov. 1984 refs
Avail: NTIS HC A99/Mf A01 CSCL 20K

A method to determine viscous damper values and damper locations for a structure which has particular damping requirements is presented. The method is intended as a starting point in a design process. The finite element approach and concept of modal strain energy are relied upon. The method was applied to a large space-based telescope in which damping of optical support structures is critical for tracking and pointing accuracy. It is indicated that the method will yield the desired amount of damping a structure provided that the complex mode shapes do not significantly deviate from the classical shapes. The characterization of nonviscous dampers is considerably more complicated than viscous dampers, it is suggested that the method be used in the early phases of design. If viscous damping values are known, the range of other candidate dampers may be narrowed. E.A.K.

N86-21929# General Electric Co., Philadelphia, Pa. Control Systems Design.
FLEXIBLE STRUCTURE CONTROL IN THE FREQUENCY DOMAIN
R. HARDING and A. DAS *In* AFWAL Vibration Damping 1984 Workshop Proceedings 20 p Nov. 1984 refs
Avail: NTIS HC A99/MF A01 CSCL 20K

Techniques to analyze structure and controller interaction in the frequency domain are defined and used to determine the modal damping requirements of the spacecrat structure to assure control system stability and performance. Gain and phase versus frequency techniques are described which predict system stability in the presence of uncontrolled structural modes and errors in a priori natural frequencies and quantify control system margin for these modes. The techniques are applied to an optimally controlled single axis satellite with very large solar arrays. Control system actuator and sensor configurations are based upon system controllability and observability of four dominant structural modes. E.A.K.

N86-21931# Martin Marietta Aerospace, Denver, Colo.
PASSIVE AND ACTIVE CONTROL OF SPACE STRUCTURES (PACOSS) Abstract Only
C. WHITE *In* AFWAL Vibration Damping 1984 Workshop Proceedings 1 p Nov. 1984
Avail: NTIS HC A99/MF A01 CSCL 20K

An early objective of the PACOSS program was to experimentally verify that substantial passive damping was practical in test articles generally representative of large space structure in arrangement, dimensional size, and frequency range. Two 60-foot, truss-type test articles were designed, fabricated, and tested. For one large generic test article (LGTA) in one plane, The diagonal members are Lexan;l in the other plane, the five lower bays have included discrete link dampers in the diagonals. The other LGTA has only Plexiglas diagonals in one plane, and also includes the five bays of link dampers in the other plane. E.A.K.

N86-21953*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE LATDYN USER'S MANUAL
J. M. HOUSNER, P. E. MCGOWAN, A. L. ABRAHAMSON, and M. G. POWELL Jan. 1986 212 p refs
(NASA-TM-87635; NAS 1.15:87635) Avail: NTIS HC A10/MF A01 CSCL 20K

The LATDYN User's Manual presents the capabilities and instructions for the LATDYN (Large Angle Transient DYNamics) computer program. The LATDYN program is a tool for analyzing the controlled or uncontrolled dynamic transient behavior of interconnected deformable multi-body systems which can undergo large angular motions of each body relative other bodies. The program accommodates large structural deformation as well as large rigid body rotations and is applicable, but not limited to, the following areas: (1) development of large flexible space structures; (2) slewing of large space structure components; (3) mechanisms with rigid or elastic components; and (4) robotic manipulations of beam members. Presently the program is limited to two dimensional problems, but in many cases, three dimensional problems can be exactly or approximately reduced to two dimensions. The program uses convected finite elements to affect the large angular motions involved in the analysis. General geometry is permitted. Detailed user input and output specifications are provided and discussed with example runstreams. To date, LATDYN has been configured for CDC/NOS and DEC VAX/VMS machines. All coding is in ANSII-77 FORTRAN. Detailed instructions regarding interfaces with particular computer operating systems and file structures are provided. Author

N86-22113*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
DIRECT MODEL REFERENCE ADAPTIVE CONTROL OF A FLEXIBLE ROBOTIC MANIPULATOR
D. R. MELDRUM 15 Dec. 1985 90 p refs
(Contract NAS7-918)
(NASA-CR-176659; JPL-PUB-85-100; NAS 1.26:176659) Avail: NTIS HC A05/MF A01 CSCL 05H

Quick, precise control of a flexible manipulator in a space environment is essential for future Space Station repair and satellite servicing. Numerous control algorithms have proven successful in controlling rigid manipulators wih colocated sensors and actuators; however, few have been tested on a flexible manipulator with noncolocated sensors and actuators. In this thesis, a model reference adaptive control (MRAC) scheme based on command generator tracker theory is designed for a flexible manipulator. Quicker, more precise tracking results are expected over nonadaptive control laws for this MRAC approach. Equations of

motion in modal coordinates are derived for a single-link, flexible manipulator with an actuator at the pinned-end and a sensor at the free end. An MRAC is designed with the objective of controlling the torquing actuator so that the tip position follows a trajectory that is prescribed by the reference model. An appealing feature of this direct MRAC law is that it allows the reference model to have fewer states than the plant itself. Direct adaptive control also adjusts the controller parameters directly with knowledge of only the plant output and input signals. Author

07

POWER

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

A86-12676*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION POWER SYSTEM
A. F. FORESTIERI and C. R. BARAONA (NASA, Lewis Research Center, Cleveland, OH) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-20, Nov. 1984, p. 666-671.

It is pointed out that space station planning at NASA began when NASA was created in 1958. However, the initiation of the program for a lunar landing delayed the implementation of plans for a space station. The utility of a space station was finally demonstrated with Skylab, which was launched in 1972. In May 1982, the Space Station Task Force was established to provide focus and direction for space station planning activities. The present paper provides a description of the planning activities, giving particular attention to the power system. The initial space station will be required to supply 75 kW of continuous electrical power, 60 kW for the customer and 15 kW for space station needs. Possible alternative energy sources for the space station include solar planar or concentrator arrays of either silicon or gallium arsenide. G.R.

A86-15624#
COMPARISON OF SOLAR PHOTOVOLTAIC AND SOLAR DYNAMIC POWER PLANTS FOR SPACE STATION/COLUMBUS APPLICATION
W. WESTPHAL (Telefunken AG, Wedel, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 17 p.
(IAF PAPER 85-33)

A comparative evaluation is made of photovoltaic solar arrays and several alternative primary power systems for space station application which generally use solar collectors and thermodynamic converters (solar dynamic) as main power plant components. Results of the study show that the planar photovoltaic array remains the primary candidate for space stations in the initial operating capability, considering its highly matured state and short time to implementation. However, as the station size grows, the solar array may become inoperable due to a large area increase, and then solar dynamic primary power will complement the existing solar arrays and replace them beyond the 300-kW user load threshold. When the power demand surpasses the 450-500-kW user load, a nuclear heat source will be substituted for the solar collector/absorber. V.L.

A86-15625#
A HIGH-FREQUENCY AC APPROACH TO SPACE STATION POWER SYSTEM DESIGN
D. E. CHARHUT and J. W. MILDICE (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 5 p.
(IAF PAPER 85-35)

Space Station power system requirements are complex and have many variables. For this reason, a single power system cannot satisfy all the varying capability, schedule, and technology needs of the Space Station system over its lifetime. The portion of the power system which interconnects the diverse elements should have maximal flexibility and versatility. The present paper is concerned with the central power system core, which is commonly called power management and distribution (PMAD). Attention is given to details regarding the employed hardware, engineering and management considerations, the general development program, Space Station system comparisons, and a summary of test program efficiency and losses results. G.R.

A86-15708#
DYNAMIC POWER GENERATION FOR SPACE APPLICATIONS
J. P. MULLIN and R. F. MCKENNA (Sundstrand Corp., Rockford, IL) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p. refs
(IAF PAPER 85-151)

Dynamic power generation can provide the large power needs of future space applications as evidenced by the serious consideration of its use for NASA's Space Station. A review of the dynamic options is presented with a detailed look at the dynamic organic Rankine system. Direct distribution of 400 Hz ac power is explained, including the significant benefits realized compared to both dc and high frequency ac. Finally, a two-phase thermal management system is defined that is capable of managing the thermal loads of a spacecraft and controlling a liquid-vapor fluid mixture in zero gravity. Author

A86-15710#
A LOGISTICS MODEL FOR LARGE SPACE POWER SYSTEMS
H. H. KOELLE (Berlin, Technische Universitaet, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 15 p. refs
(IAF PAPER 85-153)

A logistics model of a typical space power system (SPS) that may exist in the first half of the next century is described. The primary inputs for this model are life cycle duration, power level of the SPS at the end of the life cycle, availability of space power units, specific mass of the SPS as a function of time, and power level for a single SPS unit. The model comprises 60 equations describing the interrelationships between the system variables and parameters. This study shows that the use of lunar resources and available chemical propulsion technology can lead to a substantial reduction of the logistics cost to build and operate a fleet of space power systems. The analysis shows that construction activity could commence early in the next century and lead to about 100 space units of 5 GW power, providing about 15 percent of the world energy demand by the middle of the next century. C.D.

A86-18042*# Colorado State Univ., Fort Collins.
CURRENT COLLECTION FROM THE SPACE PLASMA THROUGH DEFECTS IN SOLAR ARRAY INSULATION
R. S. ROBINSON (Colorado State University, Fort Collins), R. P. STILLWELL, and H. R. KAUFMAN Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, Nov.-Dec. 1985, p. 631-641. refs
(Contract NSG-3196)

Operating high-voltage solar arrays in the space environment can result in anomalously large currents being collected through small insulation defects. Tests simulating the electron collection have shown that there are two major collection modes. The first involves current enhancement by means of a surface phenomenon involving secondary electron emission from the surrounding

insulator. In the second mode, the current collection is enhanced by vaporization and ionization of the insulator material, in addition to the surface enhancement of the first mode. The electron collection due to surface enhancement (first mode) has been modeled. Using this model, simple calculations yield realistic predictions. Author

A86-19845*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE STATION MOMENTUM CONTROL AND REBOOST REQUIREMENTS FOR TWO POWER GENERATION CONCEPTS
J. T. FARMER, U. M. LOVELACE (NASA, Langley Research Center, Hampton, VA), D. M. BADI (New York, Polytechnic Institute, Brooklyn), and W. F. CUDDIHY (Bionetics Corp., Hampton, VA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 14 p. refs
(AIAA PAPER 86-0379)

Results are presented of dynamic structural analyses of 75 and 300 kW versions of a solar dynamic (SD) power supply for the Space Station (MSS). The SD is being seriously considered as an alternative to solar panels due to lower areal and mass requirements and higher efficiencies. The functioning principle is to use parabolic concentrators to focus sunlight on a heat engine to boil liquids to drive a turbine. Potential problems are foreseen in terms of the torques which would be experienced by the MSS and the subsequent orbital stability effects. The stability would be altered by changing aerodynmaic drag, altered moment of inertia and angular momentum and the altered center of mass location. The problem is exacerbated by the need to first equip the MSS with solar panels while the SD technology is developed. The analysis shows that the attitude control system will need to be redesigned and resized to accommodate MSS growth with either power system. The effects of the rotating parts of the SD system can be minimized, but further studies are required to determine the effects on the pointing accuracy of the SD, which must be 10 times as precise as that needed by a photovoltaic array. M.S.K.

A86-20728
ACCOMPLISHMENTS AND PLANS OF SP-100 PROGRAM
W. E. WRIGHT (DARPA, Arlington, VA) IN: Space nuclear power systems 1984; Proceedings of the First Symposium, Albuquerque, NM, January 11-13, 1984. Volume 1 . Malabar, FL, Orbit Book Co., Inc., 1985, p. 37-39.

The SP-100 program is proceeding toward concept definitions for a space nuclear reactor which is safe and suitable for civilian and military applications. The selection of a specific design and demonstration of the base technologies was scheduled for the end of 1985, to be followed by engineering development and ground testing in 1986. The main current uses/users thus far anticipated are communications satellites, both military and civilian, radar (and possibly laser) surveillance and remote sensing systems, and manufacturing and other extensions of a space station growth scenario. The reactor will weigh no more than 3000 kg and must fit into the Orbiter bay with a payload and OTV. Three concepts are still under evaluation: a lithium-cooled reactor with thermoelectrics; an in-core thermionic system with pumped sodium-potassium coolant; and a configuration with a Stirling engine to convert reactor heat into electricity. If the engineering analyses and base tests are successful, it is expected that the flight application phase can be reached by 1991 at the latest. M.S.K.

A86-20729* National Aeronautics and Space Administration, Washington, D.C.
POTENTIAL CIVIL MISSION APPLICATIONS FOR SPACE NUCLEAR POWER SYSTEMS
J. H. AMBRUS (NASA, Washington, DC) and R. G. G. BEATTY (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space nuclear power systems 1984; Proceedings of the First Symposium, Albuquerque, NM, January 11-13, 1984. Volume 1 . Malabar, FL, Orbit Book Co., Inc., 1985, p. 43-51. refs

It is pointed out that the energy needs of spacecraft over the last 25 years have been met by photovoltaic arrays with batteries, primary fuel cells, and radioisotope thermoelectric generators (RTG). However, it might be difficult to satisfy energy requirements for the next generation of space missions with the currently used energy sources. Applications studies have emphasized the need for a lighter, cheaper, and more compact high-energy source than the scaling up of current technologies would permit. These requirements could be satisfied by a nuclear reactor power system. The joint NASA/DOD/DOE SP-100 program is to explore and evaluate this option. Critical elements of the technology are also to be developed, taking into account space reactor systems of the 100 kW class. The present paper is concerned with some of the civil mission categories and concepts which are enabled or significantly enhanced by the performance characteristics of a nuclear reactor energy system. G.R.

A86-20733
SPACE SHUTTLE INTEGRATION CONSIDERATIONS FOR NUCLEAR POWER SYSTEM
A. L. MAJOR and A. A. VIVONA, JR. (Martin Marietta Corp., Denver, CO) IN: Space nuclear power systems 1984; Proceedings of the First Symposium, Albuquerque, NM, January 11-13, 1984. Volume 1 . Malabar, FL, Orbit Book Co., Inc., 1985, p. 87-91. refs

There is renewed national interest in developing nuclear space power generation technology for the 1990s. The program objective calls for a prototype 100 kW unit in space by 1995. One conceptual design envisions a unit of approximately 3000 kg with a 6 meter length and 4 1/2 meter diameter. The nuclear subsystem mass (reactor, heat pipes and radiation shield) accounts for approximately 70 percent of the power unit's weight. Airborne Support Equipment (ASE) includes the cargo bay cradles to support the space power system within the Space Transportation System (STS) Orbiter cargo bay. Department of Defense (DOD) potential applications for nuclear space power include directed-energy weapons, electronics jamming, and surveillance operations. The National Aeronautics and Space Administration (NASA) envisions such use in providing electrical power for space stations, lunar operations, and deep planetary explorations. This paper examines some integration issues involved in using the STS and focuses on safety considerations. Author

A86-22193
AUTOMATED SPACE SIMULATION TESTING OF SATELLITE SOLAR ARRAYS
T. G. BROWN and D. R. SMITH (Ball Corp., Ball Aerospace Systems Div., Boulder, CO) IN: Environmental integration technology today for a quality tomorrow; Proceedings of the Thirtieth Annual Technical Meeting, Orlando, FL, May 1-3, 1984 . Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 435-438.

In the context continuing efforts designed to enhance the survivability of space hardware, environmental test specifications with very exacting tolerance conditions will have to be satisfied. It may, therefore, be in many cases impossible to conduct the required tests with equipment involving the use of manually operated solenoids, power supplies, and data logging. Historically, however, the majority of systems tests were performed on the basis of manual operations. For this reason, it was necessary to 'rethink' standard operating procedures, taking into account the employment of computer aided control (CAC) approaches for harsh environments. Developments related to the conduction of space simulation testing on a pair of satellite solar arrays are discussed.

Attention is given to the survivability test specification, the required facilities, the thermal-vacuum control system, and the test operations. G.R.

A86-22272
DYNAMIC POWER FOR SPACE
W. MISKELL Space (ISSN 0267-954X), vol. 1, Dec. 1985-Feb. 1986, p. 34-37, 44-46.

The development of energy generation systems for space applications is discussed. Consideration is given to solar dynamics systems, including photovoltaic cells; dielectric solar converters; and a solar dynamic power system using a heated working fluid to drive a steam turbine. Non-solar energy generation systems currently being developed include: nucler reactors for deep space probes; the SNAP-10A reactor; and the Dynamic Isotope Power System (DIPS). The components of a solar dynamic power system for the Space Station are illustrated in graphic form. I.H.

A86-23512
SPACE APPLICATIONS OF NITINOL HEAT ENGINES
K. H. HAYASHIDA, JR. (Los Alamitos High School, CA), E. C. CADY, J. L. MCNICHOLS, JR., and B. R. GALIK, JR. (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 6 p. refs
(SAE PAPER 851322)

The Nitinol Heat Engine (NHE) uses a shape-memory alloy of nickel and titanium to convert thermal energy directly to mechanical power and through a generator, to electricity. An NHE was analyzed and designed to produce power from solar irradiation in space, with radiative cooling to a deep-space heat sink. A model NHE was built and tested in a space chamber simulating the radiation and space environment, and produced results agreeing with performance predictions. Other space NHE using Space Station waste heat are also discussed. Such space NHE are demonstrated to be cost-competitive with photovoltaic cells as a source for space power. Author

A86-24778* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION POWER SYSTEM ADVANCED DEVELOPMENT
A. F. FORESTIERI, C. R. BARAONA, and M. E. VALGORA (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.9-1.16.

The objectives of the Space Station Advanced Development Program are related to the development of a set of design options and/or new capabilities to support Space Station development and operation, taking into account also a quantification of the performance and risk of key state-of-the-art technologies, and a reduction of the cost and schedule risk in Space Station development. Attention is given to the photovoltaic power system, a solar dynamic system, and aspects of power management and distribution. A major issue will be the selection of the power generation system. In view of the advantages of the solar dynamic system, it is attempted to resolve issues associated with this system. G.R.

A86-24779* National Aeronautics and Space Administration, Washington, D.C.
SP-100 PROGRAM DEVELOPMENTS
A. D. SCHNYER (NASA, Washington, DC), J. A. SHOLTIS, JR., E. J. WAHLQUIST (DOE, Washington, DC), R. L. VERGA, and R. L. WILEY (DOD, Strategic Defense Initiative Organization, Washington, DC) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.17-1.25.

An update is provided on the status of the Sp-100 Space Reactor Power Program. The historical background that led to the program is reviewed and the overall program objectives and development approach are discussed. The results of the mission studies identify applications for which space nuclear power is desirable and even essential. Results of a series of technology feasibility experiments are expected to significantly improve the earlier technology data base for engineering development. The conclusion is reached that a nuclear reactor space power system can be developed by the early 1990s to meet emerging mission performance requirements. Author

A86-24782
APPLICATION OF A PARABOLIC TROUGH CONCENTRATOR TO SPACE STATION POWER NEEDS
T. G. STERN and P. A. KOMINSKI (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.37-1.42.

In the 1990s, space missions conducted by NASA and the Air Force will involve the use of larger spacecraft with power requirements two orders of magnitude higher than today's operational spacecraft. As certain problems arise in connection with large photovoltaic (PV) array systems, a more efficient method of power conversion using solar dynamic conversion and integral thermal storage is being considered. It appears that solar thermal systems, using Rankine or Brayton cycle engine/generators, may reduce the solar aperture needed for a given power requirement by a factor of two. In the case of a utilization of such systems, a highly reliable solar dynamic system design is needed. Work related to the development of space solar concentrators has been conducted by an American aerospace company. Attention is given to collector design, optical design, performance requirements, and design options. G.R.

A86-24786
A SOLAR DYNAMIC ORC POWER SYSTEM FOR SPACE STATION APPLICATION
D. W. CHAUDOIR, R. E. NIGGEMANN, and T. J. BLAND (Sundstrand Corp., Rockford, IL) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.58-1.65.

As spacecraft electric power requirements increase from watts to hundreds of kilowatts, alternate solar dynamic power generation systems are available that possess significant advantages over the present planar solar array systems. The solar dynamic Organic Rankine Cycle (ORC) power conversion system is characterized, for the space station application, as a highly efficient mid-temperature range reliable heat engine that uses solar radiation as its energy source. An American company has been working toward the design and development of an ORC power system for the space station application, including development testing of an RFMD, receiver preliminary design, toluene stability testing, and the preliminary design of a 37.5 kW(e) ORC power system. Author

A86-24787
SPACE STATION POWER SYSTEM CHALLENGES
G. M. REPPUCCI and A. A. SORENSEN (TRW, Inc., TRW Electronics and Defense Sector, Redondo Beach, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.66-1.73.

The Space Station will be the largest space system ever launched, and the power to be provided on the station is to grow from an estimated 75 kW initially to 300 kW or more. A number of options have been considered for the design of the electrical power system. Once the basic power and safety requirements are met, cost will be the primary determinant of the choices made. The electrical power system considered consists of three subsystems, including power generation, energy storage, and power management and distribution. Various options available for the

design of the Space Station power system are discussed, taking into account power modules, power module sizing, photovoltaic systems, and solar dynamic systems. With respect to nuclear energy, it is assumed that a suitable low-risk power system will not be available by 1987-88, when the technology choices will have to be made. For this reason, this option is not further discussed in this paper. G.R.

A86-24788
A NUCLEAR REACTOR ELECTRICAL POWER SYSTEM FOR A MANNED SPACE STATION IN LOW EARTH ORBIT
S. W. SILVERMAN (Boeing Aerospace Co., Seattle, WA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.74-1.78. refs

A study was made of the system effects and interactions of a nuclear reactor power system for the space station operating at 500 km altitude. The reactor is considered in several positions - at the center of gravity; on a rigid boom; on a flexible tether; and on a free flyer coorbiting with the Space Station at the same altitude, or at a higher altitude. Each concept is analyzed to determine weight, volume, and effects on the Space Station and the Space Transportation System for a 10-year operational period. Safety requirements for the reactor and shield are examined. The analysis includes the concept for disposing of a shutdown reactor and traffic around the Space Station. Author

A86-24789* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION POWER SYSTEM ISSUES
R. J. GIUDICI (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.79-1.83.

Issues governing the selection of power systems for long-term manned Space Stations intended solely for earth orbital missions are covered briefly, drawing on trade study results from both in-house and contracted studies that have been conducted over nearly two decades. An involvement, from the Program Development Office at MSFC, with current Space Station concepts began in late 1982 with the NASA-wide Systems Definition Working Group and continued throughout 1984 in support of various planning activities. The premise for this discussion is that, within the confines of the current Space Station concept, there is good reason to consider photovoltaic power systems to be a venerable technology option for both the initial 75 kW and 300 kW (or much greater) growth stations. The issue of large physical size required by photovoltaic power systems is presented considering mass, atmospheric drag, launch packaging and power transmission voltage as being possible practicality limitations. The validity of searching for a cross-over point necessitating the introduction of solar thermal or nuclear power system options as enabling technologies is considered with reference to programs ranging from the 4.8 kW Skylab to the 9.5 gW Space Power Satellite. Author

A86-24790* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN TRADEOFFS FOR A SPACE STATION SOLAR-BRAYTON POWER SYSTEM
J. L. KLANN and P. J. STAIGER (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.84-1.97. refs

Mass, area, and station-keeping propellant needs have been estimated for a typical system. And, although important criteria such as cost, Shuttle packaging, and erection/deployment schemes were not considered, the documented trends should aid in many of the design choices to be made. Effects on system characteristics were examined for: three heat storage salts with melting temperatures from 743 to 1121 K; parabolic and Cassegrainian mirrors; module power levels of 20 and 40 kW; and, alternate pumped-loop, tube-and-fin radiator configurations, with and without micrometeoroid armoring. Author

A86-24795
SPACE STATION BRAYTON POWER SYSTEM
A. PIETSCH and S. TRIMBLE (Garrett Corp., Los Angeles, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.119-1.124.

A unique solution to the challenges of providing electrical power for the Space Station is represented by the closed Brayton cycle (CBC) power system. It is pointed out that with current technology, the CBC system can achieve solar intercept-to-electrical-bus-bar efficiencies approaching 30 percent. This value compares to efficiencies of about four percent for a photovoltaic system. The high efficiency leads to a reduced collector surface area. It is, thus, possible to reduce drag in the rarefied atmosphere of the low earth orbit. The solar CBC system incorporates a recuperator between the turbine and the compressor. The generator is integrated with the compressor/turbine rotor. A component description is presented, taking into account details regarding the collector, the receiver/thermal storage device, the Brayton rotating unit, the generator, the recuperator, the radiator, and the controls. G.R.

A86-24796* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
DIRECT SOLAR HEATING FOR SPACE STATION APPLICATION
W. E. SIMON (NASA, Johnson Space Center, Houston, TX) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.125-1.131. refs

Early investigations have shown that a large percentage of the power generated on the Space Station will be needed in the form of high-temperature thermal energy. The most efficient method of satisfying this requirement is through direct utilization of available solar energy. A system concept for the direct use of solar energy on the Space Station, including its benefits to customers, technologists, and designers of the station, is described. After a brief discussion of energy requirements and some possible applications, results of selective tradeoff studies are discussed, showing area reduction benefits and some possible configurations for the practical use of direct solar heating. Following this is a description of system elements and required technologies. Finally, an assessment of available contributive technologies is presented, and a Space Shuttle Orbiter flight experiment is proposed. Author

A86-24797* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
AUTONOMOUSLY MANAGED HIGH POWER SYSTEMS
D. J. WEEKS and R. T. BECHTEL (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.132-1.138.

The need for autonomous power management capabilities will increase as the power levels of spacecraft increase into the multi-100 kW range. The quantity of labor intensive ground and crew support consumed by the 9 kW Skylab cannot be afforded in support of a 75-300 kW Space Station or high power earth orbital and interplanetary spacecraft. Marshall Space Flight Center is managing a program to develop necessary technologies for high power system autonomous management. To date a reference electrical power system and automation approaches have been defined. A test facility for evaluation and verification of management algorithms and hardware has been designed with the first of the three power channel capability nearing completion. Author

A86-24798* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DEVELOPMENT OF THE POWER SYSTEM FOR THE UNITED STATES' MANNED SPACE STATION
E. E. KEMPKE, JR. (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.139-1.144.

The definition and preliminary design study effort for the Space Station Electric Power System is described. The requirements to be met by the Power System, the characteristics of the major technology options being considered, and the approach to be taken in the definition studies are considered. The role of advanced development in the definition process and the specific tasks to be performed in the preliminary design study are reviewed. The NASA approach to managing the complex Power System interfaces across the Space Station is also discussed. C.D.

A86-24807
IMPACT OF POWER DISTRIBUTION ON THE SPACE STATION EMI ENVIRONMENT
C. O. PISTOLE (Martin Marietta Corp., Denver, CO) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.204-1.209. refs

The relationship between the Space Station common module power distribution and EMI environment is investigated. Circuit cross coupling and radiated emissions at the various distribution voltages and frequencies are examined in order to clarify the EMI tradeoffs involved in the selection of an approach to power distribution. It is concluded that it will be difficult to build high frequency power converters and buses which are compatible with the conducted susceptibility limits of the worst case transient, due to the lower limits at the higher frequencies. EMI characteristics for dc systems are driven largely by switching and transients, and it is therefore highly desirable to use solid state or hybrid switches which can limit rise and fall times and eliminate arcing. The importance of maintaining load balance in polyphase ac systems is shown, as is the importance of keeping circuits susceptible to magnetic circuit coupling in the far field. C.D.

A86-24809
RECEIVER FOR SOLAR DYNAMIC ORGANIC RANKINE CYCLE (ORC) POWERED SPACE STATION
G. HEIDENREICH, T. BLAND, and R. NIGGEMANN (Sundstrand Corp., Sundstrand Energy Systems, Rockford, IL) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.228-1.245. refs

The employment of a Solar Dynamic Power Generation Subsystem (PGS) for the Space Station has significant advantages over the use of photovoltaic arrays. The three types of PGS considered include an Organic Rankine Cycle (ORC) system, a closed Brayton cycle system, and a Stirling cycle system. The ORG system consists of four subsystems related to the concentrator or mirror, the receiver, the Power Conversion Unit (PCU), and the space radiator. A description is given of the receiver in which the energy is both stored and transferred to the Rankine cycle working fluid. Attention is given to receiver considerations, configuration options, a steam Rankine cycle receiver, a Stirling heat pipe receiver concept, a solar collector thermal power system, solar receiver isoflux surfaces, and a heat pipe receiver with circumferential heat pipe. G.R.

A86-24811* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
PERFORMANCE ANALYSIS OF RADIATION COOLED DC TRANSMISSION LINES FOR HIGH POWER SPACE SYSTEMS
G. E. SCHWARZE (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.252-1.269. Previously announced in STAR as N85-28222.

As space power levels increase to meet mission objectives and also as the transmission distance between power source and load increases, the mass, volume, power loss, and operating voltage and temperature become important system design considerations. This analysis develops the dependence of the specific mass and percent power loss on the power and voltage levels, transmission distance, operating temperature and conductor material properties. Only radiation cooling is considered since the transmission line is assumed to operate in a space environment. The results show that the limiting conditions for achieving low specific mass, percent power loss, and volume for a space-type dc transmission line are the permissible transmission voltage and operating temperature. Other means to achieve low specific mass include the judicious choice of conductor materials. The results of this analysis should be immediately applicable to power system trade-off studies including comparisons with ac transmission systems. Author

A86-24823* Ford Aerospace and Communications Corp., Palo Alto, Calif.
BIPOLAR NICKEL-HYDROGEN BATTERY DEVELOPMENT
C. W. KOEHLER, A. Z. APPLEWHITE (Ford Aerospace and Communications Corp., Palo Alto, CA), A. M. HALL, and P. G. RUSSELL (Yardney Corp., Battery Div., Pawcatuck, CT) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.339-1.345.
(Contract NAS3-23879)

A comparison of the bipolar Ni-H2 battery with other energy systems to be used in future high-power space systems is presented. The initial design for the battery under the NASA-sponsored program is described and the candidate stack components are evaluated, including electrodes, separator, electrolyte reservoir plate, and recombination sites. The compressibility of the cell elements, electrolyte activation, and thermal design are discussed. Manufacturing and prototype test results are summarized. C.D.

A86-24835
HUBBLE SPACE TELESCOPE ELECTRICAL POWER SUBSYSTEM
J. KAPLAN (Lockheed Missiles and Space Co., Inc., Space Systems Div., Sunnyvale, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.416-1.421.

The Hubble Space Telescope Electrical Power Subsystem is designed to supply all spacecraft power during the 15-year design life of the telescope with provisions for planned on-orbit maintenance every 5 years or at shorter intervals if required. In addition to automatic charge control, the power subsystem clears load faults and through use of the on-board computer and Safe Mode equipment, isolates major faults and maintains power to all critical loads during emergency conditions. To backup the autonomous capability, sufficient subsystem monitoring and controls are provided to enable ground control of solar array power, loads and battery charging and reconditioning. Author

A86-24841
DEVELOPMENT OF AUTONOMOUS POWER SYSTEM TESTBED
J. R. BARTON, M. E. LIFFRING (Boeing Aerospace Co., Seattle, WA), and T. ADAMS (Advanced Information and Decision Systems, Mountain View, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.466-1.471.

A power system testbed has been assembled to advance the development of large autonomous electrical power systems required for the space station, spacecraft, and aircraft. The power system for this effort was designed to simulate singleor dual-bus autonomous power systems, or autonomous systems that reconfigure from a single bus to a dual bus following a severe fault. The approach taken was to provide a flexible power system design with two computer systems for control and management. One computer operates as the control system and performs basic control functions, data and command processing, charge control, and provides status to the second computer. The second computer contains expert system software for mission planning, load management, fault identification and recovery, and sends load and configuration commands to the control system. Author

A86-24857* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
DESIGN OF A REGENERATIVE FUEL CELL SYSTEM FOR SPACE STATION
M. A. HOBERECHT and L. L. RIEKER (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.202-2.207.

The NASA Space Station will employ alkaline regenerative fuel cells (RFCs) as its sole electrochemical energy storage system, in virtue of demonstrated technology readiness and a high degree of system-level design flexibility. NASA Johnson and NASA Lewis are currently engaged in the development of a 10-kW alkaline engineering model system, for 1987 delivery, which will encompass a fully autonomous 120-V system with 55 percent overall electrical efficiency and a 20,000-hr service life. O.C.

A86-24860* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
INERTIAL ENERGY STORAGE FOR ADVANCED SPACE STATION APPLICATIONS
K. E. VAN TASSEL and W. E. SIMON (NASA, Johnson Space Center, Houston, TX) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.337-2.342. refs

Because the NASA Space Station will spend approximately one-third of its orbital time in the earth's shadow, depriving it of solar energy and requiring an energy storage system to meet system demands, attention has been given to flywheel energy storage systems. These systems promise high mechanical efficiency, long life, light weight, flexible design, and easily monitored depth of discharge. An assessment is presently made of three critical technology areas: rotor materials, magnetic suspension bearings, and motor-generators for energy conversion. Conclusions are presented regarding the viability of inertial energy storage systems and of problem areas requiring further technology development efforts. O.C.

A86-24868
A NUMERICAL STUDY OF THE PERFORMANCE OF LATENT HEAT STORAGE FOR SOLAR DYNAMIC POWER SYSTEMS
A. D. SOLOMON (Oak Ridge National Laboratory, TN) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.392-2.396. refs

The structure and theoretical foundation of a simulation code for heat transfer and storage in an idealized storage module which forms part of a Brayton cycle solar power system are described. The underlying physical system is shown, and the advantages, drawbacks, and possible pitfalls of latent heat thermal energy storage are discussed. Some possible designs of a latent heat thermal energy storage module are examined. Preliminary results obtained by using analytical approximations which are crucial to 'homing in' on potential system configurations are reported and examined using the simulation code. C.D.

A86-24869
THERMAL ENERGY STORAGE FOR AN ORGANIC RANKINE CYCLE SOLAR DYNAMIC POWERED SPACE STATION
R. S. DOWNING and M. B. PAREKH (Sundstrand Corp., Rockford, IL) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.397-2.409. refs

The Organic Rankine Cycle Solar Dynamic Power System (ORC SDPS) is an attractive candidate for power generation on the Space Station. The ORC SDPS consists of a concentrator, a power conversion unit, and a receiver with a thermal energy storage system. Excess thermal energy must be stored during the period of solar insolation to power the ORC engine during orbital eclipse. Various thermal energy storage materials were considered and Lithium Hydroxide (LiOH) was selected as a primary material. Its melting point is in the range desirable for the ORC SDPS working fluid (toluene) and it has one of the highest specific thermal energy storage capacities and a low volume change upon fusion. Alternate phase change materials are also being evaluated. The criteria used in designing the thermal energy storage system is presented and discussed. Salts generally have poor thermal conductivities which result in poor heat transfer within the thermal energy storage system. Therefore, potential heat transfer enhancement schemes were identified and evaluated. A brief discussion of a material compatibility study is presented. Conclusions and recommendations are made, identifying the need of future work. Author

A86-26492*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HEAT TRANSFER IN SPACE POWER AND PROPULSION SYSTEMS
R. C. HENDRICKS, R. J. SIMONEAU, and J. W. DUNNING, JR. (NASA, Lewis Research Center, Cleveland, OH) Mechanical Engineering (ISSN 0025-6501), vol. 108, Feb. 1986, p. 40-52.

NASA's planned Space Station has projected power requirements in the 75-300 kW range; attention is presently given to the range of power system configurations thus far proposed. These are a silicon solar cell system incorporating regenerative fuel cell or battery storage, with a 10-year lifetime, a solar-dynamic power system with phase-change or regenerative fuel cell energy storage, and a combination of these two alternatives. A development status evaluation is also given for the propulsion systems that may be used by next-generation boosters. These include such novel airbreathing systems as turboramjets, air liquefaction cycle rockets, airturboramjet/rockets, and supersonic combustion ramjets. O.C.

A86-26626#
SUMMARY OF PIX-2 FLIGHT RESULTS OVER THE FIRST ORBIT
N. J. STEVENS (TRW System Integration Laboratory, Redondo Beach, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs
(Contract FI9628-84-C-0038)
(AIAA PAPER 86-0360)

The second Plasma Interaction Experiment (PIX-2) was launched into a 870 km., circular, polar orbit in January, 1983. This was an auxiliary payload experiment designed to investigate high voltage solar array interactions with the space plasma environment. Since this as a low-cost experiment, the package did not contain extensive diagnostic instrumentation. Hence, interpretation of the data has proceeded at a slow pace. In this paper the data obtained in the first orbit for both positive and negative bias sequences has been compared to simple, empirical analytical models to evaluate array performance and to compare to ground test results. It has been found that the flight behavior was in general agreement with the trends found in the laboratory for the thermal and wake environment. In the ram environment, the behavior was different than that expected in that there was suppression of current collection at voltages greater than 100 V. The comparison between the deduced plasma density for the flight data and the available environmental information indicates that the procedure used is reasonable. Author

N86-14085*# American Univ., Beirut (Lebanon).
A STUDY OF SOME FEATURES OF AC AND DC ELECTRIC POWER SYSTEMS FOR A SPACE STATION Final Report
J. I. HANANIA *In* NASA. Johnson (Lyndon B.) Space Center The 1983 NASA/ASEE Summer Faculty Fellowship Research Program Research Reports 15 p Sep. 1983 refs
Avail: NTIS HC A18/MF A01 CSCL 22B

This study analyzes certain selected topics in rival dc and high frequency ac electric power systems for a Space Station. The interaction between the Space Station and the plasma environment is analyzed, leading to a limit on the voltage for the solar array and a potential problem with resonance coupling at high frequencies. Certain problems are pointed out in the concept of a rotary transformer, and further development work is indicated in connection with dc circuit switching, special design of a transmission conductor for the ac system, and electric motors. The question of electric shock hazards, particularly at high frequency, is also explored. and a problem with reduced skin resistance and therefore increased hazard with high frequency ac is pointed out. The study concludes with a comparison of the main advantages and disadvantages of the two rival systems, and it is suggested that the choice between the two should be made after further studies and development work are completed.
Author

N86-14102*# Prairie View Agricultural and Mechanical Coll., Tex.
SOLAR CONCENTRATOR DEGRADATION IN LOW EARTH ORBIT (LEO) Final Report
R. G. THOMAS *In* NASA. Johnson (Lyndon B.) Space Center The 1983 NASA/ASEE Summer Faculty Fellowship Research Program Research Reports 12 p Sep. 1983 refs
Avail: NTIS HC A18/MF A01 CSCL 12A

The use of parabolically or spherically-shaped mirrors is being considered in order to increase the solar energy intensity on solar cells. Their use will significantly decrease the size and number of the cells needed for a particular application, hence the total array cost. Questions arise, however, regarding the long-term (five to ten years) efficiency of these devices. Performance degradation of the mirror surfaces might result from known hostile elements in the low earth orbit (LEO) environment (150-350 nautical miles). The degradation issue is addressed in light of present knowledge of this environment. The following characteristics of the LEO environment are identified for study: (1) the vacuum of space; (2) sputtering by the residual atoms and particles in space; (3) solar electromagnetic radiation; (4) contamination of the mirror surface; (5) atomic oxygen interactions with the surface; (6) bombardment of the surface by meteoroids; and (7) irradiation of the surface by ionizing particles (protons). Using the best available information for the magnitudes of the necessary quantities, a mathematical analysis was carried out, where possible, to determine the degradation in reflectance or other loss caused by each characteristic. Otherwise, reasonable estimates are made of corresponding losses, based on already published data. Author

N86-14766# Technische Univ., Berlin (West Germany). Inst. fuer Luft- und Raumfahrt.
A LOGISTICS MODEL FOR LARGE SPACE POWER SYSTEMS
H. H. KOELLE and A. JACOBS 1985 48 p refs
(ILR-MITT-149) Avail: NTIS HC A03/MF A01

A logistics model for spaceborne power plants which would send solar generated electricity to Earth from geostationary orbit was developed. If a space manufacturing facility, a maintenance and repair facility for operational units, and a space logistics operation center are included in the GEO complex, 17 Mg mass per Mw power in the 1st year and 7.1 Mg/Mw in the 50th year is predicted. Personnel requirements in GEO are 245 (1st) and 600 in the 50th year. The average mass flow from the Moon to GEO is 55,000 Mg p.a.; from the Earth come 42,000 Mg p.a. These flows require 500 lunar bus launches and 540 heavy lift launches p.a. The use of lunar resources reduces the logistic cost to 67% compared to an all Earth resources scenario. The model assumes 111 units each producing 5 GW, with 90% availiability, i.e., 500 GW, for a 50 yr life cycle. Author (ESA)

N86-16726*# TRW, Inc., Redondo Beach, Calif. Engineering and Test Div.
DESIGN, PERFORMANCE INVESTIGATION AND DELIVERY OF A MINIATURIZED CASSEGRAINIAN CONCENTRATOR SOLAR ARRAY Final Technical Report
R. E. PATTERSON May 1985 86 p
(Contract NAS8-35635)
(NASA-CR-178571; NAS 1.26:178571; REPT-42977-6002-UT-00)
Avail: NTIS HC A05/MF A01 CSCL 10A

A miniaturized Cassegrainian concentrator (MCC) solar array concept is being developed with the objective of significantly reducing the recurring cost of multikilowatt solar arrays. The desired cost reduction is obtained as a result of using very small high efficiency solar cells in conjunction with low-cost optics. In the MCC single element concept and panel concept, incident solar radiation is reflected from a primary parabolic reflector to a secondary hyperbolic reflector and finally to a 4-millimetr diameter solar cell. A light catcher cone is used to improve off-axis performance. An element is approximately 13-millimeters thick which permits efficient launch stowage of the concentrator system panels without complex optical component deployments or retractions. The MCC elements are packed in bays within graphite epoxy frames and are electrically connected into appropriate series-parallel circuits. A MCC single element with a 21 sq cm entrance aperture and a 20 percent efficient, 0.25 sq cm gallium arsenide solar cell has the same power output as 30-sq cm of 11-percent efficiency (at 68 C) silicon solar cells. The MCC concept provides the potential for a significant reduction in array cost due to a 99 percent reduction in required cell area and a 30 percent reduction in array area relative to planar array of equivalent power. Author

N86-17435# AEG-Telefunken, Wedel (West Germany).
ALTERNATING CURRRENT BUSES FOR LOW EARTH ORBITS: A VIABLE ALTERNATIVE
G. EGGERS *In* ESA Proceedings of ESA Sessions at the 16th IEEE Annual Power Electronics Specialists Conference p 17-25 May 1985 refs
Avail: NTIS HC A15/MF A01

The merits of ac buses as complements for large dc systems of space stations are outlined. Wave shapes for systems with frequencies around 400 Hz (as on Spacelab) are considered. When distribution losses are minimized, sinus represents the optimum for linear loads; square-waves for nonlinear (rectifier) loads.

Square-waves which do not contain third harmonics can be used in three-phase systems. However, relations between phase and interlinked voltage are not as simple as for sinus. Due to filters not needed and modest rating of components, square-wave systems can be realized with minimum mass-impact and high efficiency. However, fast response to inrush currents and protection of switching semiconductors become difficult. The behavior of sinus systems can be easily predicted. If 3-phase 400 Hz systems are unacceptable because of mass impact, the multi-kHz range is recommended. Author (ESA)

N86-17468# MATRA Espace, Toulouse (France).
A COMPUTER ANALYSIS TOOL FOR EVALUATION OF SOLAR ARRAY DESIGN
B. FIEUX and J. MASSON (ESA/ESTEC, Noordwijk, Netherlands) *In* ESA Proceedings of ESA Sessions at the 16th IEEE Annual Power Electronics Specialists Conference p 319-323 May 1985 refs
Avail: NTIS HC A15/MF A01

A computer tool for evaluating solar array design through definition and/or recall of input design parameters, and output of partial or final results of performances of the simulated solar array was developed. Simulation capabilities include: modeling of a solar cell as a function of physical parameters, temperature and radiation fluxes (Si or Ga As); identification of solar cell parameters from a set of measured experimental curves; evaluation of the solar array curve as a function of cell assembly, orbital environment; evaluation of solar array mean power versus life time; and evaluation of operating point with respect to the load characteristic and orbital position. Author (ESA)

N86-17840*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero Propulsion Lab.
FUTURE AIR FORCE SPACE POWER NEEDS
J. F. WISE *In* NASA. Lewis Research Center Space Photovoltaic Research and Technology 1985 p 17-21 1985 refs
Avail: NTIS HC A13/MF A01 CSCL 10B

The requirements for future power for AF satellite mission vehicles, fall into two categories. The first category is in the 1 to 50 kW range for missions of a continuous nature such as communication, navigation, surveillance, data relay and meteorology. The second category is in the multi-megawatt range for either continuous or burst power durations and are for other than solar power sources. Requirements for longer life and survivability in varying degrees are there for all systems. While the power levels do not appear difficult to achieve in view of the large array developments pursued by NASA Space Station technology, the other military requirements are very challenging and continue to be system drivers. The development of solar cells arrays should be in conjunction with other power supply technologies such as regulation and control components and energy storage subsystems. Author

N86-17868*# Communications Satellite Corp., Clarksburg, Md.
POWER REQUIREMENTS FOR COMMERCIAL COMMUNICATIONS SPACECRAFT
W. J. BILLERBECK *In* NASA. Lewis Research Center Space Photovoltaic Research and Technology 1985 p 257-278 1985 refs
Avail: NTIS HC A13/MF A01 CSCL 10B

Historical data on commercial spacecraft power systems are presented and their power requirements to the growth of satellite communications channel usage are related. Some approaches for estimating future power requirements of this class of spacecraft through the year 2000 are proposed. The key technology drivers in satellite power systems are addressed. Several technological trends in such systems are described, focusing on the most useful areas for research and development of major subsystems, including solar arrays, energy storage, and power electronics equipment. E.A.K.

N86-17869*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE STATION POWER MANAGEMENT AND DISTRIBUTION
F. TEREN *In its* Space Photovoltaic Research and Technology 1985 p 279-285 1985
Avail: NTIS HC A13/MF A01 CSCL 10B

The power system architecture is presented by a series of schematics which illustrate the power management and distribution (PMAD) system at the component level, including converters, controllers, switchgear, rotary power transfer devices, power and data cables, remote power controllers, and load converters. Power distribution options, reference power management, and control strategy are also outlined. A summary of advanced development status and plans and an overview of system test plans are presented. E.A.K.

N86-18348*# Martin Marietta Aerospace, Denver, Colo.
SPACE STATION COMMON MODULE POWER SYSTEM NETWORK TOPOLOGY AND HARDWARE DEVELOPMENT
D. M. LANDIS Apr. 1985 21 p
(Contract NAS8-36583)
(NASA-CR-178587; NAS 1.26:178587; MCR-85-621-000) Avail: NTIS HC A02/MF A01 CSCL 22B

Candidate power system newtork topologies for the space station common module are defined and developed and the necessary hardware for test and evaluation is provided. Martin Marietta's approach to performing the proposed program is presented. Performance of the tasks described will assure systematic development and evaluation of program results, and will provide the necessary management tools, visibility, and control techniques for performance assessment. The plan is submitted in accordance with the data requirements given and includes a comprehensive task logic flow diagram, time phased manpower requirements, a program milestone schedule, and detailed descriptions of each program task. Author

N86-19164# New Mexico Univ., Albuquerque. Dept. of Chemical and Nuclear Engineering.
HEAT PIPE SPACE NUCLEAR REACTOR DESIGN ASSESSMENT. VOLUME 1: DESIGN STATUS OF THE SP-100 HEAT PIPE SPACE NUCLEAR REACTOR SYSTEM Final Report, 5 May 1982 - 27 Mar. 1985
V. F. DEAN, M. S. EL-GENK, D. L. Y. LOUIE, and D. M. WOODALL Aug. 1985 52 p
(Contract F29601-82-K-0055)
(AD-A160279; NE-101(85)AFWL-144-1-VOL-1; AFWL-TR-84-126-VOL-1) Avail: NTIS HC A04/MF A01 CSCL 18I

This document reviews the design status of the SP-100, heat pipe space nuclear reactor system. It also identifies those systems and components requiring additional research to support continued SP-100 system development. The heat pipe reactor was designed to produce 100 KWe of continuous power in a space environment. The design constraints include an expected system operation time of 7 years and a maximum weight of approx. 3000 kg. The reactor, employing an unclad, highly enriched uranium dioxide core, operates as a fast reactor, and is cooled by high temperature molybdenum -- 13 percent rhenium, heat pipes with lithium working fluid. Electric power is generated by thermoelectric converters, with the bulk of the thermal energy rejected to space by a radiator panel system. GRA

N86-19165# New Mexico Univ., Albuquerque. Dept. of Chemical and Nuclear Engineering.
HEAT PIPE SPACE NUCLEAR REACTOR DESIGN ASSESSMENT. VOLUME 2: FEASIBILITY STUDY OF UPGRADING THE SP-100 HEAT PIPE SPACE NUCLEAR POWER SYSTEM Final Report, 5 May 1982 - 27 Mar. 1985
M. S. EL-GENK and J. T. SEO Aug. 1985 132 p
(Contract F29601-82-K-0055)
(AD-A160280; NE-108(85)AFWL-144-VOL-2;
AFWL-TR-84-126-VOL-2) Avail: NTIS HC A07/MF A01 CSCL 18I

This report investigated the feasibility of upgrading the power of the Heat Pipe Space Nuclear Reactor (HPSNR) system design. The report has also discussed the four primary methods for power upgrading: Increasing the thermal power output to the reactor core, pulse-mode operation, improving the heat rejection, and improving the thermal-to-electric energy conversion. GRA

N86-21577*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TECHNOLOGY FOR BAYTON-CYCLE POWERPLANTS USING SOLAR AND NUCLEAR ENERGY
R. E. ENGLISH Feb. 1986 15 p refs
(NASA-TP-2558; E-2761; NAS 1.60:2558) Avail: NTIS HC A02/MF A01 CSCL 10B

Brayton cycle gas turbines have the potential to use either solar heat or nuclear reactors for generating from tens of kilowatts to tens of megawatts of power in space, all this from a single technology for the power generating system. Their development for solar energy dynamic power generation for the space station could be the first step in an evolution of such powerplants for a very wide range of applications. At the low power level of only 10 kWe, a power generating system has already demonstrated overall efficiency of 0.29 and operated 38 000 hr. Tests of improved components show that these components would raise that efficiency to 0.32, a value twice that demonstrated by any alternate concept. Because of this high efficiency, solar Brayton cycle power generators offer the potential to increase power per unit of solar collector area to levels exceeding four times that from photovoltaic powerplants using present technology for silicon solar cells. The technologies for solar mirrors and heat receivers are reviewed and assessed. This Brayton technology for solar powerplants is equally suitable for use with the nuclear reactors. The available long time creep data on the tantalum alloy ASTAR-811C show that such Brayton cycles can evolve to cycle peak temperatures of 1500 K (2240 F). And this same technology can be extended to generate 10 to 100 MW in space by exploiting existing technology for terrestrial gas turbines in the fields of both aircraft propulsion and stationary power generation. Author

09

PROPULSION

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

A86-11346*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
HIGH-TEMPERATURE GASEOUS OXYGEN/HYDROGEN THRUSTERS FOR SPACE STATION
M. W. DOWDY and M. A. APPEL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1984 advances in aerospace sciences and engineering: Structures, materials, dynamics, and space station propulsion; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 179-183. NASA-supported research. refs

Efforts to determine the critical technologies necessary for the development of a high-temperature GO2/GH2 thruster are reviewed, for space station applications. Two types of thrust chambers are evaluated: one operable at high temperature and the other incorporating regenerative cooling. The high temperature chamber made of rhenium requires minimum cooling of the chamber wall, however, an oxidation barrier should be incorporated to prevent the rhenium thruster from readily oxidizing. The use of rhenium brought about a lower cost, lower weight, and simplicity of fabrication. The igniter-injector, the chamber, the test facility, and the test program are discussed. It is found that an obtained flow split of 58/42 increased the thruster performance from 3893 N-s/Kg to 4030 N-s/Kg for the same chamber pressure and overall mixture ratio. An increase in performance is also observed when the core mixture ratio is lowered. The thruster was tested for 1.9 hrs with no well degradation. F.J.

A86-11347#
HEALTH MONITORING FOR AN ORBIT TRANSFER VEHICLE PROPULSION SYSTEM
D. M. JASSOWSKI and F. N. COLLAMORE (Aerojet Techsystems Co., Sacramento, CA) IN: 1984 advances in aerospace sciences and engineering: Structures, materials, dynamics, and space station propulsion; Proceedings of the Winter Annual Meeting, New Orleans, LA, December 9-14, 1984 . New York, ASME, 1984, p. 185-190. refs

The extent to which health monitoring can be applied to advanced rocket propulsion systems is discussed. The equipment and functions of a rocket propulsion health monitoring system are described considering sensors, electronics, and software. The rocket system reliability, extent of life, and reduction of life cycle costs is to be enhanced. The health monitor provides a continuous evaluation of current parameters to determine the condition of the system. The conversion of physical parameters into electrical signals, the signals analysis, the data verification, and the data storage are reviewed. NASA's advanced cryogenic orbit transfer vehicle (OTV) for the late 1990's is used for this study. A schematic representation of the OTV propulsion is provided. F.J.

A86-14429*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MANRATING ORBITAL TRANSFER VEHICLE PROPULSION
L. P. COOPER (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, and ASME, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 13 p. Previously announced in STAR as N85-25385. refs
(AIAA PAPER 85-1226)

The expended capabilities for Orbital Transfer Vehicles (OTV) which will be needed to meet increased payload requirements for transporting materials and men to geosynchronous orbit are discussed. The requirement to provide manrating offers challenges and opportunities to the propulsion system designers. The

propulsion approaches utilized in previous manned space vehicles of the United States are reviewed. The principals of reliability analysis are applied to the Orbit Transfer Vehicle. Propulsion system options are characterized in terms of the test requirements to demonstrate reliability goals and are compared to earlier vehicle approaches. E.A.K.

A86-14447*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN ANALYSIS OF LOW-THRUST, RESISTOJET REBOOST FOR THE SPACE STATION
P. F. PENKO, P. J. STAIGER, and M. J. BUR (NASA, Lewis Research Center, Cleveland, OH) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 18th, Alexandria, VA, Sept. 30-Oct. 2, 1985. 7 p. refs
(AIAA PAPER 85-2042)

This paper presents results of an analysis of low-thrust orbit maintenance of the Space Station. Propellant requirements and transfer times are given for reboost of the station through various altitude increments. The reboost can readily be accomplished with thrust levels that subject the station to an acceleration of less than the desired upper limit of 10 to the -5th g's. The variation in time and the probabilistic aspect of the predicted upper-atmospheric density as well as the variation in time of sun-pointing drag areas were taken into account. Estimates of the propellant requirements at different times during an 11-year solar cycle are given. It is shown that the amount of CO2 available from the station life-support system is sufficient, over most of the solar cycle, to provide the propellant for a resistojet orbit-maintenance system. Author

A86-15652#
AN ELECTRIC PUMP FEED SYSTEM FOR APOGEE PROPULSION OF GEOSTATIONARY SPACECRAFT
R. SUNDEN (Volvo Flygmotor AB, Trollhattan, Sweden) and W. BERRY (ESA, Technical Directorate, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 17 p.
(IAF PAPER 85-72)

To define the best pump-fed propulsion system for the apogee transfer maneuver of a geostationary spacecraft, a definition study was performed on electric pumps deriving their power from the solar arrays and secondary batteries of the spacecraft. The propellants to be pumped were nitrogen tetroxide and monomethyl hydrazine. The engines used in the study were the 400 N and 3000 N bipropellant engines, and the spacecraft used for comparison purposes was Olympus-1. As a result of detailed studies of the selected candidate pump and electric motor types, the shrouded centrifugal pump, driven by an electronically commutated electric motor, was selected for both reference engines. A mass and cost analysis comparison with the conventionally used pressure-fed propulsion systems revealed about 10 percent savings of the real telecommunications payloads of the Ariane-type spacecraft at the same production cost as the conventional systems. A preliminary design analysis of the selected pump system is presented. I.S.

A86-15699*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
BEYOND LOW EARTH ORBIT - AN OVERVIEW OF ORBIT-TO-ORBIT STAGES
J. P. LOFTUS, JR. and W. L. BRASHER (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p. refs
(IAF PAPER 85-141)

New developments in upper stages are discussed. Tables revealing the dimensions, engine types, total thrust, weight, payload, and sponsor for developed and planned upper stages compatible with Space Transportation System (STS) or expendable launch vehicles are presented. An example of STS delivery capability to the Space Station at various orbital altitudes is provided. The use of aerobraking as the propulsion strategy for reusable stages is investigated. Various methods of controlling spent stages and maintaining a fragment free space environment are described. Storable propellant transfer systems and handling techniques for cryogens are studied. I.F.

A86-15701#
APPLICATION OF IUS EQUIPMENT AND EXPERIENCE TO ORBIT TRANSFER VEHICLES OF THE 90'S
E. BANGSUND, J. KEENEY, and E. COWGILL (Boeing Aerospace Co., Seattle, WA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(IAF PAPER 85-143)

This paper relates experiences with the IUS program and the application of that experience to Future Orbit Transfer Vehicles. More specifically it includes the implementation of the U.S. Air Force Space Division high reliability parts standard (SMASO STD 73-2C) and the component/system test standard (MIL-STD-1540A). Test results from the parts and component level testing and the resulting system level test program for fourteen IUS flight vehicles are discussed. The IUS program has had the highest compliance with these standards and thus offers a benchmark of experience for future programs demanding extreme reliability. In summary, application of the stringent parts standard has resulted in fewer failures during testing and the stringent test standard has eliminated design problems in the hardware. Both have been expensive in costs and schedules, and should be applied with flexibility. Author

A86-15707#
PROPELLANT SUPPLY FOR SPACE OPERATIONS
D. A. FESTER (Martin Marietta Aerospace, Denver, CO) and W. L. GILMORE (Martin Marietta Aerospace, Michoud Div., New Orleans, LA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p. refs
(IAF PAPER 85-149)

The use of two dedicated tankers of 25 K and 50 K lb or the scavenging of surplus or residual LO2 and LH2 at the end of a mission, in order to supply propellants to space and earth, is studied. Emphasis is placed on cryogenic propellant scavenging because of the cost effectiveness of this technique. A definition of surplus and residual cryogenic propellants is provided. The two basic scavenging system concepts, one using propellant tanks carried in the aft cargo carrier (ACC) and the second with tankers carried in the orbiter, are examined. A diagram of the preferred system with ET/ACC scavenging and an example of a typical scavenging mission scenario are presented. The cost of a cryogenic propellant scavenging system is investigated. An orbiter payload bay scavenging system is described and its potential use with the ET/ACC scavenging system is analyzed. I.F.

A86-15742#
A REVIEW AND ASSESSMENT OF THE PERFORMANCE OF ADVANCED ION THRUSTERS
A. R. MARTIN and A. BOND (U.K. Atomic Energy Authority, Culham Laboratory, Abingdon, England) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. refs
(IAF PAPER 85-202)

This paper is a review and updating of advanced ion thruster concepts concerned with the use of electric propulsion for orbit raising and on-orbit control of large space structures. The work done in increasing the performance of existing thrusters is examined, in an attempt to derive scaling laws for use in extrapolation to larger systems. These are coupled with some aspects of an alternative design approach, where techniques developed for high current ion source and accelerator systems, used to produce beams of energetic particles for heating plasmas in controlled thermonuclear fusion experiments, are applied to thruster extrapolation. The future performance levels, in terms of beam current and voltage, thrust and power requirements, are indicated. The applicability of such advanced thrusters to missions beyond earth orbit is discussed. Author

A86-17850*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STATUS OF ADVANCED ORBITAL TRANSFER PROPULSION
L. P. COOPER (NASA, Lewis Research Center, Cleveland, OH) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 25 p. Previously announced in STAR as N85-35225. refs
(IAF PAPER 85-164)

A new Orbital Transfer Vehicle (OTV) propulsion system that will be used in conjunction with the Space Shuttle, Space Station and Orbit Maneuvering Vehicle is discussed. The OTV will transfer men, large space structures and conventional payloads between low earth and higher energy orbits. Space probes carried by the OTV will continue the exploration of the solar system. When lunar bases are established, the OTV will be their transportation link to earth. Critical engine design considerations based upon the need for low cost payload delivery, space basing, reusability, aeroassist maneuvering, low g transfers of large space structures and man rating are described. The importance of each of these to propulsion design is addressed. Specific propulsion requirements discussed are: (1) high performance H2/O2 engine; (2) multiple engine configurations totalling no more than 15,000 lbf thrust 15 to 20 hr life; (3) space maintainable modular design; (4) health monitoring capability; and (5) safety and mission success with backup auxiliary propulsion. E.A.K.

A86-19844*# Rockwell International Corp., Canoga Park, Calif.
DESIGN DRIVERS OF THE SPACE STATION PROPULSION SYSTEM
J. GRAETCH (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 5 p.
(Contract NAS8-36418)
(AIAA PAPER 86-0378)

The objective of this paper is to describe some of the factors that are being considered by NASA in the selection of the Space Station Propulsion System. The paper describes briefly several design alternatives under consideration. The emphasis of this paper is on understanding the criteria being used by NASA, rather than a quantitative evaluation of the design alternatives. Four system evaluation criteria are suggested: cost, safety, technical readiness, and opportunities for station evolution. Within the cost criteria, the impact of the design alternatives on maintenance and resupply costs is discussed. Safety is suggested to be determined more by the nature of the propellants than the possible loss of the propulsion function. Technical readiness is primariiy an evaluation of the risk of schedule delay, more than a concern over a showstopper in the development of any of the systems. Finally, the opportunity for station evolution is described in terms of the development of an oxygen/hydrogen economy for the Space Station. Author

A86-19846#
SOLAR POWERED ELECTRIC PROPULSION ORBIT TRANSFER VEHICLE DESIGN AND OPERATIONAL EFFECTIVENESS
M. M. MAKARU (USAF, Institute of Technology, Wright-Patterson AFB, OH) and D. P. BOYARSKI (USAF, Space Command, Peterson AFB, CO) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs
(AIAA PAPER 86-0381)

The feasibility and cost effectiveness for using solar powered electric propulsion orbit transfer vehicles (EOTV) to move Block 3 NAVSTAR Global Positioning System (GPS) satellites from LEO to a 10,900 nm orbit were determined. The electric propulsion systems considered were present and 1990's technology ion engines using mercury, xenon or argon for a propellant. A systems cost model which combines payload, power sources, trajectory, and earth-to-LEO launch parameters with algorithms characterizing the electric propulsion system was used. The least costly systems which had a triptime equal to or less than 90 days were determined. These systems were 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 found that a reusable EOTV with 12 mercury ion engines powered by gallium arsenide concentrator arrays could perform the mission for 57 percent of the cost of the cheapest chemical system. Author

A86-20229#
AN ENERGY APPROACH FOR ORBITAL TRANSFERS
D. H. MAY (USAF, Aerospace Test Group, Cape Canaveral Air Force Station, FL) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 23-26. Previously cited in issue 20, p. 2858, Accession no. A84-41385. refs

A86-20734* Space Power, Inc., Sunnyvale, Calif.
REACTOR POWER SYSTEM DEPLOYMENT AND STARTUP
J. R. WETCH, C. J. NELIN (Space Power, Inc., Sunnyvale, CA), E. J. BRITT (Rasor Associates, Inc., Sunnyvale, CA), and G. KLEIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space nuclear power systems 1984; Proceedings of the First Symposium, Albuquerque, NM, January 11-13, 1984. Volume 1 . Malabar, FL, Orbit Book Co., Inc., 1985, p. 93-108. refs

This paper addresses issues that should receive further examination in the near-term as concept selection for development of a U.S. space reactor power system is approached. The issues include: the economics, practicality and system reliability associated with transfer of nuclear spacecraft from low earth shuttle orbits to operational orbits, via chemical propulsion versus nuclear electric propulsion; possible astronaut supervised reactor and nuclear electric propulsion startup in low altitude Shuttle orbit; potential deployment methods for nuclear powered spacecraft from Shuttle; the general public safety of low altitude startup and nuclear safe and disposal orbits; the question of preferred reactor power level; and the question of frozen versus molten alkali metal coolant during launch and deployment. These issues must be considered now because they impact the SP-100 concept selection, power level selection, weight and size limits, use of deployable radiators, reliability requirements, and economics, as well as the degree of need for and the urgency of developing space reactor power systems. Author

A86-24805
SPACE STATION ELECTRICAL POWER DISTRIBUTION SYSTEM DEVELOPMENT
W. E. MURRAY (Douglas Aircraft Co., Long Beach, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.179-1.196. refs

The planning and organization of the design tasks necessary to develop and optimize an electrical power distribution system for a manned space station are described, including the technical management of major issues relevant to the Space Station program. These issues include 20 kHz distribution technology problems to be addressed, distribution system architecture and development with related full-power, and partial-power performance and reliability considerations. The trade studies conducted to resolve such issues as modularity benefits versus double-voltage benefits are also discussed. The special considerations and testing required to develop and demonstrate a viable Space Station buildup capability with a minimum of extravehicular activity are treated. Additionally, the user interface requirements, the power source interface requirements, and the data base development are addressed and commonality benefits are assessed. Author

A86-24874
FEASIBILITY OF FLYWHEEL ENERGY STORAGE IN SPACECRAFT APPLICATIONS
D. R. OLMSTED (AiResearch Manufacturing Co., Torrance, CA) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 2 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 2.444-2.448. refs

The Garrett Corporation has recently developed a large-scale, high-energy-density, composite flywheel energy storage unit for

use in an electric vehicle propulsion system. This development makes composite flywheel technology a viable candidate for meeting the energy storage requirements of large spacecraft. The flywheel has a total energy storage capacity of 16 kWhr, of which 12.5 kWhr are available as usable energy. This rating is suitable for use in multiple unit systems to meet the anticipated energy storage capacity requirements of the Space Station. With further enhancement fo flywheel energy storage capability, it will be technically feasible to use this unit design as the basis for a large-scale flywheel unit for spacecraft applications. Author

A86-25187#
ION ENGINE FOR NORTH-SOUTH STATIONKEEPING OF LARGE GEOSYNCHRONOUS SATELLITES WITH LONG MISSION LIFE
S. KITAMURA, N. SAITO, Y. NAKAMURA, and H. AZUMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 373, 1985, p. 100-107. In Japanese. refs

The ion engine system for the north-south stationkeeping of two-ton geosynchronous satellites with 10-year mission life is described. The ion engine system proposed consists of four thrusters, four power processing units, and xenon tank, and provides a specific impulse of 3400 seconds, a power consumption of 1.5 kW, and has a total weight of 162 kg. The mercury ion engine with a specific impulse of 2200 seconds developed in Japan was tested with the Engineering Test Satellite III in 1982. The development schedule of the ion engine for the Engineering Testing Satellite VI Japan is described. S.H.

N86-11216*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
HEAVY LIFT LAUNCH VEHICLES FOR 1995 AND BEYOND
R. TOELLE, comp. Sep. 1985 149 p refs
(NASA-TM-86520; NAS 1.15:86520) Avail: NTIS HC A07/MF A01 CSCL 22B

A Heavy Lift Launch Vehicle (HLLV) designed to deliver 300,000 lb to a 540 n mi circular polar orbit may be required to meet national needs for 1995 and beyond. The vehicle described herein can accommodate payload envelopes up to 50 ft diameter by 200 ft in length. Design requirements include reusability for the more expensive components such as avionics and propulsion systems, rapid launch turnaround time, minimum hardware inventory, stage and component flexibility and commonality, and low operational costs. All ascent propulsion systems utilize liquid propellants, and overall launch vehicle stack height is minimized while maintaining a reasonable vehicle diameter. The ascent propulsion systems are based on the development of a new liquid oxygen/hydrocarbon booster engine and liquid oxygen/liquid hydrogen upper stage engine derived from today's SSME technology. Wherever possible, propulsion and avionics systems are contained in reusable propulsion/avionics modules that are recovered after each launch. Author

N86-15339*# Boeing Aerospace Co., Seattle, Wash.
SPACE STATION PROPULSION REQUIREMENTS STUDY Final Report
C. L. WILKINSON and S. M. BRENNAN Aug. 1985 484 p
(Contract NAS3-23353)
(NASA-CR-174934; NAS 1.26:174934; D180-28264-1) Avail: NTIS HC A21/MF A01 CSCL 21H

Propulsion system requirements to support Low Earth Orbit (LEO) manned space station development and evolution over a wide range of potential capabilities and for a variety of STS servicing and space station operating strategies are described. The term space station and the overall space station configuration refers, for the purpose of this report, to a group of potential LEO spacecraft that support the overall space station mission. The group consisted of the central space station at 28.5 deg or 90 deg inclinations, unmanned free-flying spacecraft that are both tethered and untethered, a short-range servicing vehicle, and a longer range servicing vehicle capable of GEO payload transfer. The time phasing for preferred propulsion technology approaches is also investigated, as well as the high-leverage, state-of-the-art advancements needed, and the qualitative and quantitative benefits of these advancements on STS/space station operations. The time frame of propulsion technologies applicable to this study is the early 1990's to approximately the year 2000. Author

N86-17386*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SMALL, TWO-STAGE, PARTIAL-ADMISSION TURBINE
R. F. SUTTON (Rockwell International Corp., Canoga Park, Calif.), J. L. BOYNTON (Rockwell International Corp., Canoga Park, Calif.), and D. SCHEER *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 55-62 Apr. 1985 Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21H

The Rocketdyne Orbital Transfer Vehicle (OTV) cryogenic, rocket engine system, high pressure, liquid hydrogen turbopump was designed with a two-stage, partial-admission axial turbine. The turbine is basically two single-stage, partial-admission, subsonic impulse stages designed so the kinetic energy leaving the first-stage rotor is discharged directly into the second-stage nozzle at nominal operation to minimize staging losses. Very little data were available in the literature for this type of turbine design. Therefore, it was decided to test a full-size model of the turbine design using ambient-temperature gaseous nitrogen as the working fluid. The tester design features a variable orientation second-stage nozzle to determine the optimum circumferential location for highest performance. The tester also features the capability to vary the nozzle arcs of admission and incorporates quartz windows to study the flowfield upstream of the second-stage nozzle using a laser velocimeter. The test operations will probe the efficiency and flow characteristics for three arcs of admission and the effects of second-stage nozzle circumferential orientations over wide ranges of speed and pressure ratios as well as the interstage pressure distributions. Author

N86-17416*# General Dynamics/Convair, San Diego, Calif.
ORBITAL TRANSFER VEHICLE ENGINE INTEGRATION STUDY
W. J. KETCHUM *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 375-382 Apr. 1985 Prepared in cooperation with Aerojet Techsystems Co., Sacramento, Calif.
(Contract NAS3-23772)
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21H

Industry studies were undertaken to establish the technology base for an advanced engine for Orbital Transfer Vehicles for mid-1990s IOC. This paper presents the results of a study conducted by General Dynamics Convair Division, under contract to Aerojet TechSystems Company for NASA-LeRC, to define requirements, interface conditions, and operational design criteria for new LO2/LH2 propulsion systems applicable to future Orbit Transfer Vehicles, and to assess the impacts of space basing, man rating, and low-g transfer on propulsion system design requirements. The primary study emphasis was to determine what the OTV engine thrust level should be, how many engines are required on the OTV, and how the OTV engine should be designed. This was accomplished by evaluating planned OTV missions and concepts to determine the requirements for the OTV propulsion system, conducting tradeoffs and comparisons to optimize OTV capability, and evaluating reliability and maintenance to determine the recommended OTV engine design for future development. Author

N86-17418*# Martin Marietta Aerospace, Denver, Colo.
DESIGN OPTIMIZATION FOR A SPACE BASED, REUSABLE ORBIT TRANSFER VEHICLE
L. REDD *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 391-401 Apr. 1985
(Contract NAS3-23858)
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 22B

Future NASA and DOD missions will benefit from high performance, reusable orbit transfer vehicles. With the advent of a space station, advanced engine technology, and various new vehicle concepts, reusable orbit transfer vehicles that provide significant economic benefits and mission capability improvements will be realized. Engine and vehicle design criteria previously have lacked definition with regard to issues such as space basing and servicing, man-rating and reliability, performance, mission flexibility, and life cycle cost for a reusable vehicle. The design study described here has resulted in the definition of a reusable orbit transfer vehicle concept and subsequent recommendations for the design criteria of an advanced LO2/LH2 engine. These design criteria include number of engines per vehicle, nozzle design, etc. The major characteristics of the vehicle preliminary design include low lift to drag aerocapture capability, a main propulsion system failure criteria of fail operational/fail safe, and either two main engines with a high performance attitude control system for back-up or three main engines with which to meet this failure criteria. In addition, a maintenance approach has been established for the advanced vehicle concept. Author

N86-17419*# Boeing Aerospace Co., Seattle, Wash.
THE EFFECT OF ENGINE DESIGN CHARACTERISTICS ON ORBITAL TRANSFER VEHICLE PERFORMANCE
G. R. SCHMIDT *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 403-411 Apr. 1985 refs
(Contract NAS8-36107)
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 22B

The objective in maximizing performance for a space-based Orbital Transfer Vehicle (OTV) is to minimize the propellant required to successfully complete a given reference mission and thereby reduce launch and storage costs. Engine sizing studies were conducted which examined the effect of engine design characteristics on the total propellant required to accomplish the manned and unmanned OTV missions anticipated for the 1995 to 2010 time period. Two propellant combinations, O2/H2 and N2O4/MMH, were selected as baselines. Exotic combinations such as F2/H2 and O2/CH4 were also studied to identify potential benefits and growth capabilities. Parametric results showing the effects of engine thrust, number of engines, nozzle area ratio and payload requirements are presented for various reference missions. The results indicate that the optimum engine size and thrust are not significantly affected by detailed engine design characteristics. Author

N86-17420*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION ADVANCED PROPULSION AND FLUID MANAGEMENT PROGRAM
R. J. RICHMOND and L. W. JONES *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 413-421 Apr. 1985 refs Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21H

In preparation for the development of a manned space station program of advanced technology and development to make new advanced propulsion options available for the initial space station in the 1990's is described. This paper reviews the objectives of the advanced technology and development program in propulsion, describes its origin and how it relates to the forthcoming development program. The advanced propulsion and fluid management systems to be investigated in the program are discussed along with the rationale for their selection. Finally, the systems test program is discussed. Author

N86-17421# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.
SPACE STATION PROPULSION APPROACHES AND TECHNOLOGY STATUS
S. A. EVANS, J. M. SHOJI, W. R. BISSELL, K. N. WATTS, and J. GRAETCH *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 423-433 Apr. 1985
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21H

The space station places new demands upon propulsion in terms of component life times, maintenance ease, refill, reuse, and potential interaction with other on-board systems. Interaction with other systems can be active such as integration with the environmental control/life support system for fluid supply or passive such as the contamination created by thruster exhausts. The wide range of potential candidate approaches to space station propulsion are discussed from monopropellants to oxygen/hydrogen. Component requirements and technology status are evaluated for key components such as pumps, motor, thermal beds, and resistojets. Major issues such as in-space refill are summarized. Author

N86-17422*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE O SUB 2/H SUB 2 PROPULSION MODULE FOR PLANETARY SPACECRAFT INJECTION ENERGY AUGMENTATION
B. A. PALASZEWSKI *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 435-443 Apr. 1985 refs Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21H

A propulsion module to augment the Centaur G-Prime and the Aerobraked OTV (AOTV) injection energy (C sub 3) was studied. The characteristics and performance of a variety of Earth-storable and cryogenic propulsion systems are presented. A pump-fed, cryogenic O2/H2 propulsion system enables the elimination of a three-year delta V Earth gravity assist (delta VEGA) maneuver for several planetary missions currently under consideration by the NASA. This trip time reduction can significantly reduce mission support costs, reduce spacecraft (S/C) life requirements and potentially increase the probability of mission success. This study also shows that an O2/H2 propulsion module, developed for Centaur C sub 3 augmentation can be used with a space-based AOTV in the return mode, allowing the reuse of the high-value AOTV while still delivering the required high-injection energy for direct planetary missions. The propulsion module performance was estimated for a space shuttle delivery capability to LEO of 65,000 lb sub m and 75,000 lb sub m. The required minimum thrust level to minimize gravity losses was also determined. For several currently planned NASA planetary missions, the Centaur G-Prime injection energy is augmented by a delta VEGA maneuver. For these missions, direct injection by the Centaur cannot provide a shorter trip time than the delta VEGA injection trip time. Author

N86-17423*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SOLAR THERMAL PROPULSION FOR PLANETARY SPACECRAFT
J. C. SERCEL *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 445-456 Apr. 1985 refs Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21C

Previous studies have shown that many desirable planetary exploration missions require large injection delta-V. Solar Thermal Rocket (STR) propulsion, under study for orbit-raising applications may enhance or enable such high-energy missions. The required technology of thermal control for liquid hydrogen propellant is available for the required storage duration. Self-deploying, inflatable solar concentrators are under study. The mass penalty for passive cryogenic thermal control, liquid hydrogen tanks and solar concentrators does not compromise the specific impulse advantage

afforded by the STR as compared to chemical propulsion systems. An STR injection module is characterized and performance is evaluated by comparison to electric propulsion options for the Saturn Orbiter Titan Probe (SOTP) and Uranus Flyby Uranus Probe (UFUP) missions. Author

N86-17424# Rocket Research Corp., Redmond, Wash.
ANALYSIS OF ELECTRIC PROPULSION CONCEPTS FOR NEAR-TERM MISSION APPLICATION
W. W. SMITH and S. C. KNOWLES *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 457-467 Apr. 1985 refs
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21C

A study of near-term mission application of three electric propulsion technologies has been conducted. Surveys of existing and projected electric propulsion capabilities including system mass, power level, Isp and efficiency were utilized. Space system requirements for the next 10 years for stationkeeping, orbit transfer and orbit maneuvering were used to support mission analysis comparison. The three systems considered were the arcjet, inert gas ion and pulsed plasma thrusters. Propellants considered for arcjet systems included H2, NH3 and N2H4. Stationkeeping applications were compared on the bases of system mass, power requirements, duty cycles, and thruster lifetime. Orbit transfer applications comparison included STS lift capability and trip-time requirements. The results showed that arcjet systems provided the most effective means of meeting near-term low to moderate thruster requirements. Pulsed plasma thruster systems must be increased in thrust from the existing 1-mlbf thrust level to a minimum of 10-mlbf thrust level to perform stationkeeping of 5,000 lbm + satellites. Ion systems were found to have several limitations including high inert mass, very low thrust density and long lifetime requirements. Author

N86-17427*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THERMAL ARCJET TECHNOLOGY FOR SPACE PROPULSION
T. J. PIVIROTTO and D. Q. KING *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 485-494 Apr. 1985 refs Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21C

Advanced space propulsion systems are required to meet projected Air Force needs through the year 2000. Most of these missions require a large, on-orbit impulse capability. High specific impulse (I sub sp) electric engines can provide this impulse while consuming relatively little propellant. An arcjet engine system, which operates in the range of 800 to 2000 s I sub sp, is a promising candidate to meet these projected Air Force mission needs. This electric propulsion system is ideally suited to missions currently under consideration, such as the Space-based Radar and other space platforms, because sufficient power is already installed for other functions on the spacecraft. Also, arcjet systems are attractive for NASA near-term, low-cost Mariner Mark II missions to Saturn and Uranus. Development of arcjet engines was an Air Force and NASA-sponsored activity that proceeded vigorously from its inception during the late 1950's up to the mid-1960's when the programs were terminated. This paper describes thermal arcjet technology as it was developed over two decades ago and points to the direction this technology development should proceed in the future. In particular, operation with storable propellants such as ammonia and hydrazine are considered. The performance, applicability and advantages of these systems in terms of increased payload and/or decreased trip times are discussed. Author

N86-17429*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
MICROWAVE ELECTRIC PROPULSION FOR ORBIT TRANSFER APPLICATIONS
J. C. SERCEL *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 509-518 Apr. 1985 refs Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21C

A Microwave Electric Propulsion (MEP) concept is developed for an unmanned Orbit Transfer Vehicle (OTV). The concept is based on the use of beamed microwave power and on an extrapolation of ion thruster technology. Beamed microwave power transmission is discussed in terms of its relationship to spacecraft propulsion. Characteristics of an MEP OTV are determined and performance is evaluated by comparison to a variety of alternative propulsion systems for the completion of a ten-year mission model. Author

N86-20493*# General Dynamics/Convair, San Diego, Calif. Advanced Space Programs.
ORBITAL TRANSFER VEHICLE ENGINE INTEGRATION STUDY Final Report
W. J. KETCHUM 30 Nov. 1984 51 p refs
(Contract NAS3-23772; NASA ORDER L-814740)
(NASA-CR-174842; NAS 1.26:174842; GDC-SP-84-050) Avail: NTIS HC A04/MF A01 CSCL 21H

NASA-LeRC is sponsoring industry studies to establish the technology base for an advanced engine for orbital transfer vehicles for mid-1990s IOC. Engine contractors are being assisted by vehicle contractors to define the requirements, interface conditions, and operational design criteria for new LO2-LH2 propulsion systems applicable to future orbit transfer vehicles and to assess the impacts on space basing, man rating, and low-G transfer missions on propulsion system design requirements. The results of a study is presented. The primary study emphasis was to determine what the OTV engine thrust level should be, how many engines are required on the OTV, and how the OTV engine should be designed. This was accomplished by evaluating planned OTV missions and concepts to determine the requirements for the OTV propulsion system, conducting tradeoffs and comparisons to optimize OTV capability, and evaluating reliability and maintenance to determine the recommended OTV engine design for future development. 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.

A86-10200#
AUTOMATION AND ROBOTICS FOR THE SPACE STATION - RECOMMENDATIONS
IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-21, Sept. 1985, p. 735-743.

An executive summary is given of the recommendations of the NASA advisory panel on robotics and automation technologies for the Space Station. Consideration is given to the technologies needed for the Initial Operational Capability (IOC) Space Station, including efficient man/machine interfaces for supervisory control of robots; problem oriented computer languages; integrated computer-aided engineering, and an on-site fabrication capability. A hypothetical time-line is given which describes the recommended funding guidelines of the Automation And Robotics Technology Advancement Program for the period 1985-1992. Some ways in which NASA can lead, leverage, and exploit the development of

automation and robotics technologies for the IOC Space Station are briefly reviewed. I.H.

A86-11327
1984 ADVANCES IN AEROSPACE SCIENCES AND ENGINEERING: STRUCTURES, MATERIALS, DYNAMICS, AND SPACE STATION PROPULSION; PROCEEDINGS OF THE WINTER ANNUAL MEETING, NEW ORLEANS, LA, DECEMBER 9-14, 1984
U. YUCEOGLU, ED. (Florida International University, Miami) and R. HESSER, ED. (TRW, Inc., TRW Defense and Space Systems Group, Redondo Beach, CA) Meeting sponsored by ASME. New York, ASME , 1984, 196 p. For individual items see A86-11328 to A86-11347.

A collection of papers on recent advances and developments in aerospace sciences and engineering is presented. The papers are mostly concerned with advanced composites and cover subjects such as dynamics, vibrations, wave propagation, impact resistance, materials, stress analysis, stress concentrations, fatigue and fracture, strength theories, and numerical, analytical, and experimental techniques. Space station propulsion systems and environments are also considered. C.D.

A86-14548* SRI International Corp., Menlo Park, Calif.
EXPERT SYSTEMS FOR SPACE STATION AUTOMATION
M. P. GEORGEFF and O. FIRSCHEIN (SRI International Artificial Intelligence Laboratory, Menlo Park, CA) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 5, Nov. 1985, p. 3-8. refs
(Contract NAS2-11864)

The expert systems required for automating key functions of the Manned Space Station (MSS) are explored. It is necessary that the expert systems developed be flexible, degrade gracefully in the case of a failure, and be able to work with incomplete data. The AI systems will have to perform interpretation and diagnosis, design, prediction and induction, and monitoring and control functions. Both quantitative and qualitative reasoning capabilities need improvements, as do automatic verification techniques, explanation and learning capabilities, and the use of metaknowledge, i. e., knowledge about the knowledge contained in the knowledge base. Information retrieval, fault isolation and manufacturing process control demonstrations are needed to validate expert systems for the MSS. M.S.K.

A86-15623*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AUTOMATION AND ROBOTICS - KEY TO PRODUCTIVITY
A. COHEN (NASA, Johnson Space Center, Houston, TX) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p.
(IAF PAPER 85-32)

The automated and robotic systems requirements of the NASA Space Station are prompted by maintenance, repair, servicing and assembly requirements. Trend analyses, fault diagnoses, and subsystem status assessments for the Station's electrical power, guidance, navigation, control, data management and environmental control subsystems will be undertaken by cybernetic expert systems; this will reduce or eliminate on-board or ground facility activities that would otherwise be essential, enhancing system productivity. Additional capabilities may also be obtained through the incorporation of even a limited amount of artificial intelligence in the controllers of the various Space Station systems. O.C.

A86-20426* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
FUTURE USES OF MACHINE INTELLIGENCE AND ROBOTICS FOR THE SPACE STATION AND IMPLICATIONS FOR THE U.S. ECONOMY
A. COHEN and J. D. ERICKSON (NASA, Johnson Space Center, Houston, TX) (IEEE, International Conference on Robotics and Automation, St. Louis, MO, Mar. 25-28, 1985) IEEE Journal of Robotics and Automation (ISSN 0882-4967), vol. RA-1, Sept. 1985, p. 117-123. refs

The exciting possibilities for advancing the technologies of artificial intelligence, robotics, and automation on the Space Station is summarized. How these possibilities will be realized and how their realization can benefit the U.S. economy are described. Plans, research programs and preliminary designs that will lead to the realization of many of these possibilities are being formulated.
Author

A86-20507
ROBOTICS AND THE SPACE STATION
J. N. GOWDY (Clemson University, SC) and R. S. WALLACE (Carnegie-Mellon University, Pittsburgh, PA) IN: SOUTHEASTCON '84; Proceedings of the Conference, Louisville, KY, April 8-11, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 173-176.

This paper is based on the authors' activities associated with the NASA/ASEE summer study 'Autonomy and the Human Element in Space' at Stanford University in 1983. The paper considers proposed tasks for robots in connection with space station activities. Generic capabilities needed to execute these tasks are also discussed. It is argued that NASA should sponsor robotics research which is directly connected with space activities.
Author

A86-23561* Honeywell, Inc., Minneapolis, Minn.
AUTOMATED SUBSYSTEMS CONTROL DEVELOPMENT
R. F. BLOCK (Honeywell, Inc., Space and Strategic Systems Div., Minneapolis, MN), D. B. HEPPNER (Life Systems Inc., Cleveland, OH), F. H. SAMONSKI, JR., and N. LANCE, JR. (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 14 p. NASA-sponsored research.
(SAE PAPER 851379)

NASA has the objective to launch a Space Station in the 1990s. It has been found that the success of the Space Station engineering development, the achievement of initial operational capability (IOC), and the operation of a productive Space Station will depend heavily on the implementation of an effective automation and control approach. For the development of technology needed to implement the required automation and control function, a contract entitled 'Automated Subsystems Control for Life Support Systems' (ASCLSS) was awarded to two American companies. The present paper provides a description of the ASCLSS program. Attention is given to an automation and control architecture study, a generic automation and control approach for hardware demonstration, a standard software approach, application of Air Revitalization Group (ARG) process simulators, and a generic man-machine interface.
G.R.

A86-26493#
TELEROBOTICS FOR THE SPACE STATION
M. M. CLARKE and M. A. BRONEZ (Rockwell International Corp., Space Station Systems Div., Downey, CA) Mechanical Engineering (ISSN 0025-6501), vol. 108, Feb. 1986, p. 66-72.

An evaluation is made of the configurational possibilities of the NASA Space Station, with a view to the range of EVA efforts that will have to be undertaken by Space Shuttle-based construction crews, and with emphasis on the character and effectiveness of the remote operation, or 'teleoperator' and robotic systems that such construction crews may employ to more effectively conduct Space Station assembly. Teleoperators are dexterous, general purpose man/machine systems that project human vision and

manipulation capabilities across distances and through physical barriers. Telerobots are teleoperators to which cybernetic sensor and control systems have imparted a degree of autonomy from human direction. Attention is given to the sensor and actuation systems proposed for implementation of teleoperators and telerobots. O.C.

A86-28073* California Univ., La Jolla.
ROBOTICS FOR THE UNITED STATES SPACE STATION
J. R. ARNOLD, D. R. CRISWELL (California, University, La Jolla), R. CANNON (Stanford University, CA), R. CLIFF (DARPA, Arlington, VA), A. COHEN (NASA, Johnson Space Center, Houston, TX) et al. Robotics (ISSN 0167-8493), vol. 1, Dec. 1985, p. 205-222.

Advances in robotics technology that will be necessary for the NASA Space Station to achieve its optimal level of automation are examined. The present state and emerging trends in teleoperator systems, hybrid teleoperated robots, and autonomous robots are reviewed, and scenarios of assembly, inspection, satellite servicing, and manufacturing are presented in order to illustrate potential uses of automation and robotics on the Space Station. Individual important technology development areas for Space Station robotics are surveyed, including end effectors and mechanization, control systems, telepresence and human factors, preception, manipulation in space, operation planning and data bases, and hardware maintenance. C.D.

A86-28075
PROGRAM PLAN FOR THE ASTRONAUT'S APPRENTICE
R. A. CLIFF (DARPA, Engineering Applications Office, Arlington, VA) Robotics (ISSN 0167-8493), vol. 1, Dec. 1985, p. 251-264.

The Astronaut's Apprentice is an evolutionary, open-ended R&D program which is designed to produce an ever-increasing level of automation on board the Space Station. The progression by which tasks are added to the repertoire of the autonomous robot (apprentice) parallels that used in human apprenticeship. The initial task for the Astronaut's Apprentice is to be a go-fer. This task can be accomplished with robotic technology which is essentially off-the-shelf in the terrestrial environment. It would be feasible, therefore, to make the Astronaut's Apprentice a part of the IOC Space Station. An Astronaut's Apprentice on the Space Station would provide an impetus for and definition of the 'scars' and 'hooks' required at IOC to permit evolution of advanced A&R technology on the Space Station. Author

A86-28489
SPACECRAFT APPLICATION OF EXPERT SYSTEMS
A. L. TOUSSAINT and M. E. MCFALL (Boeing Aerospace Co., Seattle, WA) IN: NAECON 1985; Proceedings of the National Aerospace and Electronics Conference, Dayton, OH, May 20-24, 1985. Volume 2 . New York, Institute of Electrical and Electronics Engineers, 1985, p. 1342-1346.

The anticipated progression of development for artificial intelligence (AI) applied to future spacecraft operation is considered. Research has demonstrated that AI software developement techniques (and knowledge-based systems in particular) can be used to provide limited spacecraft subsystem automation. A likely progression will proceed to integrated subsystem control, automated planning and scheduling, plane execution, anomaly handling, and eventually autonomous spacecraft operation. The ideas and concepts should be transferable from the Space Station to spacecraft automation in general. Two systems are discussed: ECESIS (Environmental Control Expert System in Space) and an expert system for electrical power subsystems control. D.H.

N86-10274*# Lockheed Missiles and Space Co., Palo Alto, Calif.
TEST AND EVALUATE PASSIVE ORBITAL DISCONNECT STRUTS (PODS 3)
R. T. PARMLEY, W. C. HENNINGER, S. A. KATZ, and I. SPRADLEY Aug. 1985 83 p refs
(Contract NAS2-11946)
(NASA-CR-177368; NAS 1.26:177368) Avail: NTIS HC A05/MF A01 CSCL 22B

The objectives of the Passive Orbital Disconnect Struts (PODS) test are to evaluate modal resonance of the PODS-III supports to obtain engineering data required for use of PODS-III on flight systems; determine possible performance improvements in large LO2/LH2 space applications. (1) Modal Vibration Tests. A modal resonance survey is performed on a set of six PODS-III struts assembled in a dewar simulator. The survey conditions simulate both launch and orbital loadings of the struts. The orbital load range spans a full to an empty tank. The frequencies surveyed cover the range consistent with Shuttle qualification requirements and the principal resonant modes of the strut system. (2) Benefit study. The benefit of using PODS-III supports on OTV and Space Station LO sub 2 and LH sub 2 reference tanks was compared to nondisconnect supports. Four LO sub 2 and LH sub 2 tanks were studied under various conditions: (1) holding the launch resonance at 35 Hz and varying the orbit resonance; (2) analyzing both full and emtpy tanks at launch; (3) varying orbit boundary temperaure; (4) varying the number of struts; (5) varying orbit times; and (6) using or not using vapor cooling. Author

N86-13360# European Space Tribology Lab., Risley (England).
THERMAL VACUUM TESTS ON A HINGE ACTUATOR MECHANISM
J. C. ANDERSON Paris ESA Jan. 1984 18 p refs
(Contract ESA-5199/NL-PP)
(ESA-ESTL-067; ESA-CR(P)-1921) Avail: NTIS HC A02/MF A01

A Hinge Actuator Mechanism (HAM) which provides a controlled rotary motion for deployment underwent tests in vacuum, over an isothermal range of temperatures from +62 to -68 C. The HAM always operates over this temperature range but the time taken for deployment (rotation through 90 deg) varies from 23.28 sec at +82C to 70.16 sec at -68C. The variation is due to the change in resistivity of the aluminum disk rotor in the eddy current brake used to control deployment speed. Also, at temperatures -40 C, the torque of the main bearings increases due to the different thermal contractions of the aluminum alloy housings and steel shafts which results in the elimination of radial clearance in the bearings. Author (ESA)

N86-14281*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCING AUTOMATION AND ROBOTICS TECHNOLOGY FOR THE SPACE STATION AND THE US ECONOMY Progress Report, Apr. - Sep. 1985
A. COHEN Sep. 1985 54 p refs Previously announced as N85-22460 and N85-22461 2 Vol.
(NASA-TM-87772; NAS 1.15:87772; PR-1) Avail: NTIS HC A04/MF A01 CSCL 22B

In response to Public Law 98-371, dated July 18, 1984, the NASA Advanced Technology Advisory Committee has studied automation and rebotics for use in the space station. The Executive Overview, Volume 1 presents the major findings of the study and recommends to NASA principles for advancing automation and robotics technologies for the benefit of the space station and of the U.S. economy in general. As a result of its study, the Advanced Technology Advisory Committee believes that a key element of technology for the space station is extensive use of advanced general-purpose automation and robotics. These systems could provide the United States with important new methods of generating and exploiting space knowledge in commercial enterprises and thereby help preserve U.S. leadership in space. Author

N86-18347*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN ANALYTICAL INVESTIGATION OF A CONCEPTUAL DESIGN FOR THE STATION TRANSVERSE BOOM ROTARY JOINT STRUCTURE
M. S. LAKE and H. G. BUSH Jan. 1986 34 p refs
(NASA-TM-87665; NAS 1.15:87665) Avail: NTIS HC A03/MF A01 CSCL 22B

A study was conducted to define an annular ring, discrete roller assembly concept for the space station transverse boom rotary joint. The concept was analyzed using closed-form and finite element techniques, to size structural members for a range of joint diameters and to determine necessary equivalent stiffnesses for the roller assemblies. Also, a mass study of the system was conducted to determine its practicality, and maximum loads in the joint were identified. To obtain the optimum balance between high stiffness and low structural mass in the design of the rotary joint, it is necessary to maximize the diameter of the annular ring within operational constraints (i.e., shuttle cargo bay size). Further, a rotary joint designed with the largest possible ring diameter will result in minimum operational loads in both the roller assemblies and the transition truss members while also allowing minimum design stiffnesses for the roller assemblies. Author

N86-18990*# California Univ., San Diego. Space Inst.
INDEPENDENT STUDY OF AUTOMATION AND ROBOTICS FOR THE NATIONAL SPACE PROGRAM BY THE AUTOMATION AND ROBOTICS PANEL
25 Feb. 1985 138 p
(Contract NAGW-629)
(NASA-CR-176523; NAS 1.26:176523; DE85-902185; CSI-85-01)
Avail: NTIS HC A07/MF A01 CSCL 05H

Methods are suggested for promoting continual growth in space station automation and robotics. Initial operation capability (IOC) space station design criteria are emphasized that will allow for ever-increasing levels of automation. The required technology advancement in robotics are described. The need is explained for improved human-machine interfaces, manipulators and sensors, and their combination with Earth developed robot technology into hybrid systems. The needed research base in computer science, artificial intelligence, and applied mathematics is discussed. Effects on private and Government Sectors are explained. It is shown that the Station will provide broader opportunities in time, space and society. Organizational recommendations are given for meeting Congressional goals for space station automation and robotics.
DOE

N86-19346# Dynamic Controls, Inc., Dayton, Ohio.
LINEAR ACTUATOR FOR LARGE SPACE STRUCTURE Final Report, Mar. 1983 - May 1984
G. D. JENNEY and J. A. ANDERSON 11 Sep. 1985 31 p
(Contract F33615-83-C-3601)
(AD-A161227; AFWAL-TR-85-3078) Avail: NTIS HC A03/MF A01 CSCL 22B

The impending use of large structures in space has created a requirement controlling their alignment. Structures used for energy gathering, such as antennas or solar energy concentrators, must maintain accurate mechanical alignment in order to operate at maximum efficiency. This paper describes a linear actuation approach designed to meet the alignment requirements of space structures. The approach is based upon using a fluid pump to expand and contract two chambers enclosed by metal bellows. The general configuration is valid for a wide range of force, rate and stroke requirements required for different structure designs.
GRA

N86-20789* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SELF-LOCKING TELESCOPING MANIPULATOR ARM Patent
M. F. NESMITH, inventor (to NASA) 15 Oct. 1985 8 p Filed 30 Sep. 1983
(NASA-CASE-MFS-25906-1; US-PATENT-4,547,121; US-PATENT-APPL-SN-537757; US-PATENT-CLASS-414-753; US-PATENT-CLASS-901-31; US-PATENT-CLASS-901-25; US-PATENT-CLASS-414-718; US-PATENT-CLASS-414-4; US-PATENT-CLASS-212-230) Avail: US Patent and Trademark Office CSCL 13I

A telescoping manipulator arm and pivotable finger assembly are disclosed. The telescoping arm assembly includes a generally T-shaped arm having three outwardly extending fingers guided on grooved roller guides to compensate for environmental variations. The pivotable finger assembly includes four pivoting fingers. Arcuate teeth are formed on the ends of the fingers. A rack having teeth on four sides meshes with each one of the fingers. One surface of the rack includes teeth along its entire surface which mesh with teeth of one of the fingers. The teeth at the remote end of the rack engage teeth of a gear wheel. The wheel includes a worm which meshes with a worn drive shaft of the drive motor providing a ninety degree self-locking drive for locking the fingers in a desired position. A similar drive provides a self-locking drive for positioning the telescoping arm.
Official Gazette of the U.S. Patent and Trakemark Office

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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.

A86-10145#
NEW WORLD FOR AEROSPACE COMPOSITES
W. F. DEMARIO (Northrop Corp., Materials and Process Engineering Section, Ventura, CA) Aerospace America (ISSN 0740-722X), vol. 24, Oct. 1985, p. 36-40, 42.

The applications of composites in aerospace designs are discussed. A description and an explanation of the organic and metal-matrix composites and the reinforcements used in the spacecraft industry are presented. The structural applications for organic and metal-matrix composites for spacecraft are described. Examples of their use in a primary truss assembly, upper and lower cradle assemblies, tubular struts, forward adapter and the engine support of the structure of the Shuttle are provided. The composition and function of the forward adapters of the Shuttle/Centaur and the booms of the Shutttle's remote manipulator system are described. The advantages, applications, and design improvements of thin-ply carbon-carbon are examined. The characteristics of thermoplastic polymers are explained. The development of a new composite which combines aramid and aluminum in a laminate is discussed. I.F.

A86-11809* Scripps Institution of Oceanography, La Jolla, Calif.
UTILIZATION OF SPACE SHUTTLE EXTERNAL TANK MATERIALS BY MELTING AND POWDER METALLURGY
T. S. CHERN (California, University, Scripps Institution of Oceanography, La Jolla) Acta Astronautica (ISSN 0094-5765), vol. 12, Sept. 1985, p. 693-698. refs
(Contract NAS8-35037)

The Crucible Melt Extraction Process was demonstrated to convert scraps of aluminum alloy 2219, used in the Space Shuttle External Tank, into fibers. The cast fibers were then consolidated by cold welding. The X-ray diffraction test of the cast fibers was done to examine the crystallinity and oxide content of the fibers. The compressive stress-strain behavior of the consolidated

materials was also examined. Two conceptual schemes which would adapt the as-developed Crucible Melt Extraction Process to the microgravity condition in space were finally proposed. Author

A86-13085
DEVELOPMENT OF DESIGN DATA ON AN ULTRA-HIGH MODULUS GRAPHITE/EPOXY COMPOSITE FOR SPACE APPLICATION
J. MAIDEN, R. GOUNDER, S. SEEHRA (RCA, Astro-Electronics Div., Princeton, NJ), and H. DORTH (Composite Optics, Inc., San Diego, CA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 135-149.

This paper presents a summary of the work that has been completed at RCA-Astro Electronics to develop design data on a lightweight structural material used in the design of advanced communication satellite hardware. The design data developed includes elastic constants, strength allowables, physical and thermal properties. Data have been developed on RCA-2606114 ultra high modulus graphite/epoxy material system. The mechanical and physical properties were measured at three temperature levels to simulate anticipated geosynchronous operational environments. Design data were also generated on this material conditioned to simulate the end-of-life (EOL) properties. End-of-life properties after exposing to the simulated geosynchronous environment showed, in general, a slight decrease in tensile strength, modulus and shear strength. This degradation in properties is not expected to affect the performance of the ultra high modulus material proposed for use in the spacecraft structures. Author

A86-13096
DEVELOPMENT OF NON-HEAT-CURE COMPOSITES FOR LARGE STRUCTURES
P. JUNEAU, E. MUZIANI, J. KREITZ, and F. P. CURTIS (General Electric Co., Space Div., Philadelphia, PA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 315-329.

Development of resin systems and composites that do not require elevated temperature curing processes is desirable. These systems were developed in order to provide a convenient way to fabricate large reinforced structures without the necessity of using tooling that is resistant to elevated temperatures, and thus making it possible to use low cost mold materials. In addition, since the curing process takes place at room temperature (70-80 F), essentially no strains are introduced into the composite structure, and distortions caused by mismatches in coefficient of thermal expansion of the tool and composite are absent. Mechanical properties, thermal expansivity, and sandwich beam structural data were obtained on the composite. Details of the fabrication process are also described. Author

A86-13134
MULTIPLE DAMPING MATERIALS. I POLYSILOXANE-POLYARYLESTER BLOCK COPOLYMERS: SYNTHESIS AND CHARACTERIZATION
P. J. A. BRANDT, D. C. WEBSTER, and J. E. MCGRATH (Virginia Polytechnic Institute and State University, Blacksburg) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 959-970. refs
(Contract AF-AFOSR-83-0201)

Relatively high molecular weight siloxane-ester block copolymers were prepared by two different synthetic routes. A solution technique was used to prepare well-defined, perfectly alternating block copolymers while an interfacial, phase-transfer technique was used to prepare 'random' block or segmented copolymers. The siloxane block in both types of copolymers contained either dimethyl or dimethyl and diphenyl units. Structure analysis by proton NMR and FTIR verified that the desired starting oligomers and block copolymers were prepared. Due to the high degree of incompatibility of the 'soft' siloxane segments and the 'hard' ester segments in the block copolymers, a two-phase microstructure developed at relatively low block molecular weights. This phenomena was confirmed by preliminary TEM and XPS results. A multi-phase system was also suggested by DSC and DMTA studies where two thermal transitions were observed and attributed to the components of the block copolymers. The DMTA results also showed that several of the copolymer samples may be potential multiple damping materials. Author

A86-13167* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE RADIATION EFFECTS ON AN ELASTOMER-TOUGHENED EPOXY-GRAPHITE COMPOSITE
G. F. SYKES and W. S. SLEMP (NASA, Langley Research Center, Hampton, VA) IN: National SAMPE Symposium and Exhibition, 30th, Anaheim, CA, March 19-21, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 1356-1368. refs

An elastomer-toughened epoxy-graphite composite system (CE339/T300) was evaluated for its potential durability in the space radiation environment. The physical and chemical response of this system was characterized following exposure to radiation doses equivalent to 20 to 30 years in geosynchronous orbit using 1 MeV electrons. The results show that electrons generate extensive crosslinking and embrittlement of the matrix. This embrittlement results in chemical and mechanical property changes that would limit the service life of this epoxy system in some space structure applications. Author

A86-14379*# Perkin-Elmer Corp., Danbury, Conn.
MOISTURE LOSS FROM GRAPHITE STRUCTURES FOR THE HUBBLE SPACE TELESCOPE
T. A. FACEY, N. A. DEFILIPPIS, and P. J. YOUNG (Perkin-Elmer Corp., Space Science Div., Danbury, CT) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 13-17.
(Contract NAS8-32700)
(AIAA PAPER 85-6057)

The construction and telescope assembly of the NASA's Hubble Space Telescope (HST) is described with particular reference to the features of its construction material. Due to the hygroscopic nature of the graphite-fiber reinforced epoxy, used for much of the structure of the HST, the telescope, when in orbit, suffers losses of water, absorbed during on-ground procedures, accompanied by shrinkage of the epoxy matrix, and needs periodic realignment. Using a combination of analytic, laboratory measured, and in-space measured data, an operational plan for adjusting the alignment of the HST is presented. The refocusing plan must take into account the preceding ground environment, as well as the prelaunch, lift-off, and predeployment environments of the HST-bearing Space Shuttle. I.S.

A86-14391#
MEASUREMENT OF PARTICLE CONTAMINATION
J. G. KELLEY (Rockwell International Corp., Seal Beach, CA) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 99-103.
(AIAA PAPER 85-7003)

The impact of particle contamination on spacecraft surfaces is frequently proportional to the surface area obscured. The degree of obscuration is calculated for the levels of cleanliness as defined in MIL-STD-1246A after clarifying the meaning of the size frequency distribution used there. However, it is found that shocks, vibration, and scrubbing can distort the distribution and introduce serious error if small particles are not included in the measurement. Visual appearance of a surface seems to be proportional to reflectivity which is proportional to surface obscuration. Thus, visual appearance seems a more direct measure of the effect of particle contamination than the quantitative measurements of MIL-STD-1246A. Author

A86-14400*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PROTECTIVE COATINGS FOR ATOMIC OXYGEN SUSCEPTIBLE SPACECRAFT MATERIALS - STS-41G RESULTS
A. F. WHITAKER, J. A. BURKA, J. E. COSTON, I. DALINS, S. A. LITTLE (NASA, Marshall Space Flight Center, Huntsville, AL) et al. IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 160-168.
(AIAA PAPER 85-7017)

Sixteen materials consisting of metallizations, silicones, and FEP Teflon were applied as protective coatings to selected spacecraft material surfaces and exposed on STS-41G to the LEO atomic oxygen environment. Evaluations of their protective effectiveness were made through assessing their mass loss/gain characteristics, maintenance of base material optical properties, and imperviousness to atomic oxygen attack. Generally, all coatings provided some degree of protection for the underlying material. In some cases the overcoat appeared to be too thin thereby providing inadequate protection. Author

A86-14402*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
MATERIAL INTERACTIONS WITH THE LOW EARTH ORBITAL ENVIRONMENT ACCURATE REACTION RATE MEASUREMENTS
J. T. VISENTINE and L. J. LEGER (NASA, Johnson Space Center, Houston, TX) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 175-180. refs
(AIAA PAPER 85-7019)

Interactions between spacecraft surfaces and atomic oxygen within the low earth orbital (LEO) environment have been observed and measured during Space Shuttle flights over the past 3 yr. The results of these experiments have demonstrated that interaction rates for many materials proposed for spacecraft applications are high and that protective coatings must be developed to enable long-lived operation of spacecraft structures in the LEO environment. A flight experiment discussed herein uses the Space Shuttle as an orbiting exposure laboratory to obtain accurate reaction rate measurements for materials typically used in spacecraft construction. An ion-neutral mass spectrometer, installed in the Orbiter cargo bay, will measure diurnal ambient oxygen densities while material samples are exposed at low altitude (222 km) to the orbital environment. From in situ atomic oxygen density information and postflight material recession measurements, accurate reaction rates can be derived to update the Space Station materials interaction data base. Additionally, gases evolved from a limited number of material surfaces subjected to direct oxygen impingement will be identified using the mass spectrometer. These measurements will aid in mechanistic definitions of chemical reactions which cause atom-surface interactions and in validating results of upcoming degradation studies conducted in ground-based neutral beam laboratories.
Author

A86-14403*# Communications Research Centre, Ottawa (Ontario).
RESULTS OF APPARENT ATOMIC OXYGEN REACTIONS WITH SPACECRAFT MATERIALS DURING SHUTTLE FLIGHT STS-41G
D. G. ZIMCIK (Department of Communications, Communications Research Centre, Ottawa, Canada) and C. R. MAAG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 181-189. NASA-supported research. refs
(AIAA PAPER 85-7020)

The effect of atomic oxygen interaction experienced by polymeric-based spacecraft materials is described. An experimental package (ACOMEX) flown on shuttle mission STS-41G carried out the investigation of advanced composite specimens such as carbon-epoxy and Kevlar-epoxy both with and without protective coatings added to thermal protective paints and films. Information on the exposure environment of the specimens was provided by a carbon coated atomic oxygen fluence monitor together with a photographic record. Mass loss measurements and photomicrographs made possible the analysis of the effect of interaction. After a total of about 38 hours of equivalent normal exposure at 225 km altitude the results showed that unprotected exposed surfaces exhibited severe erosion and mass loss with the possibility of seriously degrading structural and thermal performance. However, the specimens with a thin fluorocarbon overcoat showed promise of providing a protective barrier to the attack without altering the base properties of the material. F.J.

A86-14404#
EVALUATION OF OXYGEN INTERACTION WITH MATERIALS (EOIM) - STS-8 ATOMIC OXYGEN EFFECTS
K. A. SMITH (TRW, Inc., TRW Electronics and Defense Sector, Redondo Beach, CA) IN: Shuttle Environment and Operations II Conference, Houston, TX, November 13-15, 1985, Technical Papers . New York, AIAA, 1985, p. 190-197. refs
(AIAA PAPER 85-7021)

Six test samples were flown on STS-8. Unprotected Kapton and Kapton overcoated with 400 A of sputtered indium tin oxide were exposed to ram neutral atomic oxygen impingement and unprotected Kapton and Kapton overcoated with 1100 A of vacuum deposited SiO(x) were exposed to reflected oxygen impingement. The unprotected Kapton exposed to ram impingement exhibited significant increase in spectral absorptance while sources of silicon oxides and aluminum oxides formed a protective layer on the Kapton surface providing partial protection from oxygen attack. The unprotected Kapton exposed to reflected impingement and both protected Kapton samples exhibited little degradation. Capture of small alumina particles suspected to be from solid rocket exhaust occurred on the surfaces of the test specimens. Two contaminated samples with oxygen inert substrates were exposed to ram atomic oxygen flux; certain classes of outgassed contaminants may be cleaned off critical spacecraft surfaces. Author

A86-14428*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ION BEAM SPUTTER-DEPOSITED THIN FILM COATINGS FOR PROTECTION OF SPACECRAFT POLYMERS IN LOW EARTH ORBIT
B. A. BANKS, M. J. MIRTICH, S. K. RUTLEDGE, D. M. SWEC (NASA, Lewis Research Center, Cleveland, OH), and H. K. NAHRA (Cleveland State University, OH) AIAA, Aerospace Sciences Meeting, 23rd, Reno, NV, Jan. 14-17, 1985. 17 p. Previously announced in STAR as N85-30137. refs
(AIAA PAPER 85-0420)

Ion beam sputter-deposited thin films at Al2O3, SiO2, and a codeposited mixture of predominantly SiO2 with small amounts of fluoropolymer were evaluated both in laboratory plasma ashing tests and in space on board Shuttle flight STS-8 for effectiveness in preventing oxidation of polyimide Kapton. Measurements of mass loss and optical performance of coated and uncoated polyimide samples exposed to the low earth orbital environment are presented. Optical techniques were used to measure loss rates of protective films exposed to atomic oxygen. Results of the analysis of the space flight exposed samples indicate that thin film metal oxide coatings are very effective in protecting the polyimide. Metal oxide coatings with a small amount of fluoropolymer codeposited have the additional benefit of great flexibility. Author

A86-15752#
THERMOELASTIC CHARACTERISTICS TESTING ON KEVLAR SAMPLES FOR SPACECRAFT STRUCTURES
L. BALIS CREMA, R. BARBONI, A. CASTELLANI, and I. PERONI (Roma, Universita, Rome, Italy) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-215)

The tensile properties, the thermal expansion coefficient, and the thermal conductivity of woven roving (WR) reinforced Kevlar laminae were experimentally determined. Theoretical values were

calculated by simulating a lamina of fabric as an equivalent cross-ply laminate. With respect to the thermal expansion coefficient, the fabrics have shown an isotropic behavior. The thermal conductivity normal to the fabric plane has also been determined. Author

A86-17323* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
APPLICATIONS OF SPHERICAL SHELLS
T. G. WANG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 105-114. refs
(Contract NAS7-918)
(AAS PAPER 84-123)

A new technique of producing hollow spheres of many materials at a very rapid rate, at very low cost, and with high reproducibility of shell diameter and wall thickness has been developed. Shells formed of metal or of other solid materials are expected to find numerous technical and industrial applications. For example, metal shells might be used as inertial confinement fusion targets, or as the principal constituents in lightweight structural materials for NASA Space Stations or DOD large antennas and mirrors, or be employed as containers for phase-change heat-storage media, or serve as containers for hazardous materials, or be employed as catalytic surface agents. Author

A86-17835*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPATIBILITY OF GRAIN-STABILIZED PLATINUM WITH CANDIDATE PROPELLANTS FOR RESISTOJETS
M. V. WHALEN and S. P. GRISNIK (NASA, Lewis Research Center, Cleveland, OH) AIAA, JSASS, and DGLR, International Electric Propulsion Conference, 18th, Alexandria, VA, Sept. 30-Oct. 2, 1985. 21 p. Previously announced in STAR as N86-10279. refs
(AIAA PAPER 85-2014)

An examination is conducted into the suitability of grain-stabilized Pt as a resistojet thruster material for Space Station auxiliary propulsion. A series of 1000-hour tests was conducted in CO2, H2, and NH3 at 1400 C; another series was conducted at 500 C in CH4 for the same duration. SEM, Auger electron microscopy, and depth profiling analysis were used to determine the effects of propellants on the material surface as well as to evaluate possible material contamination and possible grain growth. Carbon deposition is noted on the surface of Pt/Y2O3 and Pt/ZrO2 in both the CO2 and CH4 environments. O.C.

A86-21751
DESIGN AND MANUFACTURING OF ADVANCED COMPOSITE TUBES FOR A COMMUNICATIONS SPACECRAFT
H. HILLESLAND and D. SMITH (Ford Aerospace and Communications Corp., WDL Div., Palo Alto, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 604-609.

Advanced composite tubular components have been utilized in a number of structural applications in communications spacecraft. Design tradeoff studies that include a variety of structural parameters, thermal stability, low coefficient of expansion, ease of manufacturing, and spacecraft component assembly indicate advanced composite tubular components to be one of the most efficient techniques for meeting these critical requirements. The basic design parameter, materials selection, manufacturing methods of a typical spacecraft tubular truss structure are illustrated. Author

A86-21757
METAL CLAD TUBULAR STRUCTURES FOR ATOMIC OXYGEN ENVIRONMENTS
D. M. MAZENKO, B. C. PETRIE, and R. M. BLUCK (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: National SAMPE Technical Conference, 17th, Kiamesha Lake, NY, October 22-24, 1985, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1985, p. 677-687. refs

The attractive potential attributes of aluminum clad graphite epoxy tubes are enumerated. Effects of atomic oxygen on organic spacecraft materials in low earth orbit are evaluated. Some effects on graphite epoxy structures are described. Several promising approaches for providing protection such as metallic and inorganic coatings are discussed. Development of aluminum clad graphite epoxy tubes is described and ancillary benefits are noted. Some very preliminary test results are presented. Author

A86-22999#
ADVANCED COMPOSITE MATERIALS EXPOSURE TO SPACE EXPERIMENT (ACOMEX) ON STS 41-G
D. G. ZIMCIK (Department of Communications, Communications Research Centre, Ottawa, Canada) (CASI, Canadian Conference on Astronautics, 3rd, Ottawa, Canada, Apr. 23, 24, 1985) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 31, Sept. 1985, p. 249-255.

The Advanced Composite Materials Exposure to Space Experiment, designated 'ACOMEX', flew aboard Space Shuttle mission STS 41-G to investigate the effect of atomic oxygen in low earth orbit on polymerically based composite materials (carbon-epoxy and kevlar-epoxy) with and without protective surface coatings, in addition to a number of thermal protective paints and films. Analyses of the exposed surfaces indicate significant change, representing serious degradation of both structural and thermal performance. SEM photomicrographs are presented, together with mass-loss measurements, to identify the surface morphology of the exposed specimens and the magnitude of the effect. Atention is given to a carbon-coated atomic oxygen fluence monitor which furnishes detailed data on the environment experienced by the exposed specimens. O.C.

A86-25523
THICKNESS SCALING FOR ARC DISCHARGES ON ELECTRON-BEAM-CHARGED DIELECTRICS
K. G. BALMAIN, A. BATTAGIN, and G. R. DUBOIS (Toronto, University, Canada) (IEEE, DNA, Sandia National Laboratories, and NASA, 1985 Annual Conference on Nuclear and Space Radiation Effects, 22nd, Monterey, CA, July 22-24, 1985) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-32, Dec. 1985, p. 4073-4078.
(Contract AF-AFOSR-84-0342; NSERC-A-4140)

A study of arc discharges on various thicknesses of electron-beam-charged Mylar, FEP Teflon and Kapton shows that the peak substrate current and the energy dissipated in a load registor both exhibit maxima at a particular thickness of the order of 50 microns, for one set of experiment parameters. The experiments also show that, as thickness increases, this particular thickness is the transition from near-constant to decreasing released charge, and, for Mylar, from decreasing to near-constant arc duration. This transition is interpreted as being caused primarily for thin specimens by punchthrough formation and possibly influenced by the transition from conduction-dominated to emission-dominated charging. Additional low-energy ion exposure is shown to weaken and sometimes eliminate the arc discharges without radically altering the thickness scaling. At low fluxes, the incident ions are focussed into a central spot. Author

A86-25672* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SCREENING AND TESTS OF MATERIALS FOR SPACE APPLICATIONS
J. J. SCIALDONE (NASA, Goddard Space Flight Center, Greenbelt, MD) Journal of Environmental Sciences (ISSN 0022-0906), vol. 29, Jan.-Feb. 1986, p. 24-26. refs

The outgassing properties of materials and other considerations on materials acceptance for space applications are discussed. The uses of the outgassing data for the evaluation of important performance characteristics of a space system are indicated. The deficiencies and advantages of the ASTM-E595-77 test method and materials acceptance criteria are discussed. Also discussed are the advantages for the selection of the materials and the uses of the data provided by the long-term measurements of the outgassing rates and surface re-emission of materials. The paper concludes that the results of the ASTM method with additional derived data on the material properties can be used for the initial evaluation of a space system's characteristics. Materials data on outgassing and re-emission rates at various temperatures obtained from the more expensive, long-term QCM and TGA measurements should be obtained when a detailed analysis of a system is suggested based on the various considerations discussed in the paper. Author

A86-27140
ELECTROSTATIC CHARGING CHARACTERISTICS OF SILVERIZED TEFLON TAPE AND CARBON LOADED KAPTON SPIRAL WRAP THERMAL BLANKET MATERIALS
K. J. DEGRAFFENREID (ESL, Inc., Sunnyvale, CA) IN: International Symposium on Electromagnetic Compatibility, Wakefield, MA, August 20-22, 1985, Record . New York, Institute of Electrical and Electronics Engineers, 1985, p. 273, 274.

This paper presents results of electron vacuum chamber testing of five mil perforated silverized Teflon tape and one mil carbon loaded Kapton spiral wrap thermal blanket materials. Characterization of the electrostatic charging and discharging behavior of the ungrounded materials in the simulated geosynchronous orbit substorm environment is presented. The relative effectiveness of various grounding techniques in mitigating charging effects is also discussed. Author

N86-10279*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
COMPATIBILITY OF GRAIN-STABILIZED PLATINUM WITH CANDIDATE PROPELLANTS FOR RESISTOJETS
M. V. WHALEN and S. P. GRISNIK 1985 21 p refs Presented at the 18th Intern. Elec. Propulsion Conf., Alexandria, Va., 30 Sep. - 2 Oct. 1985; cosponsored by AIAA, DGLR and JSASS
(NASA-TM-87118; E-2725; NAS 1.15:87118; AIAA-85-2014)
Avail: NTIS HC A02/MF A01 CSCL 21I

Resistojets are candidates for space station auxiliary propulsion, and should be characterized by both long life and multipropellant operations, requirements limited by available materials. Grain stabilized platinum is examined for use as a resistojet thruster material. Use of platinum in other applications indicates it can be used at moderately high temperatures for extended periods of time. Past results indicate that grain-stabilized platinum should be sufficiently inert in candidate propellant environments. Therefore, compatibility of platinum-yttria (P/Y2O3) and platinum-zirconia (Pt/ZrO2) with carbon dioxide, methane, hydrogen and ammonia is examined. A series of 1000 hr tests in CO2, H2, and NH3 is conducted at 1400 C and a series of 1000 hr tests in CH4 is conducted at about 500 C. Scanning electron microscopy, Auger electron spectroscopy and depth profiling analysis are then used to determine the effects of propellants on the material surface, to evaluate possible material contamination and to evaluate grain growth. The results indicate that there is carbon deposition on the surface of the Pt/Y2O3 and Pt/ZrO2 in both the CO2 and CH4 environments. In the H2 environment, the Pt/Y2O3 and Pt/ZrO2 specimen surfaces are roughened. After exposure to the NH3 environment, the Pt/Y2O3 and Pt/ZrO2 are roughened and pitted over the entire heated area with some pitted areas along the grain boundaries. SEM photos show grain growth in cross-sectional views of all the Pt/Y2O3 samples and the Pt/ZrO2 samples, except that tested in methane. Mass loss measurements indicate that Pt/Y2O3 and Pt/ZrO2 would last in excess of 200,000 hr in each propellant environment. However, in NH3 both Pt/Y2O3 and Pt/ZrO2 are severely pitted, with voids up to 50 percent into the material. Pt/Y2O3 and Pt/ZrO2 are not recommended for high temperature service in NH3. Author

N86-11299*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MANUAL FOR LDEF TENSILE TESTS
W. G. WITTE, JR. Oct. 1985 40 p refs
(NASA-TM-87624; NAS 1.15:87624) Avail: NTIS HC A03/MF A01 CSCL 11D

One of the experiments aboard the NASA Long Duration Exposure Facility (LDEF) consists of a tray of approximately one hundred tensile specimens of several candidate space structure composite materials. During the LDEF flight the materials will be subjected to the space environment and to possible contamination during launch and recovery. Tensile tests of representative samples were made before the LDEF flight to obtain baseline data. Similar tests will be made on control specimens stored on earth for the length of the LDEF flight and on recovered flight specimens. This manual codifies the details of testing, data acquisition, and handling used in obtaining the baseline data so that the same procedures and equipment will be used on the subsequent tests. Author

N86-11300# Martin Marietta Aerospace, Denver, Colo.
METALLURGICAL CHARACTERIZATION OF THE INTERFACES AND THE DAMPING MECHANISMS IN METAL MATRIX COMPOSITES Progress Report, 4 Feb. 1984 - 12 Jun. 1985
M. S. MISRA 12 Jun. 1985 11 p
(Contract N00014-84-C-0413)
(AD-A156507; MCR-85-605-ISSUE-1; PR-1) Avail: NTIS HC A02/MF A01 CSCL 11D

Metal matrix composites are candidate structural materials for space applications. Large structures in space encounter natural and hostile disturbances, which introduce vibrations of a broad spectrum of frequencies. These vibrations must be damped fast enough for effective maneuverability and dynamic dimensional precision. In the vibrational control designs of such structures, damping capacity of the structural material is a significant parameter. If metal matrix composites are to be used for space structures; their intrinsic damping behavior needs to be clearly understood and improved if necessary, through metallurgical modifications. In this report, a graphite-aluminum composite has been selected to study the microstructural features and mechanisms responsible for dissipating vibrational energy. The objectives of this program were to develop a reliable test technique to accurately measure the damping capacity of metal matrix composites; perform metallurgical characterization of the interface structures; investigate the damping mechanism in metal matrix composites; and recommend microstructural modifications to enhance damping in metal matrix composites. GRA

N86-12249# Los Alamos National Lab., N. Mex.
GROUND-BASED INVESTIGATIONS OF ATOMIC OXYGEN INTERACTIONS WITH SPACE STATION SURFACES
J. B. CROSS, D. A. CREMERS, and D. F. TUCKER 1985 12 p Presented at the AIAA Thermophys. Conf., Williamsburg, Va., 18 Jun. 1985
(Contract W-7405-ENG-36)
(DE85-014082; IA-UR-85-2220; CONF-850607-4) Avail: NTIS HC A02/MF A01

Ground-based simulation and testing facilities were developed to investigate atomic oxygen interactions with space station surfaces which include a high kinetic energy O-atom source, a sample exposure chamber and a high sensitivity molecular beam apparatus. The sample exposure chamber is suited for surveying materials for their O-atom reactivity through weight loss measurements. The high sensitivity molecular beam apparatus will be used to determine reaction mechanisms through measurements

of reaction product identity, translational and internal state of products, and angular distribution of reaction products. The O-atom source, based on the use of a laser sustained discharge, demonstrated O-atom translational temperatures of 8 to 9000 K and is presently operating with 50% oxygen in argon using 500 watts of CO2 laser power which is expected to produce velocities of 4 to 5 km/s. One hour exposures of kapton, two types of fiber glass epoxy materials, and MgF2 coated optics were accomplished and preliminary results indicate that the coated aluminum optics have very low reaction rates while kapton has the highest rate. DOE

N86-13267*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SPACE SHUTTLE MECHANISTIC STUDIES TO CHARACTERIZE ATOMIC OXYGEN INTERACTIONS WITH SURFACES
L. J. LEGER and J. T. VISENTINE *In* NASA. Marshall Space Flight Center 2d Workshop on Spacecraft Glow p 270-273 Sep. 1985
Avail: NTIS HC A13/MF A01 CSCL 03B

A materials interaction experiment has been approved to study atomic oxygen interaction mechanisms and develop coatings for Space Station elements requiring long-lived operation in the LEO environment. A brief summary of this experiment is presented and the required exposure conditions are reviewed. Author

N86-15391*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STUDIES OF MOLECULAR PROPERTIES OF POLYMERIC MATERIALS: AEROSPACE ENVIRONMENTAL EFFECTS ON THREE LINEAR POLYMERS Final Technical Report, 1 Nov. 1984 - 31 Oct. 1985
W. L. HARRIES (Old Dominion Univ., Norfolk, Va.), H. R. RIES (Old Dominion Univ., Norfolk, Va.), C. A. BRADBURY (Old Dominion Univ., Norfolk, Va.), S. L. GRAY (Old Dominion Univ., Norfolk, Va.), W. D. COLLINS (Old Dominion Univ., Norfolk, Va.), S. A. T. LONG, and E. R. LONG, JR. Dec. 1985 42 p refs
(Contract NCC1-90)
(NASA-TM-87532; NAS 1.15:87532) Avail: NTIS HC A03/MF A01 CSCL 11B

The development of crystal handling techniques for reflection infrared spectroscopy and methods for the fabrication and testing of tensile specimens are discussed. Data from mechanical, ac and dc electrical, and electron paramagnetic resonance studies conducted to determine the effects of 0.1-MeV and 1.0-MeV electron radiation on Mylar, Kapton, Ultem, and metal-doped Ultem are presented. Total doses ranging from 1 X 10 to the 8 rads to 1 X 10 to the 10 rads and dose rates from 5 X 10 to the 7 rads/hr to 1 X 10 to the 9 rads/hr were employed. The results of a study on the effects of aircraft service-environment fluids on Ultem are also reported. The weights and mechanical properties of Ultem were evaluated before and after exposure to water, JP4, Skydrol, an antifreeze, and a paint stripper.

N86-15392*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STUDIES OF MOLECULAR PROPERTIES OF POLYMERIC MATERIALS: AEROSPACE ENVIRONMENTAL EFFECTS ON THREE LINEAR POLYMERS (POLYMER DURABILITY)
In its Studies of Molecular Properties of Polymeric Materials: Aerospace Environmental Effects on Three Linear Polymers p 1-34 Dec. 1985 refs
Avail: NTIS HC A03/MF A01 CSCL 11B

Aerospace environmental effects on polymeric materials were studied. The polymers under study are being considered for use as structural materials for spacecraft and advanced aircraft. It is necessary to understand the durability of these polymers to the environment in which they are to be used. G.L.C.

N86-18550# SRI International Corp., Menlo Park, Calif.
NEW POLYMERIC MATERIALS EXPECTED TO HAVE SUPERIOR PROPERTIES FOR SPACE-BASED USE Final Report, Apr. 1981 - Jun. 1983
D. B. COTTS and Z. REYES Jul. 1985 222 p
(Contract F19628-81-C-0075)
(AD-A160285; RADC-TR-85-129) Avail: NTIS HC A10/MF A01 CSCL 11I

The properties of electrically conducting, semiconducting and semiinsulating polymers were surveyed and their conduction mechanism, mechanical properties, and suitability for spacebased use evaluated. Correlations between molecular structure, conductivity, and mechanical properties were drawn, and a comprehensive model of electrical conductivity in organic polymers was formulated. Although the most widely studied electrically conducting polymers are not robust enough for most space-based uses, several commercial materials, including pyrolyzed Kapton and polyvinyl carbazole, appear to have the necessary combination of electrical, thermal, and mechanical properties. The main obstacle to the selection of new or modified materials for spacecraft use is the lack of strength, thermal stability, and radiation resistance--not their conductivity. Several synthesis procedures are identified that would raise the value of these properties to acceptable levels for materials that have the required electrical properties. The wide range of data reported in the literature can be reconciled by a theory of conductivity in which the limiting feature is the rate at which electrons are transferred between localized charges states. Some of the new polymers identified by this model have been prepared. They possess relatively high electrical conductivities and, unlike the majority of electrically conducting polymers, are processable in organic solvents. GRA

N86-21573# General Electric Co., Schenectady, N. Y.
DEVELOPMENT OF SPACECRAFT MATERIALS AND STRUCTURES FUNDAMENTALS Final Scientific Report, 1 Jun. 1984 - 31 May 1985
S. PROCHAZKA and S. L. DOLE Aug. 1985 87 p
(Contract F49620-83-C-0101)
(AD-A161338; SRD-85-021; AFOSR-85-0974TR) Avail: NTIS HC A05/MF A01 CSCL 11B

Compacts of boron carbide powders with specific surface area = or 8 sq m/g were sintered in argon at temperatures near 2200C. Several of these powders were prepared by attrition milling of abrasive grade boron carbide. Densification to 95+% of theoretical density could be obtained only with compositions that had appropriate amounts of excess carbon. The microstructures were fine grained and uniform but underwent abnormal grain growth above 2235C accompanied by transgranular microcracking. This grain growth could be inhibited by increasing the carbon content. Mechanical damping capacity was measured by the free beam and cantilevered beam techniques on boron carbide and other materials. Methods to enhance the damping capacity in a beam structure were analyzed. The flexural strength of sintered boron carbide was evaluated and related to powder processing and sintering parameters. Author (GRA)

N86-21598*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THERMALLY INDUCED STRESSES AND DEFORMATIONS IN LAYERED COMPOSITE TUBES
D. E. COOPER (Virginia Polytechnic Inst. and State Univ., Blacksburg), D. COHEN (Virginia Polytechnic Inst. and State Univ., Blacksburg), C. Q. ROUSSEAU (Virginia Polytechnic Inst. and State Univ., Blacksburg), M. W. HYER (Virginia Polytechnic Inst. and State Univ., Blacksburg), and S. S. TOMPKINS *In* Virginia Polytechnic Inst. and State Univ. Proceedings of the 2nd Annual Review of the Center for Composite Materials and Structures 37 p Apr. 1985 Sponsored in part by NASA
(Contract NAG1-343)
Avail: NTIS HC A15/MF A01 CSCL 11D

The thermally induced stresses and deformations in layered, orthotropic tubes are studied. The motivation for studying tubes is their likely application for use in space structures. Tubes are a

strong candidate for this application because of their high structural efficiency, as measured by stiffness per unit weight, and their relative ease of fabrication. Also, tubes have no free edges to deteriorate or delaminate. An anticipated thermal condition for tubes in space is a circumferential temperature gradient. This type of gradient will introduce dimensional changes into the structure and may cause stresses large enough to cause damage to the material. There are potentially large differences in temperatures at different circumferential locations on the tube. Because of this, the effects of temperature dependent material properties on the stresses and deformations may be important. The study is composed of three parts: experiments to determine the functional form of the circumferential gradient and to measure tube deflections; an elasticity solution to compute the stresses and deformations; and an approximate approach to determine the effects of temperature dependent material properties. Author

N86-21887*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
EXPERIMENTAL MEASUREMENT OF MATERIAL DAMPING FOR SPACE STRUCTURES
E. F. CRAWLEY and R. L. SHEEN *In* AFWAL Vibration Damping 1984 Workshop Proceedings 18 p Nov. 1984 refs Sponsored in part by US Air Force
(Contract NAGW-21)
Avail: NTIS HC A99/MF A01 CSCL 20K

A procedure for the measurement of material damping is described. The free decay of free-free beams, when lofted into free fall in vacuum, was recorded. Tests were performed on aluminum, graphite/epoxy, and graphite/magnesium metal matrix materials. Specimens with a fundamental free-free frequency below the elaxation frequency showed a higher level of damping and of stress dependence than predicted. For 0 sub 8 laminates, a material damping ratio of 0.00055 was found for fequencies varying from 45 Hz to 237 Hz. The damping was neither stress nor frequency dependent. For 90 sub 8 laminates, the damping ratio ranged from 0.0055 to 0.0066 as frequency ranged from 42 Hz to 143 Hz. Damping ratios for 90 sub 8 specimens were independent of stress. Experimentally measured damping ratios for metal matrix specimens with unidirectional graphite fibers, magnesium matrix, and either titanium or magnesium foil, ranged from .00039 to .00099, depending upon the matrix material, frequency, and possibly the stress range involved. E.A.K.

N86-21894# Martin Marietta Aerospace, Denver, Colo. Aerospace Div.
A DERIVATION OF EQUIVALENT LINEAR VISCOUS AND ELASTIC CONSTANT FOR VISCOELASTIC MATERIALS
S. R. DAHL and R. B. RICE *In* AFWAL Vibration Damping 1984 Workshop Proceedings 8 p Nov. 1984
Avail: NTIS HC A99/MF A01 CSCL 20K

A testing method to directly measure the hysteresis characteristics of a viscoelastic material for shear displacement was devised. Three commonly available materials were tested over a frequency range of 0.1 to 100 Hz. Though the materials are essentially nonlinear, linear elastic and viscous damping parameters were approximated using an equivalent energy approach valid for specific frequencies and amplitudes. The linearized parameters can be used in linear structural and control systems analysis programs for the analysis of structures with distributed discrete passive damping mechanisms. E.A.K.

N86-22460*# Auburn Univ., Ala. Dept. of Physics.
SURFACE ANALYSIS OF SPACE TELESCOPE MATERIAL SPECIMENS Final Report
A. T. FROMHOLD and K. DANESHVAR 15 Jun. 1985 120 p
(Contract NASA ORDER H-78184B)
(NASA-CR-178712; NAS 1.26:178712) Avail: NTIS HC A06/MF A01 CSCL 03A

Qualitative and quantitative data on Space Telescope materials which were exposed to low Earth orbital atomic oxygen in a controlled experiment during the 41-G (STS-17) mission were obtained utilizing the experimental techniques of Rutherford backscattering (RBS), particle induced X-ray emission (PIXE), and ellipsometry (ELL). The techniques employed were chosen with a view towards appropriateness for the sample in question, after consultation with NASA scientific personnel who provided the material specimens. A group of eight samples and their controls selected by NASA scientists were measured before and after flight. Information reported herein include specimen surface characterization by ellipsometry techniques, a determination of the thickness of the evaporated metal specimens by RBS, and a determination of trace impurity species present on and within the surface by PIXE. Author

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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.

A86-11403#
DATA SYSTEMS FOR THE SPACE STATION AND BEYOND
J. R. GARMAN IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 9-17. refs
(AIAA PAPER 85-5040)

This paper addresses the use of data systems within the Space Station Program both as management and engineering tools as well as operational components, flight and ground, of the overall Space Station system and the effects that can be projected across the Agency back into Shuttle operations and forward into future development and operational programs. In sum, this paper discusses the changing nature of software architectures and the growing leverage of software and computers on the success of a major program like the Space Station. It contrasts the characteristics of the flight and ground support systems for the Space Station to those of the Shuttle and prior programs, and pleads the case for an end to unique project support systems and architectures in the name of cost, evolution, and technology transparency. It examines the JSC strategy toward data systems and the application of that macroarchitecture and approach toward data systems development and utilization on the Space Station Program. Author

A86-11414*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
STANDARDS FOR SPACE DATA SYSTEMS
E. B. CONNELL (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Computers in Aerospace Conference, 5th, Long Beach, CA, October 21-23, 1985, Technical Papers . New York, AIAA, 1985, p. 100-102.
(AIAA PAPER 85-5061)

NASA has chaired the Consultative Committee for Space Data Systems (CCSDS) for the past four years. During that time, a top-level, end-to-end reference model for space data sytems has been developed that identifies the functions anad services which must be provided by space data systems, and defines the interfaces between major functional elements. A group of definitions for standard protocols has been derived by analyzing these interfaces, and a set of detailed guidelines for space data system standards is in the final stages of negotiation among member CCSDS agencies. Two guidelines that address packet telemetry and channel coding have been approved and are being incorporated into the internal standards of member agencies. Others (packet telecommand, time code, standards data format unit) are in review within CCSDS technical panels and will soon be submitted for approval. These guidelines provide a mechanism for significant cost savings in the implementation of space data systems by allowing reuse of hardware and software for different payloads

and for missions, and by enabling the substitution of new technology/higher performance elements at key points in the data system without causing major perturbations in the remainder of the system. Author

A86-17744
INTERNATIONAL COOPERATION IN ASSURING CONTINUITY OF ENVIRONMENTAL SATELLITE DATA
K. D. HODGKINS, J. M. MACLURE, R. O. MASTERS (NOAA, National Environmental Satellite, Data, and Information Service, Washington, DC), and R. B. CLUPEK (EPA, Office of External Affairs, Washington, DC) Space Policy (ISSN 0265-9646), vol. 1, Nov. 1985, p. 415-422. refs

Methods of maintaining the free flow of international meteorological remote sensing satellite data are described. The exchange of technical satellite information and bilateral cooperation are discussed; examples of organizations which assure the international exchange of data are provided. Various means of sharing future Space Station polar-orbiting platform data are studied. Institutional models based on already established international organizations are evaluated for the proper selection of an international monitoring system. Important factors which need to be considered in establishing an international organization to provide continuous availability and access to satellite data are: national security, cost and control, the transfer of technical information, and the role of nonparticipating nations. I.F.

A86-18367
DEVELOPING SPACE STATION SYSTEMS
R. HATHAWAY Space (ISSN 0267-954X), vol. 1, Sept. 1985, p. 10-13.

The communication requirements for the Space Station are discussed. The functions of the main station, free flying and polar platforms, and OTVs are examined. The development of a data relay satellite for communication between the ground and the Space Station is studied. The data management system is to include: (1) onboard computer hardware, (2) onboard computer software, and (3) a high speed data bus; a description of these subsystems is provided. The communication advantages of the Space Shuttle are discussed. The need for steering antennas in order to utilize the Space Station as a news-gathering system and to provide television program transmissions is analyzed. Various links which will provide economical communication between the Space Station and other orbiting vehicles are proposed. The monitoring and control of the Space Station's position and orbit will be achieved with a broadband telemetry link. The development and functions of a tracking and data relay satellite system are examined. I.F.

A86-21880*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION DATA SYSTEMS DEVELOPMENT
J. P. BIGHAM, JR. (NASA, Johnson Space Center, Houston, TX) IN: EASCON '84; Proceedings of the Seventeenth Annual Electronics and Aerospace Conference, Washington, DC, September 10-12, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 135-139.

The content and status of the evolving Space Station Data System (SSDS) development program are presented. High level system requirements and schedules are reviewed, and the challenges of SSDS development are discussed. Present content of the program consists of three major activities: (1) two contracted parallel Space Station Data System architecture studies; (2) the space station phase B definition studies to be awarded in early 1985; and (3) a test bed project for the evaluation and proof-of-concept of data systems technology for space station applications and for the advanced development of long-lead hardware and software for the initial and growth space station configurations. An overview of the present SSDS concept is provided, and the roles of NASA centers in this activity are summarized. Author

A86-21973* Honeywell, Inc., Bloomington, Minn.
OPTICAL PROCESSING FOR FUTURE COMPUTER NETWORKS
A. HUSAIN, P. R. HAUGEN, L. D. HUTCHESON (Honeywell Physical Sciences Center, Bloomington, MN), J. WARRIOR (Honeywell Technology Strategy Center, Roseville, MN), N. MURRAY, and M. BEATTY (NASA, Langley Research Center, Hampton, VA) Optical Engineering (ISSN 0091-3286), vol. 25, Jan. 1986, p. 108-116. refs
(Contract NAS1-17657)

In the development of future data management systems, such as the NASA Space Station, a major problem represents the design and implementation of a high performance communication network which is self-correcting and repairing, flexible, and evolvable. To obtain the goal of designing such a network, it will be essential to incorporate distributed adaptive network control techniques. The present paper provides an outline of the functional and communication network requirements for the Space Station data management system. Attention is given to the mathematical representation of the operations being carried out to provide the required functionality at each layer of communication protocol on the model. The possible implementation of specific communication functions in optics is also considered. G.R.

A86-27777* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
REVIEW OF LASER AND RF SYSTEMS FOR SPACE PROXIMITY OPERATIONS
K. KRISHEN and H. O. ERWIN (NASA, Johnson Space Center, Houston, TX) IN: ITC/USA/'85; Proceedings of the International Telemetering Conference, Las Vegas, NV, October 28-31, 1985 . Research Triangle Park, NC, Instrument Society of America, 1985, p. 1-25. refs

The development of ranging and tracking systems for NASA space missions is discussed. Among the systems described are: rendezvous and docking (RAD) radar systems for the Gemini and Apollo programs; the Shuttle Rendezvous Ku-band radar system; and laser and TV docking systems RAD sensors systems for the Space Station. A multi-target microwave tracking system for Shuttle applications in the future is also described. I.H.

N86-14478*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ANALOG FM/FM VERSUS DIGITAL COLOR TV TRANSMISSION ABOARD SPACE STATION
M. M. HART Oct. 1985 16 p refs
(NASA-TM-87578; NAS 1.15:87578) Avail: NTIS HC A02/MF A01 CSCL 17B

Langley Research Center is developing an integrated fault tolerant network to support data, voice, and video communications aboard Space Station. The question of transmitting the video data via dedicated analog channels or converting it to the digital domain for consistancy with the test of the data is addressed. The recommendations in this paper are based on a comparison in the signal-to-noise ratio (SNR), the type of video processing required aboard Space Station, the applicability to Space Station, and how they integrate into the network. Author

N86-15177*# Houston Univ., Clear Lake, Tex.
SOME KEY CONSIDERATIONS IN EVOLVING A COMPUTER SYSTEM AND SOFTWARE ENGINEERING SUPPORT ENVIRONMENT FOR THE SPACE STATION PROGRAM
C. W. MCKAY and R. L. BOWN *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 221-230 1985 refs
Avail: NTIS HC A25/MF A01 CSCL 09B

The space station data management system involves networks of computing resources that must work cooperatively and reliably over an indefinite life span. This program requires a long schedule of modular growth and an even longer period of maintenance and operation. The development and operation of space station computing resources will involve a spectrum of systems and software life cycle activities distributed across a variety of hosts,

an integration, verification, and validation host with test bed, and distributed targets. The requirement for the early establishment and use of an apporopriate Computer Systems and Software Engineering Support Environment is identified. This environment will support the Research and Development Productivity challenges presented by the space station computing system. Author

N86-20472*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 2: OPTIONS DEVELOPMENT DR-5. VOLUME 1: TECHNOLOGY OPTIONS
May 1985 379 p refs Prepared in cooperation with Ford Aerospace Communications Corp., Sunnyvale, Calif., IBM Federal Systems Div., Cape Canaveral, Fla. and Radio Corporation of America, Hollywood, Calif.
(Contract NAS5-28082)
(NASA-CR-177839; NAS 1.26:177839; MDC-H1343A) Avail: NTIS HC A17/MF A01 CSCL 22B

The second task in the Space Station Data System (SSDS) Analysis/Architecture Study is the development of an information base that will support the conduct of trade studies and provide sufficient data to make key design/programmatic decisions. This volume identifies the preferred options in the technology category and characterizes these options with respect to performance attributes, constraints, cost, and risk. The technology category includes advanced materials, processes, and techniques that can be used to enhance the implementation of SSDS design structures. The specific areas discussed are mass storage, including space and round on-line storage and off-line storage; man/machine interface; data processing hardware, including flight computers and advanced/fault tolerant computer architectures; and software, including data compression algorithms, on-board high level languages, and software tools. Also discussed are artificial intelligence applications and hard-wire communications. M.G.

N86-20473*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 1: FUNCTIONAL REQUIREMENTS DEFINITION, DR-5
Dec. 1985 308 p refs
(Contract NAS5-28082)
(NASA-CR-177838; NAS 1.26:177838; MDC-H1343A-REV) Avail: NTIS HC A14/MF A01 CSCL 22B

The initial task in the Space Station Data System (SSDS) Analysis/Architecture Study is the definition of the functional and key performance requirements for the SSDS. The SSDS is the set of hardware and software, both on the ground and in space, that provides the basic data management services for Space Station customers and systems. The primary purpose of the requirements development activity was to provide a coordinated, documented requirements set as a basis for the system definition of the SSDS and for other subsequent study activities. These requirements should also prove useful to other Space Station activities in that they provide an indication of the scope of the information services and systems that will be needed in the Space Station program. The major results of the requirements development task are as follows: (1) identification of a conceptual topology and architecture for the end-to-end Space Station Information Systems (SSIS); (2) development of a complete set of functional requirements and design drivers for the SSIS; (3) development of functional requirements and key performance requirements for the Space Station Data System (SSDS); and (4) definition of an operating concept for the SSIS. The operating concept was developed both from a Space Station payload customer and operator perspective in order to allow a requirements practicality assessment. M.G.

N86-20474*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 3: TRADE STUDIES, DR-5, VOLUME 1
Dec. 1985 383 p refs 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177842; NAS 1.26:177842; MDC-H1343A-VOL-1)
Avail: NTIS HC A17/MF A01 CSCL 22B

The primary objective of Task 3 is to provide additional analysis and insight necessary to support key design/programmatic decision for options quantification and selection for system definition. This includes: (1) the identification of key trade study topics; (2) the definition of a trade study procedure for each topic (issues to be resolved, key inputs, criteria/weighting, methodology); (3) conduct tradeoff and sensitivity analysis; and (4) the review/verification of results within the context of evolving system design and definition. The trade study topics addressed in this volume include space autonomy and function automation, software transportability, system network topology, communications standardization, onboard local area networking, distributed operating system, software configuration management, and the software development environment facility. M.G.

N86-20475*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 2: OPTIONS DEVELOPMENT, DR-5. VOLUME 2: DESIGN OPTIONS
Dec. 1985 435 p 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177840; NAS 1.26:177840; MDC-H1341A-VOL-2)
Avail: NTIS HC A19/MF A01 CSCL 22B

The primary objective of Task 2 is the development of an information base that will support the conduct of trade studies and provide sufficient data to make key design/programmatic decisions. This includes: (1) the establishment of option categories that are most likely to influence Space Station Data System (SSDS) definition; (2) the identification of preferred options in each category; and (3) the characterization of these options with respect to performance attributes, constraints, cost and risk. This volume contains the options development for the design category. This category comprises alternative structures, configurations and techniques that can be used to develop designs that are responsive to the SSDS requirements. The specific areas discussed are software, including data base management and distributed operating systems; system architecture, including fault tolerance and system growth/automation/autonomy and system interfaces; time management; and system security/privacy. Also discussed are space communications and local area networking. M.G.

N86-20476*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 3: TRADE STUDIES, DR-5, VOLUME 2
Dec. 1985 298 p refs 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177843; NAS 1.26:177843; MDC-H1343A-VOL-2)
Avail: NTIS HC A13/MF A01 CSCL 22B

Results of a Space Station Data System Analysis/Architecture Study for the Goddard Space Flight Center are presented. This study, which emphasized a system engineering design for a complete, end-to-end data system, was divided into six tasks: (1); Functional requirements definition; (2) Options development; (3) Trade studies; (4) System definitions; (5) Program plan; and (6) Study maintenance. The Task inter-relationship and documentation flow are described. Information in volume 2 is devoted to Task 3: trade Studies. Trade Studies have been carried out in the following areas: (1) software development test and integration capability; (2) fault tolerant computing; (3) space qualified computers; (4) distributed data base management system; (5) system integration test and verification; (6) crew workstations; (7) mass storage; (8) command and resource management; and (9) space communications. Results are presented for each task. B.W.

N86-20477*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 2: OPTIONS DEVELOPMENT, DR-5. VOLUME 3: PROGRAMMATIC OPTIONS
Dec. 1985 240 p refs 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177841; NAS 1.26:177841; MDC-H1343A-VOL-3)
Avail: NTIS HC A11/MF A01 CSCL 22B

Task 2 in the Space Station Data System (SSDS) Analysis/Architecture Study is the development of an information base that will support the conduct of trade studies and provide sufficient data to make design/programmatic decisions. This volume identifies the preferred options in the programmatic category and characterizes these options with respect to performance attributes, constraints, costs, and risks. The programmatic category includes methods used to administrate/manage the development, operation and maintenance of the SSDS. The specific areas discussed include standardization/commonality; systems management; and systems development, including hardware procurement, software development and system integration, test and verification. M.G.

N86-20478*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 1: FUNCTIONAL REQUIREMENTS DEFINITION, DR-5. APPENDIX: REQUIREMENTS DATA BASE
Dec. 1985 559 p 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177847; NAS 1.26:177847; MDC-H1343A) Avail: NTIS HC A25/MF A01 CSCL 22B

Appendix A contains data that characterize the system functions in sufficient depth as to determine the requirements for the Space Station Data System (SSDS). This data is in the form of: (1) top down traceability report; (2) bottom up traceability report; (3) requirements data sheets; and (4) cross index of requirements paragraphs of the source documents and the requirements numbers. A data base users guide is included that interested parties can use to access the requirements data base and get up to date information about the functions. M.G.

N86-20479*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 4: SYSTEM DEFINITION REPORT
Dec. 1985 574 p refs 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177844; NAS 1.26:177844; MDC-H1343A) Avail: NTIS HC A25/MF A01 CSCL 22B

Functional/performance requirements for the Space Station Data System (SSDS) are analyzed and architectural design concepts are derived and evaluated in terms of their performance and growth potential, technical feasibility and risk, and cost effectiveness. The design concepts discussed are grouped under five major areas: SSDS top-level architecture overview, end-to-end SSDS design and operations perspective, communications assumptions and traffic analysis, onboard SSDS definition, and ground SSDS definition. M.G.

N86-20480*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 4: SYSTEM DEFINITION REPORT. APPENDIX
Dec. 1985 610 p 7 Vol.
(Contract NAS5-28082)
(NASA-CR-177845; NAS 1.26:177845; MDC-H1343A) Avail: NTIS HC A99/MF A01 CSCL 22B

Appendices to the systems definition study for the space station Data System are compiled. Supplemental information on external interface specification, simulation and modeling, and function design characteristics is presented along with data flow diagrams, a data dictionary, and function allocation matrices. M.G.

N86-20481*# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.
SPACE STATION DATA SYSTEM ANALYSIS/ARCHITECTURE STUDY. TASK 5: PROGRAM PLAN
Dec. 1985 135 p
(Contract NAS5-28082)
(NASA-CR-177846; NAS 1.26:177846; MDC-H1343A) Avail: NTIS HC A07/MF A01 CSCL 22B

Cost estimates for both the on-board and ground segments of the Space Station Data System (SSDS) are presented along with summary program schedules. Advanced technology development recommendations are provided in the areas of distributed data base management, end-to-end protocols, command/resource management, and flight qualified artificial intelligence machines. M.G.

N86-21352*# Computer Technology Associates, Inc., Columbia, Md.
STATE OF THE ART SURVEY OF NETWORK OPERATING SYSTEMS DEVELOPMENT
7 Jun. 1985 224 p
(Contract NAS5-28583)
(NASA-CR-177853; NAS 1.26:177853) Avail: NTIS HC A10/MF A01 CSCL 20F

The results of the State-of-the-Art Survey of Network Operating Systems (NOS) performed for Goddard Space Flight Center are presented. NOS functional characteristics are presented in terms of user communication data migration, job migration, network control, and common functional categories. Products (current or future) as well as research and prototyping efforts are summarized. The NOS products which are revelant to the space station and its activities are evaluated. B.G.

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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.

A86-15614*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
COMMONALITY ANALYSIS FOR THE NASA SPACE STATION COMMON MODULE
L. E. POWELL and E. E. BEAM (NASA, Marshall Space Flight Center, Huntsville, AL) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-22)

The concept of commonality to enhance cost savings, as applied to NASA's Space Station Common Module (CM), is explored. The equipment to be included in the CM is organized by subsystems of structure, power, thermal, command and data handling, environmental control and life support, and crew station. The weight, volume, and quantity of each instrument item will be subsequently added to support a cost model. The CM concept, its reference configuration, power distribution and management, and cost sensitivity options are discussed in detail. Some computer programs are outlined, stressing the importance of the existing capabilities of the STS and the optimum commonality case. I.S.

A86-19563* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE FIRST SPACELAB MISSION
H. CRAFT (NASA, Marshall Space Flight Center, Huntsville, AL) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 363-369.

The role of the mission manager in coordinating the payload with the space transportation system is studied. The establishment of the investigators working group to assist in achieving the mission objectives is examined. Analysis of the scientific requirements to assure compatibility with available resources, and analysis of the payload in order to define orbital flight requirements are described. The training of payload specialists, launch site integration, and defining the requirements for the operation of the integrated payload and the payload operations control center are functions of the mission manager. The experiences gained from the management of the Spacelab One Mission, which can be implemented in future missions, are discussed. Examples of material processing, earth observations, and life sciences advances from the First Spacelab Mission are presented. I.F.

A86-22266
WORKING IN SPACE
C. R. FARRIS (ILC Industries, Inc., Space Systems Div., Houston, TX) Space (ISSN 0267-954X), vol. 1, Dec. 1985-Feb. 1986, p. 4-8.

The development of specialized tools for servicing satellites in space is discussed. Consideration is given to the trunnion pin attachment device (TPQD) which was used to capture the Solar Max satellite during NASA Shuttle mission 41-B. Additional Shuttle tests of satellite servicing tools focused on three servicing functions, including satellite deployment, satellite capture, and operational repairs on satellites. The design requirements for stanardized satellite tool designs which correspond well to the servicing requirements of satellites is emphasized. A list of the Leasat mission support hardware is given. I.H.

A86-22376
ANNUAL RELIABILITY AND MAINTAINABILITY SYMPOSIUM, PHILADELPHIA, PA, JANUARY 22-24, 1985, PROCEEDINGS
Symposium sponsored by IEEE, ASME, AIAA, et al . New York, Institute of Electrical and Electronics Engineers, 1985, 519 p. For individual items see A86-22377 to A86-22411.

The topics covered include measures of customer satisfaction, maintainability, reliability and maintainability (R&M) modeling, international reliability standards, maintenance planning and field data analysis, methodologies and simulation, and R&M techniques and tools. Aspects of a RADC system R&M, R&M education and training, software reliability, integrated diagnostics, and civil aircaft system safety are discussed. Attention is given to operational readiness and availability, R&M economic factors, influencing the front-end designs, product reliability growth processes, and mechanical reliability. In addition, consideration is given to questions of reliability testing and operational processes, statistical applications in R&M development, and reliability improvement techniques. I.S.

A86-23964
ORBITAL REPLACEMENT UNITS
C. M. HEMPSELL (British Aerospace, PLC, Space and Communications Div., Stevenage, England) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 63-70.

The design and functions of orbital replacement units (ORUs) are studied. The components of the 1.3 x 1.0 x 0.7 m, 87.9 kg ORUs, including cold plate and grapple points, are described. The application of ORUs on the Space Station, space platforms, and modules, which are structures designed for in-orbit maintenance and servicing, is investigated. Proposed transportation and servicing system designs for the in-orbit infrastructure are analyzed. The advantages and disadvantages of the function split and servicing split implementation procedures are examined. I.F.

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GROWTH

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

A86-15931*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
POTENTIAL SPACE STATION EVOLUTION AND GROWTH MODES
E. B. PRITCHARD, E. K. HUCKINS, III, and S. J. KATZBERG (NASA, Langley Research Center, Hampton, VA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(IAF PAPER 85-484)

User requirements for the first ten years of space station operation are assessed, and space station system capabilities to meet those needs are delineated. A module length of about 11.5 m with external interconnects best meets growth needs, and a power unit which provides 42 KW is desirable. Four growth scenarios for the manned element of the space station program are studied, and typical growth configurations are described. The full dual keel configuration is attractive at this point due to its increased flexibility. C.D.

A86-21883* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
NASA'S SATELLITE RELAY TRACKING AND DATA ACQUISITION PROGRAM
J. J. SCHWARTZ (NASA, Goddard Space Flight Center, Greenbelt, MD) and L. SCHUCHMAN (Stanford Telecommunications, Inc., McLean, VA) IN: EASCON '84; Proceedings of the Seventeenth Annual Electronics and Aerospace Conference, Washington, DC, September 10-12, 1984 . New York, Institute of Electrical and Electronics Engineers, 1984, p. 157-162.

The Tracking and Data Acquisition System (TDAS) is currently being planned to support NASA missions and the Space Station and will serve as a replacement to the present Tracking and Data Relay Satellite System (TDRSS). Its operational date is currently projected for the late 1990s. Near term objectives involve the definition of a TDAS architecture, the development of functional and performance specifications and implementation of a TDRSS-to-TDAS transition plan. The present paper provides an overview of the baseline TDAS architecture and summarizes key ingredients of system and technology studies in progress. In particular, this paper addresses a summary of projected mission requirements for the TDAS era; a characterization of the space segment constellation; use of lasers, 60 GHz, and multibeam 30/20 GHz technologies; ground architecture and operational interfaces; a distributed hardware/software processing concept for more flexible and reliable interfaces, signal processing and operations. Also included is a status summary of the TDAS program plan for the 1984-1990 time frame. Finally, an overview is presented of NASA's current plans to augment the TDRSS to meet the Space Station IOC requirements in the time period 1993-2000. Author

A86-24808* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
TETHERED NUCLEAR POWER FOR THE SPACE STATION
D. J. BENTS (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.210-1.227. Previously announced in STAR as N85-26912. refs

A nuclear space power system the SP-100 is being developed for future missions where large amounts of electrical power will be required. Although it is primarily intended for unmanned spacecraft, it can be adapted to a manned space platform by tethering it above the station through an electrical transmission line which isolates the reactor far away from the inhabited platform and conveys its power back to where it is needed. The transmission line, used in conjunction with an instrument rate shield, attenuates reactor radiation in the vicinity of the space station to less than one-one hundredth of the natural background which is already there. This combination of shielding and distance attenuation is less than one-tenth the mass of boom-mounted or onboard man-rated shields that are required when the reactor is mounted nearby. This paper describes how connection is made to the platform (configuration, operational requirements) and introduces a new element the coaxial transmission tube which enables efficient transmission of electrical power through long tethers in space. Design methodology for transmission tubes and tube arrays is discussed. An example conceptual design is presented that shows SP-100 at three power levels 100 kWe, 300 kWe, and 1000 kWe connected to space station via a 2 km HVDC transmission line/tether. Power system performance, mass, and radiation hazard are estimated with impacts on space station architecture and operation. B.W.

A86-24836* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SPACE POWER SYSTEMS - 'SPACECRAFT 2000'
K. A. FAYMON (NASA, Lewis Research Center, Cleveland, OH) IN: Intersociety Energy Conversion Engineering Conference, 20th, Miami Beach, FL, August 18-23, 1985, Proceedings. Volume 1 . Warrendale, PA, Society of Automotive Engineers, Inc., 1985, p. 1.422-1.424.

The program 'Spacecraft 2000' has the objective to identify critical, high-payoff, potential spacecraft technologies, taking into account the formulation, advocation, and the management of the requisite technology development programs. This program represents a joint NASA-industry program. The technology areas addressed by 'Spacecraft 2000' are related to spacecraft power/energy storage, thermal control/thermal management, power management and distribution, autonomous operation-control, on-board system integration, spacecraft environmental interactions, secondary propulsion, communications technologies, a total system response approach, and system-subsystem technology verification. The expected benefits of a development of advanced technologies include decreased spacecraft bus system weights, decreased mission costs, increased reliability/lifetimes, and increased operational flexibility. G.R.

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EXPERIMENTS, TETHERS, AND PLATFORMS

Includes descriptions and requirements of experiments 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.

A86-11956
NASA OPENS MICROGRAVITY FACILITY FOR WORK IN MATERIALS RESEARCH
Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Oct. 14, 1985, p. 109, 111.

The recently opened Microgravity Materials Science Laboratory (MMSL) offers U.S. scientists and engineers 'the opportunity to conduct scientific experiments in an earth-normal gravity environment using equipment which functionally duplicates facilities available on the Space Shuttle'. Companies can conduct materials research in the laboratory before starting formal efforts in their own labs. Such an approach will decrease the costs and risks a company must currently accept to assess new microgravity processing methods. G.R.

A86-12243
SPACE TETHERS DANGLE THE FUTURE ON A THREAD
G. R. GRAF Space World (ISSN 0038-6332), vol. V-10-262, Oct. 1985, p. 24-27.

The present paper is concerned with the Tethered Satellite System (TSS) which is to provide a new tool for the Space Shuttle. A number of projects based on the utilization of 'tether dynamics' have been considered. However, advanced concepts can only be considered seriously, after basic information regarding tethers in actual use has been acquired. In the first tether mission, in 1988, an electrodynamic satellite is to be dragged through the atmosphere more than 60 miles below the Shuttle. Attention is also given to a 22,300-mile tower proposed by Tsiolkovsky (1895), a counterbalanced space tether system called a 'skyhook', and cable cars (part way) to the stars. G.R.

A86-12926*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVING SYSTEM IMPLEMENTATION
M. J. DONOHOE, B. A. WALTON (NASA, Goddard Space Flight Center, Greenbelt, MD), and D. VANE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Earth Observing Systems: EOS - A Subset of Space Station Conference, Virginia Beach, VA, Oct. 8-10, 1985. 10 p. refs
(AIAA PAPER 85-2080)

The Earth Observing System (EOS) is a planned major earth science program initiative using the Polar Platforms of the Space Station. The Polar Platform resource capabilities will allow a multi-disciplinary, long term mission life approach to future earth science measurements. The EOS will be the subject of an Announcement of Opportunity (AO) in 1986. The EOS concept and the planned implementation approach is outlined. Author

A86-12927#
NOAA AND POLAR PLATFORMS
S. R. SCHNEIDER (NOAA, National Environmental Satellite, Data, and Information Service, Washington, DC) AIAA, Earth Observing Systems: EOS - A Subset of Space Station Conference, Virginia Beach, VA, Oct. 8-10, 1985. 7 p. refs
(AIAA PAPER 85-2081)

This report gives an overview of NOAA's involvement in the Space Station Polar Platform program. Issues addressed include instrumentation, servicing, communications, and operational requirements. Author

A86-12930*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
PASSIVE MICROWAVE PRECIPITATION MEASUREMENTS FOR EOS
R. W. SPENCER (NASA, Marshall Space Flight Center; Universities Space Research Association, Huntsville, AL) AIAA, Earth Observing Systems: EOS - A Subset of Space Station Conference, Virginia Beach, VA, Oct. 8-10, 1985. 5 p. refs
(AIAA PAPER 85-2089)

It is currently planned to mount a Special Sensor Microwave/Imager (SSM/I) on the manned Space Station (MSS) to obtain quantitative global precipitation data. Passive SSM/I instruments could also be included on other satellites, and function in the 19.35 GHz, V/H polarization, 22.35 GHz, V polarization, 37.0, V/H polarization, and 85.5 GHz, V/H polarization modes. Two polar orbiting satellites and the unit on the MSS would be needed to establish a database sufficient for studying monthly, daily and diurnal precipitation variations that are accurate for local regions. Realization of an effective system depends on the development of algorithms for discriminating between rainfall, snow, light rain and ocean background radiation patterns. M.S.K.

A86-12935#
THE SPACE STATION POLAR PLATFORMS - INTEGRATING RESEARCH AND OPERATIONAL MISSIONS
J. H. MCELROY and S. R. SCHNEIDER (NOAA, National Environmental Satellite, Data, and Information Service, Washington, DC) AIAA, Earth Observing Systems: EOS - A Subset of Space Station Conference, Virginia Beach, VA, Oct. 8-10, 1985. 12 p. refs
(AIAA PAPER 85-3000)

The instrumentation planned for the polar-orbiting segment of the Space Station will provide both real-time and long-term archival data. It is expected that the instrumentation will include an X-ray imager, total energy and electron detectors, a proton-electron spectrometer, a plasma monitor and a gamma ray detector. Data will also be gathered on the earth radiation budget, upper atmosphere activities and constituent species, ocean spectra and atmospheric absorption lines. SAR, scatterometer, imaging and altimeter applications will be found for radar units. The multiple-instrumented polar-orbiting platforms will permit correlations to be calculated on the radiation environment and atmosphere, ocean, weather, land and biosphere phenomena. M.S.K.

A86-14443*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TETHERS AND ASTEROIDS FOR ARTIFICIAL GRAVITY ASSIST IN THE SOLAR SYSTEM
P. A. PENZO and H. L. MAYER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA and AAS, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 9 p. NASA-supported research. refs
(AIAA PAPER 84-2056)

Analytical models are defined for gravity-assist trajectory changes for spacecraft passing massive compact bodies. The models are applied in an examination of the benefits of lowering a tether to an asteroid during a flyby in order to gain a trajectory change equivalent to that from a massive body (planet). Direct flybys yield velocity gains while retrograde flybys shed velocity. The magnitude of the effects are a function of the proximity to the body during flyby. This inherently limits the gravity assist technique used around planets, which usually have atmospheres and can have intense radiation fields. If a spacecraft could extend a tether (such as to be tested on the Orbiter) to snag on an asteroid surface, the potential trajectory/velocity change of the spacecraft would be limited mainly by the tether strength. The encounter physics are treated as a soft collision. Possible applications of the asteroid tether technique are outer planet, Mars and main belt asteroid exploration missions. M.S.K.

A86-15098
HIGH-LEVEL SPACECRAFT CHARGING IN THE LOW-ALTITUDE POLAR AURORAL ENVIRONMENT
M. S. GUSSENHOVEN, D. A. HARDY, F. RICH, W. J. BURKE (USAF, Geophysics Laboratory, Bedford, MA), and H.-C. YEH (Boston College, Chestnut Hill, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 90, Nov. 1, 1985, p. 11,009-11,023. refs
(Contract F19628-82-K-0011)
(AD-A162145; AFGL-TR-85-0291)

Regions of intense keV electron precipitation, such as inverted-V structures, at times colocate with ionospheric plasma depletion regions in the high-latitude polar ionosphere. When Defense Meteorological Satellite Program (DMSP) F6 and F7 satellites, at 840 km, enter these regions in darkness, ion signatures of high spacecraft-to-ambient plasma potential differences (several hundred volts negative) are observed with the new SSJ/4 ion detectors. A systematic survey of charging events and the environment in which they occur was made using the DMSP F6 and F7 precipitating ion and electron detectors, the SSIE thermal plasma probes, and the SSM (F7 only) vector magnetometer. The charging events of November 26, 1983, are analyzed in detail since they occurred on both satellites. Critical levels of number flux and average energy for the precipitating electrons, and the threshold density of the thermal ionospheric ions are defined for different levels of spacecraft charging. Author

A86-15331* Ball Aerospace Systems Div., Boulder, Colo.
RETROREFLECTOR FIELD TRACKER
F. E. WARGOCKI, A. J. RAY (Ball Corp., Ball Aerospace Systems Div., Boulder, CO), and G. E. HALL (NASA, Marshall Space Flight Center, Huntsville, AL) IN: State-of-the-art imaging arrays and their applications; Proceedings of the Meeting, San Diego, CA, August 21-23, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 283-291. refs
(Contract NAS8-34795)

An electrooptical position-measuring instrument, the Retroreflector Field Tracker or RFT, is described. It is part of the Dynamic Augmentation Experiment - a part of the payload of Space Shuttle flight 41-D in Summer 1984. The tracker measures and outputs the position of 23 reflective targets placed on a 32-m solar array to provide data for determination of the dynamics of the lightweight structure. The sensor uses a 256 x 256 pixel CID detector; the processor electronics include three Z-80 microprocessors. A pulsed laser diode illuminator is used. D.H.

A86-15348* Lockheed Missiles and Space Co., Palo Alto, Calif.
LONG LIFE FEASIBILITY STUDY FOR SIRTF
L. G. NAES and T. C. NAST (Lockheed Research Laboratories, Palo Alto, CA) IN: Cryogenic optical systems and instruments; Proceedings of the Meeting, San Diego, CA, August 23, 24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 22-34.
(Contract NAS2-11155)

The Phase A baseline for the Shuttle Infrared Telescope Facility (SIRTF) consists of an 85-cm diameter Cassegrain telescope, cooled to temperatures in the range from 10 to 20 K to provide background limited imaging for up to six instruments contained within a multiple instrument chamber (MIC). Colder temperature zones are also provided. A cryogenics system for a 15-day mission lifetime was first considered. In another study, the feasibility was assessed to extend the lifetime of the baseline SIRTF concept to at least six months, taking into account a mission involving the use of a space platform or a free-flyer configuration. According to the considered requirements, the optics temperature is to be kept below 10 K for at least 30 days. The temperatures are not to exceed 20 K at the end of the six months mission. It is shown that by using solid hydrogen, long-life operation is feasible with present technology. G.R.

A86-15638#
MICROGRAVITY ENVIRONMENT QUALITY ABOARD A LOW EARTH ORBIT SPACE STATION
R. BOUDREAULT (Canadian Astronautics, Ltd., Ottawa, Canada) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 15 p. refs
(IAF PAPER 85-53)

The importance of the microgravity environment in material processing in space (MPS) is discussed. The features that make microgravity useful for MPS, which are the reduction of buoyancy driven convection, containerless processing, and the elimination of sedimentation, are described. A comparison of the operating characteristics of the Space Shuttle, Space Station, EURECA, and Leasecraft microgravity support systems is provided. The calculation of the proper MPS spacecraft geometry which minimizes microgravity contamination is described and microgravity acceleration values for the spacecraft studied are given. The effect of atmospheric drag and crew operations on the quality of microgravity is investigated. An example revealing the importance of the proper microgravity environment is presented. I.F.

A86-15719*# Arizona Univ., Tucson.
NOVEL EXTRATERRESTRIAL PROCESSING FOR SPACE PROPULSION
K. RAMOHALLI (Arizona, University, Tucson), W. DOWLER, J. FRENCH (California, University, Jet Propulsion Laboratory, Pasadena), and R. ASH (Old Dominion University, Norfolk, VA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 15 p. refs
(IAF PAPER 85-166)

In the present quantitative consideration of space processing concepts for chemicals, theoretical parametric calculations are supplemented by a bench scale experiment. Attention is given to the case of water splitting to generate hydrogen and oxygen for a simple rocket motor that can be used in periodic thrusting. This concept of in situ propellant production is treated in detail and compared with more recent energy and materials technologies. O.C.

A86-17305#
SPACE TELESCOPE - THE PROTO-SPACE PLATFORM
H. GURSKY (U.S. Navy, E. O. Hulburt Center for Space Research, Washington, DC) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 60-74. refs

The design and uses of the Space Telescope (ST) are described. The ST provides: (1) improved spatial resolution, (2) improved signal-to-noise for studying point images and spectra, (3) improved signal-to-noise for studying short time variability, and (4) near-simultaneous photometric and spectral data over a spectral range of 0.1-1 micron. The use of the ST to produce data which provides a better understanding of planetary science, global clusters, galaxian distances, and evolutionary galaxies is discussed. The design requirements for the ST are examined and a diagram of the ST is presented. The use of the focal plane of the ST is described. The maintainability of ST and its functions as a space platform are investigated. I.F.

A86-17308#
ASTRONOMY AND THE SPACE STATION
H. GURSKY (U.S. Navy, E. O. Hulburt Center for Space Research, Washington, DC) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 89-107.

The utilization of the Space Station for astronomical missions is studied. A review of the advances in astronomy because of the ability to observe from space and a description of previous astronomical missions are provided. The requirements for astronomical observation are improved sensitivity, angular resolution, and spectral resolution. The use of the Space Station as an observing site, a service base, and an assembly base for astronomical missions is examined. Examples of astronomical observing facilities, assembly in space, and construction in space, made possible by the Space Station are presented. I.F.

A86-17309#
THE SPACE STATION POLAR PLATFORM - INTEGRATING RESEARCH AND OPERATIONAL MISSIONS
J. H. MCELROY and S. R. SCHNEIDER (NOAA, Washington, DC) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 108-130. refs

An astronaut-tended platform in sun-synchronous, near-polar orbit for extensive earth observations is proposed. The functions of the operational, and research and development instruments necessary for observation of solar-terrestrial interactions, the earth's atmosphere, meteorology, oceanography, and remote sensing of solid earth and vegetation from the polar platform are examined. A list of the proper positioning of the instruments on the alpha and beta platforms is provided. The data processing of the information collected and its global distribution are studied. The platform servicing and international cooperation required for the effectiveness of this platform are discussed. I.F.

A86-17310#
PLANETARY EXPLORATION IN THE SPACE STATION ERA
D. MORRISON (Hawaii, University, Honolulu) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 131-149.

The use of the Space Station in planetary science is discussed. A review of the planetary program, which developed from earth-based studies, to reconnaissance with fly-by spacecraft, to extensive studies with orbiters and atmospheric probes, and then to detailed investigations wth landers, is presented. A planned study of Mars involving rover and sample return missions, and a comet sample return mission, which would utilize the Space Station are described. The function of the Space Station as a support for planetary missions and as a microgravity laboratory are examined; examples of experiments to be conducted in the Space Station laboratory are provided. I.F.

A86-17312#
THE POTENTIAL OF MATERIALS PROCESSING USING THE SPACE ENVIRONMENT
J. T. ROSE and T. D. FITZPATRICK (McDonnell Douglas Astronautics Co., St. Louis, MO) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 167-200. refs

The scientific, economic, structural, and political problems and advantages of material processing in space (MPS) are discussed. The microgravity environment provides the setting for new developments in biological materials, metal alloys and composites, and semiconductor crystals and glasses. The benefits of the Space Shuttle for MPS are described. A review of the history of MPS in the U.S. and abroad is presented. The electrophoresis operations in space (EOS) project is examined; the problems encountered with static electrophoresis and continuous flow elelctrophoresis on earth, and the increases in concentration, flow rate, and purity provided by EOS are studied. The economic and commercial advantages possible by conducting EOS and MPS within the Space Station are investigated. I.F.

A86-17316
ELECTROPHORESIS OPERATIONS IN SPACE FOR PHARMACEUTICAL PROCESSING
D. W. RICHMAN (McDonnell Douglas Corp., St. Louis, MO) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 11-16.
(AAS PAPER 84-107)

Electrophoresis experiments on board Shuttle are reviewed, with emphasis given to the pharmaceutical processing applications

of electrophoresis in zero-gravity. In its first demonstration on the fourth flight of the Shuttle in June 1982, a protein sample was separated that contained five hundred times more protein than would have been possible on earth. The chamber used for the separation has been flown on five additional Shuttle missions to further demonstrate the advantages of space-based pharmaceutical processing. Development of a scaled-up Production Prototype electrophoresis chamber for the Shuttle Payload Bay is described in detail. Attention is also given to the long range goals of NASA's Electrophoresis Operations in Space (EOS) program which is to install a production unit on board an earth-orbiting facility, such as Space Station, by the year 1989. I.H.

A86-17322
A CONTAINER MATERIAL FOR ALLOY PROCESSING IN NEAR ZERO GRAVITY
A. V. COOKE (Martin Marietta Laboratories, Baltimore, MD) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 83-104. refs
(AAS PAPER 84-122)

A low-cost TiB2 cathode container coating with good durability has been developed for space processing applications. The durability and longevity of the material has been proven over two and one-half years of full plant exposure testing in both passive (static) and dynamic (electrolysis) exposure tests. Calculations for return on investment indicate that the present payload period for a TiB2-coated Dalles cell is approximately half of the anticipated coating life. Some potential materials processing applications of the container coating are described, including: open vessel containment; transfer and forming operations; collection sumps, and phase separation. I.H.

A86-19259* Stanford Univ., Calif.
A SIMPLE MICROGRAVITY TABLE FOR THE ORBITER OR SPACE STATION
O. K. GARRIOTT (NASA, Johnson Space Center, Houston, TX) and D. B. DEBRA (Stanford University, CA) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 5, no. 3, 1985, p. 161-163.

Methods of limiting perturbations in microgravity experiments are proposed. An acceleration level below 10 to the -4th m/s-squared is necessary to maintain an undisturbed microgravity environment. Machinery vibrations, crew motion, and the firing of vernier thrusters produce acceleration levels greate than 10 to the -4th m/s-squared. The use of a weak spring system or simple electromagnets to isolate an experimental table from these factors is described. The manners in which crew motion and vernier firing are countered by the springs are examined. The steady acceleration caused by atmospheric drag, gravity gradient force, and steady rotation can be maintained below 10 to the -th m/s-squared; however, the springs can protect the table from these accelerations if required. I.F.

A86-19535* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
THE LARGE DEPLOYABLE REFLECTOR - A TECHNOLOGY DEVELOPMENT CHALLENGE
R. B. PITTMAN (NASA, Ames Research Center, Moffett Field, CA) and R. GUALDONI (NASA, Washington, DC) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 106-113.

The proposed Large Deployable Reflector (LDR) telescope is an astrophysical orbiting platform whose aperture is of the order of 20 m, and is dedicated to observations in the IR and sub-mm wavelengths. NASA is currently planning a 5-year technology development program that will allow the requisite hardware and software to reach the state required for economical and reliable implementation. A computer model simulation is envisioned toward this end that will encompass and integrate structural, thermal, control, optics, and systems program elements. Possession of the enabling technology is foreseen for the early 1990s. O.C.

A86-19537* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
RADIO INTERFEROMETRY FROM SPACE PLATFORMS
D. H. ROBERTS, S. H. MORGAN, B. F. BURKE, J. F. JORDAN, R. A. PRESTON, and E. C. HAMILTON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 120-131.

While current VLBI observations are limited in their resolution by the earth diameter magnitude, which is the largest antenna separation available, as well as in their information content, because of the small number of antennas in use at a given time, the extension of VLBI to include one or more antennas in space will relieve both constraints and help to map distant radio sources with the highest possible resolution. Attention is given to the implementation of such an orbital VLBI system extension through (1) a Shuttle-launch mission, (2) a six-month to one-year near earth orbit mission based on a space platform associated with the Space Station, (3) a large orbit free flyer platform mission of more than 2-year duration, and (4) lunar and/or deep space orbits, aimed at reaching the resolution limits set by interstellar scattering. O.C.

A86-19545
OPTICAL PAYLOAD ACCOMMODATION ON A SPACE STATION
F. C. RUNGE (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 204-211.

Installation accommondation being planned for the Space Station for the exterior and interior payload equipment and operations are studied. The use of the Space Station for support of earth/ocean/atmospheric instrument technology is examined. An example of large deployable telescope assembly and extravehicular activities technology developments is presented. The function, equipment, and internal and external accommodations of the Space Station for the space infrared telescope, which is a one-meter class, cryogenically cooleld instrument, are described. The development of an advanced X-ray astrophysics facility for X-ray astronomy research is discussed. The utilization of the Space Station for storgae and assembly of a 20-m diameter, multimirror telescope with detector in the infrared and submillimter range is analyzed. I.F.

A86-19546
CO-ORBITING PLATFORM AND SERVICES TO OPTICS PAYLOADS
K. H. ROURKE (TRW, Inc., Federal Systems Div., Redondo Beach, CA) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL. June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 212-227.

The CO-Orbiting Platform is a major element in NASA's new initiative to develop and deploy a permanent space station in the early 1990's. This separate, unmanned free flying space platform supports a variety of space payloads with standard orbital services including: mechanical attachment, pointing control, electrical power, thermal control and data communications. It enhances the overall space station architecture by offering the more controlled space environments and additional mission flexibility supplied by unmanned free flying vehicles. The co-orbiting space platform additionally offers the servicing and transportation economy made possible by the nearby space station. This paper reviews the general features of space platforms drawing on previous space platform and space station studies conducted by NASA. Co-orbital characteristics and operations are reviewed. Platform services, particularly those pertinent to optics payloads are discussed; these

include viewing access, pointing stability and control; contamination environmental control; electrical power services; thermal control; and data handling, storage and two-way communications. Author

A86-19547* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVING SYSTEM (EOS) REQUIREMENTS FOR A POLAR PLATFORM
R. M. MULLER and M. J. DONOHOE (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 228-235. refs

This paper describes the requirements that the polar platform will have to meet if it is to satisfy the needs of the scientific earth observation communities in the early 1990s. The Eos is a prime mission for the polar platform. The polar platform will be a large satellite in a sun synchronous orbit that could be built up from the same components that are to be used to build the Space Station and its co-orbiting freeflying satellite. It will be serviced from the Shuttle so that it will be kept in operation and up-to-date for at least a decade. An initial set of scientific requirements has been documented by a Science and Missions Requirements Working Group (S&MRWG). These scientific requirements have been translated into derived technical requirements for the polar platform. These derived requirements are presented. Author

A86-19548
SPACE STATION EARTH REMOTE SENSING REQUIREMENTS
R. A. HOLMES (Allegheny International, Troy, MI) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 236-239.

Earth remote sensing requirements that may be expected for Space Station are presented. They include research requirements for more detailed spectral resolution, atmospheric effects on information extraction, and much more thorough probing of irradiance angle - view angle information content in scene radiance than has been done to date. Instrument development requirements for unmanned commercial and governmental satellite systems are described. Requirements posed by NASA global habitability research efforts and earth data systems developments such as the Pilot Oceans Data System, the Pilot Climate Data System, and the Pilot Land Data System are considered with a view to the role of earth satellites of many kinds as aids to better understanding of the planet and its natural systems. Author

A86-19550
SPACE STATION OPTIONS FOR ELECTRO-OPTICAL PAYLOADS
E. H. SWANSSON, M. L. COKER, and J. M. LUDWINSKI (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 248-256. refs

The design and functions of the Space Station system are reviewed. Potential electro-optical payloads and their location on the Space Station are discussed. The need for a crew to facilitate electro-optical studies is described. The servicing capabilities of the Space Station for electro-optical payloads include: (1) a manned maneuvering unit, (2) a remote manipulator system, (3) an orbital maneuvering unit, and (4) an orbital transfer vehicle. The nesting and decaying concepts, which are possible means of servicing payloads that require a free-flying environment, are examined. The systems of the Space Station that will maintain the accuracy, stability, and low level of contamination required for the electro-optical payloads are analyzed. The communication links with the ground provided by the Space Station are discussed. An example revealing that the estimated cost of transporting and servicing by the Space Station is lower than other available systems is presented. I.F.

A86-19552
BLACKBODY SIMULATORS FOR SPACE PLATFORMS
F. O. BARTELL (Alabama, University, Huntsville) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 269-271.

A new type of blackbody simulator design is described that is based on the principle that the projected solid angle of the aperture is constant when viewed from all points on the cavity wall surface. This design provides compact blackbody simulators with excellent spatial uniformity, and they are especially well suited for the calibration of space platform infrared detector arrays. Author

A86-19553
THE TIROS ISOGRID INSTRUMENT MOUNTING PLATFORM
R. A. LAUER, D. J. PODLESNEY, and D. A. AIEVOLI (RCA, Astro-Electronics Div., Princeton, NJ) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 272-286. refs

Technical requirements and system design of a precision optical mounting platform (POMP) used on the Tiros Meteorological Satellite Series is presented. The POMP, which is used to mount the sensors and satellite attitude-determination and -control components, is required to support the sensors during the satellite launch and orbit environments, to minimize the thermal gradient-induced misalignments, and to provide clear fields-of-view for sensor scanning and thermal control. It was designed for minimum weight, manufacturability,and adaptability to different sensor components. Weighing 52 lb, the POMP supports 230 lb of sensors, harness, and thermal control components. Testing and in-orbit performance (it has been flown on four spacecraft mission) have demonstrated that the POMP has maintained coalignment of sensors during sine and acoustic vibration, as well as satisfactory thermal control. Schematics and design specifications of Tiros spacecraft and POMP are included. I.S.

A86-19566* National Aeronautics and Space Administration, Washington, D.C.
SPACELAB TRANSITIONING TO SPACE STATION
R. H. BENSON and L. J. DEMAS (NASA, Washington, DC) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 387-392.

The availability of Shuttle and Spacelab makes it possible to fly a new class of scientific instruments. Thus, larger and heavier instruments can be employed, while the return of instruments after a mission provides an opportunity for instrument reconditioning and improvement in preparation for the next flight. In addition, the Shuttle provides a basic pointing capability with its Reaction Control System (RCS) which adjusts the attitude of the entire Shuttle in the desired direction. As part of Spacelab, the European Space Agency (ESA) developed an Instrument Pointing System (IPS). Early mission results are discussed, taking into account the first scientific payload carried on the Shuttle (OSTA-1), the OSS-1 payload, Spacelab 1, Spacelab 2, the Astro payload, Sunlab, and OSTA-3. Future missions are also considered, giving attention to the Solar Optical Telescope (SOT), the Shuttle Infrared Telescope Facility (SIRTF), and the Pinhole Occulter Facility (POF). It is pointed out that a number of the instruments being developed can be modified for operation on the Space Station. G.R.

A86-19657#
HISTORICAL BACKGROUND LEADING TO THE TETHERED SATELLITE SYSTEM (TSS)
M. D. GROSSI (Smithsonian Astrophysical Observatory, Cambridge, MA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 4 p. refs
(AIAA PAPER 86-0048)

Early R&D activities on the TSS carried out by researchers at the Smithsonian Astrophysical Observatory (SAO) in concert with NASA researchers are reviewed. The concept of a long, thin orbiting

wire serving as a ULF (1 Hz) antenna for radiophysics experiments was first proposed in 1972, although the seed idea ws first postulated by Tsiolkovsky a century earlier. The idea was soon expanded to be a 20-100 km TSS with satellites at both end for studying the radiation field surrounding the wire. The proposed Project Skyhook encompassed a subsatellite orbiting down to 100 km altitude for atmospheric, geomagnetic and gravity gradient research. Studies which have since been carried out are listed, covering, e.g., electromagnetic wave injection using long, orbiting tethers, tethers as an electrodynamic power supply, and the dynamics of TSS constellations. In 1985 NASA selected a 20 km long metal tether experiment for STS launch in 1988. The investigations are now concentrating on electrodynamic power systems and tethers as a means of extending instruments beyond the outgassing environment surrounding a large space platform such as the Orbiter. M.S.K.

A86-19660*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
FUTURE APPLICATIONS OF TETHERS IN SPACE
G. VON TIESENHAUSEN (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. refs
(AIAA PAPER 86-0053)

Various experiments with tethered satellite systems (TSS) have reached the stage of being considered for demonstration programs as follow-ups to the planned electrodynamic power system and atmospheric missions at the close of the 1980s. All TSS operations involve an initial separation thrust to a tethered object and then begin transferring angular momentum from one object to another while preserving the total angular momentum. The demonstrations include tethered launch of an Orbiter payload to a higher orbit, deployment of the Orbiter from the Space Station (SS), and launch of an Orbital Transfer Vehicle from the SS. The operations can be sequential, with the Orbiter providing the SS with an upward boost while being lowered to an easier deorbit position, followed by the SS releasing on OTV (or a repaired Space Telescope) to a higher orbit while the SS returns to a more favorable lower orbit. M.S.K.

A86-19937*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ASTROMETRIC TELESCOPE FACILITY - STATUS REPORT
K. NISHIOKA, B. L. SWENSON, and J. D. SCARGLE (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p. refs
(AIAA PAPER 86-0540)

The advent of the Space Station Program has provided an unexpected opportunity for the Astrometric Telescope Facility (ATF) study program by providing a potential long-duration on-orbit serviceable platform. It required a concept change for ATF from a free-flyer observatory to a Space-Station-based Observatory. The program was sent in this new direction at the start of fiscal year 1985, and program plans including study schedules and science and technical requirements are being revised and defined. The facility is designed to be versatile and capable of fulfilling the primary goal of planet detection, and to be highly useful for other astrophysics observations. Basically the ATF observing program is a long-duration plan requiring repetitive observations of single stars over a one to two decade period. These repetitive observations are needed to provide data necessary to conclusively determine the existence (or nonexistence) of planets of the Uranus and Neptune class in extrasolar planetary systems. Author

A86-21024
TUGS, FERRIES AND ACE REPAIR
B. NOLLEY Space World (ISSN 0038-6332), vol. V-12-264, Dec. 1985, p. 14-17.

The basic design characteristics of an Orbital Maneuvering Vehicle (OMV) for satellite servicing operations are considered. The system would be small enough to maneuver around a satellite in low-earth-orbit (LEO) and carry out on site repair activities. Current OMV design concepts are focused on a disk like configuration which would fit easily into the payload bay of Shuttle. The possibility of developing an Orbital Transfer Vehicle to propel satellites into geosynchronous orbit from LEO is also discussed. Artists' renderings of the OTV and OMV design concepts are provided. I.H.

A86-23552
SCIENCE REQUIREMENTS FOR SPACE STATION LABORATORY
B. LICHTENBERG AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 7 p.
(SAE PAPER 851368)

Life science research to be conducted on the Space Station is to include applied research which is needed to sustain the well being, health, and functioning of humans in space. Studies related to gaining an understanding of medical problems and basic physiological phenomena in space are also to be conducted. Other basic research is concerned with studies of gravitational and radiation biological phenomena, and investigations related to the origin and evolution of life. The facilities needed to conduct the required experiments for the considered investigations are discussed, taking into account equipment for conducting experiments with animals, a variable-g centrifuge, a high performance linear accelerator capable of delivering controlled motion to humans or animals, instrumentation for muscle studies, and equipment for cellular physiology studies. G.R.

A86-23553* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
SPACE STATION LIFE SCIENCES GUIDELINES FOR NONHUMAN EXPERIMENT ACCOMMODATION
R. ARNO (NASA, Ames Research Center, Moffett Field, CA) and J. HILCHEY (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p. refs
(SAE PAPER 851370)

Life scientists will utilize one of four habitable modules which constitute the initial Space Station configuration. This module will be initially employed for studies related to nonhuman and human life sciences. At a later date, a new module, devoted entirely to nonhuman life sciences will be launched. This report presents a description of the characteristics of a Space Station laboratory facility from the standpoint of nonhuman research requirements. Attention is given to the science rationale for experiments which support applied medical research and basic gravitational biology, mission profiles and typical equipment and subsystem descriptions, issues associated with the accommodation of nonhuman life sciences on the Space Station, and conceptual designs for the initial operational capability configuration and later Space Station life-sciences research facilities. G.R.

A86-23965
SOLIDIFICATION PROCESSES IN MICROGRAVITY
C. POTARD (CEA, Centre d'Etudes Nucleaires de Grenoble, France) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 71-74. refs

The main characteristics of solidification processes are presented with a view to demonstrating the effects of microgravity. The first effects of a weightless environment, such as levitation of matter and zero buoyancy on liquid phases, are discussed and their immediate benefits and disadvantages for material processing described. The great advantage of convectionless fluids lies not only in the possibilities of alloy crystal growth and formation of regular composite structures, but also in the testing of theories of solid-liquid interface stability up to the limits of validity. Emerging forces generated by surface tension at fluid interfaces have been shown to be of great importance in many cases. Thermocapillary convection in the bulk phase and fluid emulsion destabilization are examples of phenomena that reduce the advantage of microgravity. Levitation of matter is a challenge for material processing applications in space. Potentially highly improved or

new materials could be generated from this unique approach. Finally, a brief discussion is given concerning the criteria and logic for economic applications of a microgravity environment in material processing. Author

A86-23969
MICROGRAVITY RESEARCH IN GLASSES AND CERAMICS
G. H. FRISCHAT (Clausthal, Technische Universitaet, Clausthal-Zellerfeld, West Germany) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 90, 91. BMFT-supported research. refs

Processes in glass and ceramic high-temperature technology can be influenced by gravity if a less viscous liquid phase is present. Some examples are given. A number of microgravity experiments on diffusion, corrosion and dissolution processes in relevant glass technological systems have been conducted recently; the results are discussed briefly. Author

A86-24038*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TETHERS AND ASTEROIDS FOR ARTIFICIAL GRAVITY ASSIST IN THE SOLAR SYSTEM
P. A. PENZO and H. L. MAYER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Jan.-Feb. 1986, p. 79-82. Previously cited in issue 03, p. 251, Accession no. A86-14443. refs

A86-27052* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
FIRST RESULTS FROM SPACELAB 2
E. W. URBAN (NASA, Marshall Space Flight Center, Huntsville, AL) Nature (ISSN 0028-0836), vol. 319, Feb. 13, 1986, p. 540-542.

Preliminary results of physical experiments carried out during the Spacelab 2 Shuttle mission are summarized. Attention is given to experiments in the fields of plasma dynamics; solar physics; high-energy astrophysics; and astronomy. Plasma experiments included an ejectable plasma diagnosics package and measurements of the passive charging of the Shuttle vehicle in the surrounding space plasma. The solar physics instrument package consisted of a solar spectral irradiance monitor; a solar optical universal polarimeter (SOUP); and a solar helium abundance high-resolution telescope and spectrograph (HRTS). Astronomical observations were performed using a scanning infrared telescope (IRT) which consisted of a highly baffled herschelian telescope and 10 detectors covering wavelengths from 2 to 120 microns. Cosmic-ray nuclei were detected and analyzed using gas Cerenkov counters and a transition radiation detector. Addition experiments included a thin film fluid dynamics payload and analysis of blood samples taken from the mission specialists. Complete data records from the experiments have now been distributed for an analysis period which will take at least a year. A table listing the Spacelab 2 experiments and their principal investigators is provided. I.H.

A86-27879#
AN INDUSTRIAL PARK IN ORBIT
W. JOHNSTON, JR. (Fairchild Space Co., Germantown, MD) IN: Space, our next frontier; Proceedings of the Conference, Dallas, TX, June 7, 8, 1984 . Dallas, TX, National Center for Policy Analysis, 1985, p. 62-70.

'Leasecraft' is an orbiting platform which is intended to furnish industrial park-like support services for commercial spacecraft operators requiring longer periods of orbital operation than the Space Shuttle can currently furnish. This system will spread nonrecurring costs over many missions, and reduce hardware costs through production efficiencies that are yielded by a continuous flow of standard components. In addition, launch costs will be reduced by the fact that only one payload is transported to and from orbit, and spacecraft costs will be minimized in virtue of service life extension by on-orbit maintenance. O.C.

A86-27893#
COMMERCIALIZATION OF SPACE - TECHNICAL ISSUES
W. A. JOHNSTON, JR. (Fairchild Space Co., Germantown, MD) IN: Space, our next frontier; Proceedings of the Conference, Dallas, TX, June 7, 8, 1984 . Dallas, TX, National Center for Policy Analysis, 1982, p. 296-298.

An evaluation is made of the Space Shuttle performance and availability criteria that must be met in order for the 'Leasecraft' space industrialization orbiting infrastructure to be economically operated. Leasecraft furnishes electrical power, attitude control, orbit control, data processing, and communication services for automated manufacture or instrumentation payloads that are delivered, and recovered by the Space Shuttle for lengthy orbital operations. EVA would be used by the Space Shuttle crews in payload-changing operations. A 260-km mission altitude, rather than the present 160-km altitude, is noted to be required by the Space Shuttle in order to conserve Leasecraft fuel. O.C.

A86-28591
THE POLAR PLATFORM FOR EARTH OBSERVATION
J. H. MCELROY and S. R. SCHNEIDER (NOAA, National Environmental Satellite, Data, and Information Service, Washington, DC) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 263-275. refs
(AAS 85-133)

Issues related to the design and possible applications of an astronaut-tended polar-orbiting sensor platform for earth observation are discussed. Attention is given to the Polar Platform (PP) design concept developed by NASA in connection with the Space Station program. The PP is a carrier for a multidisciplinary unified global observing system which will integrate a variety of sensor instruments for solar-terrestrial, meteorological, oceanographic, and agricultural observations. The main advantages of the polar-orbiting concept over conventional independent observations systems stem from improvements in capacity and reliability which are made possible by astronaut servicing of platform sensors. The main sensor systems being considered for the PP include a precipitating magnetospheric particle detectors away, multispectral-imaging sensors, lidar instruments, and a high-resolution synthetic aperture radar (SAR) scanner. Design requirements of a ground-based Earth Observation Center for processing data from the PP are described in detail. I.H.

A86-29654*# Ford Aerospace and Communications Corp., Palo Alto, Calif.
DESIGN SUMMARY OF A GEOSTATIONARY FACILITY UTILIZED AS A COMMUNICATIONS PLATFORM
N. J. BARBERIS and J. V. BROWN (Ford Aerospace and Communications Corp., Western Development Laboratories Div., Palo Alto, CA) IN: Communication Satellite Systems Conference, 11th, San Diego, CA, March 17-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 627-638. NASA-supported research.
(AIAA PAPER 86-0714)

This paper describes the technical aspects of a geostationary platform facility that makes maximum use of the planned NASA space station and its elements, mainly the orbital maneuvering vehicle (OMV) and the orbital transfer vehicles (OTV). The platform design concept is described, with emphasis on the key technologies utilized to configure the platform. Key systems aspects include a design summary with discussion of the controls, telemetry, command and ranging, power, propulsion, control electronics, thermal control subsystems, and space station interfaces. The use of the facility as a communications platform is developed to demonstrate the attractiveness of the concept. The economic benefits are discussed, as well as the concept of servicing for payload upgrade. Author

N86-10173*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MICROGRAVITY MATERIALS SCIENCE LABORATORY
S. J. GRISAFFE *In* NASA, Washington Microgravity Sci. and Appl. Program Tasks p 199 May 1985
Avail: NTIS HC A10/MF A01 CSCL 22A

A Microgravity Materials Science Laboratory (MMSL) has been planned, designed, and is being developed. This laboratory will support related efforts to define the requirements for the Microgravity and Materials Processing Laboratory (MMPF) and the MMPF Test Bed for the Space Station. The MMSL will serve as a check out and training facility for science mission specialists for STS, Spacelab and Space Station prior to the full operation of the MMPF Test Bed. The focus of the MMSL will be on experiments related to the understanding of metal/ceramic/glass solidification, high perfection crystal growth and fluid physics. This ground-based laboratory will be used by university/industry/government researchers to examine and become familiar with the potential of new microgravity materials science concepts and to conduct longer term studies aimed at fully developing a l-g understanding of materials and processing phenomena. Such research will help create new high quality concepts for space experiments and will provide the basis for modeling, theories, and hypotheses upon which key space experiments can be defined and developed.
Author

N86-10734*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LIFE SCIENCES RESEARCH ON THE SPACE STATION: AN INTRODUCTION
Sep. 1985 18 p refs
(NASA-TM-86836; REPT-85408; NAS 1.15:86836) Avail: NTIS HC A02/MF A01 CSCL 06B

The Space Station will provide an orbiting, low gravity, permanently manned facility for scientific research, starting in the 1990s. The facilities for life sciences research are being designed to allow scientific investigators to perform research in Space Medicine and Space Biology, to study the consequences of long-term exposure to space conditions, and to allow for the permanent presence of humans in space. This research, using humans, animals, and plants, will provide an understanding of the effects of the space environment on the basic processes of life. In addition, facilities are being planned for remote observations to study biologically important elements and compounds in space and on other planets (exobiology), and Earth observations to study global ecology. The life sciences community is encouraged to plan for participation in scientific research that will be made possible by the Space Station research facility. Author

N86-11103*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
SAMSI: AN ORBITING SPATIAL INTERFEROMETER FOR MICRO-ARC SECOND ASTRONOMICAL OBSERVATIONS
R. V. STACHNIK (Harvard Smithsonian Center for Astrophysics, Cambridge, Mass.) and D. Y. GEZARI *In* ESA Colloq. on Kilometric Opt. Arrays in Space p 35-42 Apr. 1985 refs
(Contract NASW-3755; NSG-7176)
Avail: NTIS HC A09/MF A01 CSCL 03A

The concept and performance of (SAMSI) Spacecraft Array for Michelson Spatial Interferometry, an orbiting spatial interferometer comprised of three free-flying spacecraft, two collector telescopes and a central mixing station are described. In the one-dimensional interferometry mode orbits exist which provide natural scanning of the baseline. These orbits place extremely small demands on thrusters and fuel consumption. Resolution of 0.00001 arcsecond and magnitude limits of mv = 15 to 20 are achievable in a single orbit. In the imaging mode, SAMSI could synthesize images equivalent to those produced by equal diameter filled apertures in space, making use of the fuel resupply capability of a space station. Simulations indicate that image reconstruction can be performed with milliarcsecond resolution to a visual magnitude 12 in 12 hr of spiral scanning integration time.
Author (ESA)

N86-11104*# Harvard-Smithsonian Center for Astrophysics, Cambridge, Mass.
COSMIC: A HIGH RESOLUTION, LARGE COLLECTING AREA TELESCOPE
W. A. TRAUB and N. P. CARLETON *In* ESA Colloq. on Kilometric Opt. Arrays in Space p 43-48 Apr. 1985 refs
(Contract NSG-7176)
Avail: NTIS HC A09/MF A01 CSCL 03A

The spaceborne Coherent Optical System of Modular Imaging Collectors (COSMIC) is presented. It has high angular resolution and can produce images of complex, low-surface-brightness objects such as distant galaxies. If configured as a 36 m filled linear array, COSMIC can have 15 times better angular resolution and 10 times greater collecting area than the Space Telescope. Alternatively, if the collecting area is spread out to create an unfilled two-dimensional array, there is the additional advantage of not needing to rotate the array in order to build up a reconstructed image. Considerations which led to the design concept, scientific goals, and the potentially useful role of a space station for assembly are discussed. Author (ESA)

N86-13345*# Smithsonian Institution, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT, PHASE 2 Quarterly Report, 22 Feb. - 21 Jun. 1985
E. LORENZINI Jul. 1985 31 p
(Contract NAS8-36606)
(NASA-CR-171611; NAS 1.26:171611; QR-1) Avail: NTIS HC A03/MF A01 CSCL 22C

This Quarterly Report deals with the deployment maneuver of a single-axis, vertical constellation with three masses. A new, easy to handle, computer code that simulates the two-dimensional dynamics of the constellation has been implemented. This computer code is used for designing control laws for the deployment maneuver that minimizes the acceleration level of the low-g platform during the maneuver. Author

N86-13359*# Allied Bendix Aerospace, Teterboro, N.J. Guidance Systems Div.
ASTROPHYSICAL PAYLOAD ACCOMMODATION ON THE SPACE STATION Final Report, 10 Dec. 1984 - 15 Oct. 1985
B. P. WOODS 15 Oct. 1985 164 p refs
(Contract NAS8-36124)
(NASA-CR-178556; NAS 1.26:178556) Avail: NTIS HC A08/MF A01 CSCL 22B

Surveys of potential space station astrophysics payload requirements and existing point mount design concepts were performed to identify potential design approaches for accommodating astrophysics instruments from space station. Most existing instrument pointing systems were designed for operation from the space shuttle and it is unlikely that they will sustain their performance requirements when exposed to the space station disturbance environment. The technology exists or is becoming available so that precision pointing can be provided from the space station manned core. Development of a disturbance insensitive pointing mount is the key to providing a generic system for space station. It is recommended that the MSFC Suspended Experiment Mount concept be investigated for use as part of a generic pointing mount for space station. Availability of a shirtsleeve module for instrument change out, maintenance and repair is desirable from the user's point of view. Addition of a shirtsleeve module on space station would require a major program commitment. Author

N86-18334*# Wyle Labs., Inc., Huntsville, Ala.
ACCOMMODATION REQUIREMENTS FOR MICROGRAVITY SCIENCE AND APPLICATIONS RESEARCH ON SPACE STATION Interim Report, 24 May - 24 Dec. 1985
M. L. UHRAN, L. R. HOLLAND, and W. O. WEAR Dec. 1985 225 p
(Contract NAS3-24654)
(NASA-CR-175038; NAS 1.26:175038; JN67801) Avail: NTIS HC A10/MF A01 CSCL 22A

Scientific research conducted in the microgravity environment of space represents a unique opportunity to explore and exploit the benefits of materials processing in the virtual abscence of gravity induced forces. NASA has initiated the preliminary design of a permanently manned space station that will support technological advances in process science and stimulate the development of new and improved materials having applications across the commercial spectrum. A study is performed to define from the researchers' perspective, the requirements for laboratory equipment to accommodate microgravity experiments on the space station. The accommodation requirements focus on the microgravity science disciplines including combustion science, electronic materials, metals and alloys, fluids and transport phenomena, glasses and ceramics, and polymer science. User requirements have been identified in eleven research classes, each of which contain an envelope of functional requirements for related experiments having similar characteristics, objectives, and equipment needs. Based on these functional requirements seventeen items of experiment apparatus and twenty items of core supporting equipment have been defined which represent currently identified equipment requirements for a pressurized laboratory module at the initial operating capability of the NASA space station. Author

N86-18344# Naval Research Lab., Washington, D. C.
ASTRO-ARRAY: A SPACE-BASED, COHERENT RADIO INTERFEROMETER ARRAY
K. W. WEILER, J. H. SPENCER, and K. J. JOHNSTON 31 Oct. 1985 49 p
(Contract RR0-3406)
(AD-A160763; AD-E401375; NRL-MR-5657) Avail: NTIS HC A03/MF A01 CSCL 03B

With the proven techniques of radio astronomy and the rapidly advancing technology of space science, it is clear that the expansion of radio astronomy arrays beyond the limits of the Earth's surface is called for. Therefore, a preliminary discussion of the design and capability of a purely space based array is presented. The science which can be done with such a high resolution, high sensitivity radio telescope array is discussed and a number of the parameters of a system are developed. A coherent interferometer array is possible with reasonable extensions of present technology and such a telescope will lead to major advances in the areas of astrometry, the study of radio stars and radio supernovae, the investigation of astronomical masers, and the determination of the properties of the Milky Way nucleus and the active regions of normal galaxies, radio galaxies, and quasars. It is clear that an array of high orbit radio antennas linked to the low orbit space station represents the next logical step in the progression to continually higher resolution and sensitivity for radio astronomy. GRA

N86-18350# Air Force Geophysics Lab., Hanscom AFB, Mass.
CRRES/SPACERAD (COMBINED RELEASE AND RADIATION EFFECTS SATELLITE/SPACE RADIATION EFFECTS PROGRAM) EXPERIMENT DESCRIPTIONS Environmental Research Papers, 1 Oct. 1984 - 15 Jan. 1985
M. S. GUSSENHOVEN, E. G. MULLEN, and R. C. SAGALYN 24 Jan. 1985 196 p
(AD-A160504; AFGL-TR-85-0017; AFGL-ERP-906) Avail: NTIS HC A09/MF A01 CSCL 22A

The Space Radiation Effects (SPACERAD) Program is a comprehensive space program whose purposes, among other things, are to: (1) measure radiation-induced single event upsets (SEUs) and total-dose degradation of state-of-the-art microelectronic devices (to include VHSIC and GaAs devices) in a known space environment; (2) space qualify advanced technology microelectronic devices for operational DOD satellite systems; and (3) update the static models of the radiation belts and develop the first dynamic models of the high energy particle populations in the near-Earth environment. To accomplish these goals, AFGL has developed a space experiment complement consisting of a microelectronics experiment package (MEP), dosimeters, energetic-particle detectors, space plasma detectors, and wave and field (electric and magnetic) instruments. The experiments are to be flown as a package on the Joint Air Force/NASA Combined Release and Radiation Effects Satellite (CRRES) in FY87. The MEP will record SEUs and radiation degradation as a function of orbital position, particle type, device geometry, device technology, device material, device operating conditions, etc. The other instrumentation will be used to simultaneously measure the space environment. This document gives a brief description of the SPACERAD Program and the instruments to be flown on CRRES. GRA

N86-19336*# Smithsonian Astrophysical Observatory, Cambridge, Mass.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT (PHASE 2) Quarterly Report, 22 Jun. - 21 Sep. 1985
E. LORENZINI, D. A. ARNOLD, M. D. GROSSI, and G. E. GULLSHORN Oct. 1985 36 p refs
(Contract NAS8-36606)
(NASA-CR-178607; NAS 1.26:178607; QR-2) Avail: NTIS HC A03/MF A01 CSCL 22A

The deployment maneuver of three axis vertical constellations with elastic tethers is analyzed. The deployment strategy devised previously was improved. Dampers were added to the system. Effective algorithms for damping out the fundamental vibrational modes of the system were implemented. Simulations of a complete deployment and a subsequent station keeping phase of a three mass constellation is shown. Author

N86-19350*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOFT X-RAY TELESCOPE (SXRT)
R. MOORE *In its* Solar Terrestrial Observatory Space Station Workshop Report p 3 Jan. 1986 Previously announced as N85-34159
Avail: NTIS HC A03/MF A01 CSCL 14B

The soft X-ray telescope (SXRT) will provide direct images of the solar corona with spatial resolution of about 1 arcsecond. These images will show the global structure of the corona, the location and area of coronal holes, and the presence of even the smallest active regions and flares. The good spatial resolution will show the fine scale magnetic structure and changes in these phenomena. These observations are essential for monitoring, predicting, and understanding the solar magnetic cycle, coronal heating, solar flares, coronal mass ejections, and the solar wind. These observations complement those of the White Light Coronagraph and Ultra-Violet Coronal Spectrometer; the SXRT will detect active regions and coronal holes near the east limb, thereby giving a week or more of advanced warning for disturbed geomagnetic conditions at Earth. The instrument consists of a grazing incidence collecting mirror with a full-disk film camera at the primary focus, and a secondary relay optic that feeds a CCD camera with a field of view about the size of an average active region. Author

N86-19351*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR ULTRAVIOLET SPECTRAL IRRADIANCE MONITOR (SUSIM)
R. MOORE *In its* Solar Terrestrial Observatory Space Station Workshop Report p 4 Jan. 1986 Previously announced as N85-34160
Avail: NTIS HC A03/MF A01 CSCL 14B

The solar ultraviolet spectral irradiance monitor (SUSIM) measures the ultraviolet flux from the entire Sun with high absolute accuracy over the wavelength range 120 to 400 nm with a resolution of 0.1 nm. SUSIM consists of two identical double dispersion scanning spectrometers with 5 photodiodes, 2 photon counters, and a deuterium lamp calibration source, all sealed in a canister pressurized to 1.1 atmosphere of argon. One spectrometer is used almost continuously during sunlight, the other is used once per day as a calibration check. The observations will yield improved absolute measurements of the ultraviolet solar fluxes, provide an accurate reference for studies of variability of the solar fluxes on the time scales of the solar cycle and longer, and measure shorter term changes as well. These measurements complement the ACR measurements of the total solar irradiance. The data will be used to study the physical behavior of the Sun and the Earth's atmosphere, weather, and climate. Author

N86-19353*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
HIGH RESOLUTION TELESCOPE AND SPECTROGRAPH (HRTS)
R. MOORE *In its* Solar Terrestrial Observatory Space Station Workshop Report p 6 Jan. 1986 Previously announced as N85-34162
Avail: NTIS HC A03/MF A01 CSCL 14B

The major objectives of the high resolution telescope and spectrograph (HRTS) are: (1) the investigation of the energy balance and mass balance of the temperature minimum, chromosphere, transition zone, and corona in quiet regions on the Sun as well as in plages, flares, and sunspots; (2) the investigation of the velocity field of the lower corona to study the origin of the solar wind; and (3) the investigation of preflare and flare phenomena. The HRTS instruments consists of a telescope, an ultraviolet spectrograph, an ultraviolet spectroheliograph, and an H alpha slit display system, all housed in a thermal control cannister mounted on an instrument pointing system. Author

N86-19354*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ACTIVE CAVITY RADIOMETER (ACR)
R. MOORE *In its* Solar Terrestrial Observatory Space Station Workshop Report p 7 Jan. 1986 Previously announced as N85-34163
Avail: NTIS HC A03/MF A01 CSCL 14B

The active cavity radiometer (ACR) measures the total solar irradiance to determine the magnitude and direction of variations in the total solar radiative output. The ACR is an electrically self calibrating cavity pyroheliometer capable of measuring the total solar irradiance with an absolute accuracy better than 0.2% and capable of detecting changes in the total irradiance smaller than 0.001%. The data will be used to study the physical behavior of the Sun and the Earth's climate. Author

N86-19356*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE EXPERIMENTS WITH PARTICLE ACCELERATORS: SEPAC
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 10-11 Jan. 1986
Avail: NTIS HC A03/MF A01 CSCL 14B

The SEPAC instruments consist of an electron accelerator, a plasma accelerator, a neutral gas (N2) release device, particle and field diagnostic instruments, and a low light level television system. These instruments are used to accomplish multiple experiments: to study beam-particle interactions and other plasma processes; as probes to investigate magnetospheric processes; and as perturbation devices to study energy coupling mechanisms in the magnetosphere, ionosphere, and upper atmosphere. Author

N86-19357*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THEORETICAL AND EXPERIMENTAL BEAM PLASMA PHYSICS (TEBPP)
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 12-13 Jan. 1986 Previously announced as N85-34166
Avail: NTIS HC A03/MF A01

The theoretical and experimental beam plasma physics (TEBPP) consists of a package of five instruments to measure electric and magnetic fields, plasma density and temperature, neutral density, photometric emissions, and energetic particle spectra during firings of the particle injector (SEPAC) electron beam. The package is developed on a maneuverable boom (or RMS) and is used to measure beam characteristics and induced perturbations field (10 m) and mid field (10 m to 100 m) along the electron beam. The TEBPP package will be designed to investigate induced oscillations and induced electromagnetic mode waves, neutral and ion density and temperature effects, and beam characteristics as a function of axial distance. Author

N86-19358*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
RECOVERABLE PLASMA DIAGNOSTICS PACKAGE (RPDP)
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 14-15 Jan. 1986 Previously announced as N85-34167
Avail: NTIS HC A03/MF A01 CSCL 14B

The recoverable plasma diagnostics package (RPDP) is an ejectable and recoverable satellite with flight and ground support systems so that it can be utilized in three modes: attached to an remote manipulator system; tethered; or as a subsatellite. The satellite is well instrumented with particle and field diagnostic as well as optical sensors to: investigate the dynamics of the natural environment or ejected perturbations from particle beams; measure the characteristics and propagation of electrostatic and electromagnetic waves; study wave particle interactions; and study natural properties of the magnetosphere, ionosphere, and upper atmosphere. Author

N86-19359*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ELECTRODYNAMIC TETHER
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 16-17 Jan. 1986 Previously announced as N83-29490
Avail: NTIS HC A03/MF A01 CSCL 14B

The electrodynamic tether consists of a satellite deployed to a distance of 20 km by an electrically conducting tether. The space station hardware consists of a 12 meter deployment boom, satellite cradle, tether reel and motor, and other tether support systems. The electrodynamic tether will be used to perform a variety of wave experiments by exciting a wide spectrum of low frequency waves in the ionospheric plasma. The system can also be used to artificially generate and study field aligned currents and associated plasma effects. Hydromagnetic waves generated by the passage of the system through the space plasma are of particular interest in space plasma are of particular interest in space plasma research. Author

N86-19360*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
IMAGING SPECTROMETRIC OBSERVATORY (ISO)
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 18 Jan. 1986 Previously announced as N85-34169
Avail: NTIS HC A03/MF A01 CSCL 14B

The imaging spectrometric observatory (ISO) is discussed. The objectives of this instrument are to measure the spectral signatures of a large range of minor constituents, metastable, and excited species of both atomic and molecular ions, and neutrals in the atmosphere (from the stratosphere to the upper thermosphere). The instrument is composed of five identical spectrometers, each restricted to a given spectral range between 20 and 1200 nanometers designed for high speed operation as an imaging device. Each module is an imaging scanning spectrometer with coincident 0.5 x 0.007 degree field of view. Author

N86-19361*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ATMOSPHERIC EMISSION PHOTOMETRIC IMAGING (AEPI)
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 19 Jan. 1986 Previously announced as N85-34170
Avail: NTIS HC A03/MF A01 CSCL 14B

The atmospheric emission photometric imaging (AEPI) consists of a dual channel, low light level video system with a filter wheel to isolate the emissions of interest, mounted on a stabilized, two axis gimbal system for pointing and control. The objectives are to produce images of various atmospheric emissions to: investigate ionospheric transport processes; observe induced emissions from artificial particle injection; measure electron impact cross sections of atmospheric species; study natural aurora at high spatial and temporal resolutions and in the ultraviolet. Author

N86-19362*# Southwest Research Inst., San Antonio, Tex.
MAGNETOSPHERIC MULTIPROBES (MMP/CHEMSAT)
J. BURCH *In* NASA. George C. Marshall Space Flight Center Solar Terrestrial Observatory Space Station Workshop Report p 20-21 Jan. 1986 Previously announced as N85-34171
Avail: NTIS HC A03/MF A01 CSCL 14B

The magnetospheric multiprobes (MMP) are a set of ejectable, self contained, limited lifetime free flyers which are designed to make plasma diagnostic measurements at multiple locations within telemetry range of the space station's coorbiting platform and polar platform. When configured as CHEMSATs, one or more MMP's will conduct chemical releases as tracers or modifiers of the local plasma and field environment, while diagnostic measurements are made from other MMP's and from the nearby platform. The probes will be battery powered and will have lifetimes of a few days to several weeks. Up to 12 probes would be placed on the coorbiting platform and the polar platform every six months and two years respectively for use in the campaign mode of operation. Author

N86-19363*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
WIDE ANGLE MICHELSON DOPPLER IMAGING INTERFEROMETER (WAMDII)
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 22-23 Jan. 1986 Previously announced as N85-34172
Avail: NTIS HC A03/MF A01 CSCL 14B

The wide angle Michelson Doppler imaging interferometer (WAMDII) is a specialized type of optical Michelson interferometer working at sufficiently long path difference to measure Doppler shifts and to infer Doppler line widths of naturally occurring upper atmospheric Gaussian line emissions. The instrument is intended to measure vertical profiles of atmospheric winds and temperatures within the altitude range of 85 km to 300 km. The WAMDII consists of a Michelson interferometer followed by a camera lens and an 85 x 106 charge coupled device photodiode array. Narrow band filters in a filter wheel are used to isolate individual line emissions and the lens forms an image of the emitting region on the charge coupled device array. Author

N86-19364*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
VEHICLE CHARGING AND POTENTIAL (VCAP)
B. ROBERTS *In its* Solar Terrestrial Observatory Space Station Workshop Report p 24-25 Jan. 1986 Previously announced as N85-34173
Avail: NTIS HC A03/MF A01 CSCL 14B

The vehicle charging and potential (VCAP) payload includes a small electron accelerator capable of operating in a pulsed mode with firing pulses ranging from 600 nanoseconds to 107 seconds (100 milliamps at 1000 volts), a spherical retarding potential analyzer - Langmuir probe, and charge current probes. This instrumentation will support studies of beam plasma interactions and the electrical charging of the spacecraft. Active experiments may also be performed to investigate the fundamental processes of artificial aurora and ionospheric perturbations. In addition, by firing the beam up the geomagnetic field lines of force (away from the Earth) investigations of parallel electric field may be performed. Author

N86-19365*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
INITIAL PLACEMENT OF STO INSTRUMENTS
In its Solar Terrestrial Observatory Space Station Workshop Report p 26-37 Jan. 1986 refs Previously announced as N85-34174
Avail: NTIS HC A03/MF A01 CSCL 14B

The current plans for the placement of the Solar Terrestrial Observatory (STO) space station will make use of each of the currently planned space station elements - the manned space station, the polar platform, and the coorbiting platform. A designation of the instrument placement on each element along with a summary of the mass, volume, power and data requirements which these instrument will impose is provided in tabular form. R.J.F.

N86-19940*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE EFFECT OF ULTRADIAN AND ORBITAL CYCLES ON PLANT GROWTH
W. BERRY (California Univ., Los Angeles), T. HOSHIZAKI, and A. ULRICH (California Univ., Berkeley) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 565-575 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

In a series of experiments using sugar beets, researchers investigated the effects of varying cycles lengths on growth (0.37 hr to 48 hr). Each cycle was equally divided into a light and dark period so that each treatment regardless of cycle length received the same amount of light over the 17 weeks of the experiment. Two growth parameters were used to evaluate the effects of cycle length, total fresh weight and sucrose content of the storage root. Both parameters showed very similar responses in that under long cycles (12 hr or greater) growth was normal, whereas plants growing under shorter cycle periods were progressively inhibited. Minimum growth occurred at a cycle period of 0.75 hr. The yield at the 0.75 hr cycle, where was at a minimum, for total fresh weight was only 51 percent compared to the 24 hr cycle. The yield of sucrose was even more reduced at 41 percent of the 24 hr cycle. R.J.F.

N86-22129*# Allied Bendix Aerospace, Mishawaka, Ind. Guidance Systems Div.
HARDWARE TEST PROGRAM FOR EVALUATION OF BASELINE RANGE/RANGE RATE SENSOR CONCEPT
E. PERNIC Dec. 1985 127 p
(Contract NAS8-36144)
(NASA-CR-178710; NAS 1.26:178710; BGSD-MO-7078) Avail: NTIS HC A07/MF A01 CSCL 09B

The test program Phase II effort provides additional design information in terms of range and range rate (R/R) sensor

performance when observing and tracking a typical spacecraft target. The target used in the test program was a one-third scale model of the Hubble Space Telescope (HST) available at the MSFC test site where the tests were performed. A modified Bendix millimeter wave radar served as the R/R sensor test bed for evaluation of range and range rate tracking performance, and generation of radar signature characteristics of the spacecraft target. A summary of program test results and conclusions are presented along with detailed description of the Bendix test bed radar with accompaning instrumentation. The MSFC test site and facilities are described. The test procedures used to establish background levels, and the calibration procedures used in the range accuracy tests and RCS (radar cross section) signature measurements, are presented and a condensed version of the daily log kept during the 5 September through 17 September test period is also presented. The test program results are given starting with the RCS signature measurements, then continuing with range measurement accuracy test results and finally the range and range rate tracking accuracy test results. 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.

A86-10024#
PATH-CONSTRAINED MANEUVERING NEAR LARGE SPACE STRUCTURES
S. A. STERN (Colorado, University, Boulder) and W. T. FOWLER (Texas, University, Austin) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, Sept.-Oct. 1985, p. 548-553. refs

Spacecraft and personnel maneuvering in the vicinity of large space structures must take path constraints imposed by the structure itself into account. In this paper, the restricted path-constrained transfer problem is introduced and discussed. Further, the results are presented of numerical simulations in which the merits of a variety of techniques are developed and evaluated for the circumnavigation of large orbital structures of varying size and geometry. Also discussed are several aspects of the generalized path-constrained transfer problem in which large space structures of unspecified shape and rotational characteristic are permitted; this area of research pertains to operations near asteroidal, as well as man-made, objects. Author

A86-14440*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
INSTRUMENT POINTING TECHNOLOGY FOR SPACEBORNE SCIENCE MISSIONS OF THE 1990'S
R. A. LASKIN and S. W. SIRLIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA and AAS, Astrodynamics Conference, Seattle, WA, Aug. 20-22, 1984. 11 p. NASA-supported research. refs
(AIAA PAPER 84-2021)

The technologies which will permit sub-0.1 arcsec pointing accuracies on spacecraft in the 1990s are examined, along with the accuracies required and the current state of the art. Of particular interest are multi-mission spacecraft. Pointing accuracy can only be obtained by integrating the instrument (telescope) as part of the spacecraft, minimizing disturbances and using reaction wheels for pointing. The pointer could be isolated from complex spacecraft disturbances by soft mechanical mounts, e.g., inflatible tethers, guy-wire suspension and fluidic pointing systems. All design options are being explored for the Space Station, Earth Observing System, Co-orbiting platform and GEO platform spacecraft, and for near-term planetary spacecraft which will employ nuclear electric propulsion. M.S.K.

A86-15352
ON-ORBIT SERVICING OF CRYOGENICALLY COOLED OPTICAL SYSTEMS AND INSTRUMENTS
R. T. PARMLEY and E. HUBER (Lockheed Research Laboratories, Palo Alto, CA) IN: Cryogenic optical systems and instruments; Proceedings of the Meeting, San Diego, CA, August 23, 24, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1985, p. 70-75.

The first designs for the Space Infrared Telescope Facility (SIRTF) were based on a conduction of sortie missions involving the use of an STS-borne system. However, new developments have indicated that the SIRTF mission could be better accomplished in connection with the utilization of a free-flyer spacecraft. It is pointed out that such an approach could extend the mission life from days to years. An important factor in the extension of useful orbital life involves the replenishment of the cryogen expendables by making use of on-orbit servicing. In order to service the SIRTF free flyer, it must be retrieved from its orbit and placed on the servicing cradle on the Orbiter or Space Station. G.R.

A86-15628#
LAUNCH, RETRIEVAL, AND STAGE ASSEMBLY OPERATIONS ON A SPACE STATION
W. F. RECTOR, III and O. STEINBRONN (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-39)

Some of the major activities associated with operations and maintenance of the space-based Orbital Transfer Vehicles (OTVs) on the Space Station are discussed. Checkout and launch of large communications satellites from the Station and retrieval of satellites for servicing on the Station are addressed. Economic and performance benefits that can be derived from these activities are considered. The requirements that must be met by the Space Station and by OTVs to allow the required operations to take place efficiently are examined, and the potential Space Station servicing facility and OTV concepts that would fulfill these requirements are illustrated. Methods of carrying out the tasks related to OTV maintenance and servicing and spacecraft launch are discussed. The benefits of these types of space-based operations in terms of economics, improved mission assurance, and launch capabilities are discussed. C.D.

A86-15629#
SPACE STATION SUPPORT OF ADVANCED MISSION OPERATIONS
G. R. WOODCOCK (Boeing Aerospace Co., Huntsville, AL) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 22 p. refs
(IAF PAPER 85-41)

Space station concept evolution, current missions, and factors that shaped the present space station configuration are briefly described. New approaches and concepts for advanced manned lunar and planetary missions are presented and discussed. Support requirements of these missions, and ways in which a space station can meet the requirements, are described. It is concluded that manned lunar operations up to and including a small base can readily be supported by a 'growth' space station but that manned planetary (Mars) landing can best be supported by establishing an 'orbital shipyard' as a coorbiting adjunct to the space station. Author

A86-15630#
SPACE-BASED SERVICING
L. A. WICKMAN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 5 p.
(IAF PAPER 85-43)

The on-orbit servicing of spacecraft is studied. The previous successful on-orbit servicings resulted in spacecraft design changes which take into consideration on-orbit maintenance. The capabilities

which would be provided by an orbital servicing facility are: (1) on-orbit maintenance, (2) refurbishment, (3) assembly, and (4) repair of failures. The economic and operational advantages of on-orbit servicing are investigated. A comparison of Space Station-based servicing with Shuttle-based servicing is presented. The proposed cost effectiveness and improved capabilities of the Space Station are described and reveal the advantage of the Station in providing a variety of services. I.F.

A86-15631#
OPERATIONS PLANNING - KEY TO A SUCCESSFUL SPACE STATION FACILITY
R. L. KLINE (Grumman Aerospace Corp., Bethpage, NY) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 24 p.
(IAF PAPER 85-44)

Some operations planning aspects of the Space Station are discussed. Consideration is given to the major categories of Space Station operations including: user support operations; transportation harbor operations; ground support coordination operations; and proximity operations. The relations between individual components of the operational categories are examined. Some technological concepts are offered with respect to EVA/IVA coordination. I.H.

A86-15632*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
SPACE STATION OPERATIONS
R. H. GRAY (NASA, Kennedy Space Center, Cocoa Beach, FL) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-45)

An evaluation of the success of the Space Station will be based on the service provided to the customers by the Station crew, the productivity of the crew, and the costs of operation. Attention is given to details regarding Space Station operations, a summary of operational philosophies and requirements, logistics and resupply operations, prelaunch processing and launch operations, on-orbit operations, aspects of maintainability and maintenance, habitability, and questions of medical care. A logistics module concept is considered along with a logistics module processing timeline, a habitability module concept, and a Space Station rescue mission. G.R.

A86-15698*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DESIGN AND PERFORMANCE ANALYSIS OF AN AEROMANEUVERING ORBITAL-TRANSFER VEHICLE CONCEPT
G. P. MENEES (NASA, Ames Research Center, Moffett Field, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 14 p. refs
(IAF PAPER 85-139)

Systems requirements for design-optimized, lateral-turn performance were determined for reusable, space-based applications and low-earth orbits involving large multiple plane-inclination changes. The aerothermodynamic analysis is the most advanced available for rarefied-hypersonic flow over lifting surfaces at incidence. The effects of leading-edge bluntness, low-density viscous phenomena, and finite-rate flow-field chemistry and surface catalysis are accounted for. The predicted aerothermal heating characteristics are correlated with thermal-control and flight-performance capabilities. The mission payload capacity for delivery, retrieval, and combined operations was determined for round-trip sorties extending to polar orbits. Recommendations are given for future design refinements. The results help to identify technology issues required to develop prototype operational vehicles. Author

A86-15702#
SPACE-BASED ORBITAL TRANSFER VEHICLE
D. E. CHARHUT and W. J. KETCHUM (General Dynamics Corp., Space Systems Div., San Diego, CA) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-144)

The effectiveness of reusable launch vehicles to Low Earth Orbit has been demonstrated by the Space Shuttle. The Orbital Transfer Vehicle (OTV) is to extend reusability. It is planned to employ the OTV also in operations which will utilize the Space Station. For the Space Station, an added facility is planned which would provide a staging point for payloads that require placement at higher orbit by an OTV. It is pointed out that a space-based OTV could be more efficient since it would operate only in space and not be subjected to earth-to-orbit launch loads. Attention is given to the OTV operational scenario and mission profile, schedule, mission requirements, major program and system trades, OTV-Space Station accommodations (1997), and aspects of OTV growth. G.R.

A86-15703*# National Aeronautics and Space Administration, Washington, D.C.
THE ORBITAL MANEUVERING VEHICLE - EXTENDING THE REACH OF THE SPACE TRANSPORTATION SYSTEM
I. BEKEY (NASA, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-145)

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, operating modes, and performance capability are described. Typical mission scenarios for servicing missions from both the Shuttle and the Space Station are described. Author

A86-15706#
OTV NETWORK - NEW CONCEPT FOR THE NEXT GENERATION SPACE TRANSPORTATION SYSTEM
T. TANABE (Tokyo, University, Japan), S. NAKASUKA, and T. IWATA IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p. refs
(IAF PAPER 85-148)

The Orbit Transfer Vehicle (OTV) Network is proposed as a new concept for the next generation space transportation system. The proposed system is an integration of space based unmanned reusable OTVs and fuel stations. The OTVs, dropping into fuel stations for fuel supply on their way, carry out various missions, such as satellite delivery, recovery, or other satellite servicing. This system has some notable characteristics such that (1) a single OTV capability can be greatly enhanced; (2) the expendable part is very small; and (3) OTVs, fuel, and spacecraft can be launched separately. These characteristics yield transportation flexibility and cost effectiveness in the future large demand environments. Cost analyses based on reasonable future mission models, as well as vehicle cost models, are carried out. It is shown that for a demand level larger than 25 missions/year, the OTV Network is less expensive than current typical space transportation systems. A new type scheduler which manages OTV Network operations is also proposed. Computer simulations including this scheduler's operations are carried out, and the performance of this scheduler and the results of cost analyses are verified. Author

A86-15775*# Michigan Univ., Ann Arbor.
OPTIMAL AEROASSISTED TRANSFER BETWEEN COPLANAR ELLIPTICAL ORBITS
N. X. VINH and J. R. JOHANNESEN (Michigan, University, Ann Arbor) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 15 p. refs
(Contract JPL-956416)
(IAF PAPER 85-242)

An attempt is made to solve the problem of orbital transfer between coplanar elliptical orbits. Pure propulsive transfer is analyzed with the restriction of two impulses for the transfer. The optimal switching conditions are reviewed, and it is shown that the solution is obtained by solving a set of three nonlinear equations for three unknowns. A semianalytical solution is obtained to the problem of planar rotation of an orbit for the pure propulsive maneuver, and it is shown that, for high eccentricity and rotation angle, aeroassisted transfer is a fuel-saving maneuver. It is demonstrated that complete circularization of the intermediate orbit is not necessary in the optimal aeroassisted transfer. An analytical proof is presented, giving an explicit condition for noncircularization. A complete numerical solution is presented for a case of optimal aeroassisted transfer from a low-energy orbit to a high-energy orbit. C.D.

A86-15835#
USE OF THE MANNED MANEUVERING UNIT FOR ON-ORBIT RESCUE OPERATIONS
L. J. A. ROGERS (Martin Marietta Aerospace, Denver, CO) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-332)

The Manned Maneuvering Unit (MMU) was designed for untethered astronaut extravehicular activity (EVA). The MMU is a self-contained vehicle, which contains all the equipment needed for flight operations. By enabling the EVA crewmember to fly beyond the Orbiter payload bay, the MMU provides the capability to rendezvous with rotating satellites and stabilize them. Ground simulations have shown that the MMU can also be used to rescue disabled crewmembers in the vicinity of the Orbiter. The present paper is concerned with three potential rescue scenarios involving an employment of the MMU. The first scenario involves a utilization of the Personnel Rescue Sphere to transfer crewmembers from a disabled vehicle to a rescuing Orbiter. In the second rescue scenario, the event is considered that an EVA crewmember became untethered and drifted off into space. Attention is also given to the rescue of an MMU crewmember, taking into account the event that either the pilot became incapacitated or the MMU experienced a disabling failure. G.R.

A86-15949#
A DESIGN FOR FLUID MANAGEMENT IN SPACE
N. E. SEARBY IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p. refs
(IAF PAPER ST-85-04)

A fluid management system has been developed for space applications. The system design was based on three specific requirements of the microgravity environment in a manned space vehicle: solid-liquid-gas degassification; solid-liquid-gas separation; and algae growth and harvesting. Fluid separation is achieved using a divergent, truncated-cone separation chamber coupled with density-dependent valving. Degassification of fluids and separation of multi-level media is carried out at a high pressure level in order to move the separated media to storage areas. Operational tests of the system in a simulated low-g environment and on board Shuttle are described. A schematic diagram of the fluid management system is provided. I.H.

A86-17302*# National Aeronautics and Space Administration, Washington, D.C.
INTRODUCTION - THE SPACE INFRASTRUCTURE
I. BEKEY (NASA, Office of Space Flight, Washington, DC) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 3-8.

This book focuses on the Space Station and its associated platforms, which are the central and most visible space facilities in the thrust toward establishing a permanent presence in space. Facilities cannot be operated in isolation, however, and must have transportation for access. This is particularly true for space facilities. In order to attain the goal of permanent presence in space, the Space Station and its low altitude platforms must be developed and operated with transportation for routine access to and from the earth; local transportation between the Space Station, its platforms, and other low altitude satellites; and long-range transportation between low and geostationary orbits, and escape orbits. In addition, geostationary facilities and habitation elements must also be developed. It is in such an assembly of space facilities and transportation elements that will be vested the capabilities to service the earth, establish bases on the moon or planets, and eventually move beyond. Author

A86-17311#
THE NEXT STEPS IN SATELLITE COMMUNICATIONS
W. L. MORGAN (Clarksburg, Communications Center, MD) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 150-166.

The role of the Space Station and space platforms in communications is studied. The function of the Space Station as an assembly area for space platforms, a storage area for replacement satellite, as a satellite testing area, and as a base for a series of communication links is examined. Continued growth in telecommunications will evolve toward the demand for space platforms. The development of multiple networks on the same space frame, and the orbit locations of space platforms are described. The design and use of a multiminibeam satellite and distribution satellites are analyzed. The need for redundancy and absolute program continuity in order to refurbish and update satellites, and the ownership of satellites are discussed. I.F.

A86-17318* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
SPACE STATION PROGRAM OPERATIONS - MAKING IT WORK
G. R. PARKER (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 31-35.
(AAS PAPER 84-112)

The Space Station Program (SSP) will consist, in part, of a permanently orbiting facility composed of a mix of manned and unmanned elements. To insure that such a facility will be an operationally viable and productive one, capable of performing a myriad of assigned missions, special attention must be given to the following operational disciplines during the design and development of the SSP systems and subsystems: (1) Automation/Autonomy, (2) Customer Interfaces/Operations, (3) Habitability/Crew Productivity, (4) Maintainability, and (5) Logistics. In order to properly address these disciplines, from an operations point of view, the Director of the Space Station Task Force (SSTF) formed the Operations Working Group (OWG) in July 1982, and chartered this group to develop the top level operational technical and management-approach philosophies and requirements for the SSP. This paper attempts to summarize the results and conclusions reached by the OWG after an 18 month intensive study effort. Author

A86-17320
HUMAN ROLES IN FUTURE SPACE SYSTEMS
H. L. WOLBERS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 57-69. refs
(AAS PAPER 84-117)

U.S. and Soviet space programs to date have graphically demonstrated the value of humans working in space. The point at issue is to determine where, along the continuum from direct manual intervention to completely automated operations, the mission requirements of future space programs can best be met. The criteria of performance, cost, and risk (mission success probability) are suggested as the principal factors by which program or project managers and systems engineers should select the most effective approach to meeting specific mission objectives. Examples of the application of these criteria are presented.
Author

A86-17321
EVA OPERATIONS
T. W. HERRALA (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) IN: Permanent presence - Making it work; Proceedings of the Twenty-second Goddard Memorial Symposium, Greenbelt, MD, March 15, 16, 1984 . San Diego, CA, Univelt, Inc., 1985, p. 71-80.
(AAS PAPER 84-119)

The applications of EVA on board the Space Station are considered. The history of EVA operations in space is reviewed, with emphasis given to the Gemini, Apollo, and Shuttle missions. Some improvements in extravehicular mobility unit (EMU) technology are discussed, including: nonvent thermal control and CO2 control; heads-up audiovisual logistics displays; and radiation protection. The operational requirements of EVA on board Space Station are discussed, with attention given to: platform maintenance; satellite servicing; and scientific operations. An exploded-view diagram of a prototype EMU for Space Station is provided.
I.H.

A86-18514
A METHOD FOR COMPARISON OF TECHNOLOGIES FOR ORBITAL TRANSFER
C. ROSENE (Rice University, Houston, TX) Space Solar Power Review (ISSN 0191-9067), vol. 5, no. 3, 1985, p. 271-275.

Techniques necessary to compare and evaluate proposed orbital transfer systems are examined. The derivation of a formula for the break-even price for the operation of an OTV from LEO to GEO is presented. The formula assumes the subsystems of the OTVs are independent, and considers the cost of the vehicle, maintenance cost, and the efficiency and configuration of the vehicle. The expressions for calculating the break-even price for aerobraked and nonaerobraked systems are given. The equations allow for the comparison of different propulsive systems for the OTVs; an example comparing the thrust to mass ratio for electric, chemical, and nuclear propulsion systems is provided.
I.F.

A86-19533
SATELLITE SERVICING - LESSONS LEARNED FROM SOLAR MAXIMUM REPAIR
A. L. SPROTT and M. BAY (Fairchild Space Co., Germantown, MD) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 79-82.

The Solar Maximum Mission (SMM) satellite underwent pointing attitude control system malfunctions soon after launch, and was repaired by the Space Shuttle four years later, presaging an era in which the servicing, repair and upgrading of satellites by means of the Shuttle Orbiter and the projected NASA Space Station will be routinely undertaken. Attention is presently given to lessons learned concerning preparation training, and on-orbit execution of capture and repair during the SMM rescue mission. Extravehicular activity is noted to be an essential aspect of prospective repair efforts.
O.C.

A86-19549* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE STATION BASED OPERATIONS AND MAINTENANCE SUPPORT TO SPACECRAFT, PLATFORMS, AND ORBIT TRANSFER VEHICLE (OTV)
J. W. STEINCAMP, J. A. MULQUEEN, and J. W. MALONEY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 240-247.

The orbital servicing concepts developed for several existing and planned spacecraft are reviewed to illustrate the evolution and capabilities of Shuttle-based support services, and the potential range of future services are categorized by several criteria including transportation systems requirements, supporting facilities and equipment options, and servicing locations. Implications of Space Station-basing the services are described, along with possible implementing systems. In particular, the technique of 'formation flying' by means of which spacecraft may be physically isolated from each other while maintaining reasonable propellant requirements for maneuvers between them is explored by representative examples. OTV mission support is described as an evolutionary augmentation of the basic Space Station services.
Author

A86-19568
SPACE CONSTRUCTION TECHNOLOGY FOR LARGE SPACE OBSERVATORIES
G. R. WOODCOCK (Boeing Aerospace Co., Seattle, WA) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 402-410.

The need for space observatories in order to continue gaining knowledge of the universe is discussed. The utilization of a space station for construction, assembly, and servicing of large-aperture instruments is examined. Three classes of space construction capabilities required for astrophysical missions are studied. The first mission involves deployment and erection of a structural platform to serve as a construction, storage, and hangar facility. The construction of a 100-meter diameter RF antenna is the goal of the second mission. The third mission which involves construction of a precision structure for an optical or infrared instrument of 10-20 m aperture, installation of an actively-controlled optical reflector, and integration of a more complex spacecraft system with precision pointing requirements is described.
I.F.

A86-19802#
INVISCID/BOUNDARY LAYER PREDICTION OF AEROHEATING ON A BENT-AXIS BICONIC
G. F. POLANSKY and R. W. NOACK (Sandia National Laboratory, Albuquerque, NM) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs
(Contract DE-AC04-76DP-00789)
(AIAA PAPER 86-0303)

Newly developed inviscid and boundary layer codes are applied to the prediction of aerodynamic heating on both on-axis and bent-axis biconic orbital transfer vehicle configurations proposed by NASA. The inviscid code solves the full three-dimensional form of the nonconservative Euler equations. It features parabolic grid generation and an improved method of characteristics boundary condition. The boundary layer code solves the integral forms of the momentum and energy equations along inviscid streamlines. Generally good agreement is found in comparisons of the inviscid/boundary layer predictions with the experimental data at angles of attack up to 20 deg.
Author

A86-21068* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
ORBITAL FLIGHT TEST OF THE MANNED MANEUVERING UNIT
R. L. STEWART (NASA, Johnson Space Center, Houston, TX) IN: Society of Experimental Test Pilots, Symposium, 28th, Beverly Hills, CA, September 26-28, 1984, Proceedings . Lancaster, CA, Society of Experimental Test Pilots, 1984, p. 282-312.

Based on the experience provided by the first astronaut maneuvering unit used in the early extravehicular activities missions, a manned maneuvering unit (MMU) was developed that culminated in emergence of the M509 unit. The M509 unit, flown on the STS41-B, is a self-contained propulsive backpack. A flight support station (FSS) provides cargo bay stowage for the MMU, serves as a donning/doffing station, and provides an interface with the Orbiter gaseous nitrogen system for propellant refueling, electrical power for heaters, and temperature instrumentation. The MMU propulsion system, its control system, the electrical system and the flight displays are described. The orbital flight test has demonstrated superior handling and flying qualities of the MMU. I.S.

A86-22683*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A SHOCK CAPTURING TECHNIQUE FOR HYPERSONIC, CHEMICALLY RELAXING FLOWS
S. EBERHARDT and K. BROWN (NASA, Ames Research Center, Moffett Field, CA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. refs
(AIAA PAPER 86-0231)

A fully coupled, shock capturing technique is presented for chemically reacting flows at high Mach numbers. The technique makes use of a total variation diminishing (TVD) dissipation operator which results in sharp, crisp shocks. The eigenvalues and eigenvectors of the fully coupled system, which includes species conversion equations in addition to the gas dynamics equations, are analytically derived for a general reacting gas. Species production terms for a model dissociating gas are introduced and are included in the algorithm. The convective terms are solved using a first-order TVD scheme while the source terms are solved using a fourth-order Runge-Kutta scheme to enhance stability. Results from one-dimensional numerical experiments are shown for a two species and a three species gas. Author

A86-23518* Martin Marietta Corp., Denver, Colo.
RECENT SHUTTLE EVA OPERATIONS AND EXPERIENCE
L. J. A. ROGERS (Martin Marietta Corp., Denver, CO), C. E. WHITSETT, and M. RODRIQUEZ (NASA, Johnson Space Center, Houston, TX) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 11 p.
(SAE PAPER 851328)

This paper describes the hardware used and the experience gained during the Space Shuttle extravehicular activities (EVAs) or 'spacewalks' of 1984. Seven EVAs on four missions were conducted with objectives including hardware verification, satellite repair, hydrazine transfer, and satellite retrieval. The hardware used on these flights fall into two categories - general EVA hardware (e.g. the Manned Maneuvering Unit) and mission-unique hardware (e.g. apogee kick motor capture device, used to retrieve the WESTAR VI and PALAPA B-2 satellites). The successful completion of the mission objectives resulted in an increased knowledge of EVA operations and a broader base of Space Shuttle capabilities which are applicable to future operations. Author

A86-23520
WHY MANNED EVA?
J. F. RAYFIELD (ILC Industries, Inc., ILC Dover Div., Frederica, DE) and H. T. FISHER (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 7 p. refs
(SAE PAPER 851331)

The importance of manned extravehicular activity (EVA) in Space Transportation System (STS) missions and for the Space Station is discussed. The need for space vehicle servicing is examined including reliability/MTBF, preventive maintenance, wear-out and degradation, damage, updating, and replacement. Also considered are projected maintenance needs such as actual repair, modification, and re-configuration of the on-orbit space element. Present EVA functions such as inspect/assess, reconfigure, repair, replace components, debris capture, checkout, and verify are discussed along with new tasks projected for advanced Shuttle support such as extensive glove-tool repair-maintenance. Advantages of EVA over remote operation are pointed out as in engage/disengage, manipulate small objects, remove/replace, align apply discrete forces and torques, fasten, override, and MLI manipulation. R.R.

A86-23521
THE ROLES OF ASTRONAUTS AND MACHINES FOR FUTURE SPACE OPERATIONS
R. H. SCHAEFER, R. E. OLSEN, and F. J. ABELES (Grumman Aerospace Corp., Bethpage, NY) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p.
(SAE PAPER 851332)

A comparative assessment is made of remote operation space environment systems and human EVAs, with a view to future space missions, both individually and in combination. The tasks in question encompass servicing and construction operations on manned space station and unmanned platforms. Laboratory tests and simulations of representative remote system and EVA task performance are discussed and recommendations for additional development activities are presented. O.C.

A86-28796
CONCEPTS FOR THE EARLY REALIZATION OF A MANNED MISSION TO MARS
S. J. HOFFMAN and J. K. SOLDNER (Science Applications International Corp., Schaumburg, IL) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 377-390. Research supported by the Planetary Society.
(AAS 84-170)

A concept for a first manned mission to the planet Mars, embarking in the early-2000's time frame is presented. For this analysis no new technology other than what would conservatively be expected in the next 20 years, e.g., aerocapture technology, is assumed to exist. A four person crew consisting of a three person surface exploration team, and one orbiting crewmember, is proposed. Thirty days will be spent exploring the Martian surface and near-Mars space. A dual launch mission concept is proposed, assuming all the required mass, including OTV's and their propellant, would be carried to orbit via the present Shuttle fleet. A performance summary shows that 10 OTV's are required to inject both spacecraft on their respective trajectories to Mars, and that a total of 18 Shuttle launches are necessary to deliver the mass to the near-earth orbit staging area. Author

A86-28811
A PRELIMINARY ASSESSMENT OF MARTIAN NATURAL RESOURCE POTENTIAL
B. M. CORDELL (Space Futures Research Center, Oceanside, CA) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 627-639. refs
(AAS 84-185)

It is suggested that the discovery of significant ore deposits on Mars would be important to the development of self-sufficiency

for manned bases and might provide an economic stimulus (a 'metals' rush) to explore and establish numerous manned settlements. Most terrestrial mineralization is associated with plate tectonics which has not occurred on Mars. However, the existence of crustal swells, rifting, and volcanism on Mars and earth, plus abundant Martian volatiles, suggest that some mineralization processes may have occurred earlier in Martian history. Several non-orogenic ore formation mechanisms are evaluated for Mars. The similarities between resource-rich Africa and Mars are stressed. D.H.

A86-29646#
GEOSTATIONARY COMMUNICATIONS PLATFORM PAYLOAD CONCEPTS
W. CLOPP, JR., T. A. HAWKES, C. R. BERTLES (RCA, Astro-Electronics Div., Princeton, NJ), B. A. PONTANO, and T. KAO (COMSAT Laboratories, Clarksburg, MD) IN: Communication Satellite Systems Conference, 11th, San Diego, CA, March 17-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 577-585. refs
(AIAA PAPER 86-0697)

The commercial feasibility of various communications platform payload concepts for use in about 1998 are addressed. The concepts are defined, their recurring costs are estimated, and critical technologies needed to enable eventual commercialization are identified. Four communications service aggregation scenarios describing potential groupings of voice, video, and data services are considered. C.D.

N86-11212*# Ohio State Univ., Columbus. ElectroScience Lab.
CALCULATION OF ALLOWABLE ORBITAL SPACINGS FOR THE FIXED-SATELLITE SERVICE
Y. YAMAMURA and C. A. LEVIS Jul. 1985 78 p refs
(Contract NAG3-159)
(NASA-CR-176273; NAS 1.26:176273; TR-716548-1) Avail: NTIS HC A05/MF A01 CSCL 22A

Minimum satellite separations are calculated which satisfy a given carrier-to-interference protection ratio for the Fixed-Satellite Service (FSS) on a single-entry basis, assuming circular antenna beams. The results are presented in the form of universal contour curves, in which antenna-centered angles are the coordinates, and also in terms of the more conventional longitude and latitude separations. It is shown that orbit capacity increases with decreasing service-area size and that, for practical service areas, capacity is increased if the longitude of a satellite does not differ too greatly from that of the service area it serves. Author

N86-11221*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DESIGN AND PERFORMANCE ANALYSIS OF AN AERO-MANEUVERING ORBITAL-TRANSFER VEHICLE CONCEPT
G. P. MENEES Oct. 1985 16 p refs
(NASA-TM-86848; REPT-85398; NAS 1.15:86848) Avail: NTIS HC A02/MF A01 CSCL 22B

Systems requirements for design-optimized, lateral-turn performance were determined for reusable, space-based applications and low-Earth orbits involving large multiple plane-inclination changes. The aerothermodynamic analysis is the most advanced available for rarefield-hypersonic flow over lifting surfaces at incidence. The effects of leading-edge bluntness, low-density viscous phenomena, and finite-rate flow-field chemistry and surface catalysis are accounted for. The predicted aerothermal heating characteristics are correlated with thermal-control and flight-performance capabilities. The mission payload capacity for delivery, retrieval, and combined operations was determined for round-trip sorties extending to polar orbits. Recommendations are given for future design refinements. The results help to identify technology issues required to develop prototype operational vehicles. Author

N86-15070*# Institute for Scientific Research, Winchester, Mass.
MOLECULAR PROCESSES IN A HIGH TEMPERATURE SHOCK LAYER Semiannual Status Report, 1 May - 31 Oct. 1984
S. L. GUBERMAN 1984 8 p refs
(Contract NCC2-308)
(NASA-CR-176383; NAS 1.26:176383) Avail: NTIS HC A02/MF A01 CSCL 20H

Models of the shock layer encountered by an Aeroassisted Orbital Transfer Vehicle require as input accurate cross sections and rate constants for the atomic and molecular processes that characterize the shock radiation. From the estimated atomic and molecular densities in the shock layer and the expected residence time of 1 m/s, it can be expected that electron-ion collision processes will be important in the shock model. Electron capture by molecular ions followed by dissociation, e.g., O2(+) + e(-) yields 0 + 0, can be expected to be of major importance since these processes are known to have high rates (e.g., 10 to the -7th power cu/cm/sec) at room temperature. However, there have been no experimental measurements of dissociative recombination (DR) at temperatures (12000K) that are expected to characterize the shock layer. Indeed, even at room temperature, it is often difficult to perform experiments that determine the dependence of the translational energy and quantum yields of the product atoms on the electronic and vibrational state of the reactant molecular ions. Presented are ab initio quantum chemical studies of DR for molecular ions that are likely to be important in the atmospheric shock layer. Author

N86-16456*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
CONSIDERATION OF RADAR TARGET GLINT FROM ST DURING OMV RENDEZVOUS
M. W. MCDONALD, L. B. MALONE, and E. H. GLEASON Sep. 1985 13 p refs
(NASA-TM-86533; NAS 1.15:86533) Avail: NTIS HC A02/MF A01 CSCL 17I

The nature of radar target glint and the factors upon which it depends when using the Hubble Space Telescope as a radar target is discussed. An analysis of the glint problem using a 35 MHz or 94 MHz radar on the orbital maneuvering vehicle is explored. A strategy for overcoming glint is suggested. Author

N86-17417*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
RADIATION EXPOSURE AND PERFORMANCE OF MULTIPLE BURN LEO-GEO ORBIT TRANSFER TRAJECTORIES
S. H. GORLAND *In* Johns Hopkins Univ. The 1985 JANNAF Propulsion Meeting, Volume 1 p 383-389 Apr. 1985 refs Previously announced as N85-21228 Sponsored in part by NASA
Avail: Chemical Propulsion Information Agency, Johns Hopkins Rd., Laurel, Md. 20707 HC $78.98 CSCL 21H

Many potential strategies exist for the transfer of spacecraft from low Earth orbit (LEO) to geosynchronous (GEO) orbit. One strategy has generally been utilized, that being a single impulsive burn at perigee and a GEO insertion burn at apogee. Multiple burn strategies were discussed for orbit transfer vehicles (OTVs) but the transfer times and radiation exposure, particularly for potentially manned missions, were used as arguments against those options. Quantitative results concerning the trip time and radiation encountered by multiple burn orbit transfer missions in order to establish the feasibility of manned missions, the vulnerability of electronics, and the shielding requirements are presented. The performance of these multiple burn missions is quantified in terms of the payload and propellant variances from the minimum energy mission transfer. The missions analyzed varied from one to eight perigee burns and ranged from a high thrust, 1 g, acceleration, cryogenic hydrogen-oxygen chemical propulsion system for a continuous burn, 0.001 g acceleration, hydrogen, fueled resistojet propulsion system with a trip time of 60 days. Author

N86-19352*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
WHITE LIGHT CORONAGRAPH (WLC) AND ULTRA-VIOLET CORONAL SPECTROMETER (UVCS)
R. MOORE *In its* Solar Terrestrial Observatory Space Station Workshop Report p 5 Jan. 1986
Avail: NTIS HC A03/MF A01 CSCL 14B

The WLC and UVS together reveal the corona and the roots of the solar wind from 1.5 to 6 solar radii from sun center. The WLC measures the plasma density and spatial structure of the corona and coronal mass ejections at a plasma density and spatial structure of the corona and coronal mass ejections at a resolution of about 20 arcsec. The UVCS in combination with the WLC measures the temperature and radial outflow speed of the coronal plasma. These instruments will detect mass ejections from active regions and high speed solar wind streams from coronal holes a few days before the source regions rotate onto the face of the Sun, thus giving a week or more of advanced warning for disturbed geomagnetic conditions at Earth. Author

N86-20471*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
AEROBRAKING ORBITAL TRANSFER VEHICLE Patent Application
C. D. SCOTT, K. NAGY, B. B. ROBERTS, R. C. RIED, K. R. KROLL, and J. D. GAMBLE, inventors (to NASA) 18 Jun. 1985 15 p
(NASA-CASE-MSC-20921-1; NAS 1.71:MSC-20921-1; US-PATENT-APPL-SN-746162) Avail: NTIS HC A02/MF A01 CSCL 22B

An aerobraking orbital transfer vehicle is described. The vehicle includes an aerobraking device which also serves as a heat shield in the shape of a raked-off elliptic or circular cone with a circular or elliptical base, and with an ellipsoid or other blunt shape nose. The aerobraking device is fitted with a toroid-like skirt and is integral with the support structure of the propulsion system and other systems of the space vehicle. The vehicle is intended to be transported in components to a space station in low Earth orbit where it is assembled for use as a transportation system from low earth orbit to geosynchronous earth orbit and return. Conventional guidance means are included for autonomous flight. NASA

N86-21147*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MOBILE REMOTE MANIPULATOR VEHICLE SYSTEM Patent Application
H. G. BUSH, M. M. MIKULAS, JR., R. E. WALLSOM, and J. K. JENSEN, inventors (to NASA) 31 Jul. 1985 27 p
(NASA-CASE-LAR-13393-1; NAS 1.71:LAR-13393-1; US-PATENT-APPL-SN-760799) Avail: NTIS HC A03/MF A01 CSCL 05H

A mobile remote manipulator system is disclosed for assembly, repair and logistics transport on, around and about a space station square bay truss structure. The vehicle is supported by a square track arrangement supported by guide pins integral with the space station truss structure and located at each truss node. Propulsion is provided by a central push-pull drive mechanism that extends out from the vehicle one full structural bay over the truss and locks drive rods into the guide pins. The track switches allow the vehicle to travel in two (2) orthogonal directions over the truss structure which coupled with the bi-directional drive, allow movement in four (4) directions on one plane. The top layer of this tri-layered vehicle is a logistics platform. This platform is capable of 360 degrees of rotation and will have two (2) astronaut foot restraint platforms 18 and a space crane integral. NASA

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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.

A86-19559* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SPACE PLASMA INVESTIGATIONS ON THE FIRST SPACELAB MISSION
W. T. ROBERTS (NASA, Marshall Space Flight Center, Huntsville, AL) IN: The National Symposium and Workshop on Optical Platforms, Huntsville, AL, June 12-14, 1984, Proceedings . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 331-338.

A series of investigations was carried out during the First Spacelab Mission to study the space plasma environment from the Shuttle/Spacelab. The emphasis of the experiments was on the performance of particle injections from the Shuttle/Spacelab and studies of the ensuing effects on the orbiter, the near orbiter environment, and the earth's atmosphere. Results of these experiments, including electron beam injections, plasma injections, neutral injections, electron-plasma injections, electron-neutral injections, and ambient environmental measurements, are reviewed. V.L.

A86-19739#
ATMOSPHERIC STRUCTURE FOR LOW ALTITUDE SATELLITES AND AEROBRAKED ORBITAL TRANSFER VEHICLES
K. S. W. CHAMPION (USAF, Geophysics Laboratory, Bedford, MA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 12 p. refs
(AIAA PAPER 86-0186; AD-A163602; AFGL-TR-86-0018)

Several STS missions gathered data on the characteristics of the lower thermosphere and upper mesosphere, atmospheric region traversed by low-orbit satellites and which will be traversed by aeroassisted orbital transfer vehicles (AOTV). Atmospheric density profiles were calculated from inertial drag data and on-board accelerometers. Comparisons are made between the Orbiter data and the predictions of the Air Force Model Atmosphere, with attention given to observed fluctuations that are not present in the model data. The Orbiter data cover passages in April, June and twice in November. The magnitude of the observed variations indicate that further data will be required, both on the short term (5-hr and 15-min) scales, and annual and seasonal variations, if AOTVs are to reliably employ aeroassists for orbital maneuvers. The model atmospheres appear accurate for 20-80 km altitude, then become preliminary for the 80-120 km altitude interval. Improvements are yet needed for the 120-200 km altitude region, for which a solid database is already in hand. M.S.K.

A86-19926#
LARGE SPACE SYSTEMS - NATURAL ENVIRONMENT INTERACTIONS IN POLAR ORBIT
M. E. KIRKPARTRICK, N. J. STEVENS, C. S. UNDERWOOD, J. E. HOWARD (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA), and W. N. HALL (USAF, Geophysics Laboratory, Bedford, MA) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 17 p. USAF-supported research. refs
(AIAA PAPER 86-0521)

In this paper, a space station, operating in a 400 km polar orbit, is used to review and evalute possible environmental interactions. The polar orbit was chosen because the naturally occurring environmental variations, coupled with both known and suspected size interactions, produced a more severe case for consideration. The interactions of concern are auroral beam charging in high latitudes, high voltage solar array operations,

atomic oxygen attack on surfaces, meteoroid and debris damage, variable magnetic field effects and fluctuating environment effects. A review of the low earth environments and the resulting hazardous spacecraft interactions, as well as possible mitigation techniques, will be discussed. Author

A86-24595#
SPACE DEBRIS - A HAZARD FOR THE SPACE STATION?
E. A. ROTH ESA Bulletin (ISSN 0376-4265), no. 44, Nov. 1985, p. 63-65.

More than 3000 paylaods and an additional 12,000 objects have been put in orbit since 1957. Despite the decay of debris due to lower atmosphere air drag and subsequent burn-up on re-entry, the growth rate exceeds 200 objects a year. NORAD statistics, showing 50 percent of the objects to be debris from satellite breakups, opens the question of self-regeneration of the debris population from the large suspected quantity of potentially lethal objects of less than 10 cm that are not trackable. The need is pointed out for the development of advanced ground-based or in-orbit tracking sensors and the reduction of future debris through: minimization of the number of objects at spacecraft separation, de-orbiting satellites for reentry at the end of their lifetime, draining the residual fuel of the launcher's final stages to prevent subsequent explosion, and increasing the debris decay rate through conducting satellite destruction tests at low altitudes. It is concluded that the hazard space debris represents for the Space Station cannot yet be answered satisfactorily. R.R.

A86-25525* Systems Science and Software, La Jolla, Calif.
THE ROLE OF UNNEUTRALIZED SURFACE IONS IN NEGATIVE POTENTIAL ARCING
G. A. JONGEWARD, I. KATZ, M. J. MANDELL, and D. E. PARKS (Systems Science and Software, La Jolla, CA) (IEEE, DNA, Sandia National Laboratories, and NASA, 1985 Annual Conference on Nuclear and Space Radiation Effects, 22nd, Monterey, CA, July 22-24, 1985) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-32, Dec. 1985, p. 4087-4091. refs
(Contract NAS3-23881)

The observed arcing on negatively biased solar arrays exposed to plasma environments is shown to be due to an effective charge layer on the interconnect formed by ion collection from the plasma. Time scales to form this layer are shown to be in agreement with experimental observations. A quantitative theory is presented which predicts arcing threshold dependence on plasma density and external potentials. After breakdown, the discharge process is modeled as space charge limited transport to nearby coverslips. Peak currents and decay times predicted by this model are compared with experimental observations. Author

A86-25697* Air Force Geophysics Lab., Hanscom AFB, Mass.
SCATHA SURVEY OF HIGH-LEVEL SPACECRAFT CHARGING IN SUNLIGHT
E. G. MULLEN, M. S. GUSSENHOVEN, D. A. HARDY (USAF, Geophysics Laboratory, Bedford, MA), T. A. AGGSON, B. G. LEDLEY (NASA, Goddard Space Flight Center, Greenbelt, MD) et al. Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Feb. 1, 1986, p. 1474-1490. refs
(AD-A165444; AFGL-TR-86-0057)

The statistical occurrence of spacecraft charging at near-geosynchronous orbit in daylight is studied with reference to results of an experiment conducted on the SCATHA satellite. In particular, it is found that: (1) the external current that creates high negative satellite frame potentials is the high-energy electron current from the electron population with energies greater than about 30 keV; (2) the electron current to the satellite from particles with energies less than about 30 keV neither drives the frame potential nor provides the current to balance the high-energy populations; and (3) the ion current provided from the entire range of measured ions is also not the primary source of the balancing current. V.L.

N86-12248# Aerospace Corp., El Segundo, Calif. Lab. Operations.
THE AEROSPACE SPACECRAFT CHARGING DOCUMENT
A. L. VAMPOLA, P. F. MIZERA, H. C. KOONS, J. F. FENNELL, and D. F. HALL 3 Jun. 1985 52 p
(Contract F04701-83-C-0084)
(AD-A157664; TR-0084A(5940-05)-10; SD-TR-85-26) Avail: NTIS HC A04/MF A01 CSCL 22A

This document presents basic information on spacecraft charging in the Earth's magnetosphere, documents principal results from the engineering experiments on the USAF P78-2 satellite which was flown as part of the joint USAF-NASA spacecraft charging program (SCATHA), and makes recommendations for methods for alleviating the deleterious effects of spacecraft charging. It is intended as a primer for spacecraft designers and spacecraft program managers. GRA

N86-13923*# Lockheed Missiles and Space Co., Huntsville, Ala. Computational Mechanics Section.
HIGH-ALTITUDE PLUME COMPUTER CODE DEVELOPMENT Final Report
B. J. AUDEH and J. E. MURPHY 1 Jul. 1985 28 p refs
(Contract NAS8-34970)
(NASA-CR-171600; NAS 1.26:171600; LMSC-HEC-TR-F042501) Avail: NTIS HC A03/MF A01 CSCL 09B

The flowfield codes that have been developed to predict rocket motor plumes at high altitude were used to predict plume properties for the RCS motor which show reasonable agreement with experimental data. A systematic technique was established for the calculation of high altitude plumes. The communication of data between the computer codes was standardized. It is recommended that these outlined procedures be more completed, documented and updated as the plume methodology is applied to the varied problems of plume flow and plume impingement encountered by space station design and operation. Author

N86-19740*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
CHARACTERIZATION OF EMI GENERATED BY THE DISCHARGE OF A VOLT SOLAR ARRAY Final Report
P. LEUNG 1 Nov. 1985 24 p refs
(Contract NAS7-918)
(NASA-CR-176537; JPL-PUB-85-82; NAS 1.26:176537) Avail: NTIS HC A03/MF A01 CSCL 10A

The interaction of a high-voltage solar array with the space plasma environment is investigated in a laboratory simulation experiment. Discharges are observed to occur when the solar array is at a sufficiently high negative bias with respect to the plasma. The frequency of occurrence of discharge is found to depend critically on the plasma density and on the geometry of the array. The electromagnetic interference (EMI) associated with a discharge is also measured. The amplitude of EMI increases with the magnitude of the high voltage. Since the discharge-generated EMI is of significant amplitude, its effect on the performance of systems in space must be evaluated. 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.

A86-10567
WILL COLUMBUS FIND ENOUGH USERS?
R. JAQUES Interavia (ISSN 0020-5168), vol. 40, Sept. 1985, p. 986, 987.

Current plans for the ESA Columbus Space Station (SS) co-orbiter are reviewed. A manned laboratory pressure module is intended to be attached to the SS to share power and living quarters. A Resource Module will be added 10 yr later and permit autonomy in co-orbit. The configuration would be accompanied by free-flying platforms, either co-orbiting or polar-orbiting, and a service vehicle. Initiatives are under way to generate commercial and scientific participation in the Columbus project by providing access to low-g laboratories and documentation, and by developing expert systems to assist payload users. Materials science and pharmaceuticals experiments are receiving the greatest industrial attention at present. It is not yet known whether the ownership of the SS will be in the form of a condominium or a commune.
M.S.K.

A86-10999#
HIGH VOLTAGE SOLAR ARRAY FOR MPD PROPULSION SYSTEM
K. IJICHI, T. GOHNAI, M. GOTOH (Mitsubishi Electric Corp., Kamakura, Japan), H. FUJII (Mitsubishi Electric Corp., Manufacturing Development Laboratory, Amagasaki, Japan), and K. KURIKI (Tokyo, University, Japan) AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 18th, Alexandria, VA, Sept. 30-Oct. 2, 1985. 8 p.
(AIAA PAPER 85-2047)

Series-parallel switching of solar arrays has been demonstrated to provide high voltage power to charge capacitors using ground use solar arrays. To prevent arcing on solar arrays, conductive coating of solar cell cover glass is proposed based on the analysis of space plasma interactions. The arrangement of solar array modules to supply high voltage is studied, and it is found that at least twice as much voltage difference as that of an array module is unavoidable between solar array modules, and they should be taken into the design. The concept of high power bus system is proposed as an application of this high voltage solar array system.
Author

A86-11553
. . .AND THE HEART FLIES WITH YOU [. . . A SERDTSE LETIT S TOBOI]
N. RUDNYI and I. IUDIN Moscow, Izdatel'stvo Sovetskaia Rossiia, 1984, 240 p. In Russian.

The main trends in aerospace medicine and biology are examined in a popular way with reference to Soviet manned space flights. Particular consideration is given to the design of life support systems, the development of space suits, questions of hygiene, factors of nourishment, and the effects of weightlessness. The development of support systems for long-term flights on the Salyut stations is discussed.
B.J.

A86-11759
SATELLITE POWER SUPPLY USING SOLAR ARRAYS [ENERGIEVERSORGUNG VON SATELLITEN MIT SOLARGENERATOREN]
J. RATH (Telefunken AG, Wedel, West Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 9, July-Aug. 1985, p. 224-229. In German.

The use of solar arrays as the power supply system for satellites is discussed. The structure and characteristics of silicon solar cells, commonly used in space applications, are described. The current and voltage characteristics of a solar cell are examined, and the operating conditions which influence the electrical data are explained, noting advances in solar array technology. Advantages of the flexible array design are discussed giving examples of satellites utilizing these various array types. Future advances in flexible solar arrays, which involve increasing efficiency and voltage, and reduce mass and cost, are presented.
I.F.

A86-11808
AN APPROACH TO THE DYNAMICS OF MODULAR REPETITIVE STRUCTURES
C. ARDUINI (Roma, Universita, Rome, Italy) Acta Astronautica (ISSN 0094-5765), vol. 12, Sept. 1985, p. 661-666. ESA-supported research. refs

The dynamics of modular structures is approached in this paper by means of the discrete Fourier transform. This method, applied to a structure with N bays and ring type boundary conditions, leads to N uncoupled systems of the size of a single bay. For other boundary conditions, it leads to a 'spectrally resolved' eigenproblem, that is a form whose dominant terms in each field of frequency are evidenced. Approximate reduced models in narrow frequency fields can therefore be generated by using the 'spectral condensation' technique. The method can be applied with general boundary conditions, but the present paper deals mostly with the 'clamped edges' boundary condition and shows that numerical advantages can be obtained, particularly for the large space structures.
Author

A86-11889
THE GROWTH OF GASB UNDER MICROGRAVITY CONDITIONS
E. LENDVAY, M. HARSY, T. GOROG, I. GYURO, I. POZSGAI (Magyar Tudomanyos Akademia, Muszaki Fizikai Kutato Intezet, Budapest, Hungary) et al. Journal of Crystal Growth (ISSN 0022-0248), vol. 71, May-June 1985, p. 538-550. refs

A high quality GaSb bicrystal was grown in a Bridgman-type arrangement under microgravity conditions on board Salyut 6. Rutherford backscattering measurements indicate oxide and damage free surfaces. Scanning electron microscopy revealed microfacets on the space-grown sample. The morphology of the sample suggests a crystallization quite free of a wall effect. A comparison is given between space and terrestrial GaSb ingots, showing differences in surface quality, crystal perfection, and hole mobilities. In the space-grown sample a Hall mobility of about 2700 per sq cm/v/s value was found, while for the terrestrial control this value was only 2000 per sq cm/v/s.
Author

A86-12049
THE SOYUZ-13 - ORION-2 SPACE OBSERVATORY [OBSERVATORIIA V KOSMOSE: 'SOIUZ-13' - 'ORION-2']
V. A. AMBARTSUMIAN, B. V. RAUSHENBAKH, G. A. GURZADIAN, K. P. FEOKTISTOV, P. I. KLIMUK et al. Moscow, Izdatel'stvo Mashinostroenie, 1984, 248 p. In Russian.

The large-scale astrophysical experiment conducted aboard the Orion-2 observatory (carried by Soyuz-13) in December 1973 is described. Particular attention is given to the design and operating principle of the observatory, its installation on Soyuz-13, and stellar observations with the participation of the cosmonauts. The scientific results obtained are discussed, with emphasis on hot and cold stars, the Mg II 2800 doublet in stellar spectra, nebulae in the ultraviolet, circumstellar nebulae, the spectral classification of stars according to UV observations, and the physical parameters of stellar atmospheres.
B.J.

A86-12250#
'WEIGHTLESS SPACE' AS A LABORATORY - THE SPACELAB D1 MISSION
P. R. SAHM (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) and R. JANSEN (DFVLR, Cologne, West Germany) ESA Bulletin (ISSN 0376-4265), no. 43, Aug. 1985, p. 68-76.

Experimental goals for the Spacelab D1 mission, financed entirely by the German government, are described. The 70 experiments were contained in seven racks: the Materials Science Double Rack, a Process Chamber, the Medea for solidification of metallic and semiconductor materials, a Biorack, a Vestibular Sled, and the thermostated chambers of the System Rack. Fluid physics tests were designed to examine capillarity, interfacial fluid flow, diffusion and critical point phenomena. The solidification of 13 different alloys was to be examined, along with the growth of 14 crystals and the processes of Marangoni convection in six different situations. Bioscience experiments were planned in cell functions, developmental processes and vegetal gravity perception, as well as space adaptation syndrome in humans. Trials were also scheduled to study the accuracy of Cs atomic clocks, synchronization between on-board and ground-based clocks and distance measurements between the Orbiter and the ground.
M.S.K.

A86-12362#
PRELIMINARY MEDICAL RESULTS OF THE 5-MONTH FLIGHT ONBOARD SALYUT-7-SOYUZ-T
E. I. VOROBEV, O. G. GAZENKO, E. B. SHULZHENKO, A. I. GRIGOREV, A. S. BARER et al. IN: International developments in space stations and space technologies; Proceedings of the Thirty-fifth Congress, Lausanne, Switzerland, October 7-13, 1984 . New York, AIAA, 1985, p. 209-215.
(IAF PAPER 84-184)

Two Soviet astronauts performed a long-term space flight during the time from June 27 to November 23, 1983. Medical investigations regarding the two men were performed during and after the flight. The investigations had the objective to acquire more data about the reaction of the human body to a prolonged exposure to weightlessness. The present paper is concerned with the preliminary results of the medical studies. Attention is given to the general characterization of the 150-day flight, a general characterization of the status of the crew, measurements conducted during lower body negative pressure tests, measurements made during exercise tests, the physiological and hygienic aspects of astronauts during extravehicular activity, biochemical examinations, and postflight examinations. The obtained data have demonstrated once again that man can efficiently and productively work in long-term space flights.
G.R.

A86-12363#
PERIODISATION AND CLASSIFICATION OF ADAPTIVE REACTIONS OF MAN IN PROLONGED SPACE FLIGHTS
O. G. GAZENKO, E. B. SHULZHENKO, A. I. GRIGOREV, and A. D. EGOROV IN: International developments in space stations and space technologies; Proceedings of the Thirty-fifth Congress, Lausanne, Switzerland, October 7-13, 1984 . New York, AIAA, 1985, p. 216-225. refs
(IAF PAPER 84-185)

With respect to physiological changes, weightlessness appears to be the most important of various factors to which the human body is subjected during a space flight. The changes produced in the vital functions of the body during an exposure to weightlessness are considered, taking into account adaptive reactions and the time of their occurrence. It is found that the phase of completion of primary adaptive reactions (4-6 weeks in duration), is characterized by the further development of adaptive reactions and the recovery (partial or complete) of the final adaptive effects of certain functions. The period of relative stabilization of adaptation reactions represents the attainment of a new level with respect to the functioning of basic systems of the body.
G.R.

A86-13003
INVESTIGATION OF THE POSSIBILITY OF BUILDING LARGE LIGHT-WEIGHT METAL MIRRORS FOR THE LONG-WAVE IR SPECTRUM
E. A. VITRICHENKO, O. A. EVSEEV, V. I. ISAEV, V. I. LAPSHIN, V. N. LEONOV et al. (Optiko-Mekhanicheskaia Promyshlennost', vol. 52, Mar. 1985, p. 13-16) Soviet Journal of Optical Technology (ISSN 0038-5514), vol. 52, March 1985, p. 140-143. Translation. refs

The possibility of fabricating a light-weight main telescope mirror from a specially chosen aluminum alloy is investigated. The construction for such a mirror was developed, and two samples were fabricated and tested. A factor of 10 decrease in weight was achieved; a spherical surface having an aperture D/f-prime = 1/2 and an rms deviation of 0.65 microns was fabricated in 120 hours of machining time. The mirror shape remained stable for a least a month.
Author

A86-13287
THE IDENTIFICATION OF NATURAL FORMATIONS BASED ON THE RESULTS OF SPECTRAL AND ENERGY MEASUREMENTS FROM SPACE [IDENTIFIKATSIIA PRIRODNYKH OBRAZOVANII PO REZUL'TATAM SPEKTROENERGETICHESKIKH IZMERENII IZ KOSMOSA]
L. I. KUSELEVSKII, A. A. KOVALEV, and V. E. PLIUTA (AN BSSR, Institut Fiziki, Minsk, Belorussian SSR) Issledovanie Zemli iz Kosmosa (ISSN 0205-9614), July-Aug. 1985, p. 98-104. In Russian. refs

Photographs obtained on board the orbital station 'Salyut-4' were used to study the spectral and energy characteristics of the upper boundary layer over selected regions of the USSR. The influence of the sample volume on the statistical classifications for spectral features in the range 0.4-0.8 microns is examined in detail. The most informative spectral features were chosen according to Shannon's criterion of information content. A list of the spectral classifications is given.
I.H.

A86-13288
THE CLASSIFICATION OF NATURAL IMAGES BY THEIR OPTICAL CHARACTERISTICS USING SMALL VOLUMES OF EXTRACTED DATA [K VOPROSU O KLASSIFIKATSII PRIRODNYKH OBRAZOVANII PO IKH OPTICHESKIM KHARAKTERISTIKAM PRI MALYKH OB'EMAKH VYBOROK]
N. S. ABRAMOVICH, A. A. KOVALEV, and V. E. PLIUTA (AN BSSR, Institut Fiziki and Institut Matematiki, Minsk, Belorussian SSR) Issledovanie Zemli iz Kosmosa (ISSN 0205-9614), July-Aug. 1985, p. 105-111. In Russian. refs

A computer algorithm has been developed to classify the spectral bands of natural scenes on earth according to their optical characteristics. The algorithm is written in FORTRAN-1V and can be used in spectral data processing programs requiring small data loads. The spectral classifications of some different types of green vegetable canopies are given in order to illustrate the effectiveness of the algorithm.
I.H.

A86-13822#
MOMS-01 - MISSIONS AND RESULTS
J. BODECHTEL, R. HAYDN, J. ZILGER (Muenchen, Universitaet, Munich, West Germany), D. MEISSNER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany), P. SEIGE (DFVLR, Oberpfaffenhofen, West Germany) et al. IN: Monitoring earth/s ocean, land, and atmosphere from space - Sensors, systems, and applications. New York, AIAA, 1985, p. 524-535. refs

The modular optoelectronic multispectral scanner, MOMS, is designed for regional and global optical remote sensing applications. In two space missions it was mounted on the Shuttle Pallet Satellite SPAS aboard Shuttle flights STS-7 June 1983 and STS-11 February 1984. The missions served the technological space verification of the sensor and the demonstration of geoscientific and application-oriented experiments in worldwide distribution areas. Future development aims at the realization of a complex remote sensing device adaptable for different mission

types and platforms, e.g., short-term missions aboard the Shuttle, free-flying missions with various space buses (EURECA, the European Retrievable Carrier of ESA, RADARSAT of Canada) or for the man-tended polar platform of the Space Station. Author

A86-14275
SALYUT MISSION REPORT
N. KIDGER Spaceflight (ISSN 0038-6340), vol. 27, Nov. 1985, p. 420, 421.

The Soyuz T-13 flight was launched in June 1985 with the primary goal of delivering two cosmonauts to the Salyut 7 space station to effect repairs and carry out experiments. Docking was accomplished manually, the station batteries were recharged, and inspections were made of the control panels, wiring and on-board color television cameras. Visual wavelength photographs were taken of the earth and air samples were gathered within the station. The Progress 24 cargo capsule rendezvoused and docked 2 weeks after the two cosmonauts, bringing fuel, oxidizer and ship's stores sufficient for an extended mission. M.S.K.

A86-14827
UNCERTAINTY AND CONTROL - SOME ACTIVITIES AT DFVLR
G. GRUEBEL (DFVLR, Institut fuer Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany) IN: Uncertainty and control; Proceedings of the International Seminar, Bonn, West Germany, May 1985 . Berlin and New York, Springer-Verlag, 1985, p. 1-47. refs

Some activities at DFVLR which deal with system modelling and performance evaluation under uncertainty, as well as feedback control applications, are reported. Activities in applied nonlinear parameter identification, on-line wind measurement and prediction, stochastic simulation, and sensor diagnosis via analytic redundancy are briefly described. Applications of feedback control are examined, including model-following control for inflight simulation, robust stabilization of high-performance aircraft, aircraft flutter stability augmentation via active mode decoupling, and active damping of mechanical lightweight structures based on finite element modelling. C.D.

A86-15063
THE RUSSIANS ARE COMING?
L. DORR, JR. Space World (ISSN 0038-6332), vol. 5, Nov. 1985, p. 14-17.

Although the 'kosmolyot' mini-shuttle has successfully completed four test flights, no evidence has yet appeared that an operational shuttle program is an established goal for the U.S.S.R. A new medium-size booster (SL-X-16), capable of placing 15 tons in orbit, is being developed for the kosmolyot but has yet to fly. Additionally, a 220 ft tall superbooster, attributed Saturn V power and the capacity of lifting a Soviet shuttle or a space station section into orbit, has been on a launch pad for over a year. Only speculations are now available as to whether the forces currently relegating the new generation of Soviet space vehicles to the status of hangar queens are fiscal, the lack of suitable applications at the present time, or a deficiency in technology. M.S.K.

A86-15338
DEVELOPMENT OF THE STARLAB LARGE FORMAT DETECTORS
E. ROBERTS, T. STAPINSKI, A. RODGERS, and D. CARDEN (Mount Stromlo and Siding Spring Observatories, Canberra, Australia) IN: State-of-the-art imaging arrays and their applications; Proceedings of the Meeting, San Diego, CA, August 21-23, 1984 . Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 344-352. refs

The Starlab satellite telescope will use four advanced high performance detectors, operating on the Intensified Photon Counting CCD Array principle. The operation of the detectors is summarized. The baseline design is presented. This design has to meet stringent electro-optic performance specifications while addressing the electronic and mechanical requirements of a large unit operating in space. The tasks being undertaken to develop the detector are outlined, including design, construction and test of prototype detectors, the development of a computer simulation of the detector and supporting technology studies. The detector has the flexibility to be applied to a variety of ground-based and space projects. Author

A86-15612#
EUROPEAN POLICY OF SPACE TRANSPORTATION SYSTEMS
M. BIGNIER (ESA, Paris, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 4 p.
(IAF PAPER 85-19)

The objectives and the principal stages of the ESA Space Station Program are briefly reviewed. In particular, attention is given to Phase A and Phase B studies within the Columbus Preparatory Programme, financial status and the schedule of this program, principal problems facing the ESA, and preparation for Phase C/D. The forms of cooperation with the United States and plans for the Autonomous Columbus, including ARIANE 5 - HERMES - Autonomous Columbus - Data Relay Satellite and the associated ground elements, are also discussed. V.L.

A86-15613#
OVERVIEW OF JAPANESE POLICY ON SPACE STATION
S. KOBAYASHI (Tokyo, University, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p.
(IAF PAPER 85-20)

In connection with the U.S. Space Station project, NASA invited Japan, European countries, and Canada to participate and cooperate in the early phase of research and development in 1982. In response to this invitation, an ad-hoc committee on the Space Station program was formed in the Space Activities Commission of Japan on August 31, 1982. This paper provides a summary of the final report of the ad-hoc committee. This report, named 'Basic Plan for Japanese Participation in the Space Station Program', was approved on April 10, 1985 by the Space Activities Commission. Attention is given to fundamental considerations, a mission model and elements, and the basic plan for Japanese participation. G.R.

A86-15615#
SPACE CONSTRUCTION AND SERVICING SYSTEMS DESIGN FOR THE SPACE STATION ERA
D. M. GOSSAIN, S. S. SACHDEV, P. KUMAR, and J. A. MIDDLETON (Spar Aerospace, Ltd., Toronto, Canada) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(IAF PAPER 85-23)

The Space Station will form the basis of a new space infrastructure planned to be in place by the mid-1990s. The infrastructure will provide a permanent human presence in space and add new dimensions to space operations, including extensive construction and servicing activities. These activities will require a number of man/machine systems. This paper describes a Space Construction and Servicing Systems (SCSS) concept design which takes an integrated view of construction and servicing activities and the systems required for operations. Analysis of the activities to identify generic tasks and their hierarchy is described, as well as the options available for performing these tasks. Allocation of the tasks between man and machine and the role of manipulators is discussed, including the design approach to shifting more tasks from man to machine over time. The insights provided by the SCSS concept in aggregation of tasks for system definition, as well as commonality of systems, subsystems, and assemblies within SCSS, are discussed. An architecture of SCSS for the Space Station era is presented, and a design for an Integrated Servicing and Test Facility on the Space Station is described. Author

A86-15616#
CONCEPT OF JAPANESE EXPERIMENT MODULE
Y. MORISHITA, M. SAITO, and K. SHIRAKI (National Space Development Agency of Japan, Tokyo) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-24)

Japanese participation in the NASA Space Station takes the form of the Japanese Experiment Module (JEM), which is a multipurpose experiment package concerned with materials processing, life sciences, advanced technologies for microgravity environments, etc. The JEM architecture consists of a pressurized module, an exposed work deck, an experiment logistics module, experiment gases and water storage, a fixed manipulator, and an airlock. The multipurpose design of JEM is intended to accommodate unforeseen mission requirements that may emerge in 10-20 years. O.C.

A86-15617#
FEASIBILITY STUDY OF A MANNED SPACE STATION LAUNCHED AND ASSEMBLED WITH EUROPEAN VEHICLES
C. COUGNET (Matra, S.A., Toulouse, France), P. DUTTO (CNES, Toulouse, France), and P. EYMAR (Aerospatiale, Les Mureaux, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 14 p.
(IAF PAPER 85-25)

A study of a proposed European space station architectural concept that would rely exclusively on the use of the Ariane 5 system for its servicing and orbital insertion is presented. The main mission requirements, the monomodule and multimodule approaches to the station concept, and its interfaces with other spacecraft, such as Hermes, are discussed in detail. The possibility of reusing the Columbus Space Station elements was considered, and it was concluded that the Columbus pressurized module, as well as numerous subsystems and equipment of a Columbus resource module, could be reused without major modifications. It was found that the payload capacity of the Hermes was insufficient for the projected space station, which would require use of an automatic transfer vehicle in addition to Hermes. I.S.

A86-15618#
THE EURECA DESIGN CONCEPT
W. NELLESSEN (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 17 p.
(IAF PAPER 85-26)

The concept of EURECA (European Retrievable Carrier) is described, highlighting the most important design considerations for the sizing, development, operations, and utilization of the carrier. The structure, thermal control, electrical power, attitude and orbit control, communications and data handling, are discussed. The first EURECA mission is discussed, and planned future missions are briefly described. The EURECA system capabilities, launch configuration, functional schematic, communication system, and other facilities are diagrammed. C.D.

A86-15620#
THE SUPPORT TECHNOLOGY PROGRAMME FOR COLUMBUS TECHNICAL CONTENT AND IMPLEMENTATION
R. BARBERA and G. BOLTON (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-29)

The present Columbus Preparatory Program reflects a synthesis of previous studies of the European Space Agency (ESA) with investigations performed on a national basis by several countries, taking into account also the option offered by the U.S. regarding a participation in the NASA Space Station program. Following an approach similar to the one adopted by NASA with its Space Station Advanced Development programs, it was decided to perform a Columbus Preparatory Support Technology Program (PSTP). It is pointed out that the PSTP is now in an advanced process of full implementation. The technical content of the PSTP and details regarding its implementation are discussed, taking into account aspects of structures, thermal control, environment and life support, power generation, power distribution and management, energy storage, altitude and orbit control, the communication systems, and crew systems. Attention is also given to technology test beds and questions of status and planning. G.R.

A86-15621#
AN OVERVIEW OF CANADIAN TECHNOLOGY FOR SPACE STATION
K. H. DOETSCH (National Aeronautical Establishment, Ottawa, Canada) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p.
(IAF PAPER 85-30)

Canada has agreed to participate with the USA, Europe and Japan in Phase B of the development of the Space Station. The paper addresses the preliminary studies, which have already been completed, concerning potential Canadian users of, and suppliers to, the Space Station infrastructure. Plans during the present phase include studies of an Integrated Servicing and Test Facility, Solar Arrays, and a Remote Sensing Facility which could be provided by Canada to the infrastructure, and a Canadian User Development Program. The requirements for on-orbit servicing and testing of satellites and the role, in this function, both of humans and of the autonomous systems, which may be used for servicing satellites remotely from the Space Station, provide new technological challenges. The requirements which can be satisfied to meet broad user demands through an unpressurized, integrated servicing and test facility controlled by the crew, either from a pressurized work station or during extravehicular activity, are addressed. Author

A86-15622#
OVERVIEW OF JAPANESE TECHNOLOGY DEVELOPMENT FOR SPACE STATION
T. ARA (National Space Development Agency of Japan, Tokyo), K. NITTA (National Aerospace Laboratory, Tokyo, Japan), and M. NAGATOMO (Tokyo, University, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-31)

The results of a study by the National Space Development Agency (NASDA) of Japan to identify technologies for development in connection with a Japanese space station. Among the technologies considered are: a manipulator arm for space construction; a docking mechanism for an earth-to-space transfer vehicle; high-energy particle resistant computers for a space-based laboratory; and power components to be used on an exposed platform. The development of solar power collector to be used as a furnace for materials processing experiments is also discussed. The design features of a four-meter solar concentrator are listed in a table. I.H.

A86-15626#
LIQUID GAUGING TECHNOLOGIES FOR SPACE STATIONS UTILIZATION
R. MONTI and C. GOLIA (Napoli, Universita, Naples, Italy) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 19 p.
(IAF PAPER 85-36)

Technologies apt to determine the liquid content in reservoirs in near zero gravity environment are discussed in the framework of space stations. After having classified the various aspects of the methods, particular attention is paid to a number of thermodynamics methods. The mathematical models are briefly described, and some preliminary numerical simulations are presented to describe the response capability of each method. Author

A86-15627#
DEFINITION OF PROBABLE COLUMBUS OPERATION SCENARIOS
G. ALTMANN, H. KUMMER (ESA, Paris, France), and H. KEHR (DFVLR, Cologne, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 20 p.
(IAF PAPER 85-38)

The present status of the definition of the operational concepts envisaged for the Columbus space segments for manned and unmanned orbital operations is described. The Columbus program concept is reviewed, and its general operations principles are summarized. Some probable flight operations scenarios are given, discussing the planning of flight operations, on-board versus ground operations for manned elements, attached or integrated pressurized module operations, free-flying servicing operations, and communications. C.D.

A86-15633#
THE ACTIVE PROTECTION OF LONG-TERM SPACE STATION FROM IMPACTS OF SMALL MACROPARTICLES AND METEOROIDS
V. P. KOROBEINIKOV (AN SSSR, Matematicheskii Institut, Moscow, USSR) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p. refs
(IAF PAPER 85-46)

The probability of a collision of small cosmic bodies with large long-term operating cosmic stations is considered. The effects of particles collisions with elements of the stations are discussed. The principle possibilities for using solar radiation and transparent closed and opened envelopes for the protection from micrometeorites impacts are studied. Possibilities of applications of electromagnetic waves, particle beams and special cosmic 'shield' and gas filled balloons for the protection from minimeteorites which mass does not exceed 100 g are discussed. Author

A86-15634#
EUROPEAN ASPECTS OF USING THE SPACE STATION
K. K. REINHARTZ (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) and W. LEY (DFVLR, Cologne, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 14 p.
(IAF PAPER 85-47)

European studies of the applications of Space Station/Columbus elements have identified a growing interest in the use of future space-based scientific facilities. A set of 17 model missions is defined which covers most current areas of space research and applications. Analysis of the requirements of the different missions has begun to provide a preliminary user input into the Columbus design studies. It is shown that planning and implementation of an effective utilization program for the Space Station/Columbus elements will be a complex task requiring close cooperation between scientists and engineers from many disciplines. I.H.

A86-15637#
UTILIZATION OF SPACE STATIONS IN THE FIELD OF LIFE SCIENCES
M. VIEILLEFOSSE (CNES, Toulouse, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p. refs
(IAF PAPER 85-51)

A number of French life science experiments conducted in space are presented. The influence of microgravity and the space environment on physiology, ontogeny, and phylogeny is studied. The equipment, its function, and the results of cardiovascular, neurosensoral, eye, cellular, and genetic experiments are described and diagrams are provided. The importance of a space station facility for space medicine and physiology, and the role of man on the space station is discussed. A list of necessary captors, treatment and analysis, storage, stimulation, and plant and animal facilities on a space station is presented. I.F.

A86-15639#
SPACE STATION UTILIZATION FOR ASSEMBLY OF LARGE SPACE ANTENNA
K. MATSUMOTO, Y. OHKAMI, T. KIDA (National Aerospace Laboratory, Chofu, Japan), T. IIDA, K. OKAMOTO (Ministry of Posts and Telecommunications, Radio Research Laboratories, Koganei, Japan) et al. IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. refs
(IAF PAPER 85-54)

Attention is given to the results of a feasibility study concerning Space Station use as a working area for the assembly and/or deployment of large antennas. The antennas in question have such applications as earth observation, astronomical observations, energy transmission, and telecommunications. The concept of an enclosed spacecraft hangar is developed and discussed. O.C.

A86-15640#
TOWARDS AN EUROPEAN IN-ORBIT INFRASTRUCTURE
J.-C. BOUILLOT and A. PERARD (CNES, Paris, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p.
(IAF PAPER 85-55)

Attention is given to the prospective performance and design features of the Columbus space station, Ariane 5 booster, and Hermes reusable manned spacecraft, which will significantly enhance European capabilities in space. These three programs are envisioned as constituting a manned spaceflight infrastructure capable of long term development and expansion in the direction of space commercialization. The Ariane booster/Hermes orbiter system, in particular, is anticipated to be capable of yielding significant reductions in cost/kg to orbit. O.C.

A86-15641#
PLATFORM SERVICING - IMPACTS ON SYSTEM COST
J. MAJUS and H. SAX (DFVLR, Cologne, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 29 p.
(IAF PAPER 85-56)

A method is presented by means of which questions concerning the conduct of on-orbit servicing for future space stations can be structured and analyzed in a comprehensive fashion. Orbit servicing is essential to the achievement of space station elements' indefinite lifetime', reducing life cycle costs, upgrading instrumentation, replenishing raw materials, and adapting systems to new scientific objectives. The analysis method developed is applied in a cost comparison study for different servicing options. O.C.

A86-15642#
SPACE PLATFORM - A NEW APPROACH TO SPACE OPERATIONS
R. C. PARKINSON (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 6 p.
(IAF PAPER 85-59)

In January 1985, the Columbus proposal for participating in the Manned Space Station program was adopted by the European Space Agency (ESA). One of the elements of the Columbus program involves the employment of an unmanned, multiuser Space Platform. The Space Platform is intended as a permanent facility (or facilities) in low earth orbit to which users can attach payloads on a rental basis for as long a period as required. Two polar orbiting Platforms can provide earth observation coverage not possible from a Space Station orbiting at 28.5 degrees. Challenges associated with the Space Platform concept are related to the extended capabilities offered by the Platform, the multiuser capabilities, and modularity in the Platform design. G.R.

A86-15645#
ASTRONOMICAL MODULE FOR SPACE STATIONS ON THE BASIS OF A TRANSPORT SPACESHIP
M. M. GOGOSHEV and M. M. GOGOSHEV (Natsionalna Astronomicheska Observatoriia, Stara Zagora, Bulgaria) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-63)

The development of an astronomical module for orbital stations is proposed. The four principal blocks of the Soyuz and Progress transport ships consist of: (1) an instrumentation and aggregate section, (2) descent cabin, cargo module, (3) orbital control section, and (4) a docking unit. The proposed reconstruction of the transport ship to an astronomical module, which includes the substitution of a research unit for the cargo module and a reduction in size of the other section, is described and diagrams are provided. The main systems, blocks, and units of the telescope are diagramatically presented. The components and functions of the azimuthal mounting system and the pointing system, which has an orientation precision of 1-3 arc seconds, are examined. The role of the astronomer-astronaut in the module is discussed. I.F.

A86-15646#
ROBUS - A TELESCOPE AND TECHNOLOGY CARRIER FOR COLUMBUS
N. PAILER (Dornier System GmbH, Friedrichshafen, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-64)

The retrievable platform ROBUS telescope mission concept, derived from the German X-ray satellite ROSAT, was developed to answer the requirements of reusability and cost effectiveness, and of being able to utilize the Shuttle and the Columbus systems. One of the key features that makes ROBUS an ideal telescope carrier is flexibility, realized in three versions for different applications (ROBUS-1, for short-term missions; ROBUS-2, for astronomical long-term (1-2 yr) missions; and ROBUS-3, for long-term missions which include an orbital transfer system, allowing ROBUS-3 to be independent of the Shuttle orbit). In addition, several telescopes compatible with ROBUS are available and can be accommodated by a flexible mounting system. The ROBUS concept can be modified for use in demonstrations of the rendezvous and docking (RVD) technique, by adding a docking mechanism, rendezvous equipment, and a power generation system, as well as the attitude and orbital control systems and a propulsion system. I.S.

A86-15648#
A EUROPEAN INITIATIVE FOR IN-ORBIT DEMONSTRATION OF TECHNOLOGY DEVELOPMENTS
H. STOEWER (ESA, Systems Engineering Dept., Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 23 p.
(IAF PAPER 85-68)

The objectives of the ESA in-orbit technology demonstration program are to provide regular in-orbit flight opportunities for European space technologies, for the purpose of verification and for achieving their timely availability for future missions, as well as to select critical technologies for in-orbit testing. Examples of technological developments selected during the last two years from almost 100 technologies screened for testing are: a capacitive accelerometer for microgravity measurements, a space rigidized inflatable antenna, an atomic oxygen effects experiment, a new yaw earth sensor, an electrostatic levitator for materials sciences, an aluminum coating experiment, a helium cryostat, laser diode range finder, a liquid slosh experiment, advanced solar arrays for high voltage solar power systems, a two-phase heat transport system, a surface potential monitor, and accommodation studies of various carriers. Descriptions of these technologies and design diagrams are included. I.S.

A86-15650#
EXTENDABLE AND RETRACTABLE TELESCOPIC MAST FOR DEPLOYABLE STRUCTURES
H. RIEGER, M. SCHMID (Dornier System GmbH, Friedrichshafen, West Germany), and M. AGUIRRE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(IAF PAPER 85-70)

The principle of the Extendable and Retractable Mast (ERM), built originally for ground radio-link applications, is adapted for application in the deployment of a solar array and positioning of an unfurlable antenna. The proposed technical design concept of a space ERM establishes the basis for a mast family to cover a wide range of user demands. Application of carbon fiber reinforced plastics technology and telescopic tube sections in the design of the ERM results in high strength and stiffness of the mast at minimum mass. Good pointing accuracy can be reached with the ERM design by minimizing the number of tube sections and tube joints for a required deployed length. I.S.

A86-15653#
KINEMATIC ANALYSIS OF A LARGE DEPLOYABLE TRUSS ANTENNA
G. BRAZZINI, Y. BROUSTET, C. GARNIER, and P. PICARD (Aerospatiale, Les Mureaux and Cannes, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p.
(IAF PAPER 85-74)

A prototype flight model of a large deployable reflector is presented and used for analysis and design/mission assessment. The selected concept has a growth capability in the range of 5 to 30 m in diameter and the reflecting meshes permit operational frequencies from 1 GHz to 2.5 GHz. The antenna consists of a flexible knitted gold-plated Mo mesh stretched over a rigid deployable truss. In-orbit predictions demonstrated concept validity and clarified the critical points with regard to kinematics. The CPU times (in IBM environment) do not exceed 7 min. Details of the software code are covered. I.S.

A86-15659#
IMPROVED DESIGN AND VERIFICATION CONCEPTS FOR SPACECRAFT STRUCTURES
E. HORNUNG (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) and C. STAVRINIDIS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 73 p. INTELSAT-ESA-sponsored research. refs
(IAF PAPER 85-82)

Significant advantages can be gained through the improvement of load definition in spacecraft design and test procedures. Dynamic qualification test methodologies can be improved through the use of an upgraded structure test model representing spacecraft assembly and representative transient loads for design and testing. This methodology may avoid qualification difficulties by means of an upgraded structural assembly model and the performance of worksmanship failure checks on the flight model. O.C.

A86-15661#
THE MULTIMISSION PLATFORM (PFM)
P. VALLET (Matra, S. A., Toulouse, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p.
(IAF PAPER 85-85)

A multimission platform (PFM) designed for CNES to provide the payload instruments of the remote sensing satellites with electrical power supply, fine attitude and orbit control, on-board data management, telemetry, telecommand, and tracking is described. The platform organization, electrical power supplies, on-board data management, operating modes, launch and acquisition sequence, and wide variety of missions to which PFM can be adapted are discussed. The PFM is used by the SPOT-1 and SPOT-2 satellites of CNES in the minimum version and will

be used by ESA for the ERS-1 spacecraft in a maximum version. Detailed technical specifications and a series of block diagrams and schematics are included. I.S.

A86-15695#
HERMES SPACE PLANE PROGRAM MISSION AND SYSTEM ASPECT
A. DE LEFFE, J. SIMON, L. MARECHAL, J. C. CRETENET, and D. DE STAERKE (CNES, Toulouse, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p.
(IAF PAPER 85-136)

The projected Hermes missions are described in detail, including autonomous manned flight missions connected with scientific and technological aims, in-orbit servicing missions, and manned transport missions and space-station servicing. In addition, a detailed description of the Hermes system (space plane, the crew, payloads, and ground segment) is given, and the Hermes utilization cycle is considered. B.J.

A86-15700#
EUROPEAN ORBIT TRANSFER AND SERVICING VEHICLE APPROACHES
W. KLEINAU (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany), U. RIEDEL (ERNO Raumfahrttechnik GmbH, Bremen, West Germany), and P. EYMAR (Aerospatiale, Les Mureaux, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 16 p. refs
(IAF PAPER 85-142)

The main tasks of the Orbit Transfer and Service Vehicle (OTSV) are to provide transportation, servicing, and repair potentials for the European Space Segment, particularly the Columbus system, with the objective of enhancing autonomous operational capabilities. Both modular and integrated and both unmanned and manned vehicles are the main options for a future (gradually emerging) OTSV layout. Attention is given to OTSV examples conceived for specific European requirements as defined in particular by the Columbus manned and unmanned elements. The appearance of an unmanned OTSV as the first step is seen for mid-1994. B.J.

A86-15709#
10 MW SATELLITE POWER SYSTEM - A SPACE STATION MISSION BEYOND 2000
M. NAGATOMO (Tokyo, University, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(IAF PAPER 85-152)

The use of the 10 MW Satellite Power System (SPS) to develop Space Station missions is proposed. The main structures and subsystems of the 10 MW SPS, which are solar arrays, antennas, a microwave system, cryogenic power distribution system, and the robotics, are described. The electrical propulsion of the 10 MW SPS from LEO to GEO is studied. The operation testing of the 10 MW SPS includes: (1) a LEO experiment phase, (2) an orbit transfer phase, and (3) a GEO experiment phase. The adaptation of the 10 MW SPS for a Space Station is analyzed. The potential advantages to be provided by the Space Station project are examined. I.F.

A86-15711#
TECHNOLOGICAL DEVELOPMENTS FOR 2D-DEPLOYABLE SOLAR CELL ARRAY
K. MIURA, M. NATORI, and M. SAKAMAKI (Tokyo, University, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p. refs
(IAF PAPER 85-154)

The purpose of this paper is to report technological developments for 2D-deployable, planar, tension-stabilized large membrane space structures, such as the solar cell array, the space radar, and the solar sail vessel. The major efforts of the developments are focused on the design of blankets and the design of systems including the deployment mechanisms. Marked progress has been made in regard to the fabrication method of large blankets. The method provides that the blanket can be fabricated in a small facility, that the blanket is made in a folded state, and that the resulting package is a 2D-deployable structure. In order to promote the development of the 2D-array system, an experimental mission on board a space flyer unit is planned and the outline of the mission is presented. Author

A86-15713#
A NEW APPROACH TO OPTIMUM SIZING AND IN-ORBIT UTILIZATION OF SPACECRAFT PHOTOVOLTAIC POWER SYSTEM
M. S. IMAMURA and B. H. KHOSHAIM (Midwest Research Institute, Riyadh, Saudi Arabia) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p.
(IAF PAPER 85-156)

This paper presents a systems approach to optimization of the size and orbital life of photovoltaic systems via minimizing the nighttime energy demand while maximizing the daytime energy consumption. The Day-Night Management of Load (DANMOE) strategy calls for sizing the system to a pre-selected day/night average load power ratio and operating the spacecraft in orbit within the day and night capacity capability, rather than the conventional single orbital average power capability. Examples for the Space Station and the telecommunication satellites show that the reduction in their specific masses can be substantial using any of the photovoltaic system technologies. The DANMOE scheme may also be used effectively to extend the life of batteries on currently orbiting satellites, and hence prolong their lifetime. The paper also discusses other benefits at the spacecraft level and the method of implementing the DANMOE approach. Author

A86-15714#
ORBITAL TRANSPORTATION OF SOLAR POWER SATELLITE
K. KURIKI (Tokyo, University, Japan), Y. SASAO, and Y. KONDO (Ishikawajima-Harima Heavy Industries, Co., Ltd., Tokyo, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p. refs
(IAF PAPER 85-157)

The use of the magnetoplasmadynamic (MPD) thruster as the propulsion system for orbital transportation of solar power satellite (SPS) is studied. The resistojet, arcjet, ion engine, and MPD arcjet, which are possible systems for the orbital transportation of SPS, are described. The MPD arcjet is the most preferred system because it has a wide coverage of specific impulse 1000-6000 s, low voltage discharge, simple structure and operation, and various atoms and molecules can be used as propellant. The components of the electric power system and the propulsion power system of the MPD arcjet are given. The operation and performance of the MPD thruster are examined. The impact of the plasma exhaust on the magnetospheric environment is investigated. Two methods of in-orbit procurement of propellent, the gas dynamic method and magnetic method, are described; the gas dynamic method is the superior method in LEO. I.F.

A86-15733#
PROSPECTS AND PROBLEMS OF HEAVY LIFT ELECTROMAGNETIC THRUSTERS FOR SOLAR POWER SATELLITE (SPS) DEVELOPMENT
C. RIOUX, F. RIOUX-DAMIDAU (Paris VI, Universite; Paris XI, Universite, Orsay, France), and L. DESCHAMPS (Electricite de France, Direction des Etudes et Recherches, Clamart, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-187)

The prospects for electromagnetic propulsion as a means for launching from earth are considered. The loss of speed due to the braking action of the atmosphere on the projectile is briefly analyzed, along with the selection of the electromagnetic beam inclination. The needed characteristics of an electromagnetic launcher are summarized, and the subsystems of a typical propulsion system are outlined, including the energy storage, the shaping system, the propulsion tube, and installed electric power.

It is concluded that ballistic propulsion of heavy payloads using electromagnetic devices is probably feasible without using advanced technologies. C.D.

A86-15740#
ELECTRIC PROPULSION IN EUROPE
C. BARTOLI, A. ATZEI, H. VON ROHDEN, A. TRIPPI (ESA, European Space Research and Technology Center, Noordwijk, Netherlands), H. W. LOEB (Giessen, Universitaet, West Germany) et al. IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 21 p. refs
(IAF PAPER 85-200)

This paper presents the major activities carried out in Europe in the field of Electric Propulsion. Four lines of development are presently pursued. Two different models from the RIT family of radio-frequency ion thrusters are being developed in Germany. The RIT-10 thruster, operating in the thrust range of 10 mN, is due to be flight tested on board of the European Retrievable Carrier EURECA in 1988. A scaled-up version of this thruster, the RIT-35, is under development and it is mainly intended as the basic element of an Electric Propulsion Module for future interplanetary missions. Field Emission Electric Propulsion (FEEP) and Magneto-Plasma Dynamic (MPD) thrusters are also undergoing extensive research and testing. The paper describes the research, development and qualification programs associated with the electric propulsion systems mentioned above and the work done by European industries and Universities. Finally an account is given of future interplanetary missions for which the use of primary electric propulsion is envisaged. Author

A86-15747#
INFLATABLE, SPACE-RIGIDIZED STRUCTURES - OVERVIEW OF APPLICATIONS AND THEIR TECHNOLOGY IMPACT
M. C. BERNASCONI (Contraves AG, Zurich, Switzerland) and G. G. REIBALDI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 16 p. refs
(IAF PAPER 85-210)

The technology of inflatable, chemically-rigidized membranes for the realization of large space structures has been investigated in Europe during the last few years, with emphasis on antenna reflectors. The paper discusses the near-term applications, which can be covered by the present technology, or small modifications thereof. The discussion is subdivided into three parts. First, the application fields are surveyed. In the second part, the development status in the different areas is presented. Finally, the suitability of the available materials is discussed and the needed developments are summarized. Author

A86-15748#
AN ADAPTIVE STRUCTURE CONCEPT FOR FUTURE SPACE APPLICATIONS
K. MIURA (Tokyo, University, Japan) and H. FURUYA IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-211)

The purpose of this paper is to present a concept of the adaptive structure for future space applications. The definition of the adaptive structure is that the structure can purposefully vary its geometric configuration as well as its physical properties. Future space activities need such sophisticated structures. It is shown that the variable geometry (VG-) truss is the basic form of the adaptive structure. It consists of the repetition of an octahedral truss module and some of the truss members can vary their lengths continuously by actuators. By this mechanism, the VG-truss can change its configuration arbitrarily in 3D-space; while the inherent high stiffness is kept during the transformation. The basic formulations for its geometry as well as vibrational properties are established. The functional model which is controlled by a computer demonstrates satisfactorily the basic motions of the VG-truss. Some applications such as the second generation manipulator arm, the support architecture for a space station, and others are discussed. Author

A86-15753#
SPACECRAFT DESIGN FOR DAMPING
E. HILBRANDT (Dornier System GmbH, Friedrichshafen, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p.
(IAF PAPER 85-217)

The integration of damping into the design cycle of spacecraft is discussed. Three passive techniques for load and response reduction, which are vibration isolation, vibration absorption, and vibration control by passive damping, are examined. The damping design must take into account the total spacecraft design, launch conditions, and mission requirements; engineering considerations for damping application are described. An example of damping application for the Exosat structure is presented. The mathematical models applied for identification of damping effectiveness and for damping verification are given. The material representation, layer analysis, and global integration for layer damping is studied and diagrams are provided. I.F.

A86-15754#
DAMPING OF COMPOSITE PLATE FOR SPACE STRUCTURES - PREDICTION AND MEASUREMENT METHODS
M. MARCHETTI (Roma, Universita, Rome, Italy), F. MORGANTI, L. MUCCIANTE, and C. BRUNO (Selenia Spazio S.p.A., Rome, Italy) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 16 p. Research sponsored by the Ministero della Pubblica Istruzione. refs
(IAF PAPER 85-218)

Damping behavior of Gr/Ep, Kevlar/Ep, and glass fiber/Ep composites, used in spacecraft structures, was evaluated experimentally and analytically to correlate the energy dissipated in the composite to the lamination typology. The experimental results on the frequency response performed on samples of different materials and geometry were compared with the results of finite element analysis. The results suggest a way to extrapolate the method for the evaluation of damping of complex structures. I.S.

A86-15757#
OUT OF PLANE COEFFICIENT OF THERMAL EXPANSION AND ITS INFLUENCE ON REFLECTOR THERMAL DISTORTIONS
G. G. REIBALDI, L. FANCHI (ESA, Mechanical Systems Div., Noordwijk, Netherlands), P. CORDERO (Construcciones Aeronauticas, S.A., Madrid, Spain), and M. MARCHETTI (Roma, Universita, Rome, Italy) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. refs
(Contract ESA-5263/82-NL/GM)
(IAF PAPER 85-221)

Finite element techniques can be reliably used to predict the out-of-plane coefficient of thermal expansion of structural sandwich panels used in 300-3000 GHz reflector antenna construction. The influence of carbon fiber reinforced plastic laminate facings yields transverse effects greater than those produced by aluminum alone, due to Poisson's ratio-constraining effects. Simple models supporting preliminary design phases for these reflectors yield meaningful results, allowing configuration evaluation and interface impact analyses to be conducted. O.C.

A86-15758#
GSR3 - SOLAR ARRAY STRUCTURE CONCEPT
A. PLAGNE, J. P. REAU, and J. L. BASTARD (Aerospatiale, Les Mureaux and Cannes-la-Bocca, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 7 p.
(IAF PAPER 85-222)

A third-generation rigid foldout solar array, designated GSR3, is under development for future telecommunications and TV satellites. The GSR3 concept has been projected to be able to furnish end-of-life solar array performance of the order of more than 35 W/kg, using state-of-the-art, mass-produced solar cells and GSR1 recurring deployment mechanisms. Attention is presently given to the GSR3's ultralightweight panel structure technology's

mechanical performance, and to the manufacturing procedures and development and qualification tests employed. O.C.

A86-15759#
DEVELOPMENT AND TESTING OF MODULAR FRAME STRUCTURE FOR ADVANCED EARTH OBSERVATION SPACECRAFT
H. MITSUMA and M. YAMAMOTO (National Space Development Agency of Japan, Tsukuba Space Center, Sakura, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p.
(IAF PAPER 85-223)

A modular frame structure (MFS), fabricated of CFRP, was developed for the Japanese Earth Resources Satellite-1 (ERS-1) and future spacecraft structures, and the design was verified by performing modal survey, sinusoidal vibration, and acoustic tests. The developed MFS showed outstanding behavior under all environmental tests performed, and has the potential of easy handling. The modular system consists of the mission module (MM), bus module (BM), solar array, and synthetic aperture radar (SAR) antenna. The MM contains the SAR, visible and near-infrared radiometer, mission data (MD) transmitter, and MD recorder. The BM contains the reaction control subsystem, attitude control subsystem, and electronics for housekeeping functions. Detailed specifications and a series of explanatory diagrams are included. I.S.

A86-15760#
STRUCTURAL ANALYSIS AND DESIGN OF A POLARIZATION SENSITIVE REFLECTOR
K. PFEIFER, R. LEITNER, and W. WEISS (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. Sponsorship: European Space and Technology Centre.
(Contract ESTEC-5494/84/NL-CM)
(IAF PAPER 85-224)

For frequency reuse by orthogonal polarization, a suitable reflector configuration has been developed and built. The selected system with a diameter of about 1.1 m consists of two Kevlar fiber sandwich shells oriented one behind the other. To minimize thermal stresses the thermal expansion coefficients of all the laminates used were adjusted to the quasi-isotropic laminate of the reflector shells. A finite element analysis was performed. Calculations were done for an acceleration of 15 g and for the most critical sun irradiation conditions, where the surface of the antenna is partly shadowed. Even for the latter case only a small maximum deflection of less than 0.65 mm is obtained. All stresses are low and within the strength limits. Author

A86-15762#
AN OPTIMAL SLEWING MANEUVER APPROACH FOR A CLASS OF SPACECRAFT WITH FLEXIBLE APPENDAGES
T. KIDA, I. YAMAGUCHI, Y. OHKAMI (National Aerospace Laboratory, Chofu, Japan), K. HIRAKO, and H. SOGA (Toshiba Corp., Kawasaki, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 10 p. refs
(IAF PAPER 85-227)

The control problem encountered in the large angle attitude reorientation or slewing maneuver of flexible spacecraft is discussed, and some control algorithms for a class of spacecraft with elastic appendages are proposed. These algorithms have the advantages of both fast optimal attitude slewing, in the sense of Pontriagin's maximum principle, and robustness against model uncertainties in the sense of the LQ optimal closed-loop regulator. The validity of the algorithms is demonstrated with ground-based hardware experiments using a flexible spacecraft laboratory model mounted on a single-axis air-bearing table. C.D.

A86-15764#
ATTITUDE CONTROL FOR A DATA RELAY SATELLITE - A DECENTRALIZED APPROACH
L. PASSERON and CH. GARNIER (Aerospatiale, Cannes-la-Bocca, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 13 p. refs
(Contract CNES-83-0766)
(IAF PAPER 85-229)

The design of an attitude control system for a large, flexible Data Relay Satellite is addressed. The derivation of symbolic formulation for the spacecraft's equations of motion is considered, and the resulting model is interfaced with the NASTRAN program's outputs. The decentralized two-layer attitude control law is described along with advances in the subservient control theory. The layout of the attitude control hardware is presented, and simulation results are displayed, in particular for the station-keeping mode. C.D.

A86-15783#
EXACT ANALYTIC SOLUTION OF SPACE RELATIVE MOTION EQUATION
C. WANG (Beijing Automatic Control Engineering Institute, People's Republic of China) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-253)

An exact analytical solution to the space relative motion equation is obtained with a formulation in terms of the orbital coordinates and the Hill canonical variables. The model is extended to define and prove a theorem for gravitationally perturbed basic and relative motion. The model is considered valid for solving problems of parabolic and hyperbolic motion of a satellite relative to a space station. M.S.K.

A86-15791#
RENDEZVOUS AND DOCKING NAVIGATION SENSORS - SURVEY, EXPERIMENTAL RESULTS, AND DEMONSTRATION PROPOSAL
B. KUNKEL (Messerschitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) and P. HARTL (Stuttgart, Universitaet, West Germany) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 18 p. refs
(IAF PAPER 85-265)

The current rendezvous and docking (RVD) proximity sensor technologies are reviewed, along with possible applications scenarios. The most likely uses will be for mating with the Space Station or co-orbiting platforms, either in the same or polar orbits, or with platforms in GEO. Autonomous performance is necessary to avoid the costs of transporting humans to space, to access satellites in areas where no access is available to manned platforms, and to allow remote control from ground stations. The RVD systems will operate at long-range for detection and lock-on, at hold points, in fly-around maneuvers, at short range and in proximity. The sensors will operate using microwave (s and Ku bands), laser or passive imaging capabilities, the latter requiring CCD cameras which could sense laser- or microwave-illuminated targets. M.S.K.

A86-15792#
IMPLEMENTATION OF AN ADVANCED LASER RANGING CONCEPT
R. SCHWARTE, V. BAUMARTEN, B. BUNDSCHUH, R. DAENEL, W. GRAF (Siegen, Universitaet-Gesamthochschule, West Germany) et al. IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 9 p. refs
(IAF PAPER 85-266)

The design and performance features of a pulsed laser diode rangefinder (PLR) which has been operated with mm-accuracy in a prototype configuration are described. The device was developed of rendezvous and docking maneuvers, alignment, position control, contour and vibration monitoring of large space structures, in-flight control of free-flying platforms and for robotic vision for automated repair and service systems. Using a 5 nsec pulse and a 905 nm wavelength, the PLR system measures distance by the time-of-flight

method. The laser pulses are fed to the sensor head through optic fibers. Return flashes are carried to an avalanche photodiode by optic fibers. Picosec tuning is achieved by applying a modified dual-slope interpolation procedure to quantize the time measurments with respect to a quartz clock. M.S.K.

A86-15795#
RESULTS ON THERMAL CONDITIONS OF CRYSTAL GROWTH PROCESSES IN SPACE AND ON EARTH
R. KUHL (Deutsche Akademie der Wissenschaften, Institut fuer Raumforschung, Berlin, East Germany), H. SUESSMANN (Halle-Wittenberg, Universitaet, Halle, East Germany), and L. L. REGEL (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 14 p. refs
(IAF PAPER 85-271)

The experimental apparatus, techniques and selected data from experimentation on Bridgman directional solidification of crystals on-board the Salyut-6 and -7 space stations are described. Two tubular furnaces were employed, CRYSTAL and MAGMA, each equipped with resistance heaters supplying from 200-1200 C of heat. Data has been gathered on the temperature profiles and their evolution within the sample chambers in both terrestrial and space conditions. Additionally, the changes in the profiles induced by aging of the equipment after years of use in space were tracked. Finally, the probes and techniques used to generate the temperature profiles are discussed. M.S.K.

A86-15798#
THE RESULTS OF THE SPACE TECHNOLOGICAL EXPERIMENTS PERFORMED WITH THE SUPERCONDUCTING AND MAGNETIC ALLOYS
B. P. MICHAILOV, R. S. TORCHINOVA, and M. I. BYCHKOVA (AN SSSR, Institut Metallurgii, Moscow, USSR) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 6 p. refs
(IAF PAPER 85-276)

The results of long-term experimentation of the growth of superconducting intermetallic alloys in microgravity conditions on-board the Salyut-6 space station are discussed. The compounds MoGa5, Mo3Ga and Nb2Sn were formed by liquid-phase diffusion (LPD) and PB-Sn Gd3Co and (Gd0.2Tb0.8)3Co were synthesized by bulk crystallization. The LPD-formed materials exhibited a different phase diffusion than observed in the same materials grown in equivalent conditions on the earth. The results permitted identification of superconducting phase transitions at 18.3 and 5.7 K for the materials studied. The materials formed by bulk crystallization techniques in space displayed different magnetic properties than the same materials grown in the terrestrial gravity field. M.S.K.

A86-15815#
LIFE SUPPORT SYSTEM STUDY OF JAPANESE EXPERIMENT MODULE OF SPACE STATION
S. KANDA, H. FUJIMORI, A. HATTORI, T. SHIMIZU (Kawasaki Heavy Industries, Ltd., Kobe, Japan), and H. MATSUMIYA (Biosystems International, Inc., Tokyo, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. refs
(IAF PAPER 85-302)

An essential element of the Japanese Experiment Module (JEM) that is Japan's contribution to the NASA Space Station program is the Environmental Control and Life Support System (ECLSS), which ensures crew safety and establishes optimum conditions for their activities in the JEM. ECLSS controls pressure, temperature, humidity, oxygen partial pressure, CO2 partial pressure, and trace contaminants. Since Space Station mission durations will be much longer than Space Shuttle ones, CO2 absorption and oxygen regeneration are critical ECLSS functions; attention is accordingly given to the use of solid amine and salcomine-based systems for these respective tasks. The features of the Gas Recycle System for Controlled Ecological Life Support are also discussed. O.C.

A86-15818#
CONCEPT STUDY OF REGENERABLE CARBON DIOXIDE REMOVAL AND OXYGEN RECOVERY SYSTEM FOR THE JAPANESE EXPERIMENT MODULE
K. OTSUJI (Mitsubishi Heavy Industries, Ltd., Nagoya Aircraft Works, Nagoya, Japan), M. HIRAO (Mitsubishi Heavy Industries, Ltd., Kobe Shipyard and Engine Works, Kobe, Japan), and S. SATO (Mitsubishi Heavy Industries, Ltd., Takasago Technical Institute, Takasago, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. refs
(IAF PAPER 85-305)

A regenerable carbon dioxide removal subsystem using steam-desorbed solid amine and an oxygen recovery subsystem using Sabatier methane cracking have shown good potential for application to the Japanese Experiment Module. The basic characteristics of these subsystems, obtained from the results of a fundamental performance test program, are presented. A trace contaminant removal process is also studied and discussed. The energy-saving efficiency of the carbon dioxide removal subsystem is evaluated in terms of blower power reduction, steam reduction, and waste heat utilization techniques. Finally, the entire environmental control and life support system of the Japanese Experiment Module are evaluated. C.D.

A86-15838#
EARTH SATELLITE COLLISION PROBABILITY IN SPACE STATION ERA
M. NAGATOMO and K. SATO (Tokyo, University, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-336)

The collision between artificial orbiting objects has been predicted for the near future when the Space Station is operated. The model of population of orbiting objects in the near-earth space has been determined based on the data of registered satellites and estimation of other debris. If the model is determined, a collision probability for a certain size of satellite with known orbital parameters to collide with other orbiting satellites and debris can be calculated statistically. The collision probability is shown as a function of orbital altitude and inclination angle of the satellite. The change of the population of satellites due to new satellites launching and decay of orbital altitude has been predicted with a continuum model. The annual satellite generation rates were assumed and periodical variation of atmospheric density caused by solar activity were considered in ths calculation. The calculated results have been applied for prediction of the collision of a Space Station with other orbiting objects. Finally a result of preliminary study on feasibility of an orbital surveillance radar to detect colliding orbiting objects to take some action to prevent a catastrophic damage of a large space system will be presented. In this case, relative motion of colliding bodies to a target body is of our concern. The directional distributions of the colliding objects will determine the performance of the radar system. Some results of calculation has been presented. Author

A86-15856#
FUTURE EUROPEAN DATA RELAY SYSTEM - TECHNICAL OPTIONS
G. BERRETTA (ESA, Paris, France) and C. SOPRANO (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 21 p. refs
(IAF PAPER 85-362)

The purpose of this paper is to present and compare the technical options for a future Data Relay Satellite (DRS) system which should satisfy the European needs in the 90's. The mission requirements, as known at present, are listed, and a summary of system options is given, complemented by an analysis of alternative payload technologies, one of these technologies being related to optical laser links. Preparatory studies and developments are also outlined. Finally an initial reference concept and an indicative DRS programme schedule are briefly presented. Author

A86-15867#
USUDA DEEP SPACE STATION WITH 64-METER-DIAMETER ANTENNA
T. NOMURA, T. HAYASHI, T. NISHIMURA, H. HIROSAWA, and M. ICHIKAWA (Tokyo, University, Japan) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p. refs
(IAF PAPER 85-381)

Institute of Space and Astronautical Science (ISAS), Japan, constructed a new deep space ground station with 64-meter-diameter antenna at Usuda-cho, Nagano, in 1984. The station has successfully operated in the tracking of 'Sakigake', the first Japanese interplanetary spacecraft that ISAS launched on January 8, 1985. This paper describes the facilities and the features of the Usuda Station, the results of Sakigake tracking, as well as the features of the softwares for trajectory generation and orbit determination that have been developed for deep space missions. Author

A86-15879#
QUASAT PROGRAM - THE ESA REFLECTOR
G. G. REIBALDI (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) and M. C. BERNASCONI (Contraves AG, Zurich, Switzerland) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 8 p.
(Contract ESA-5845/84/NL/MS)
(IAF PAPER 85-400)

Quasat is a joint ESA/NASA cooperative mission for a free-flying VLBI antenna to be used with the U.S. and European ground arrays. The spaceborne reflector has a diameter of 15 m or more and is operated at three frequencies: 1.6, 5 and 22 GHz. These requirements are very stringent and very difficult to satisfy. The reflector proposed by the European Space Agency as part of the Quasat assessment study is presented. Such reflector uses the Inflatable Space Rigidized technology under development within ESA. Results of the performances envisaged from such design are discussed together with the manufacturing and testing problems envisaged for such reflector. Results derived by different reflector design but using the same Inflatable Space Rigidized technology are also presented. Author

A86-15882#
THE ISO DEVELOPMENT PROGRAMME
W. A. FRANK (ESA, Noordwijk, Netherlands) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 5 p.
(IAF PAPER 85-404)

The Phase A configuration of the ESA's Infrared Space Observatory (ISO) satellite, which will have a mass of 1800 kg, consists of two modules coupled structurally by a framework that serves to decouple them thermally. The payload module houses cryogenic subsystems with cooled radiation shields, and optical subsystems with scientific payloads. The service module encompasses more common spacecraft subsystems for propulsion and orbit control. The scientific payload carried by the former module incorporates an IR camera, a photopolarimeter, and short and long wavelength spectrometers. O.C.

A86-15897#
A MODEL FOR THE COMPARISON, FOR COST-EFFECTIVENESS, OF EXPENDABLE, REUSABLE AND SERVICEABLE SPACECRAFT
J. A. VANDENKERCKHOVE (ESA, Paris, France) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 17 p. refs
(IAF PAPER 85-425)

An economic model is developed in order to undertake comparative studies of the use of expendable, reusable, and serviceable spacecraft in such applications as earth observation, scientific research, and microgravity research missions. Total project costs for the number of flights envisaged are the sum of applicable non-recurrent and recurrent spacecraft costs, the launch, rendezvous and docking costs, retrieval costs, and servicing risks and operations costs. O.C.

A86-15932#
ARCHEPOLIS - A SPACE STATION FOR THE 2010'S
E. LANSARD (CNES, Groupe de Recherche de Geodesie Spatiale, Toulouse, France), I. BARRUOL, D. BOYER-GIBAUD, M. FABRE, J. SCHNEIDER et al. IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 15 p.
(IAF PAPER 85-485)

The main features of two prize-winning architectural projects for the design of a space station are presented. The basic criteria for such a space station are summarized, and the choice of a modular envelope for the design is explained. The interior design and the way of life it accommodates are described. In particular, a wide central common room favors group cohesion, whereas privacy is preserved in individual cells. Inner circulation is minimized and the space harbor is moved away from pressurized zones by using space tethers. The interior arrangements and features to improve the quality of relaxation are designed to ease the accommodation to microgravity. C.D.

A86-16749
THE USE OF PHOTOVOLTAIC POWER GENERATORS WITH SOLAR CONCENTRATORS IN THE POWER SUPPLY SYSTEMS OF SPACE VEHICLES [ISPOL'ZOVANIE FOTOELEKTRICHESKIKH GENERATOROV S KONTSENTRATORAMI SOLNECHNOGO IZLUCHENIIA V SISTEMAKH ENERGOPITANIIA KOSMICHESKIKH APPARATOV]
M. B. KAGAN and V. A. LETIN (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Istochnikov Toka, Moscow, USSR) Geliotekhnika (ISSN 0130-0997), no. 3, 1985, p. 12-16. In Russian.

An attempt is made to optimize the extent of concentration and the temperature of a solar array with respect to the minimum specific power per unit mass. With reference to experimental results for Si, GaAs, and GaAlAs-GaAs solar arrays, it is shown that the degree of concentration and the optimum temperature are largely determined by the temperature gradient of the power. Thus, as the power temperature gradient is reduced by a factor of about 3, from 0.5 for Si to 0.15 for GaAlAs, the optimum degree of concentration increases by a factor of about 15. V.L.

A86-17306#
THE EUROPEAN REUSABLE SPACE PLATFORMS SPAS AND EURECA
D. E. KOELLE (ERNO Raumfahrttechnik GmbH, Ottobrunn, West Germany) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 75-81.

The paper deals with the new space systems, 'Reusable Platforms', which have been made feasible by the U.S. Space Shuttle. The first of this kind was SPAS-01, an experimental platform developed as industrial venture by MBB, and flown twice in 1983 and 1984. The first operational reusable platform for micro-g-applications, called Eureca, is now under development for ESA as a European program. Both platforms are described with their technical and operational features. Author

A86-17604#
THE SPACELAB INSTRUMENT POINTING SYSTEM PERFORMANCE AND OPERATIONS
A. E. HAMMESFAHR (Dornier System GmbH, Friedrichshafen, West Germany) AIAA, Shuttle Environment and Operations Conference, 2nd, Houston, TX, Nov. 13-15, 1985. 9 p. ESA-supported research.
(AIAA PAPER 85-6073)

This paper gives a summary description of the Instrument Pointing System which is a subsystem of the Spacelab providing a versatile three axis pointing capability to any experiment requiring precision orientation towards celestial objects in the arc-second range. A general description of the mechanical and electrical

configuration is followed by a more detailed discussion of the software and controller concept and its operational capabilities. Based on very detailed performance simulation runs and on the preliminary results of the first flight of IPS on the SL-2 mission, a summary of the performance capabilities in dependence of the payload characteristics and mission configuration is presented and discussed. Author

A86-17612#
THE OPERATION OF THE SPACELAB SCIENTIFIC AIRLOCK
G. R. BOLTON, A. BOSSCHE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands), and G. R. TER HAAR (Fokker, Schiphol, Netherlands) AIAA, Shuttle Environment and Operations Conference, 2nd, Houston, TX, Nov. 13-15, 1985. 8 p. refs
(AIAA PAPER 85-7046)

The scientific Airlock is in effect a 'Lock' which both separates two incompatible environments - a pressurized spacecraft interior and the vacuum of space - and provides safe transfer from one to the other. It is a convenient means of rapidly mounting experiments in space and after the required exposure retracting them into the Spacelab. Its great advantage is that it can both accelerate space research and substantially reduce cost. The Scientific Airlock was successfully flown on the first Spacelab mission in November 1983 and a second time in May 1985. This paper describes briefly the construction and working principles of the Airlock and its main features and elaborates on the experience in operating experiments during the first two Scientific Airlock missions. Further, a view is given on future Airlock application and developments. Author

A86-17742
EUROPEAN SPACEFLIGHT AT THE CROSSROADS
H. O. RUPPE (Muenchen, Technische Universitaet, Munich, West Germany) Space Policy (ISSN 0265-9646), vol. 1, Nov. 1985, p. 390-408.

Europe's future space development is discussed. A space program establishing objectives is required for Europe's active participation in space. Four areas of space activity, the ground segment, launch vehicles, payload, and space operations, are investigated. The development of a launch vehicle which will achieve the lowest possible specific transport costs is examined; the engine design and development of Ariane 5 are described. Payload capacities of 5-8 tons in LEO for unmanned spaceflight and 10-20 tons in LEO for manned spaceflight are estimated for the year 2000 and beyond. Technological growth in the areas of space stations, reentry vehicles, transportation in space, orbital operations, and tools is studied. The budget necessary for the proposed space advances is analyzed. I.F.

A86-17818
SALYUT MISSION REPORT
N. KIDGER Spaceflight (ISSN 0038-6340), vol. 27, Dec. 1985, p. 469-471.

The repair of Salyut 7 by the crew of the Soyuz T-13 is examined. The manual docking of the spacecraft with the Salyut, and the recharging of the storage batteries are described. The automatic Progress 24 docked with the Salyut and delivered supplies to the crew; with the supplies the restoration of the Salyut was completed and medical and earth observation experiments were conducted. The launching and docking of Kosmos 1699, a scientific satellite with radio systems for precise determination of its orbital elements, and a telemetric system for the transmission of data to earth are discussed. The attachment of two small solar panels to the main panel of the Salyut is described. I.F.

A86-18370
EURECA - THE REUSABLE SATELLITE EMERGES
G. PARDOE Space (ISSN 0267-954X), vol. 1, Sept. 1985, p. 34-37, 42.

The system capabilities of the European Retrievable Carrier (Eureca) are examined. The design of the 4 ton Eureca, which is to be launched and retrieved by the Space Shuttle, is described. The components of the temperature control, data handling, and measure and control subsystems are analyzed. The mission profile and design life of the Eureca are discussed. The main function of the carrier is for utilization in microgravity research; the facilities available for material and life science experiments are described. The improvements required for its application to nonmicrogravity experiments, such as astronomical, solar earth observation, and technology, are discussed. The estimated cost for operating the Eureca, including industrial development, launch and retrieval, flight operations, and core payload, is studied. I.F.

A86-19260
FIRST PAYLOAD FOR THE EUROPEAN RETRIEVABLE CARRIER EURECA
G. SEIBERT (ESA, Microgravity Office, Paris, France) and A. HAHNE (ESA, Space Science Dept., Noordwijk, Netherlands) Earth-Oriented Applications of Space Technology (ISSN 0277-4488), vol. 5, no. 3, 1985, p. 239-246.

The European retrieval carrier, Eureca, to be used for scientific experiments in a very-low acceleration environment is described. The launch and retrieval of the 2.2 m long and 3.5 ton space platform by the Space Shuttle is examined. The advantages of a microgravity environment for material processing, the study of enzyme biochemistry, botany, and exobiology/radiation biophysics are discussed. The payload of Eureca-1 is classified into core paylod facility experiments, microgravity add-on experiments, and nonmicrogravity experiments. A description of the facilities for crystal growth, material science, protein crystallization, and botany experiments is provided. Nonmicrogravity experiments to be conducted include: (1) solar observation, (2) astronomy, (3) atmospheric physics, and (4) technology. I.F.

A86-19658*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
DEVELOPMENT STATUS OF FIRST TETHERED SATELLITE SYSTEM
J. M. SISSON (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p.
(AIAA PAPER 86-0049)

An MOU between NASA and Italian research organizations has assigned the responsibilities for the development, payload integration, launch and operation of a Tethered Satellite System (TSS). The TSS will include a deployer mounted on a Spacelab pallet, science equipment on a customized mission support structure and a satellite connected to the Orbiter by a tether. The satellite is 1.6 m in diameter and can weight up to 500 kg. The deployer will be insulated from the Orbiter because of the conductive nature of the tether. The first mission is to demonstrate the TSS technology, perform electrodynamic investigations of the interaction of the tether with ambient space plasma, and gather data on atmospheric interactions in the lower thermosphere, geomagnetic phenomena and gravimetric characteristics. The first TSS will be deployed 20 km outward from the Orbiter and the earth on a strand of tin-coated copper wire wrapped in Teflon insulation, braided Kevlar and a Nomek jacket. The first strand is designed to accommodate 53 N tension. The satellite on the end of the tether will be a multimission platform for facile changeout of the scientific package from mission-to-mission. M.S.K.

A86-19659#
DEVELOPMENT STATUS OF THE FIRST TSS SATELLITE
A. LORENZONI (CNR, Rome, Italy) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 11 p.
(AIAA PAPER 86-0052)

The first tethered satellite system (TSS) satellite, to be deployed from the Orbiter, was designed on the bases of the mission objectives, modularity and a requirement of multi-mission capability. Engineering tests on the first flight will cover closed-loop and man-in-the-loop operation, reeling out and in, scientific instrument performance and stationkeeping. The TSS satellite comprises three modules: a service module (SM), an auxiliary propulsion module (APM) and a payload module (PM). The total weight of the 1.6 m

diam satellite is to be 66 kg. Up to three missions will be carried out with the satellite, with follow-ups to the initial flight to include atmospheric trials. Small thrusters on the satellite will permit oscillation damping when unreeled from the Orbiter. Details of the thermal control, the electrical power distribution, the on-board data handling, and the telemetry and telecommand subsystems, the S-band transponder characteristics, the microstrip antenna and the auxiliary propulsion subsystem are provided. Finally, hardward modelling and testing procedures are outlined. M.S.K.

A86-19683#
A CONTINUOUS MODEL FOR TETHER ELASTIC VIBRATIONS IN TSS
S. BERGAMASCHI (Padova, Universita, Padua, Italy), A. SINOPOLI (Venezia, Universita, Venice, Italy), and S. CUSINATO AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p. refs
(Contract CNR-PSN-85,037)
(AIAA PAPER 86-0087)

Purpose of this work is to present and discuss a model where the tether of the Tethered Satellite System is simulated as an elastic continuum. First the assumptions are discussed, then the Lagrangian formulation is adopted to write the equations of motion and the boundary conditions. Finally, the eigenvalues of the problem are found, and results are given for longitudinal, in-plane transversal and out-of-plane transversal vibrations. Author

A86-19812#
AN EXPERT SYSTEM FOR FAULT DIAGNOSIS IN ORBITAL REFUELING OPERATIONS
G. A. BOY (ONERA, Centre d'Etudes et de Recherches de Toulouse, France) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 10 p. Research supported by the Delegation Generale pour l'Armement and ONERA. refs
(Contract DRET-84-1396)
(AIAA PAPER 86-0322)

Operator Assistants (OA) are on-line expert systems which are evaluated iteratively using human factors methods to validate the level of automation. The OA is applied where there is a triangular interaction between operator, the expert system, and the system being controlled. A simulator (HORSES) is described which involves the human operator, the orbital refueling system (ORS), and the expert system. The OA in this case is being configured using a fuzzy set approaoch for the situation recognition process and a canonical structure of the knowledge base. HORSES is being developed through experimental trials, verification of a human operator model and the expert system, and analyses of the system logic relative to user logic and human as opposed to automated diagnosis. Details of the process being implemented to define the requirements and operational form of the expert system are discussed, with emphasis on the presence of the human operator in the loop to aid in identifying when the expert system might fail and require intervention by the operator. The simulator is designed to aid astronauts in the diagnoses of problems on an ORS.
M.S.K.

A86-19857#
THE TETHERED PLATFORM - A TOOL FOR SPACE SCIENCE AND APPLICATION
S. BERGAMASCHI (Padova, Universita, Padua, Italy) and P. MERLINA (Aeritalia S.p.A., Turin, Italy) AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 9 p. CNR-sponsored research. refs
(AIAA PAPER 86-0400)

A numerical study is presented of the dynamics of a tethered elevator system (TES) for exploiting the gravity gradient in the space environment from the Manned Space Station (MSS). The study includes a 5 d.o.f. model for simulating the dynamics of a system composed of the MSS, the tether, an elevator travelling the tether, and a science and technology platform (SATP) at the far end. The elevator would move along the tether, thereby being able to change its microgravity environment from 0.01-0.00001 g. Attention is given to the dynamics involved in transferring a parcel from the MSS to the SATP on the TES. Consideration is limited to motions induced in the orbit plane. The kinetic energy of the system is obtained, the Lagrangian is derived, and a control logic is introduced for the resulting motions. Attention is also given to the effects of tether elasticity. M.S.K.

A86-20227#
DYNAMICS OF A SUBSATELLITE SYSTEM SUPPORTED BY TWO TETHERS
A. K. MISRA and G. S. DIAMOND (McGill University, Montreal, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 12-16. Previously cited in issue 06, p. 727, Accession no. A84-17854. refs
(Contract NSERC-A0967)

A86-20247#
COMMENT ON 'A GENERAL FORMULATION FOR LIBRATIONAL DYNAMICS OF SPACECRAFT WITH DEPLOYING APPENDAGES'
K. W. LIPS (Department of Communications, Communications Research Centre, Ottawa, Canada) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 9, Jan.-Feb. 1986, p. 125, 126; Authors' Reply, p. 126, 127. refs

A86-21379
DETERMINATION OF THE MOTION OF THE SALYUT-6 AND SALYUT-7 ORBITAL COMPLEXES WITH RESPECT TO THE CENTER OF MASS IN THE GRAVITY GRADIENT STABILIZATION MODE ACCORDING TO MEASUREMENT DATA [OPREDELENIE DVIZHENIIA ORBITAL'NYKH KOMPLEKSOV 'SALIUT-6' I 'SALIUT-7' OTNOSITEL'NO TSENTRA MASS V REZHIME GRAVITATSIONNOI ORIENTATSII PO DANNYM IZMERENII]
V. A. SARYCHEV, M. IU. BELIAEV, V. V. SAZONOV, and T. N. TIAN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 23, Nov.-Dec. 1985, p. 829-842. In Russian. refs

A method is described for determining the relative motion of the Salyut-6 and Salyut-7 complexes in the single-axis gravity gradient stabilization mode according to readings of onboard sensors. The sensors make it possible to measure components of the geomagnetic field strength vectors and the sun position in a fixed coordinate system. The measurement results are processed by the least squares method using integration of the equations of motion of the orbital complex with respect to the center of mass. Examples of the determination of actual motions are presented.
B.J.

A86-21382
EVOLUTION OF THE ROTATIONS OF A SYMMETRIC SATELLITE WITH VISCOELASTIC RODS ABOUT THE CENTER OF MASS IN A CIRCULAR ORBIT [EVOLIUTSIIA VRASHCHENII SIMMETRICHNOGO SPUTNIKA S VIAZKOUPRUGIMI STERZHNIAMI VOKRUG TSENTRA MASS NA KRUGOVOI ORBITE]
V. G. VILKE, V. G. DEMIN, and IU. G. MARKOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 23, Nov.-Dec. 1985, p. 863-868. In Russian.

An analysis is made of the motion of a symmetric satellite about the center of mass in the case when four flexible viscoelastic rods are attached to the equatorial plane of the ellipsoid of inertia of the satellite. It is assumed that the center of mass of the system moves in a circular orbit in a Newtonian force field. The averaging method in canonical variables is used to obtain approximate equations describing the evolution of the rotational motion of the system. B.J.

A86-21388
DISSIPATION OF HIGH-POWER MICROWAVE RADIATION ENERGY IN THE IONOSPHERE [O DISSIPATSII ENERGII MOSHCHNOGO SVCH-IZLUCHENIIA V IONOSFERE]
A. M. VASIUTKIN, V. L. KRASOVSKII, and V. N. ORAEVSKII Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 23, Nov.-Dec. 1985, p. 909-911. In Russian. refs

The anomalous absorption of the energy of intense microwave radiation in the ionosphere connected with the excitation of plasma oscillations as a consequence of decay processes is analyzed with reference to the development of satellite solar power stations. It is shown that, for sufficiently high energy fluxes, the anomalous dissipation can exceed Joule losses. B.J.

A86-21393
THE LATITUDE CHARACTERISTICS OF THE ATMOSPHERE IN PROBLEMS OF AUTONOMOUS NAVIGATION [O SHIROTNYKH KHARAKTERISTIKAKH ATMOSFERY V ZADACHAKH AVTONOMNOI NAVIGATSII]
E. V. GAUSHUS, K. G. KONSTANTINOV, IU. N. ZYBIN, and O. A. IVANOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 23, Nov.-Dec. 1985, p. 938-940. In Russian.

The operation of the Delta autonomous navigation system on the Salyut-7 station is discussed. It is shown that the accuracy of determining the orbital position of the station was improved substantially by using an empirical relationship between the solar eclipse height and geographic latitude. B.J.

A86-21394
ACTIVE ORIENTATION OF INSTRUMENTATION IN PHYSICAL EXPERIMENTS IN SPACE [AKTIVNAIA ORIENTATSIIA APPARATURY KOSMOFIZICHESKIKH EKSPERIMENTAKH]
A. P. ALEKSANDROV, A. M. GALPER, V. M. GRACHEV, V. V. DMITRENKO, and S. E. ULIN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 23, Nov.-Dec. 1985, p. 941-943. In Russian. refs

Telescope-pointing considerations are described for an experiment carried out on the Salyut-7 - Soyuz - Cosmos-1443 complex involving measurements of geomagnetically trapped high-energy electrons in the region of the Brazilian magnetic anomaly. The requirement was that the telescope axis be pointed at an angle of 90 deg to the geomagnetic field strength vector during passage through the anomaly region. Experiments performed with a gamma telescope demonstrated the effectiveness of the proposed technique. B.J.

A86-21517
SCIENCE REACHES ORBIT - THE DEVELOPMENT OF SPACELAB
A. WARD Space (ISSN 0267-954X), vol. 1, June 1985, p. 3-6.

Attention is given to the development history, design features and operational capabilities of the NASA Space Shuttle-borne Spacelab orbital experiment module, in which as many as four scientists can work simultaneously under power supplied by the Shuttle Orbiter. The experiments of the first Spacelab mission covered astronomy, solar physics, space plasmas, atmospheric physics, and earth observations. The third mission, which as of this writing was scheduled for launch in July, 1986, will be another multidisciplinary mission incorporating experiments in life sciences and materials. Future Spacelab flights include a dedicated earth observation mission. O.C.

A86-21522
INSIDE STAR CITY
T. FURNISS Space (ISSN 0267-954X), vol. 1, June 1985, p. 40, 41, 44.

An account is given of a recent visit by a Westerner to the USSR's Soviet Cosmonaut Training Center in Tyuratam, and an evaluation is made of current and near- and long-term development trends in Soviet spacecraft design and mission planning. Attention is given to the proportion of military-related missions undertaken thus far and in the foreseeable future, as well as to the medical problems that have been encountered in attempts to extend manned mission durations to levels associated with future space station sojourns and interplanetary flights. O.C.

A86-21907
SCINTILLATIONS AND RANDOM REFRACTION DURING OCCULTATIONS BY TERRESTRIAL ATMOSPHERE
G. M. GRECHKO, A. S. GURVICH, V. KAN, S. V. SOKOLOVSKII (AN SSSR, Institut Fiziki Atmosfery, Moscow, USSR), and S. A. SAVCHENKO (AN SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR) Optical Society of America, Journal, A: Optics and Image Science (ISSN 0740-3232), vol. 2, Dec. 1985, p. 2120-2123. refs

The results of obserations of atmospheric refraction fluctuations and scintillations performed aboard the Salyut-6 orbiter are reported. Bodies of various angular diameters (sun, planets, and stars) were used for the observations. It was ascertained that random variations in refraction owing to the horizontally layered structure of the refractive index take place almost everywhere in the upper trophosphere and lower stratosphere. Observations of refraction made it possible to obtain estimates of the characteristic parameters of its horizontally layered structure. A spectrum of glitter was calculated on the basis of observed scintillations of enus. Author

A86-22242
EUROPE - TOWARDS A NEW LONG-TERM PROGRAMME
R. GIBSON Space Policy (ISSN 0265-9646), vol. 1, Feb. 1985, p. 3-6.

The establishment of a new space program for Europe by the European Space Agency (ESA) is examined. The funding of mandatory and optional programs by the ESA is discussed. Budgetary allocations for programs in the areas of science, telecommunications, earth observations, microgravity research, support technology, launchers, and orbiting capacity are studied. The different views of ESA members on the development of launchers and in-orbit infrastructures are analyzed. The involvement of ESA in the U.S. Space Station program or development of a program independently is investigated. I.F.

A86-22243
UK SPACE POLICY
G. PARDOE (General Technology Systems, Ltd., Brentford, England) Space Policy (ISSN 0265-9646), vol. 1, Feb. 1985, p. 10, 11.

The involvement of the UK in space exploration and commercialization is examined. The role of the Department of Trade and Industry in space research is described. The need for an increase in the national space budget, in order to promote space activities, is analyzed. The development of an agency to establish a national space policy and to supervise its implementation is discussed. I.F.

A86-22244
INTERNATIONAL INVOLVEMENT IN THE US SPACE STATION PROGRAMME
J. M. LOGSDON (George Washington University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 1, Feb. 1985, p. 12-25. refs

This article considers the issues surrounding the nature and extent of involvement in the U.S. space station initiative. The motives and objectives of U.S. cooperation with its allies are analyzed from the perspective of both the USA and its potential partners. Guidelines for the forthcoming negotiations between these parties are elaborated through a review of past experience in international space cooperation. Developing a framework for collaboration will require significant trade-offs and will have to accommodate a number of not always consistent interests. Author

A86-23197
THE MISSION OF SOYUZ T-10-1
P. S. CLARK British Interplanetary Society, Journal (Space Chronicle) (ISSN 0007-084X), vol. 39, Jan. 1986, p. 36, 37.

The abort of the Soyuz T-10-1 mission of Sept. 26, 1983 is described. It is stated that the T-9 crew was to hand Salyut 7 over to the intended T-10-1 crews, and the T-10-1 crew was to complete EVA work begun by the T-9 crew. The possibility that the T-10-1 crew was to only add solar cell panels to Salyut 7 (the intent of the failed T-8 mission) and not continue to man the Salyut is discussed. I.F.

A86-23543
THE FREON PUMP PACKAGE - A NEW FACILITY FOR SPACECRAFT THERMAL CONTROL
A. DUWELZ (Societe Europeenne de Propulsion, Paris, France) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p.
(SAE PAPER 851357)

After the first flight of Spacelab, the European Space Agency (ESA) decided to develop the Eureca project. The project has the objective to provide a space platform with a guaranteed level of microgravity in the range from 0.0001 to 0.00001 g. The materials science experiments envisaged require, in addition to the microgravity environment, also servicing facilities. Thus, active cooling loops are needed for accurate thermal control. Such loops, based on operations involving forced circulation of Freon, water, or ammonia, are currently under development. The implementation of the circulation process requires the employmnent of a pump. Pumps can be sources of vibration and noise which can disturb the conditions required for the experiments. The present paper is concerned with the development of a pump with operational characteristics which will not interfere with the experimental conditions. Attention is given to the Freon Pump Package (FPP) design description, and the tradeoffs needed to obtain obtain a very silent pump unit. G.R.

A86-23546
THERMAL DESIGN ASPECTS OF EURECA DURING SHUTTLE CARGO BAY PARKING PHASES
U. LAUX and W. D. EBELING (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p.
(SAE PAPER 851361)

The object of thermal control design of ESA's EURECA carrier is to keep all spacecraft components within specified temperature limits and at the same time minimize the required heater power by defining particular attitude constraints of the Orbiter. The attitude sequences had to be selected where an overheating of the batteries is precluded (due to low T-sensitivity of hydrazine), which in turn implies a potentially too low hydrazine-T. To reduce computer calculations, a decision tool was developed, which allows the user to identify potentially favorable Orbiter attitude sequences without detailed thermal analyses. It was found, that even under very favorable Orbiter attitudes, there exists a heater-power demand of at least 100 W, in particular, for components with low thermal inertia. I.S.

A86-23547
THERMAL ACCOMMODATION OF PAYLOADS ON GERMAN SPACELAB MISSION D1
B. SCHWARZ and H. P. HAFKEMEYER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 13 p. refs
(SAE PAPER 851362)

The fluid-loop- and the air-loop-cooling systems for the Module-located payloads of the German Spacelab D1 mission are described in detail. The Module's payload accomodation thermal analysis was conducted to verify that the system's cooling provisions are sufficient to maintain each individual component within its temperature limits, and that the system's requirements are not violated. In addition, the thermal system analysis of the Unique Support Structure (USS) of D1 is presented, covering the on-orbit hot and cold case conditions and the descent from cold and hot on-orbit conditions. Design diagrams and graphs are presented. I.S.

A86-23549
DESIGN AND TEST OF A SPACE DEPLOYABLE RADIATOR
B. MOSCHETTI, M. AMIDIEU (Aerospatiale, Cannes, France), and B. TATRY (CNES, Toulouse, France) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p.
(SAE PAPER 851364)

A space-deployable radiator concept has been developed to increase power dissipation through a variation of radiator area from fully stowed to fully deployed positions; it is also intended for use by existing spacecraft, without requiring extensive architectural redesign. The radiator configuration encompasses a deployable hinged panel, in which surface-embedded heat pipes dissipate the heat throughout, and a thermally loaded rotating joint that is coaxial with the panel hinge. The prototype unit is of 800 x 600 mm, with five embedded heat pipes and two radiative faces. For the solstice conditions experienced by a geosynchronous satellite, dissipation capability is 160 W and unit internal temperature is of the order of 30 C. O.C.

A86-23550
ANALYZER FOR OUTGASSING EFFECTS OF SPACECRAFT SURFACES
H. P. HAFKEMEYER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 12 p. refs
(SAE PAPER 851365)

An analyzer program package has been developed as an extension of an exiting plume impingement model analyzer. Particle fluxes impinging on the preselected surfaces are determined and summed up on the basis of all the surface elements involved, together with the appropriate view factors and shading factors. The method is also used to calculate the local particle flux density at any location, if that location is contained as a checkpoint surface in the geometrical model. A simple case is computed, yielding outgassing-induced local mass flow densities and mass fluxes on selected surfaces. O.C.

A86-23551
ADVANCED THERMAL CONTROL TECHNOLOGIES FOR EUROPEAN SPACE STATION MODULES
P. MOELLER and H. KREEB (Dornier System GmbH, Friedrichshafen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p. refs
(SAE PAPER 851366)

The European activities regarding the U.S. Space Station are currently mainly concerned with studies related to the Columbus program. The first step involves a pressurized module attached to the Space Station, and a free-flying platform. In future Space Station modules and platforms, the role of thermal management will become much more significant because of the expected long duration of the missions. In addition, large quantities of waste heat will have to be dissipated. As current heat transport systems utilizing heat pipes or pumped liquid loops have severe limitations, more advanced thermal control technologies are needed. The present paper is concerned with such technologies. Attention is given to future thermal control requirements, the definition of a European two-phase model system, aspects of space platform thermal control, an experimental program, a hybrid radiator concept, and maintenance aspects. G.R.

A86-23554
COLUMBUS ECLSS
A. I. SKOOG (Dornier System GmbH, Friedrichshafen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 11 p. ESA-BMFF-supported research. refs
(SAE PAPER 851371)

Activities related to a European participation in the U.S. Space Station program have been coordinated into the Columbus program. The present paper is concerned with the Environmental Control and Life Support System (ECLSS) concepts for the Columbus elements of a Space Station, taking into account the evolutionary incorporation of advanced hardware to a stepwise closure of the life support system and necessary technology development activities. The Spacelab and Shuttle life support equipment is of a first generation open loop type and oriented to short mission durations, while the continuous space activity to be provided by the U.S. Space Station and Columbus will require advanced life support systems of a second generation, with regenerative functions and increasing loop closure. Attention is given to ECLSS design requirements, Columbus laboratory module ECLSS, service vehicle ECLSS, resource module ECLSS, and aspects of a safe haven philosophy. G.R.

A86-23570
CELSS EXPERIMENT MODEL AND DESIGN CONCEPT OF GAS RECYCLE SYSTEM
K. NITTA, M. OGUCHI (National Aerospace Laboratory, Tokyo, Japan), and S. KANDA (Kawasaki Heavy Industries, Ltd., Submarine Designing Dept., Kobe, Japan) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 14 p. refs
(SAE PAPER 851393)

In order to prolong the duration of manned missions around the earth and to expand the human existing region from earth to other planets such as a Lunar Base or a manned Mars flight mission, the CELSS becomes an essential factor of the future technology to be developed through utilization of the Space Station. The preliminary system engineering and integration efforts regarding CELSS have been carried out by the Japanese CELSS concept study group for clarifying the feasibility of hardware development for Space Station Experiments and for getting the time phased mission sets after Fy 1992. The results of these studies are briefly summarized, and the design and utilization methods of a gas recycle system for CELSS experiments are discussed. Author

A86-23571
UTILIZATION OF MEMBRANES FOR H2O RECYCLE SYSTEM
H. OHYA (Yokohama National University, Japan) and M. OGUCHI (National Aerospace Laboratory, Chofu, Japan) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 9 p.
(SAE PAPER 851394)

Conceptual studies of closed ecological life support systems (CELSS) carried out at NAL in Japan for a water recycle system using membranes are reviewed. The system will treat water from shower room, urine, impure condensation from gas recycle system, etc. The H2O recycle system is composed of prefilter, ultrafiltration membrane, reverse osmosis membrane, and distillator. Some results are shown for a bullet train of toilet-flushing water recycle equipment with an ultrafiltration membrane module. The constant value of the permeation rate with a 4.7 sq m of module is about 70 l/h after 500 h of operation. Thermovaporization with porous polytetrafluorocarbon membrane is also proposed to replace the distillator. Author

A86-23572
THE C23A SYSTEM, AN EXAMPLE OF QUANTITATIVE CONTROL OF PLANT GROWTH ASSOCIATED WITH A DATA BASE
M. ANDRE, A. DAGUENET, D. MASSIMINO, and A. GERBAUD (CEA, Centre d'Etudes Nucleaires de Cadarache, Saint-Paul-les-Durance, France) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 12 p. refs
(SAE PAPER 851395)

The C23A (Chambres de Culture Automatique en Atmospheres Artificielles) system which is used for the controlled study of plant physiology is described. The modular plant growth chambers and instruments for the study of canopies, isolated plants with a separate root compartment, and acquatic plants are examined. The uses of a mass spectrometer and a CO2 infrared analyzer to monitor shoot and root atmospheres, and of a chemical autoanalyzer to calculate uptake rates for elements are analyzed. The microprocessors, central computer, and satellite microcomputers of the computer system control the culture chambers and measuring systems, provide visual or graphical control, and store all data in short- and long-term files. Examples of experimental studies conducted in the C23A system evaluating the photosynthesis and photorespiration of various plants are presented. I.F.

A86-23574
DESCRIPTION OF CONCEPT AND FIRST FEASIBILITY TEST RESULTS OF A LIFE SUPPORT SUBSYSTEM OF THE BOTANY FACILITY BASED ON WATER RECLAMATION
H. R. LOESER (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) AIAA, SAE, ASME, AIChE, and ASMA, Intersociety Conference on Environmental Systems, 15th, San Francisco, CA, July 15-17, 1985. 14 p.
(SAE PAPER 851397)

A water reclamation module which controls the temperature and humidity of the air within the Botany Facility is proposed. The water reclamation process is achieved by condensation with a heat pump and capillary transport of the condensate back into the soil of the plant growth chamber. An analysis is conducted to calculate the circulation flow rates and specific power consumption. The design of a prototype water reclamation module which utilizes a Peltrier element and a condenser/wick assembly to return elements to the soil and the experimental conditions are described. The module is evaluated in terms of condensation rate and condensor temperature as a function of the cold side mass of flow rate; the water reclamation process proves applicable for the Botany Facility. I.F.

A86-23616
STELLAR SCINTILLATIONS ACCORDING TO OBSERVATIONS ON BOARD THE 'SALYUT-7' ORBITAL STATION [MERTSANIIA ZVEZD PO NABLIUDENIIAM S ORBITAL'NOI STANTSII 'SALIUT-7']
A. S. GURVICH, I. ZAKHAROV, V. KAN, V. V. LEBEDEV, A. A. NESTERENKO (AN SSSR, Institut Fiziki Atmosfery, Moscow, USSR; Ceskoslovenska Akademie Ved, Astronomicky Ustav, Prague, Czechoslovakia) et al. Akademiia Nauk SSSR, Izvestiia, Fizika Atmosfery i Okeana (ISSN 0002-3515), vol. 21, Dec. 1985, p. 1235-1241. In Russian. refs

Measurements of the rms brightness of stars have been carried out on board the 'Salyut-7' orbital station using the EFO-1 photometer system. The technical characteristics of the EFO-1 photometer are described, and some examples of the brightness recordings for the bright stars, Vega, Arctur, Deneb, are given. It is shown that brightness scintillations can occur anywhere and are probably caused by layered inhomogeneities in the atmospheric temperature profile at altitudes of 20-40 km. The rms temperature variation for a atmospheric layer 100 m thick was estimated in the range 0.2-0.4 K. I.H.

A86-23961
ASTRONOMY FROM THE SPACE STATION
J. K. DAVIES (Birmingham University, England) (British Interplanetary Society, Space Station Applications Symposium, London, England, Sept. 25, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 51-56. refs

The suitability of the basic Space Station for astronomical missions is reviewed. For many types of astronomical missions the manned Space Station is unsuitable, but certain instruments that can be operated from it are identified. The requirements for free flying astronomical platforms, possibly based on the Eureca or British Aerospace space platform are discussed. The astronomical uses to which space platforms and the associated space infrastructure can be put are given, and a number of large space astronomy missions are described. It is clear that astronomers must take advantage of the facilities that will be available in the Space Station era. Author

A86-23962
APPLICATIONS OF ESA'S EURECA
S. R. DAUNCEY (General Technology Systems, Ltd., Brentford, England) (British Interplanetary Society, Space Station Applications Symposium, London, England, Sept. 25, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 57-60. ESA-supported research.

Eureca, the European Retrievable Carrier, due to become operational in 1988, provides a technological and scientific link to the Space Station era. It is designed to be recovered six or nine months after launch by Shuttle. Eureca can then be re-fitted with different payload elements and re-flown, having been designed for a nominal 10-year, 5-flight life. The first is designed primarily for microgravity experiments, ESA having funded five materials science and life science facilities, which account for some two-thirds of the one tonne payload. There are two other 'add-on' microgravity experiments and Eureca-1 also carries instruments that exploit its solar pointing, stable platform and technological capabilities. The potential non-microgravity users distinguish three types of improved Eureca mission to meet the needs of the astronomical and earth sciences and for technology development. ESA is receiving frequent enquiries from inside and outside Europe and serious plans are already being made to procure at least one more.
Author

A86-23963
COLUMBUS - DISCOVERING USERS
D. HARDY (Royal Aircraft Establishment, Farnborough, England) (British Interplanetary Society, Space Station Applications Symposium, London, England, Sept. 25, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 61, 62.

Columbus is a potential European contribution to the U.S. Space Station Program. The project is managed by the European Space Agency and consists, as of mid-September 1985, of Phase B (project definition) studies of four elements, each of which is based on pre-existing national studies. These are: a pressurized module (Italy), a resource module (FRG), a servicing vehicle (France) and polar- and co-orbiting platforms (UK). Supporting studies include technology, operation and utility of the elements and their proposed missions. Ten ESA Member States are participating. Author

A86-23966
THE SPACE PLATFORM FROM A USER'S POINT OF VIEW
R. C. PARKINSON (British Aerospace, PLC, Space and Communications Div., Stevenage, England) (British Interplanetary Society, Space Station Applications Symposium, London, England, Sept. 25, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 75-79.

The Space Platform is one element being studied within the Columbus program for European participation in the U.S. Space Station low earth orbit infrastructure. A potential for four or more Platforms currently exists. Two would be polar orbiting Platforms with different equator crossing times. The other two would co-orbit with the Manned Space Station and fulfill astronomy and microgravity rules. The Space Platform is proposed as a permanent, unmanned, serviceable multi-user facility to which payloads could be attached on a rental basis for as long or as short a period as desired. The most significant advantage it offers is a reduction in operating costs by sharing facility costs among a number of users and avoiding the need to launch a supporting 'satellite bus' with each group of payloads. This paper presents current British Aerospace thinking about the performance and services provided to the user on each of the three Platform types being studied.
Author

A86-23968
THE COLUMBUS SPACE PLATFORM
R. C. PARKINSON (British Aerospace, PLC, Stevenage, England) (Towards Columbus and the Space Station Symposium, Bonn, West Germany, Oct. 3, 4, 1985) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 85-89.

The Space Platform is one of four elements being studied as part of the European Columbus program of participation in the Manned Space Station. The Space Platform is intended to provide a permanent, serviceable multi-user facility in low earth orbit to which users can attach for long or short periods as required. An eventual potential for four or more Platforms can be foreseen; two in polar orbit and additional Platforms co-orbiting with the main Space Station. This paper discusses the problems of integrating the Platform into the overall plans for future European orbital infrastructures, and the challenges posed by the Platform design itself. Author

A86-23970
STANDARDISATION OF INTERFACES WITHIN THE SPACE INFRASTRUCTURE
C. M. HEMPSELL (British Aerospace, PLC, Space and Communications Div., Stevenage, England) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 92-96.

Studies conducted into the Space Station program and general in-orbit infrastructure show the desirability of maximizing interface compatibility. The standards set should be as flexible and as universal as possible, ranging from grapple points to system/system docking/berthing ports with upwards compatibility between all levels. A common interface standard configuration is presented to show the feasibility of achieving these requirements. It suggests three levels of interface may be needed: (1) a grapple point; (2) an unmanned interface; and (3) a manned interface, with active and passive elements to each level, with the latter two having a combined active/passive alternative to give an androgynous port. The most important long-term features of the Space Station program are the interface standards that it will set. These will not only affect the Station and its associated systems but all subsequent spacecraft that are required to interact with the Space Station Infrastructure. Thus, these standards will effectively be fixed for all time. Because of this long-term consideration, it is felt desirable that these interfaces are agreed at the widest possible international level. Author

A86-24125
JAPANESE ROLE IN NASA'S SPACE STATION MAY INCLUDE SPACE VEHICLES AND AN EXPERIMENT MODULE
E. SEKIGAWA Commercial Space (ISSN 8756-4831), vol. 1, Fall 1985, p. 82-84.

Japan's national space vehicle program is described. The three phases of the program involve: (1) the leasing of launch space on the Space Shuttle and Ariane to conduct microgravity experiments; (2) the use of a Japanese built free-flyer in which to conduct space experiments, and continued use of foreign facilities; and (3) the use of the Space Station/Japanese free-flyer combination, and the development of the Japanese minishuttle. The design and funding for the Japanese laboratory module that is to be attached to the U.S. Space Station is examined. The development of experimental packages for the module, such as

high-frequency heating devices, and electromagnetic lifter, and a light-collecting heater, is investigated. The goal of the Japanese government to promote private commercialization of space is discussed. I.F.

A86-24589#
EUROPE'S FUTURE IN SPACE
R. LUST (ESA, Paris, France) (Western European Union, Colloquium on the Space Challenge for Europe, Munich, West Germany, Sept. 19, 1985) ESA Bulletin (ISSN 0376-4265), no. 44, Nov. 1985, p. 8-15.

The science program developed during ESA's ministerial conference in Rome at the beginning of 1985 and its impact on industry, education, technology, and politics is discussed. The first unified program of its kind, it is built on four major mission concepts. The Spacelab program, for microgravity research and development is covered with respect to past achievements and future goals, such as the development and exploitation of multiuse facilities. The program of earth observation which covers the present Meteosat, a planned European remote-sensing satellite (which will collect data on coastal, ice and global ocean processes), and a precise orbit-positioning satellite (POPSAT) providing information for the solid-earth sciences. Telecommunications providing significant commercial interest, and future missions including Olympus and the possible use of two-satellite systems with microwave and optical links are presented. The Ariane space transportation program's success and ESA concerns and future goals including the Europeanization of the French Hermes manned spaceplane program, cooperation with NASA on the Space Station program, and the flight of the European Retrievable Carrier (Eureca) are some of the other points discussed. R.R.

A86-24591#
THE NEED FOR IN-ORBIT DEMONSTRATION OF EUROPE'S NEWEST SPACE TECHNOLOGIES
H. STOEWER (ESA, Systems Engineering Dept., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 44, Nov. 1985, p. 26-31.

The complex technologies being developed for the European space program require more regular in-orbit equipment and component testing. Twelve developments were chosen to assess the justification for such an in-orbit testing program: a capacitive accelerometer for microgravity measurements, a space rigidized inflatable antenna, the atomic oxygen effects of various spacecraft materials, a yaw earth sensor, an electrostatic levitator for materials sciences, an aluminum coating experiment, a helium cryostat, a laser diode range finder, a liquid slosh experiment, high-voltage solar power systems, a two-phase heat transport system, and a surface potential monitor. R.R.

A86-24597#
THE SPACELAB INSTRUMENT POINTING SYSTEM (IPS) AND ITS FIRST FLIGHT
H. HEUSMANN and P. WOLF (ESA, Directorate of Space Transportation Systems, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 44, Nov. 1985, p. 75-79.

The development of the Instrument Pointing System (IPS) as part of Spacelab's experimental apparatus for open Pallet direct space exposure, and its test flight aboard the Shuttle Orbiter are discussed. The IPS is a three-axis-controlled platform with stellar, sun and earth pointing modes, and a better than 1 arcsec pointing ability. The development of an 'inside-out gimbal' configuration with the platform acting like a joint between the unstable Shuttle and the inertially stabilized payload facilitated close to hemispherical pointing and the adaptability for payloads of almost any size. Gimbal axes torquers counteract Orbiter acceleration due to crew movement and thruster firings, and facilitate target acquisition and precision pointing, by command from a crew-engaged computer preprogrammed for all possible control steps. Carrying an experimental solar-physics payload, the IPS correctly performed all intended functions and withstood launch and orbital loads. Several anomalies were detected and successfully corrected in-flight. R.R.

A86-24610#
THE LIFE SCIENCES ON BOARD OF SPACELAB D1 [DIE LEBENSWISSENSCHAFTEN AN BORD VON SPACELAB D1]
S. PAECH Luft- und Raumfahrt (ISSN 0173-6264), vol. 6, 4th Quarter, 1985, p. 106, 108-110. In German.

During the last few years, it was realized that a study of the effects of weightlessness can be of fundamental importance even in the area of biology, taking into account biological organisms from a cell to a human being. This importance is related to the fact that only experiments under conditions of weightlessness can provide information of an indirect nature regarding the mechanisms by which gravity affects biological organisms. For this reason, biological experiments of very different chracteristics formed a part of the D1 mission. The most important of these experiments are discussed, taking into account studies involving cells and other microorganisms, hatching experiments concerning frogs and flies, the effects of weightlessness on germinating plants, questions regarding the control of the transport of hormones during cell growth in plants by gravity, the behavior of the human body during the transition to weightlessness conditions, and functional disturbances caused by conditions of weightlessness. G.R.

A86-24611#
THE PAYLOAD CONTROL CENTER OF THE DFVLR FOR D1 AND FUTURE MANNED MISSIONS IN OBERPFAFFENHOFEN [DAS NUTZLASTKONTROLLZENTRUM DER DFVLR FUER D1 UND ZUKUENFTIGE BEMANNTE MISSIONEN IN OBERPFAFFENHOFEN]
M. GASS (DFVLR, Weltraum-Betriebszentrum, Oberpfaffenhofen, West Germany) Luft- und Raumfahrt (ISSN 0173-6264), vol. 6, 4th Quarter, 1985, p. 111, 113, 114. In German.

The NASA Center in Houston is concerned with the control of manned space missions cnducted by NASA. The D1 mission represents the first space flight in which, in addition to Houston, a European control center was utilized. It is planned to employ a European control center also in future manned space flights which involve manned missions of West Germany and ESA. The feasibility of a decentralized control of the scientific part of a mission was demonstrated with the D1 mission, taking into account a situation in which the control of the Space Shuttle mission itself was conducted from Houston. During the first Spacelab flight in autumn 1983, the German Space Operations Center of the DFVLR in Oberpfaffenhofen was already employed for data processing in a real time operation. Attention is given to aspects of communications, the facilities in the GSOC, and plans related to Columbus, the European contribution to the U.S. Space Station. G.R.

A86-24648
FROM OTS TO OLYMPUS - BAE'S COMMUNICATORS
T. FURNISS Flight International (ISSN 0015-3710), vol. 129, Jan. 11, 1986, p. 24-28.

A development history and program management account is presented for the ESA's Orbital Test Satellite (OTS), which explored the performance capabilities of three-axis stabilization; the European Communications Satellites (ECSs), which encompass Eutelsat, Marecs, Skynet, and Telecom; and Olympus 1, a demonstration satellite furnishing direct broadcast, business, and experimental communications. Attention is given to the design features and performance projections made to date for Olympus 1, which will be launched by Ariane in 1987 into geostationary orbit. O.C.

A86-25185#
STUDY OF ELECTROTHERMAL HYDRAZINE THRUSTER FOR LARGE SPACECRAFT
R. SEKITA, N. SAITO, C. IIDA, R. NAGASHIMA, S. KITAMURA et al. Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 373, 1985, p. 82-89. In Japanese.

An electrothermal hydrazine thruster (EHT) system for large spacecraft is investigated. The EHT system developed provides a propulsion of 250mN and a lower electric power consumption (e.g., 250W) as compared with HiPEHT and ACT, and slighter than the

ACT, and in addition to these it offers a high reliability in its performance when compared with HiPEHT. The EHT is applied to the reaction control system (RCS) of engineering Testing Satellite V for the testing. It is found that the EHT is very useful as the RCS for the satellite. Further investigation for the commercialization of the EHT is in progress. S.H.

A86-25186#
MPD ARCJET SYSTEM
K. KURIKI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 33, no. 373, 1985, p. 89-100. In Japanese. refs

The current status and future prospects of the magnetoplasmadynamic (MPD) arcjet system are described. Recent research activities on the chemical rocket and electric propulsion are discussed. The characteristics of various MPD arcjet systems including the Komaba-I system developed by the Institute of Space and Astronautical Science of the Tokyo University are analyzed. The applications of the MPD arcjet system to the satellite test, lunar mission, free flyer test, space station test, and heliospheric exploration are discussed. S.H.

A86-25484
ESTIMATION OF CERTAIN PARAMETERS OF THE MKF-6M INSTRUMENTATION ON THE BASIS OF DATA OBTAINED DURING A SPACE FLIGHT [OTSENKA NEKOTORYKH PARAMETROV APPARATURY MKF-6M PO MATERIALAM, POLUCHENNYM V KHODE KOSMICHESKOGO POLETA]
V. A. KUCHUMOV (Gosudarstvennyi Nauchno-Issledovatel'skii i Proizvodstvennyi Tsentr Priroda, USSR) and S. A. KADNICHANSKII (Tsentral'nyi Nauchno-Issledovatel'skii Institut Geodezii, Aerofotos'emki i Kartografii, Moscow, USSR) Issledovanie Zemli iz Kosmosa (ISSN 0205-9614), Nov.-Dec. 1985, p. 53-59. In Russian.

A stability analysis of photometers in the spectral channels of the MKF-6M multispectral scanner was carried out on the basis of Salyut-6 data. The possibility of using these photometers as reference standards in multispectral photometry is noted. In addition, a method for estimating the angular parameters of the relative orientation of a multispectral camera using space photographs is described. Such estimates are made for the MKF-6M camera. B.J.

A86-25562
SPACECRAFT FIBERGLASS STRUT CHARGING/DISCHARGING AND EMI
K. G. BALMAIN, M. GOSSLAND (Toronto, University, Canada), and K. KARIA (Spar Aerospace, Ltd., Toronto, Canada) (IEEE, DNA, Sandia National Laboratories, and NASA, 1985 Annual Conference on Nuclear and Space Radiation Effects, 22nd, Monterey, CA, July 22-24, 1985) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-32, Dec. 1985, p. 4438-4440. Research supported by Spar Aerospace, Ltd.
(Contract NSERC-A-4140)

Glass-fiber-epoxy struts used in spacecraft extendable masts were exposed to a 20 keV electron beam. Discharges were observed, and near-field measurements used to deduce the radiated emission spectrum for comparison with spacecraft specifications. Author

A86-26273
SOVIET SPACE ACTIVITIES - 20 YEARS FROM SALYUT TO SOYUZ [DIE RAUMFAHRTAKTIVITAETEN DER UDSSR - 20 JAHRTE SALUT-SOJUS]
W. A. KRAL Astronautik (ISSN 0004-6221), vol. 22, no. 3, 1985, p. 82-84. In German.

Past, present, and future Soviet space activities are briefly discussed. The development of the Salyut and Soyuz programs is reviewed, and the configuration and goals of the Salyut 7 mission are described. Data on the Progress and Soyuz-T transport spacecraft are given, and the spacecraft are depicted along with the Soviet space station. C.D.

A86-26459
FROM SATELLITES TO THE SPACE STATION - THE TRENDS TOWARDS LARGER STRUCTURES IN SPACE
M. FUCHS (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: Space: The commercial opportunities; Proceedings of the International Business Strategy Conference, London, England, October 31, November 1, 1984 . Pinner, England, Online Publications, 1984, p. 103-111.

A development history is presented for the Space Station concepts that have been entertained in the wake of Skylab and Spacelab. Germany and Italy have recently proceeded to invest the expertise gained during Spacelab participation in an ESA-sponsored on-orbit infrastructural system; this has become the 'Columbus' program, which has entered the system configuration concept-definition stage. Columbus is envisioned as a space platform encompassing a modular payload carrier, a resources module furnishing power, control, heat management, etc., and a service vehicle providing a transfer capability for payloads, expendables, and crews. O.C.

A86-26461
A EUROPEAN PERSPECTIVE ON THE US SPACE STATION PROPOSAL
J. COLLET, G. PETERS, and D.-J. SHAPLAND (ESA, Directorate of Space Transportation Systems, Paris, France) IN: Space: The commercial opportunities; Proceedings of the International Business Strategy Conference, London, England, October 31, November 1, 1984 . Pinner, England, Online Publications, 1984, p. 125-135.

ESA member states have approved a preparatory program for the development of a large cryogenic booster engine, designated HM60, which will be available after 1994 and will constitute the basic building block for a European launch vehicle capable of placing 8 tons of payload on a geostationary orbit of 15 tons in low earth orbit. In this latter case, the launcher may be man-rated to carry a manned spacecraft, such as the reusable Hermes orbiter. This development effort is a part of ESA's Long Term Preparatory Program, which will manage European cooperation with NASA in the construction and operation of a Space Station. In addition, Germany and Italy are collaborating on the 'Columbus' European Space Station. O.C.

A86-26462
INVESTING IN SPACE
A. J. SUMNER (Kleinwort Benson Development Capital, Ltd., England) IN: Space: The commercial opportunities; Proceedings of the International Business Strategy Conference, London, England, October 31, November 1, 1984 . Pinner, England, Online Publications, 1984, p. 137-146.

Space commercialization-related investments must be made in view of the character of the current uses and status of orbital space. These characteristics include political sensitivity, defense orientation, a high degree of secrecy, an unsettled legal climate, potentially exponential increases in investment, and protracted time scales for investments' bearing of dividends. The present discussion considers the ways in which these features resemble terrestrial investments, so that existing practices can be applied to investment policy-making. O.C.

A86-26883#
EXPERIMENTAL SYSTEM IDENTIFICATION FOR EXPERIMENTAL/ANALYTICAL CORRELATION AND MODELLING
N. NIEDBAL (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: Combined experimental/analytical modeling of dynamic structural systems; Proceedings of the Joint Mechanics Conference, Albuquerque, NM, June 24-26, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 195-204. refs

The dynamic qualification of spacecraft structures is considered, taking into account the use of modal survey tests to verify normal mode parameters. A survey is conducted of the state of the art of the classical sine-dwell methods and of some experimental modal analysis methods. The advantage of the new methods is

that appropriated exciter forces, in the sense of the sine-dwell method are unnecessary. It is pointed out that in Europe the classical sine-dwell method is preferred to measure the normal mode parameters of the undamped structure for correlation and modelling of experimental and analytical results. Because of its superior flexibility, the model survey test concept is expected to attract increasing interest for purposes of dynamic qualification of future spacecraft structures. G.R.

A86-26884#
USING MODAL SUBSTRUCTURING TECHNIQUES IN MODELLING LARGE FLEXIBLE SPACECRAFT
A. BERTRAM (DFVLR, Institut fuer Aeroelastik, Goettingen, West Germany) IN: Combined experimental/analytical modeling of dynamic structural systems; Proceedings of the Joint Mechanics Conference, Albuquerque, NM, June 24-26, 1985 . New York, American Society of Mechanical Engineers, 1985, p. 205-220. ESA-supported research. refs

For reasons of safety and reliability, prior to the launch of a spacecraft, it must be demonstrated that the structure can withstand all loads to be expected during launch and throughout its life in orbit. In the case of large spacecraft for future space missions, an experimental investigation of the complete structure will be impossible, and the spacecraft will have to be separated into substructures. A modal description of structural dynamics is discussed, taking into account dynamic equations of a coupled system, coupling conditions, and structural modifications. Questions regarding the application of the substructuring techniques are also considered, giving attention to test data requirements, the selection of a suitable mode set, and a realistic description of the interface in the coupling approach. G.R.

A86-27700
DEVELOPMENT OF THE GRAPHITE EPOXY SATELLITE STRUCTURE
T. KATOH and K. YAMADA (Toshiba Corp., Space Program Div., Kawasaki, Japan) IN: ICCM - V; Proceedings of the Fifth International Conference on Composite Materials, San Diego, CA, July 29-August 1, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1985, p. 409-418.

Developmental work carried out on the application of graphite-epoxy composites to the primary structure of the future high-power geosynchronous communication satellite to be launched by the H-1 launch vehicle is reported. The design, analysis, fabrication, and tests of the satellite primary structure and its components are described. Using composites made with Toray M40 type and Toray T300 type unidirectional prepregs or woven cloth, a satellite structure weight of 59 kg was achieved. A full-scale satellite structure assembly has been fabricated and subjected to static load test and modal survey test. The structure meets both strength and stiffness requirements of the H-1 launch vehicle interface. I.S.

A86-28074
DESIGN TECHNIQUES FOR ROBOTS - SPACE APPLICATIONS
R. J. HAMANN (Fokker, Schiphol, Netherlands) Robotics (ISSN 0167-8493), vol. 1, Dec. 1985, p. 223-250.

Analytical techniques and technologies required for the design and development of robotic manipulators in space are defined and investigated. A space manipulator system is defined and described, and manipulator kinematics and dynamics, methods for path construction, obstacle avoidance techniques, and robot languages are discussed. Control aspects are investigated, including robot control methods, the selection of a Manipulator Arm control system, and the definition of simulation cases. Manipulator Arm functions to be performed and their requirements in terms of processing power, memory size, and data flows are listed and used to define the electrical architecture, bus requirements, and software organization. A program for future design studies for the Manipulator Arm is briefly discussed. C.D.

A86-28576* Howard Univ., Washington, D. C.
EUROPE/UNITED STATES SPACE ACTIVITIES
P. M. BAINUM, ED. (Howard University, Washington, DC) and F. VON BUN, ED. (NASA, Washington, DC) San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 61), 1985, 442 p. For individual items see A86-28577 to A86-28597.

Among the topics discussed are: the Olympus satellite program; trends in the Italian space technology; and ESA Space Station planning. Consideration is also given to cooperative international programs, including the Eurostar platform, the Tethered Satellite System, and the SPAS system; space science and applications programs; and the development of next generation space propulsion systems. Among the specific propulsion technologies discussed are: LOX/LR2 engines; the Ariane 5 solid propellant booster; and propulsion systems for earth-to-orbit vehicles. I.H.

A86-28577
THE ITALIAN SPACE PROGRAM
G. BENEDETTI (CNR, Rome, Italy) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 9-15.
(AAS 85-101)

A brief description of individual space programs administered by the Italian Space Agency is given. Among the activities discussed are: the ITALSAT program; the MONOMIC program to develop gallium arsenide ICs for a 12-GHz receiver; IRIS propulsion stage development; and the Tethered Satellite System (TTS). The design and implementation of an advanced X-ray astronomy satellite (SAX) for observations in the energy range 2-200 keV are described in detail. A joint project between NASA and ISA to develop VLBI technologies for geodetic measurements from space is also described. I.H.

A86-28582
ESA SPACE STATION PLANNING
J. COLLET (ESA, Directorate of Space Transportation Systems, Paris, France) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 97-103.
(AAS 85-113)

The evolution of the European Space Station program, Columbus, is briefly described. Considerations is given to the technical issues addressed during the planning phase of the initial Columbus Preparatory Program (CPP), including: the preliminary cost and schedule baselines for development and operation of Columbus hardware; design definition with respect to the pressurized module (PM) and supporting platforms of the Columbus Space Station; and the design of servicing vehicles and resource modules (RMs) to support PM operations in the free-flying mode. The role of cooperative agreements between ESA and NASA in the development of preliminary Columbus Space Station designs is also discussed. I.H.

A86-28583
JAPANESE POLICY ON PARTICIPATION IN THE SPACE STATION PROGRAM
T. MORI (Science and Technology Agency, International Space Affairs Div., Tokyo, Japan) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 105-112.
(AAS 85-114)

Some of the ways that Japan can benefit from participation in the NASA Space Station program are discussed. Consideration is given to four goals of the Japanese space program which would be significantly advanced by participation in Space Station, including: promotion of advanced technology development on earth; enhancement of space operations and activities; promotion of international cooperation in large-scale space projects; and utilization of the space environment for commercial applications such as materials processing, earth observation, pharmaceuticals production, and communications. A list of some possible missions for a Japanese Space Station module is provided. I.H.

A86-28584
EUROPEAN MISSION MODELS FOR MANNED AND UNMANNED SPACE STATION ELEMENTS
W. LEY (DFVLR, Cologne, West Germany) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 113-131.
(AAS 85-115)

Topics of interest in the ESA Space Station Long-term Preparatory Program to develop European element for the NASA Space Station are discussed. Among the specific topics discussed are: Space Station launcher development; in-orbit-infrastructures for Space Station; and cooperation with NASA in the field of Manned Space Systems. The instrumentation requirements of scientific platforms on board Space Station are considered, with emphasis given to applications in materials sciences, life sciences, space science, earth observation, and communications and support systems. A laboratory configuration incorporating experimental facilities for these applications is described. I.H.

A86-28585
SPACE STATION PLATFORM
P. J. CONCHIE (British Aerospace, PLC, Space and Communications Div., Stevenage, England) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 133-138.
(AAS 85-117A)

The requirements for a multi-user Space Platform maintained on-orbit by periodic visits by the Space Shuttle, and servicing a series of payloads, has evolved since the concept was first formulated within NASA in the mid-1970's. This paper gives a brief survey of the history of the Space Platform concept, and then 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. Author

A86-28587
TETHERED SATELLITE SYSTEM - PRESENT PROGRAM AND FUTURE APPLICATIONS
E. VALLERANI, F. BEVILACQUA, and F. GIANI (Aeritalia S.p.A., Turin, Italy) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 161-173. refs
(AAS 85-124)

The design of tethered satellite system (TSS) for NASA Shuttle applications is described. The TSS consists of a satellite module which is attached to a deployer by a tether. The deployer is in turn attached to the Spacelab pallet inside the Orbiter cargo bay. While the satellite is not operating, the satellite module is clamped to the deployer module for storage. Deployment of the satellite module is carried out by thrusters and control of tension on the tether during deployment is performed by a core equipment component which consists of switches, an electron gun, a variable resistor element, and voltage and current monitors. In addition to the plasma physics applications of TSS, attention is given to experimental applications in aeronomy, geology, seismology, and remote sensing. Cooperative role of the Italian Space Agency in developing the TSS design for Shuttle is emphasized. I.H.

A86-28589
A EUROPEAN SPACE IN-ORBIT INFRASTRUCTURE
P. W. SHARP (ERNO Raumfahrttechnik GmbH, Bremen, West Germany) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 215-248.
(AAS 85-128)

The results of the ESA Long-Term Preparatory Program (LTPP) to identify candidate designs for an in-orbit materials processing platform, the In-Orbit Infrastructure (IOI), are presented. Attention is given to several design issues associated with IOI architectures, mission scenarios, payload accommodations, and servicing and exchange requirements. The most probable areas of commercial space processing which would require an IOI platform are identified including crystal growth, electrophoresis, and metal alloy and composites processing. A Re-entry Vehicle (REV) system for returning processed materials to earth from the IOI platform is also described. Detailed line drawing of the principal IOI candidate configurations are provided. I.H.

A86-28594
TRANSIENT DYNAMICS DURING THE EXTENSION OF FLEXIBLE MEMBERS
V. J. MODI (British Columbia, University, Vancouver, Canada) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 313-337. refs
(Contract NSERC-67-1547)
(AAS 85-137)

Complex interactions between flexibility, deployment and attitude dynamics are investigated for three distinct configurations involving beam, tether and plate type appendages. Both transient as well as steady state phases are explored. The study suggests that for critical combinations of parameters the systems can become unstable, however, suitable control strategies are available to restore stability. The results are applicable to the next generation of communications satellites with large flexible antennas and solar panels, deployment and retrieval of tethered subsatellite systems, and the Orbiter based manufacture of structural components aimed at construction of space-platforms. Author

A86-28728
REDUCTION TECHNIQUES IN DYNAMIC SUBSTRUCTURES FOR LARGE PROBLEMS
B. G. PRAKASH and M. S. S. PRABHU (Indian Space Research Organization, Satellite Centre, Bangalore, India) Computers and Structures (ISSN 0045-7949), vol. 22, no. 4, 1986, p. 539-552. refs

Questions regarding the advantages of a use of dynamic substructuring concepts are considered. Dynamic substructuring using fixed interface modes is very attractive, but problems can arise in connection with the presence of a large number of interface degrees of freedom (dofs) at the system level. This is particularly true in the case of large and complex structures. In the conducted investigation, free vibration of the Indian Remote Sensing Satellite (IRS) forms the base for studying the effectiveness of different methods of reducing the number of interface dofs. The results show that the use of Ritz vectors is not feasible, while the employment of junction modes is uneconomical. Static condensation leads to erroneous results, even for frequencies, when applied to interface dofs in the substructure synthesis method. It is suggested to use recursive substructuring to overcome this problem. G.R.

A86-29209
OPTIMIZATION OF THE QUANTIZED DISTRIBUTION FUNCTION OF THE FIELD OVER THE TRANSMITTING ANTENNA APERTURE OF A SATELLITE SOLAR POWER STATION [OB OPTIMIZATSII DISKRETNOI FUNKTSII RASPREDELENIIA POLIA PO APERTURE PEREDAIUSHCHEI ANTENNY SKES]
V. A. VANKE, S. K. LESOTA, and A. V. RACHNIKOV Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 31, Feb. 1986, p. 286-291. In Russian. refs

Consideration is given to a 10-step amplitude distribution of the field over an SPS transmitting-antenna aperture. The form of the distribution is optimized for the maximum efficiency of power transmission for transmitting and receiving antenna radii of 500 and 5000 m, respectively. It is shown that a quantized amplitude distribution can be obtained for which the level of all the sidelobes at the receiving end does not exceed 5 microwatts/sq cm in the case of tolerances on the rms deviations of the radii and amplitudes of the steps equal to 1 and 8 percent, respectively. B.J.

A86-29258
EVOLUTION OF THE ROTATIONS OF A SYMMETRIC SATELLITE CARRYING A VISCOELASTIC ANTENNA ABOUT ITS CENTER OF MASS IN CIRCULAR ORBIT [ZVOLIUTSIIA VRASHCHENII SIMMETRICHNOGO SPUTNIKA, NESUSHCHEGO VIAZKOUPRUGUIU ANTENNU, VOKRUG TSENTRA MASS NA KRUGOVOI ORBITE]
IU. G. MARKOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 24, Jan.-Feb. 1986, p. 3-8. In Russian. refs

The averaging method is used to obtain approximate equations describing the evolution of the rotations of a symmetric rigid satellite with a homogeneous viscoelastic antenna. The system is represented as a ring onto which a viscoelastic film is stretched. Transverse deformations of the membrane accompanied by energy dissipation are responsible for the evolution of regular precession. Steady-state motions of the system are determined, and their stability is analyzed. The present study is of interest in connection with the design of satellite solar power stations. B.J.

A86-29264
REGIME OF GENERALIZED GRAVITY-GRADIENT ATTITUDE CONTROL ON THE SALYUT-6 - COSMOS-1267 AND SALYUT-7 - COSMOS-1443 ORBITAL COMPLEXES [REZHIM OBOBSHCHENNOI GRAVITATSIONNOI ORIENTATSII NA ORBITAL'NYKH KOMPLEKSAKH 'SALIUT-6' - 'KOSMOS-1267' I 'SALIUT-7' - 'KOSMOS-1443']
I. K. KOSTENKO, V. I. VETLOV, A. G. NYRKOV, V. A. SARYCHEV, and V. V. SAZONOV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 24, Jan.-Feb. 1986, p. 46-51. In Russian.

In the generalized gravity-gradient attitude control regime, the orbital complexes rotate about the longitudinal axis directed approximately along the local vertical. The mean power extraction from the solar arrays of the Cosmos satellites during the attitude stabilization is calculated. Also presented are telemetry data characterizing the motion of the complex with respect to the center of mass in this regime. B.J.

A86-29485#
FLEXIBILITY CONTROL OF SOLAR BATTERY PADDLES. I - A METHOD OF VIBRATION AND ATTITUDE CONTROL BASED ON OUTPUTS OF SOLAR INSTRUMENT SENSORS
T. FUKUDA, H. HOSOKAI (Tokyo Science University, Japan), Y. KURIBAYASHI (Mitsubishi Electric Corp., Kamakura, Japan), and N. YAJIMA (Ministry of International Trade and Industry, Mechanical Engineering Laboratory, Sakura, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 29, Jan. 1986, p. 208-213. refs

Flexible solar battery paddles of spacecrafts have low frequency vibrational characteristics due to the stringent limitation of the weight of launched rockets. The basic problem dealt with here is how to estimate and control the vibrational modes of flexible booms of the arrays even in large angle attitude maneuvers. First a proposed mode estimation method using the outputs of solar cells is shown to give good estimates of the vibrational modes. Then, it is shown that even static output maximization control in a desired direction cannot work stably without flexibility control based on the mode estimation, and that the boom is controlled dynamically based on the feedback control theory so as to suppress the vibration of the arrays even in large angle attitude maneuvers.
Author

A86-29490
MANNED WORKPLACE IN SPACE, STARTED AS A U.S. CONCEPT, NOW HAS GLOBAL IMPACT
J. C. LOWNDES Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 18-21.

Negotiations have begun between NASA, ESA, and Canadian and Japanese space authorities in order to define a program for international cooperation in the development and operation of a manned space station. These talks are giving emphasis to avoidance of equipment duplication and to insuring the compatibility of the various hardware packages. The level of financial commitment by each of the potential partners remains unclear. In addition, obstacles have arisen in virtue of European and Japanese desires for autonomy, the protection of proprietary data, and flight safety considerations that would place any vehicle approaching within 20 km of the space station under NASA control. The reliability of Space Shuttle transportation in the wake of the Challenger Orbiter's destruction is also in doubt, especially with respect to the three-orbiter fleet's scheduling. O.C.

A86-29491
EUROPEANS EXPLORING INDEPENDENT ROLE IN SPACE
J. M. LENOROVITZ Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 25-29.

ESA's Columbus space station program will proceed at first in the guise of the joint US/international development of a manned space station, but will eventually take the form of an independent facility. The Ariane 5 heavy launcher is an essential element of the Columbus effort, as is the Hermes orbiter, which will conduct in-orbit repair, resupply, and cargo transfer operations. The success of commercially oriented space station programs is acknowledged to depend on ESA's ability to lead industrial efforts in a highly organized and gradual fashion. The primary industrial interest is in microgravity processing, as demonstrated during Spacelab missions aboard the Space Shuttle. O.C.

A86-29492
SPAR AEROSPACE LEADS THE WAY IN CANADA'S PARTICIPATION
W. H. GREGORY Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 32-34.

The extent of Canadian participation in the development of the NASA Space Station remains to be defined, and will be determined in the course of negotiations between NASA and the Canadian Ministry of Science and Technology. While commercial space applications are of primary interest to Canada, it is the ability to service (repair or modify) satellites or spacecraft in orbit that may be of primary importance. A degree of US participation in such servicing operations is expected. Canadian companies envision arohotic servicing shelter for spacecraft with removable covers that employs a large manipulator arm 50-60 ft long. O.C.

A86-29493
LIFE SCIENCES MODULE FOR SPACE STATION WILL BE MADE IN JAPAN
E. SEKIGAWA Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 37, 39.

The National Space Development Agency (NASDA) of Japan is sponsoring the design efforts of ten Japanese manufacturers on a laboratory module that figures in the Phase B definition studies of the NASA space station program Complementing this space station program, NASDA is planning a study concerning an unmanned free flying platform that can furnish microgravity environments for experimental packages; this free flier would be assembled, launched and controlled from the space station. In addition, development work has begun on a manned space shuttle-like vehicle designated Himes, whose performance would be comparable to that of a sounding rocket. The Navstar GPS would provide Himes' navigation, guidance and control, and a microwave landing system would handle approaches and landings. O.C.

A86-29660#
ETS-V SYSTEM
H. MURAYAMA, K. NAKAMARU, S. YAMADA (National Space Development Agency of Japan, Tokyo, Japan), T. UEDA, R. KASAI (Mitsubishi Electric Corp., Kamakura, Japan) et al. IN: Communication Satellite Systems Conference, 11th, San Diego, CA, March 17-20, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 676-680. refs (AIAA PAPER 86-0723)

System design contents and status of Engineering Test Satellite-V (ETS-V) of Japan are described, especially for its characteristics and some topics such as fuel sloshing effects and growth capability. Based on the system design and component/subsystem design, PFM is now being manufactured.

It is anticipated that ETS-V will play the role of frontier for technology development of Japanese 3-axis stabilized large geostationary spacecrafts. Author

A86-29700
A PERMANENT LUNAR BASE - ALTERNATIVES AND CHOICES
H. H. KOELLE (Berlin, Technische Universitaet, West Germany) Space Policy (ISSN 0265-9646), vol. 2, Feb. 1986, p. 52-59. refs

The procedures involved in the development of a lunar base are discussed. A design concept for a lunar base and the technological programs required to achieve the construction of this base are described. The use of a logistics support model to evaluate the cost effectiveness of a space transportation system is examined. The components for a complete earth-lunar space transportation system including a heavy lift launch vehicle and a manned orbital transfer vehicle are analyzed. The cost-benefit ratios of various lunar base concepts need to be compared in order to select the best design for the structure. I.F.

N86-10097*# Commissariat a l'Energie Atomique, Grenoble (France). Centre d'Etudes Nucleaires.
DIRECTIONAL SOLIDIFICATION OF MONOTECTIC AND HYPERMONOTECTIC ALUMINUM-INDIUM ALLOYS UNDER MICRON-G
C. POTARD *In* NASA, Washington Microgravity Sci. and Appl. Program Tasks p 81-82 May 1985
Avail: NTIS HC A10/MF A01 CSCL 22A

The objective of this program is to analyze the mechanisms involved in the composite solid structure formation obtained from a miscibility gap alloy under microgravity. The metallic system aluminum-indium was chosen for its low critical temperature, broad miscibility gap, and rather well-known thermodynamic properties. The experiment was performed aboard the Salyut-7 spacecraft. The theories of capture of particulates by an advancing front were not able to explain the observations made on SPAR and Salyut-7 experiments. A new model was developed based on the filtration theory considering the globules population: the solid/liquid interface is like a filter of negligible thickness for the globules and its efficiency is limited by a pressure barrier measured for Al-In alloys by ground based experiments. The Materials Experiment Assembly (MEA)-3 experiment was consequently adjusted to take into account the new model. The behavior of the globules in an interacting population on the solid front is, of course, an essential factor in the theory. The theory is at present being completed by results obtained by the Laboratoire d'Aerothermique of Meudon. The hydrodynamic and thermal interactions between pairs of globules placed in a temperature gradient have been calculated showing a large reduction of the Marangoni effect compared to the isolated globule. Physico-chemical properties of metallic liquid interface are currently being investigated. R.J.F.

N86-10187# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
THE FIRST GERMAN SPACELAB MISSION D1 REPORTS Progress Report [ERSTE DEUTSCHE SPACELAB-MISSION D1-REPORT]
Oct. 1984 4 p In GERMAN
(PR-1) Avail: NTIS HC A02/MF A01

The Spacelab mission; Spacelab specifications and technical concept; Spacelab history, and scheduling from December 1984 to October 1985 are discussed. Author (ESA)

N86-10188# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
THE FIRST GERMAN SPACELAB MISSION D1 REPORTS Progress Report [ERSTE DEUTSCHE SPACELAB-MISSION D1-REPORT]
Dec. 1984 8 p In GERMAN
(PR-2) Avail: NTIS HC A02/MF A01

Spacelab D1 payload integration; aerospace medicine in weightlessness; process technology; NAVEX program: Earth observation, communication and navigation; project management; the environmental control and life support systems; the MEDEA, Biorack payloads; and the Mirror heating facility are discussed. Author (ESA)

N86-10189# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
THE FIRST GERMAN SPACELAB MISSION D1 REPORTS Progress Report [ERSTE DEUTSCHE SPACELAB-MISSION D1-REPORT]
Feb. 1985 7 p In GERMAN
(PR-3) Avail: NTIS HC A02/MF A01

Astronaut preparation with the Spacelab training simulator; project planning for the Columbus and Ariane 5 programs; the D1 - Transport platforms: a 4 m wide and 6.5 m long special container for integral payload transport; milestones of the European space programs since 1969; and opinions against manned space flights are discussed. Author (ESA)

N86-10746# Joint Publications Research Service, Arlington, Va.
ASSESSMENT OF STATE OF CHRONOTROPIC AND INOTROPIC HEART FUNCTION AT DIFFERENT DEGREES OF PHYSICAL FITNESS Abstract Only
V. V. AKSENOV and I. G. TAZETDINOV *In its* USSR Rept.: Life Sci. Biomed. and Behavioral Sci. (JPRS-UBB-85-023) p 62-63 18 Sep. 1985 Transl. into ENGLISH from Fiziol. Cheloveka (Moscow), v. 11, no. 1, Jan. - Feb. 1985 p 96-101 Original language document announced in IAA as A85-27781
Avail: NTIS HC A06

An approach to the mathematical analysis of cardiosignals is developed which makes it possible to quantitatively evaluate the chronotropic and inotropic functions of the heart from a systems point of view. Combining statistical, cross-correlation, and frequency analyses, this approach makes it possible to assess physical-training level in aerospace and sports medicine. As an example, cardiosignals from the flight commanders and engineers on the Salyut-5 and Salyut-6 orbital stations were analyzed. It is concluded that the mathematical analysis of cardiosignals recorded in conditions of rest makes it possible to evlauate physical-training level as the potential readiness of regulatory systems to provide for the required high level of body functioning under physical loads. B.J. (IAA)

N86-11102# Centre d'Etudes et de Recherches Geodynamiques et Astronomiques, St. Vallier de Thiey (France).
TRIO: A KILOMETRIC ARRAY STABILIZED BY SOLAR SAILS
A. LABEYRIE, B. AUTHIER, T. DEGRAAUW, E. KIBBLEWHITE, and G. WEIGELT *In* ESA Colloq. on Kilometric Opt. Arrays in Space p 27-33 Apr. 1985 refs
Avail: NTIS HC A09/MF A01

A spaceborne optical array (TRIO) consisting of 2 to 4 telescopes spaced up to 1000 m apart, at Lagrange point 5 of the Earth-Moon trajectory is described. For kilometric baselines and variable aperture patterns allowing image reconstructions, TRIO has free flying telescopes and a focal station. Small solar sails point and stabilize the system. Electrostatic mounts support the telescopes. Many apertures can be utilized in later versions. Author (ESA)

N86-11110# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Mathematical Support Div.
PRELIMINARY STUDIES OF A SPINNING TETHER-CONNECTED TRIO CONCEPT
E. B. CRELLIN *In* ESA Colloq. on Kilometric Opt. Arrays in Space p 91-94 Apr. 1985 refs
Avail: NTIS HC A09/MF A01

Use of a slowly spinning interferometer configuration with the telescopes attached to the central station using tethers of equal length, including tether configuration, mass and storage is discussed. Slow rotation allows measurements of each source at different baseline angles. When the maximum baseline length is reached, the tethers can be retracted (stopping at intermediate

lengths for further measurements, if required) and the telescopes recaptured by the central station. The attitude change to another source can be performed with the rigid configuration.
Author (ESA)

N86-12163# State Dept., Washington, D. C. Bureau of Public Affairs.
US SPACE PROGRAMS: COOPERATION AND COMPETITION FROM EUROPE
H. R. MARSHALL, JR. and C. SABOE, ed. May 1985 6 p
(BPA-CP-695) Avail: NTIS HC A02/MF A01

International activities demonstrate the many applications of space science and technology for peaceful purposes and provide opportunities for contribution by scientists of other countries to the tasks of increasing human understanding and use of space. Cooperative activities range from flight of foreign spacecraft to groundbased study and analysis of data. Activities include contributions of experiments or payloads to be flown in space, joint projects to develop flight hardware, use of data provided by satellites, and joint publication of scientific results. These cooperative programs are generally carried out under government-to-government science and technology agreements coordinated by the State Department. In addition, NASA provides, on a reimbursable basis, commercial services such as deployment of telecommunication satellites. G.L.C.

N86-13350# MATRA Espace, Toulouse (France).
REVIEW OF IMPLICATIONS AND USEFULNESS OF SPACECRAFT SERVICING IN LOW EARTH ORBIT (LEO) Final Report
C. COUGNET, G. BERGER, P. LEBOUAR, L. KERSTEIN (MBB, Ottobrunn, West Germany), H. WARTENBERG (MBB, Ottobrunn, West Germany), M. SPIES (MBB, Ottobrunn, West Germany), WIDJAJA (SENER), and J. DELTORO Paris ESA 22 Oct. 1984 709 p refs
(Contract ESA-5610/83/NL)
(MATRA-092/CC/AB/225-84; ESA-CR(P)-2013) Avail: NTIS HC A99/MF A01

The usefulness, technical and operational implications, and cost effectiveness of the orbital servicing of a spacecraft performed on-board the Space Station, with a direct involvement of man, and automatically in spacecraft orbit with a servicer vehicle were investigated. Mission analysis; and identification and analysis of servicing functions and operations, and of the impacts of servicing requirements on spacecraft design are outlined. Design evolution of a EURECA type platform is discussed. A philosophy and definition of elements required by the servicing functions on board the space station are established. Servicing elements for automatic orbital servicing are defined. Orbital servicing supporting technologies are reviewed. Economic aspects of a platform mission performed with and without orbital servicing are compared.
Author (ESA)

N86-13352# European Space Agency, Paris (France).
EURECA: AN INTRODUCTION TO EUROPE'S FREE-FLYING RETRIEVABLE CARRIER
N. LONGDON, comp. May 1985 21 p refs Original contains color illustrations
(ESA-BR-30; ISSN-0250-1589) Avail: NTIS HC A02/MF A01

The European Retrievable Carrier (EURECA) is a reusable platform launched by the Shuttle, released in a free flying mode for 6 months or more, and then retrieved by the Shuttle Orbiter and returned to Earth. Payload capacity is up to 1000 kg. The first EURECA payload is primarily dedicated to material and life sciences which benefit from the microgravity environment. The versatility of the system is demonstrated by the fact that a quarter of the payload weight is taken up by space science and technological experiments. The EURECA provides an excellent test bed to demonstrate in-flight technologies such as direct data relay from low Earth orbits via geostationary satellites to a central operations center, rendezvous and docking, and in-orbit servicing. Earth observation possibilities, and commercial applications (new materials, crystal growth, proteins, and pharmaceutical products) are numerous. Author (ESA)

N86-13356*# National Aeronautics and Space Administration, Washington, D.C.
REPORT ON THE FINDINGS OF THE JAPANESE INVESTIGATIVE TEAM ON US SPACE STATION DESIGN (KEIDANREN)
Sep. 1985 127 p Transl. into ENGLISH of "Homi Uchu Kichi Keika Chosatan Hokokusho, Ucho (Space)" Rept-23 Space Development Promotion Council (Keidanren), Tokyo, Japan, 1985 p 1-113 Transl. by Scientific Translation Service, Inc., Santa Barbara, Calif.
(Contract NASW-4004)
(NASA-TM-77659; NAS 1.15:77659) Avail: NTIS HC A07/MF A01 CSCL 22B

The objectives, itinerary and results of the Japanese Investigative Team on U.S. Space Station Design (Keidanren), consisting of members of the Space Development Promotion Council and representatives of Japanese industries involved in Japan's space station development effort are presented. This team visited NASA facilities in February, 1985. The objectives of the study team are to gather information on preliminary design efforts toward space station planning in Japan and the promotion of Japanese space related industries, as well as the evaluation of the present status of space environment exploitation in the U.S. This report is intended to be a basic reference for government agencies and industry in addressing the course of action to be taken in the future development of Japan's space station participation. Author

N86-13363# Dornier-Werke G.m.b.H., Friedrichshafen (West Germany).
TWO-PHASE HEAT TRANSPORT SYSTEMS: SYSTEM DEFINITION, VOLUME 1 Final Report
H. KREEB, P. MOELLER, N. H. PENNINGS (Royal Netherlands Aircraft Factories Fokker), R. S. BHATTI (Societe Anonyme Belge de Constructions Aeronautiques), J. P. MATHIEU (Societe Anonyme Belge de Constructions Aeronautiques), and S. VANOOST (Societe Anonyme Belge de Constructions Aeronautiques) Paris ESA 28 Jan. 1985 132 p refs
(Contract ESA-5669/83/NL-PB(SC))
(ESA-CR(P)-2052) Avail: NTIS HC A07/MF A01

A heat transport system for space stations (including Columbus) and platforms, with heat rejection capacity in the range 10 to 15 kW per module/platform for a 10 yr mission is defined. A two-phase flow loop driven by an electrically powered liquid pump and with capillary assisted evaporators is selected. To fulfil the requirements of narrow temperature control limits, each two-phase flow concept requires a complex control device. A modular design solution dictates the parallel configuration of all evaporators and heat pipe based radiator panels. A program culminating in integration and test of a demonstration model of the complete system is proposed. Author (ESA)

N86-13902# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
STUDY ON DESIGN TECHNIQUES FOR ROBOTS (SPACE APPLICATIONS). VOLUME 1, PART A: TECHNICAL RESULTS Final Report
R. J. HAMANN, comp. and W. VANLEEUWEN, comp. Paris ESA Feb. 1985 138 p 4 Vol.
(Contract ESA-5718/83/NL-AN(SC))
(FOK-TR-R-84-110-VOL-1-PT-A; ESA-CR(P)-2048-VOL-1) Avail: NTIS HC A07/MF A01

A space manipulator system is defined, and the kinematics and dynamics of the system are outlined. A system with seven degrees of freedom, rotating joints, electrical actuation, a toroidal work area, and planar/rotational maneuvering is advocated. Its basic application is servicing and maintenance of low Earth orbit platforms for materials processing. The fully extended arm must be able to move a 750 kg payload at 0.02 m/sec. A dedicated

programming system must be defined for collision and obstacle avoidance. Author (ESA)

N86-13903# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
STUDY ON DESIGN TECHNIQUES FOR ROBOTS (SPACE APPLICATIONS). VOLUME 1, PART B: TECHNICAL RESULTS Final Report
R. J. HAMANN, comp. and W. VANLEEUWEN, comp. Paris ESA Feb. 1985 247 p refs 4 Vol.
(Contract ESA-5718/83/NL-AN(SC))
(FOK-TR-R-84-110-VOL-1-PT-B; ESA-CR(P)-2048-VOL-2) Avail: NTIS HC A11/MF A01

Control aspects of robots for maintenance and servicing of low Earth orbit materials processing platforms were studied. Electrical architecture and software organization were analyzed. Work required to develop the robot was identified. Active force feedback control is advocated. Author (ESA)

N86-13904# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
STUDY ON DESIGN TECHNIQUES FOR ROBOTS (SPACE APPLICATIONS). VOLUME 2: TECHNICAL APPENDICES Final Report
R. J. HAMANN, comp. and W. VANLEEUWEN, comp. Paris ESA Feb. 1985 121 p 4 Vol.
(Contract ESA-5718/83/NL-AN(SC))
(FOK-TR-R-84-110-VOL-2; ESA-CR(P)-2048-VOL-3) Avail: NTIS HC A06/MF A01

Forward and inverse kinematics of a robot manipulator system for maintenance and servicing of space platforms; software availability; robot languages; control models and plots; coupling and decoupling; and modeling errors are summarized.
Author (ESA)

N86-13905# Royal Netherlands Aircraft Factories Fokker, Schiphol-Oost. Space Div.
STUDY ON DESIGN TECHNIQUES FOR ROBOTS (SPACE APPLICATIONS). VOLUME 3: EXECUTIVE SUMMARY Final Report
R. J. HAMANN, comp. and W. VANLEEUWEN, comp. Paris ESA Feb. 1985 44 p refs 4 Vol.
(Contract ESA-5718/83/NL-AN(SC))
(FOK-TR-R-84-110-VOL-3; ESA-CR(P)-2048-VOL-4) Avail: NTIS HC A03/MF A01

A space manipulator system is defined, and the kinematics and dynamics of the system are outlined. A system with seven degrees of freedom, rotating joints, electrical actuation, a toroidal work area, and planar/rotational maneuvering is advocated. Its basic application is servicing and maintenance of low Earth Orbit platforms for materials processing. The fully extended arm must be able to move a 750 kg payload at 0.02 m/sec. A dedicated programming system must be defined for collision and obstacle avoidance. Control aspects; electrical architecture; and software organization were analyzed. Work required to develop the robot was identified. Active force feedback control is advocated.
Author (ESA)

N86-14135# Joint Publications Research Service, Arlington, Va.
OPTIMUM CONTROL PROGRAMS IN PROBLEM OF INTERORBITAL FLIGHT WITH CONTINUOUS THRUST Abstract Only
S. A. ISHKOV and V. V. SALMIN *In its* USSR Rept.: Space (JPRS-USP-85-005) p 42 30 Sep. 1985 Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 22, no. 5, Sep. - Oct. 1984 p 702-711 Original language document announced in IAA as A85-15257
Avail: NTIS HC A08

Various thrust-vector-control programs are examined for the transfer of a spacecraft with a low-thrust engine between noncoplanar circular Keplerian orbits. The averaging method is used to obtain the model of spacecraft motion; and the optimal control program is determined which minimizes fuel consumption with allowance for constraints connected with spacecraft rotation. Calculations are made of the energy characteristics of interorbit transfers from a low geocentric orbit to a stationary satellite orbit.
B.J.(IAA)

N86-14163# Joint Publications Research Service, Arlington, Va.
STABILITY OF STATIONARY MOTIONS OF TWO TETHERED BODIES IN ORBIT UNDER INFLUENCE OF GRAVITATIONAL AND AERODYNAMIC FORCES Abstract Only
Y. M. LEVIN *In its* USSR Rept.: Space (JPRS-USP-85-005) p 81 30 Sep. 1985 Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 22, no. 5, Sep. - Oct. 1984 p 675-682 Original language document announced in IAA as A85-15254
Avail: NTIS HC A08

The motion of a tethered system of two satellites in geometric orbit is examined. The main satellite is assumed to move in circular orbit at a height of 200 to 250 km above the Earth's surface, while the subsatellite-probe, attached to the main satellite by a thin tether, is assumed to orbit the Earth at a height of 100 to 150 km. In the dynamic analysis the subsatellite is considered as a material point, while the tether is considered as an extensible and ponderable flexible filament. Aerodynamic forces acting on the probe and tether are considered, and it is noted that the stationary motions of the system consist in its uniform revolution as a rigid body about the Earth. The stability of these stationary motions is analyzed, and it is shown that constraints imposed on the tether parameters by the stability requirement are more rigorous than constraints on tether strength. IAA

N86-14181# Joint Publications Research Service, Arlington, Va.
METHODS FOR COMPLEX SPACE EXPERIMENT IN USSR FOR STUDYING LAND FROM MANNED SPACECRAFT Abstract Only
B. V. VINOGRADOV *In its* USSR Rept.: Space (JPRS-USP-85-005) p 118 30 Sep. 1985 Transl. into ENGLISH from Issled. Zemli iz Kosmosa (Moscow), no. 5, Sep. - Oct. 1984 p 100-106 Original language document announced in IAA as A85-16946
Avail: NTIS HC A08

A combined space experiment involves use of surface, aerial and space vehicles and instrumentation. The implementation of such an experiment requires adherence to a number of rules relating to the comparability of data: temporal, spectral and spatial. In the USSR such experiments have become increasingly complex and have proceeded through the following states: (1) study of space survey transfer function (geophysical experiment in 1969-Ustyurt Plateau); (2) study of reliability and detail of recognition of natural features from space photographs (informational experiment in 1970-Salsk steppes); (3) study of effectiveness of special mapping, revision of existing maps and compilation of new types of maps (mapping experiment in 1971-Altay and Balkhash key sectors); (4) study of dynamics of natural and anthropogenic systems by successive surveys for registry and prediction of changes (dynamic experiment in 1978-Salsk key sector); and (5) study of rhythmic change in natural systems for registry of short-period changes, their prediction and choice of optimum survey conditions (phenological experiment in 1981-Kyzylkum key sector). Author

N86-14199# Joint Publications Research Service, Arlington, Va.
LIST OF RECENT SOVIET SPACE LAUNCHES
In its USSR Rept.: Space (JPRS-USP-85-005) p 141-143 30 Sep. 1985 Transl. into ENGLISH from various Russian articles
Avail: NTIS HC A08

A list of recent Soviet space launches (21 March 1985 to 19 July 1985) with orbital parameters is given. The majority is in the Cosmos series (26 launches, two of which are multiple, Cosmos 1635 through 1642 (8), and Cosmos 1650 through 1652 (3); the list also includes an Ekran (TV broadcast satellite), Prognoz-10 (to study interplanetary and near-Earth shock waves caused by the interaction of the solar wind and Earth's magnetosphere -- a joint operation with Czechoslovakia), 2 Molniya-3's (communications satellites), the Soyuz T-13 (manned - docked

with Salyut-7), and Progress-24 (made joint docking with Soyuz T-13 and Salyut-7). F.M.R.

N86-14284# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
FIRST GERMAN SPACELAB MISSION D1 REPORTS [ERSTE DEUTSCHE SPACELAB-MISSION D1-REPORT]
Apr. 1985 6 p In GERMAN
Avail: NTIS HC A02/MF A01

Spacelab payload delivery to NASA and payload integration; experiments in weightlessness; vegetation growth; the problem of water supply; single crystal production; Earth observations from space; satellite applications for photomapping, land use diagnosis and atmospheric research; development of a synchronizing process for telecommunication satellites; earthquake prediction; and water surface measurement are discussed. Author (ESA)

N86-14494# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Space Div.
FUTURE COMMUNICATION SPACE SEGMENT. COMPARISON STUDY OF EUROPEAN CONCEPTS. VARIABLE CONFRONTATION CONTROL
Paris ESA Jul. 1983 219 p refs Prepared in cooperation with ERNO Raumfahrttechnik GmbH, Bremen, West Germany and Logica Ltd., London
(Contract ESTEC-4817/81/NL-MD)
(MBB-URV-134/83; ESA-CR(P)-2065) Avail: NTIS HC A10/MF A01

Technical solutions for cost effective implementation and management of the space segment of a European telecommunication network for the 1990's were compared. The most promising concept is an Ariane launched modular platform where the program cost could be lowered to 44% (depriciation rate 0 %) of a reference system with a conventional concept and design. A cost advantage of a cluster type concept is not observed. Comparing individual satellite systems with modular assembly concepts (with a sharing of the service functional bus system) the cost break even point is reached after the third payload module is docked to the central service modules. High system reliability requirements could be covered after the attachment of the second transfer orbit docking system to the service module satellite. Potential benefits of a European satellite assembly system are high due to its modular approach and the inherent high service bus system reliability. The GEO-assembly approach shows high mission flexibility and could provide a good payload adaptability to varying demands, and soft system start-up cost. Author (ESA)

N86-14550# Erno Raumfahrttechnik G.m.b.H., Bremen (West Germany).
FLUID SLOSH STUDIES. VOLUME 2: STUDY OF SLOSH DYNAMICS OF FLUID FILLED CONTAINERS ON SLOWLY ROTATING SPACECRAFT Final Report
K. EBERT Paris ESA 29 Nov. 1984 103 p refs 2 Vol.
(Contract ESA-5328/83/NL-BI(SC))
(ESA-CR(P)-2077-VOL-2) Avail: NTIS HC A06/MF A01

Fuel sloshing during slow rotation of spacecraft is discussed. The theory for slowly rotating spacecraft is developed completely for the three-dimensional case with no rotational symmetry. Expressions for the axisymmetric case are also derived. The three-dimensional problem (tanks with offset from the spin axis) is solved numerically only for spherical tanks. Tanks on the spin axis can have an arbitrary axisymmetric shape. The stability of the system is analyzed. Two cases are distinguished: dynamic instability caused by parameter combinations; and instability caused by liquid viscosity. In the dynamically instable region, the eigenfrequency of the satellite motion and of the internal rotational motion of the liquid coincide. The time constant of the dynamic instability is much smaller than the time constant for the instability caused by the energy dissipation in the boundary layer of the liquid. The control of the attitude motion of rotating systems is easier for slow spin rate because time constants of the rotational motion of the liquid depend directly on the spin rate and are large for slow rotations; and the motion of the free surface is stabilized by surface tension effects. Author (ESA)

N86-14638# Technische Hogeschool, Delft (Netherlands). Dept. of Mechanical Engineering.
DYNAMICS OF SPATIAL MECHANISMS WITH FLEXIBLE LINKS
J. B. JONKER Dec. 1984 59 p refs Presented at 16th Theoretical and Applied Mechanics International Congression, Lingby, Denmark, Aug. 1984
(WTHD-171) Avail: NTIS HC A04/MF A01

A finite element procedure for the formulation of nonlinear differential equations of motion for spatial mechanisms with flexible links is presented. A (slider) truss element, (slider) beam element, and a hinge element are described. Methods for the calculation of transfer functions of multidegree of freedom mechanisms are presented. The theory is completed with the formulation of dynamics. Due to the approach with finite element notions, the method includes the description of the mechanical behavior of flexible link mechanisms. The equations derived are applicable to rigid link mechanism dynamics and to flexible link mechanisms as well. Author (ESA)

N86-15881# Joint Publications Research Service, Arlington, Va.
DETERMINATION OF INCREMENT OF BACILLUS SUBTILIS BIOMASS IN WEIGHTLESSNESS
F. BERGTER, D. HARZ, P. J. MULLER, K. MUND, U. GUNTER, T. HESSE, R. HARTMANN, G. WANKE, M. G. TAIRBEKOV, G. P. PARFENOV et al. *In its* USSR Report: Space Biology and Aerospace Medicine, Vol. 19, No. 4, Jul. - Aug. 1985 (JPRS-USB-85-006) p 92-95 4 Nov. 1985 refs Transl. into ENGLISH from Kosmich. Biol. i Aviakosmich. Med. (Moscow), v. 19, no. 4, Jul. - Aug. 1985 p 63-65
Avail: NTIS HC A08

This paper presents the results of a microbiological experiment carried out by the Soviet and GDR scientists onboard SALYUT-6. The experiment was performed using a Bacillus subtilis suspension in the Jena unit. The purpose of the experiment was to study the time-course variations of the cell biomass increase in zero-g. The cell culture development was measured with respect to the utilization rate of glucose or casein hydrolysate in the nutrient medium and the rate of protein accumulation in cells. It has been shown that the rate of biomass increment in zero-g lags behind the 1 g level. It can be concluded that the decreased metabolic activity of bacterial cells in zero-g is associated with changes in the cell population distribution and physiochemical parameters of the nutrient medium. Author

N86-16247# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany).
FIRST GERMAN SPACELAB MISSION D1 REPORTS [ERSTE DEUTSCHE SPACELAB-MISSION D1-REPORT]
Jun. 1985 7 p In GERMAN
Avail: NTIS HC A02/MF A01

The D1 Spacelab mission scientific space freight was dispatched from Bremen to the NASA Cape Canaveral launching site on a Boeing 747 freight and on a Lockheed C5A Galaxy. The Spacelab standard racks were integrated into the space laboratory (level 3 integration) and the payload elements to be exposed to space environment on the launcher structure. Simulations of the functions with the Columbia space shuttle were tested. Mission phases under flight conditions were tested in the integration hall at MBB-ERNO. Fluid shift under weightlessness was studied by measuring the eye's internal pressures with a tonometer. Author (ESA)

N86-17371# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
COMPENSATING STRUCTURE AND PARAMETER OPTIMIZATION FOR ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
D. C. CEBALLOS Jun. 1985 24 p refs Submitted for publication
(INPE-3564-PRE/770) Avail: NTIS HC A02/MF A01

A Feedback Double Path Compensating (FDPC) control structure is considered for the attitude control of a flexible spacecraft, where vibration modes and modelling errors are present. Parameter optimization is applied for finding the controller, so as to have optimized behavior for a high order model. The second-order FDPC controller was tested for the one axis attitude control of a space-craft with flexible appendages, whose dynamics was approximated by a fourteenth-order linear invariant model. The results are found to be satisfactory. Author

N86-17375# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Product Assurance Div.
MEASUREMENT OF THERMO-OPTICAL PROPERTIES OF THERMAL CONTROL MATERIALS
Jul. 1984 28 p refs
(ESA-PSS-01-709-ISSUE-1; ISSN-0379-4059) Avail: NTIS HC A03/MF A01

Equipment and procedure for determining the solar absorptance and total hemispherical emittance properties of thermal control materials are described. The size of samples required for measurements at ESTEC and the precautions to be taken are specified. Author (ESA)

N86-17376# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
TOWARDS DIGITAL COMPUTER SIMULATION OF THE DYNAMICS OF FLEXIBLE SPACECRAFT
P. T. L. M. VANWOERKOM 5 Oct. 1983 90 p refs
(Contract NIVR-1910)
(NLR-TR-83106-U; B8569032; AD-B095075L) Avail: NTIS HC A05/MF A01

A method based on a sequence of modified modal transformations for numerical simulation of the dynamics of flexible spacecraft equipped with actuators and sensors was developed. The spacecraft assembly is treated as a sampled data system, characterized by locally constant inputs and by outputs at discrete times. The result consists of a system of exact difference equations, which describes the transition of the spacecraft assembly state from one point in time to the next. In this manner, the usual numerical integration of the differential equations of the spacecraft assembly is replaced by exact, numerical, discrete propagation with difference equations. The associated time interval is determined mainly by measurement times, control update times, and measurement and system noise simulation requirements. Author (ESA)

N86-17436# Fabrica Italiana Apparecchi Radio S.p.A., Milan (Italy). Space Div.
THE GIOTTO POWER SUPPLY SUBSYSTEM
E. RE *In* ESA Proceedings of ESA Sessions at the 16th IEEE Annual Power Electronics Specialists Conference p 27-37 May 1985 refs
Avail: NTIS HC A15/MF A01

The requirements and components of the Giotto power supply subsystem are described. Requirements are: transfer of electrical power between the solar array, the batteries, and spacecraft loads (including each experiment); main bus voltage control using shunt and battery discharge regulation; switching and protection electronics for the experiments, the heaters, and other spacecraft systems; transfer of power to the AOCMS, data handling subsystems, and the despin motor control electronics from dedicated converters; and provision of telecommand and telemetry functions to operate and monitor the system configuration and functioning. The major components are: power control unit; power distribution unit; four batteries; battery regulator units containing a battery discharge regulator and a battery charge regulator; data handling converter; service converter; and external power dumpers (dissipative elements of the shunt regulator). Author (ESA)

N86-18375# University Coll., London (England). Dept. of Electrical Engineering.
GEOPHYSICAL RADAR ALTIMETERS FOR THE 1990'S
H. D. GRIFFITHS and C. G. RAPLEY *In* ESA Proceedings of EARSeL/ESA Symposium on European Remote Sensing Opportunities: Systems, Sensors, and Applications p 157-165 Jun. 1985 refs Sponsored by ESA
Avail: NTIS HC A12/MF A01

Satellite-borne altimeter concepts for altimetric mission are described. These include developments in on-board adaptive processing algorithms and advances in radar hardware technology, which allow significantly-increased coverage of land and land ice surfaces. Beam-limited altimeters overcome the fundamental disadvantages of pulse-limited instruments over these surfaces, and allow considerably lower transmitter powers, though at the expense of large antenna structures and severe spacecraft pointing constraints. Concepts for antenna signal processing utilizing multiple antenna beams to give increased spatial coverage as well as improved performance over nonocean surfaces are presented. Author (ESA)

N86-18379# European Space Agency, Paris (France).
SPACE STATION: ESA VIEWS ON REQUIREMENTS FOR EXPERIMENTAL AND OPERATIONAL EARTH OBSERVATION MISSIONS
G. DUCHOSSOIS *In its* Proceedings of EARSeL/ESA Symposium on European Remote Sensing Opportunities: Systems, Sensors, and Applications p 189-199 Jun. 1985 refs
Avail: NTIS HC A12/MF A01

The requirements of spaceborne experimental and operational Earth observations are reviewed, and an unmanned polar platform element, composed preferably of two platforms in adequately phased orbits is recommended as part of the European contribution to the US Space Station. Possible configuration and resources capabilities for such platforms are provided, together with candidate payloads. Author (ESA)

N86-18437# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany).
SPACELAB SPECIAL: EURECA
Jul. 1985 10 p In GERMAN Original contains color illustrations
Avail: NTIS HC A02/MF A01

The European Retrievable Carrier EURECA designed for payload elements and experiments in weightlessness in materials science and life sciences, in remote Earth observation, astrophysics, and in fundamental research is presented. The EURECA and Shuttle Pallet Satellite can be applied for a rendezvous mission demonstration and for docking tests without changes in weight, volume, and dimensions. The Navigation Experiment payload for investigation of atomic timing device behavior for on-board and ground clock synchronizing was delivered to the D1 integration team. The NASA mission experts' training and preparations are presented. Flight assessment shows high precision. Author (ESA)

N86-18842# Consiglio Nazionale delle Ricerche, Frascati (Italy). Ist. di Fisica dello Spazio Interplanetario.
THE TETHERED SATELLITE SYSTEM PROJECT
M. DOBROWOLNY *In* ESA The Seventh ESA Symposium on European Rocket and Balloon Programs and Related Research p 211-216 1985 refs
Avail: NTIS HC A18/MF A01

The Tethered Satellite System project consists in flying a subsatellite tethered to a space shuttle orbiter at variable distances up to 100 Km from the shuttle. An electrodynamic mission with the tether made up of conducting material and an atmospheric mission using a tether of insulating material are planned. For the

atmospheric mission, the tethered satellite orbit is at 130 km altitude, allowing information to be collected from an area where a free flying satellite would soon be lost due to atmospheric drag. The electrodynamic mission uses the potential difference induced by the tether in active space plasma physics experiments.
Author (ESA)

N86-18844# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Space Science Dept.
LABORATORY SIMULATION OF THE ELECTRODYNAMIC INTERACTION OF THE TETHERED SATELLITE WITH THE IONOSPHERE
J. P. LEBRETON, C. BONIFAZI (CNR, Frascati, Italy), H. ARENDS, M. HAMELIN (CNRS, Orleans, France), R. DEBRIE (CNRS, Orleans, France), and M. DOBROWOLNY (CNR, Frascati, Italy) *In its* The Seventh ESA Symposium on European Rocket and Balloon Programs and Related Research p 221-225 1985 refs
Avail: NTIS HC A18/MF A01

The I-V characteristics of a spherical body of 10 cm diameter were investivated in a large plasma chamber in which the plasma environment of the electrodynamic tethered satellite is well reproduced. The relative velocity of the plasma with respect to the test body is 8 km/sec. Floating potential profiles are measured upstream and downstream of the test body. The measurements are made for a range of normalized body potential between -1000 and +400. The influence of an axial magnetic field on the sheath potential profile and on the current collecting capability of the body is investigated. The experimental results, compared to theoretical models, indicate a key role of the Earth's magnetic field in the interaction of the tethered satelite with ionospheric plasma.
Author (ESA)

N86-19347# Royal Netherlands Aircraft Factories Fokker, Amsterdam.
DEPLOYABLE RADIATOR STUDY Final Report
A. F. J. MORGOWNIK 18 Mar. 1983 195 p refs 2 Vol.
(Contract ESTEC-4437/80-NL-AK(SC); NIVR-2326)
(FOK-TR-R-85-0265-VOL-1; ESA-CR(P)-2109-VOL-1) Avail: NTIS HC A09/MF A01

A radiator for the space platform of the Columbus Space Station program is studied. A preliminary design of a 10 kW deployable radiator with two phase flow heat pipes feeder line is presented. A preference is found for a folding rigid panel concept, which has a lower mass for up to 20 kW. A strong preference for a parallel condenser network is shown. A flow performance analysis of the parallel feeder system gives a pressure drop of 0.1 bar, well within the specifications. The condensers are located on the heat pipe evaporators, in the middle of the heat pipes. In this way a four times higher capacity per heat pipe is obtained. The developed feeder system design requires no bends in the heat pipes.
Author (ESA)

N86-19348# Royal Netherlands Aircraft Factories Fokker, Amsterdam.
SPACE STATION STUDY: THERMAL CONTROL
A. F. J. MORGOWNIK 27 Feb. 1985 99 p refs 2 Vol.
(Contract ESTEC-4437/80-NL-AK(SC); NIVR-2326)
(FOK-TR-R-85-019-VOL-2; ESA-CR(P)-2109-VOL-2) Avail: NTIS HC A05/MF A01

The heat rejection of the space platform of the Columbus Space Station program is analyzed in order to establish guidelines for further studies. A preliminary heat rejection capability of 125 W/sq m is determined. It is found that the integration of feeder lines in the radiator panels leads to a high reliability against meteoroid impact. Investigation of potential heat pipe layouts results in a preference for using low to moderate transport capacity heat pipes (10 to 100 Wm). A preliminary comparison of three types of coating shows that white silicate paint results in highest radiation efficiency, even when degrading is taken into account.
Author (ESA)

N86-19909*# National Aerospace Lab., Tokyo (Japan).
CELSS EXPERIMENT MODEL AND DESIGN CONCEPT OF GAS RECYCLE SYSTEM
K. NITTA, M. OGUCHI, and S. KANDA (Kawasaki Heavy Industries Ltd., Kobe, Japan) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 35-46 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

In order to prolong the duration of manned missions around the Earth and to expand the human existing region from the Earth to other planets such as a Lunar Base or a manned Mars flight mission, the controlled ecological life support system (CELSS) becomes an essential factor of the future technology to be developed through utilization of space station. The preliminary system engineering and integration efforts regarding CELSS have been carried out by the Japanese CELSS concept study group for clarifying the feasibility of hardware development for Space station experiments and for getting the time phased mission sets after FY 1992. The results of these studies are briefly summarized and the design and utilization methods of a Gas Recycle System for CELSS experiments are discussed.
Author

N86-19910*# Yokohama National Univ. (Japan). Dept. of Chemical Engineering.
UTILIZATION OF MEMBRANES FOR H2O RECYCLE SYSTEM
H. OHYA and M. OGUCHI (National Aerospace Lab., Tokyo, Japan) *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 47-53 Jan. 1986
Avail: NTIS HC A99/MF A01 CSCL 06K

Conceptual studies of closed ecological life support systems (CELSS) carried out at NAL in Japan for a water recycle system using membranes are reviewed. The system will treat water from shower room, urine, impure condensation from gas recycle system, and so on. The H2O recycle system is composed of prefilter, ultrafiltration membrane, reverse osmosis membrane, and distillator. Some results are shown for a bullet train of toilet-flushing water recycle equipment with an ultraviltration membrane module. The constant value of the permeation rate with a 4.7 square meters of module is about 70 1/h after 500th of operation. Thermovaporization with porous polytetrafluorocarbon membrane is also proposed to replce the distillator.
Author

N86-19911*# Commissariat a l'Energie Atomique, Cadarache (France). Service de Radioagronomie.
THE C23A SYSTEM, AN EXMAPLE OF QUANTITATIVE CONTROL OF PLANT GROWTH ASSOCIATED WITH A DATA BASE
M. ANDRE, A. DAGUENET, D. MASSIMINO, and A. GERBAUD *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 55-64 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The architecture of the C23A (Chambers de Culture Automatique en Atmosphere Artificielles) system for the controlled study of plant physiology is described. A modular plant growth chambers and associated instruments (I.R. CO2 analyser, Mass spectrometer and Chemical analyser); network of frontal processors controlling this apparatus; a central computer for the periodic control and the multiplex work of processors; and a network of terminal computers able to ask the data base for data processing and modeling are discussed. Examples of present results are given. A growth curve analysis study of CO2 and O2 gas exchanges of shoots and roots, and daily evolution of algal photosynthesis and of the pools of dissolved CO2 in sea water are discussed.
R.J.F.

N86-19912*# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Raumfahrttechnik G.m.b.H.
DESCRIPTION OF CONCEPT AND FIRST FEASIBILITY TEST RESULTS OF A LIFE SUPPORT SUBSYSTEM OF THE BOTANY FACILITY BASED ON WATER RECLAMATION
H. R. LOESER *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 65-76 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

The Botany Facility allows the growth of higher plants and fungi over a period of 6 months maximum. It is a payload planned for the second flight of the Eureca platform around 1990. Major tasks of the Life Support Subsystem (LSS) of the Botany Facility include the control of the pressure and composition of the atmosphere within the plant/fungi growth chambers, control of the temperature and humidity of the air and the regulation of the soil water content within specified limits. Previous studies have shown that various LSS concepts are feasible ranging from heavy, simple and cheap to light, complex and expensive solutions. A summary of those concepts is given. A new approach to accomplish control of the temperature and humidity of the air within the growth chambers based on water reclamation is discussed. This reclamation is achieved by condensation with a heat pump and capillary transport of the condensate back into the soil of the individual growth chamber. Some analytical estimates are given in order to obtain guidelines for circulation flow rates and to determine the specific power consumption. R.J.F.

N86-19920*# National Aerospace Lab., Tokyo (Japan).
GAS AND WATER RECYCLING SYSTEM FOR IOC VIVARIUM EXPERIMENTS
K. NITTA and K. OTSUBO *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 185-200 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

Water and gas recycling units designed as one of the common experiment support system for the life science experiment facilities used in the Japanese Experiment Module are discussed. These units will save transportation and operation costs for the life science experiments in the space station. These units are also designed to have interfaces so simple that the connection to another life science experiment facilities such as the Research Animal Holding Facility developed by the Rockheed Missiles and Space Company can be easily done with small modification. R.J.F.

N86-19921*# National Aerospace Lab., Tokyo (Japan).
WATER RECYCLING SYSTEM USING THERMOPERVAPORATION METHOD
K. NITTA, A. ASHIDA (Hitachi Ltd., Tokyo, Japan), K. MITANI (Hitachi Ltd., Tokyo, Japan), K. EBARA (Hitachi Ltd., Tokyo, Japan), and A. YAMADA *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 201-225 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

A water recycling system concept for the crew of the space station is presented. A thermopervaporation method is a new key technology used for the distillation process, utilizing a hydrophobic membrane. An experimental study of thermopervaporation revealed that the permeation depends on the gap between the membrane and the cooling surface in the condensation room: the steam diffusion occurs with gaps less than 5 mm while natural convection becomes dominant with gaps more than 5 mm. A brief discussion of the system operation is also described. Author

N86-19931*# Commissariat a l'Energie Atomique, Cadarache (France). Service de Radioagronomie.
CAN PLANTS GROW IN QUASI-VACUUM?
M. ANDRE and C. RICHAUD *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 395-404 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

It was found that the growth of plants is possible under absolute pressure 14 times lower than the atmospheric pressure. In first approximation, plants ignore the absence of nitrogen and only react to the partial pressure of O2. Hence the growth of plantlets was delayed under low pressures of O2 in both cases with and without nitrogen. The CO2 availability being limited by the carbon content of the seed, the final results after 20 days were very similar. R.J.F.

N86-19932*# Commissariat a l'Energie Atomique, Cadarache (France). Service de Radioagronomie.
WHEAT RESPONSE TO CO2 ENRICHMENT: CO2 EXCHANGES TRANSPIRATION AND MINERAL UPTAKES
M. ANDRE, H. DUCLOUX, and C. RICHAUD *In* NASA. Ames Research Center Controlled Ecological Life Support Systems p 405-428 Jan. 1986 refs
Avail: NTIS HC A99/MF A01 CSCL 06K

When simulating canopies planted in varied densities, researchers were able to demonstrate that increase of dry matter production by enhancing CO2 quickly becomes independant of increase of leaf area, especially above leaf area index of 2; dry matter gain results mainly from photosynthesis stimulation per unit of surface (primary CO2 effect). When crop density is low (the plants remaining alone a longer time), the effects of increasing leaf surface (tillering, leaf elongation here, branching for other plants etc.) was noticeable and dry matter simulation factor reached 1.65. This area effect decreased when canopy was closed in, as the effect of different surfaces no longer worked. The stimulation of photosynthesis reached to the primary CO2 effect. The accumulation in dry matter which was fast during that phase made the original weight advantage more and more neglectible. Comparison with short term measurements showed that first order long term effect of CO2 in wheat is predictible with short term experiment, from the effect of CO2 on photosynthesis measured on reference sample. R.J.F.

N86-20178# Joint Publications Research Service, Arlington, Va.
USSR REPORT: SPACE
13 Jan. 1986 186 p Transl. into ENGLISH from various Russian articles
(JPRS-USP-86-001) Avail: NTIS HC A09

Numerous aspects of the U.S.S.R. space program are discussed. Manned space flight, geometrical optics, airglow, planets, photointerpretation, space maintenance, comets, gamma ray bursts, soil analysis, and radar maps are among the topics covered.

N86-20179# Joint Publications Research Service, Arlington, Va.
FEOKISTOV REVEALS DETAILS OF SALYUT-7 REACTIVATION
K. FEOKISTOV *In its* USSR Report: Space (JPRS-USP-86-001) p 1-6 13 Jan. 1986 Transl. into ENGLISH from Pravda (Moscow, USSR), 5 Aug. 1985 p 3; 8
Avail: NTIS HC A03

In a routine check a problem in one of the units of the Salyut-7 radio system, through which commands from the Earth pass, was discovered. As a result, radio contact from the station ceased and it became impossible to obtain telemetry information on the condition of the station's on-board navigation systems. It became clear that in order to restore normal operation it would be necessary to have a crew on board. But to do this a scheme had to be worked out for guiding a transport ship to the silent station at an undetermined point in the expanse of space, to prepare a ship and crew for the flight and for performing this unusual task, to outfit this ship with the new equipment needed for such an operation, to work out a new ballistic path for the approach and to train the specialists of the Flight Control Center. The technology developed in order to approach the station is discussed. On 6 June the spacecraft Soyuz T-13, manned by V. Dzhanibekov and V. Savinykh, was put into orbit. After corrections to its orbit were completed, on the morning of 8 June the spacecraft approached the station. When the ship and station exited from shadow they were at a distance of about ten kilometers from each other. V. Dzhanibekov aligned the ship's lateral axis with that of the station, observing it through the porthole of the ship's descent craft while V. Savinykh entered data into the computer according to Dzhanibekov's commands. At a distance of two and one half

kilometers the automatic equipment executed the last correction maneuver and the crew took manual control. The calculations of the on-board computers were accurate enough that the corrections to the approach trajectory that had to be made manually were insignificant. R.J.F.

N86-20180# Joint Publications Research Service, Arlington, Va.
PREPARATION OF COSMONAUTS FOR SALYUT-7 REACTIVATION MISSION
Y. GLAZKOV *In its* USSR Report: Space (JPRS-USP-86-001) p 10-13 13 Jan. 1986 Transl. into ENGLISH from Pravda (Moscow, USSR), Sep. 1985 p 3
Avail: NTIS HC A03

The preparations of the cosmonauts who flew to the crippled Salyut-7 Space Station in order to reactivate it are discussed. The development of a laser range finder and a night vision instrument that were used on the mission is discussed. R.J.F.

N86-20181# Joint Publications Research Service, Arlington, Va.
SOYUZ T-13 LANDS WITH COSMONAUTS DZHANIBEKOV AND GRECHKO
In its USSR Report: Space (JPRS-USP-86-001) p 50 13 Jan. 1986 Transl. into ENGLISH from Sotsialisticheskaya Industriya (Moscow, USSR), 27 Sep. 1985 p 1
Avail: NTIS HC A03

On 26 September 1985, at 1352 hours Moscow time, Vladimire Dzhanibekov and Georgiy Grechko returned to Earth in the Soyuz T-13 spaceship after completing the planned program of joint research and experiments. Vladimir Vasyutin, Viktor Savinykh and Aleksandr Volkov are continuing to work on board the manned complex Salyut-7 -- Soyuz T-14. Delivered to Earth were research materials and experiments performed by Vladimire Dzhanibekov and Viktor Savinykh and also by the crew of five cosmonauts. The fourth long-term expedition on Salyut-7 began 8 June 1985, following the successful docking of the Soyuz T-13 ship with the station. In the course of their flight, Vladimir Dzhanibekov and Viktor Savinykh restored the station to working order, demonstrating courage and high professional skill in doing this. The cosmonauts carried out an extensive program of scientific-technical research, and made an egrees into open space to install extra solar panels. For the first time, a crew has been partially replaced, which ensures the continuous operation of the manned space complex over an extended time, and substantially heightens the effectiveness of its use in the interests of science and the economy. R.J.F.

N86-20182# Joint Publications Research Service, Arlington, Va.
COMMENTARY ON 237 DAY EXPEDITION TO SALYUT-7
S. A. BOVIN *In its* USSR Report: Space (JPRS-USP-86-001) p 54-62 13 Jan. 1986 Transl. into ENGLISH from Zemlya i Vselennaya (Moscow, USSR), no. 2, Mar. - Apr. 1985 p 9-15
Avail: NTIS HC A03

The 237 day flight of Soviet cosmonauts aboard the Salyut-7 station, the longest in the history of the space age, has been completed (Zemlya i Vselennaya, 1983, No 1, p. 2; 1984, No. 1, p. 6; No 3, p. 2; No 6, p. 2 - Ed.). The crew in flight performed a large volume of medical, biological, technological, astrophysical, geophysical as well as preventive maintenance work. The flight to the Salyut-7 station began on 8 February 1984 aboard the Soyuz T-10 transporter. The goal of the flight was to discover how successfully a group of three persons could tackle scientific-technical problems in lengthy orbital flight. For successful management of this experiment and the corresponding medical examinations directly on board the station, cardiologist O. Yu. At'kov was included in the crew. Besides the standard medical apparatus, a special apparatus was also delivered to the station for better observation of the condition of the cosmonauts during the lengthy flight. The presence of a doctor on board the station provided an objective assessment of the state of the crew and, if necessary, the length flight could be curtailed. At'kov conducted two very important experiments involving fundamental aspects of biology. In the Membrana experiment on red blood cells and artificially-created analogs of biological membranes, interesting results were obtained revealing the features of the functions and vital cell components responsible for communication with the environment. In the experiment Genom, an attept was made to employ the advantages conferred by weightlessness to separate large fragments of the DNA molecule, enabling a faster deciphering of the human genetic code. R.J.F.

N86-20183# Joint Publications Research Service, Arlington, Va.
INTERVIEW WITH COSMONAUTS KIZIM AND SOLOVYEV
G. I. VOROBYEV *In its* USSR Report: Space (JPRS-USP-86-001) p 63-70 13 Jan. 1986 Transl. into ENGLISH from Zemlya i Vselennaya (Moscow, USSR), no. 2, Mar. - Apr. 1985 p 16-22
Avail: NTIS HC A03

An interview with Salyut-7 cosmonauts who completed a 237 day mission space is given. Spaceborne experiments in medicine, oceanography, astrophysics and mineral exploration are discussed. R.J.F.

N86-20184# Joint Publications Research Service, Arlington, Va.
BLAGOV ON DEVELOPMENT OF COSMONAUT EVA PROGRAMS
V. D. BLAGOV *In its* USSR Report: Space (JPRS-USP-86-001) p 71-79 13 Jan. 1986 Transl. into ENGLISH from Zemlya i Vselennaya (Moscow, USSR), no. 2, Mar. - Apr. 1985 p 2-8
Avail: NTIS HC A03

The recollections of V.D. Blagov, the second-in-command during the first space walk in outer space, are given. Some details of space maintenance procedures and tools are given. R.J.F.

N86-20236# Joint Publications Research Service, Arlington, Va.
INFLUENCE OF AERODYNAMIC MOMENT ON GRAVITATIONAL ORIENTATION REGIME FOR SALYUT-6, SOYUZ COMPLEX Abstract Only
V. A. SARYCHEV and V. V. SAZONOV *In its* USSR Report: Space (JPRS-USP-86-001) p 130 13 Jan. 1986 Transl. into ENGLISH from Kosmicheskiye Issledovaniya (Moscow, USSR), v. 23, no. 1, Jan. - Feb. 1985 p 63-83
Avail: NTIS HC A03

Within the framework of a simple mechanical model a study was made of the motion of the Salyut-6 - Soyuz orbital complex relative to its center of mass in a uniaxial gravitational orientation regime. The satellite is assumed to be a solid body having the configuration of a cylinder to which are attached three plates, solar cells. The orbit of the satellite center of mass in absolute space is considered circular. The effect of gravitational and restoring aerodynamic moments on the satellite is taken into account. The satellite equations of motion allow the natural introduction of a small parameter: the ratio of the longitudinal moment of inertia to the transverse moment of inertia. The Krylov-Bogolyubov method is used in constructing formal two-parameter integral surfaces of these equations describing oscillations and rotations of the satellite about the longitudinal axis directed approximately along the local vertical. Such satellite motions can be regarded as nominal unperturbed motions in a gravitational orientation regime. A numerical investigation of these integral surfaces was carried out. The resonances between satellite motion about its longitudinal axis and oscillations of this axis relative to the local vertical considerably intensify the influence exerted on the satellite by the nonpotential component of the aerodynamic moment. Examples are given in which such intensification results in strong oscillation of the Satellite and disruption of the gravitational orientation regime. R.J.F.

N86-20242# Joint Publications Research Service, Arlington, Va.
GEOLOGICAL INFORMATION CONTENT OF SPACE PHOTOGRAPHS OBTAINED IN DIFFERENT SPECTRAL RANGES IN COURSE OF GOBI-KHANGAI EXPERIMENT (MUSHUGAY-GURVANBOGD TEST RANGE) Abstract Only
V. I. MAKAROV and G. I. VOLCHKOVA *In its* USSR Report: Space (JPRS-USP-86-001) p 140 13 Jan. 1986 Transl. into ENGLISH from Issledovaniye Zemli iz Kosmosa (Moscow, USSR), no. 2, Mar. - Apr. 1985 p 52-58 Original language document was announced in IAA as A85-37118
Avail: NTIS HC A03

The Gobi-Khangai experiment was carried out from aboard the Salyut-6 Soyuz-39 orbital complex by a Soviet-Mongolian crew in April 1981. A multizonal space photographic survey of the Mushugay-Khuduk region was made. This area is situated in the north-central part of the Gobi, directly to the east of Gurvan-Bogd Range in the Gobi Altai. Included are the results obtained in an earlier (June 1973) survey of this same territory from the ERTS-1 satellite under different illumination conditions. The availability of data from two surveys made it possible to analyze photographic conditions more fully than would have been possible on the basis of the results of only one survey. The strengths and weaknesses of the two surveys are compared. The space photographs served as an excellent base for compiling a map of Quaternary deposits far exceeding the accuracy of maps compiled by surface methods. These photographs made possible a considerable upgrading of earlier published geological and tectonic maps. The comparative analysis of the geological content of space photographs obtained in different spectral ranges indicated that for visual interpretation under conditions similar to the Gobi Altai it is sufficient to have images in the spectral range 0.8 to 0.9 microns the range 0.6 to 0.7 microns can be recommended as an additional range. A need for other ranges would arise only for obtaining synthesized images. Author

N86-20251# Joint Publications Research Service, Arlington, Va.
METHODS FOR STUDYING RECENT TECTONICS USING MATERIALS FROM REMOTE AND SURFACE DATA Abstract Only
A. A. FREYDLIN, Y. G. FARRAKHOV, and L. F. VOLCHEGURSKIY *In its* USSR Report: Space (JPRS-USP-86-001) p 147-148 13 Jan. 1986 Transl. into ENGLISH from Issledovaniye Zemli iz Kosmosa (Moscow, USSR), no. 1, Jan. - Feb. 1985 p 32-38 Original language document was announced in IAA as A85-29904
Avail: NTIS HC A03

Methods for the complex study of tectonic formations to the east of the near-Caspian depression have been developed on the basis of the interpretation of space (Salyut-4) and aerial photographs in conjunction with other types of geological and geophysical data. This approach led to the determination of: (1) the location and structure of recent tectonic zones; (2) the correlation of interpreted elements relief and deep teconic characteristics of the region; (3) the connection between oil deposits and tectonic and neotectonic activity; and (4) the role of tectonic processes in the formation of dispersed-sand massifs in the eastern Caspian region. B.J. (IAA)

N86-20445# Joint Publications Research Service, Arlington, Va.
SALYUT-7 ELECTROPHORESIS EXPERIMENTS AID MEDICAL RESEARCH
T. CHESANOVA *In its* USSR Report: Space (JPRS-USP-86-002) p 45 10 Feb. 1986 Transl. into ENGLISH from Leningradskaya Pravda (Leningrad, USSR), 13 Oct. 1985 p 2
Avail: NTIS HC A05

Experiments performed by crews of Salyut orbiting stations have been aimed at obtaining extrapure hemagglutinin and other surface proteins of the influenza virus, using the method of electrophoresis. The series of space experiments called Tavriya demonstrated that such products can be obtained comparatively quickly and easily in conditions of zero gravity. A new generation electrophoretic unit called EFU-Robot is now in use on the Salyut-7 station. The EFU-Robot can be programmed by a cosmonaut to select samples of substances purified in the course of experiments and automatically transfer the samples from the unit's working chamber to ampoules, using syringes. Preparations obtained during the current manned orbital mission were delivered to Earth recently by cosmonauts. Author

N86-20452# Joint Publications Research Service, Arlington, Va.
IDENTIFICATION OF NATURAL FORMATIONS FROM RESULTS OF SPECTRAL-ENERGY MEASUREMENTS FROM SPACE Abstract Only
L. I. KISELEVSKIY, A. A. KOVALEV, and V. Y. PLYUTA *In its* USSR Report: Space (JPRS-USP-86-002) p 69-70 10 Feb. 1986 Transl. into ENGLISH from Issledovaniye Zemli Iz Kosmosa (Moscow, USSR), no. 4, Jul. - Aug. 1985 p 98-104 Original language document was announced in IAA as A86-13287
Avail: NTIS HC A05

Photographs obtained on board the orbital station Salyut-4 were used to study the spectral and energy characteristics of the upper boundary layer over selected regions of the USSR. The influence of the sample volume on the statistical classifications for spectral features in the range 0.4-0.8 microns is examined in detail. The most informative spectral features were chosen according to Shannon's criterion of information content. A list of the spectral classifications is given. I.H.

N86-20453# Joint Publications Research Service, Arlington, Va.
CLASSIFICATION OF NATURAL FORMATIONS BASED ON THEIR OPTICAL CHARACTERISTICS USING SMALL VOLUMES OF SAMPLES Abstract Only
N. S. ABRAMOVICH, A. A. KOVALEV, and V. Y. PLYUTA *In its* USSR Report: Space (JPRS-USP-86-002) p 70 10 Feb. 1986 Transl. into ENGLISH from Issledovaniye Zemli Iz Kosmosa (Moscow, USSR), no. 4, Jul. - Aug. 1985 p 105-111 Original language document was announced in IAA as A86-13288
Avail: NTIS HC A05

A computer algorithm has been developed to classify the spectral bands of natural scenes on Earth according to their optical characteristics. The algorithm is written in FORTRAN-IV and can be used in spectral data processing programs requiring small data loads. The spectral classifications of some different types of green vegetable canopies are given in order to illustrate the effectiveness of the algorithm. I.H.

N86-21561*# National Aeronautics and Space Administration, Washington, D.C.
MANNED SPACEFLIGHT IN THE NINETIES: THE EUROPEAN PERSPECTIVE
W. FINKE Jan. 1985 11 p Transl. into ENGLISH of "Die Bemannte Raumfahrt in den Neunziger Jahren: Eine Europaeische Perspektive" presented at the International Symposium Towards Columbus and Space Station, 1985 p 1-9 Symposium held in Bad Godesberg, West Germany, 2 Oct. 1985 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-77697; NAS 1.15:77697) Avail: NTIS HC A02/MF A01 CSCL 22A

The inaugural speech for the international space travel symposium which took place in Bad Godesberg, West Germany on 2 Oct. 1985 explains why Europe must take an active part in all aspects of manned space travel for the nineties, including the development of the space station itself and the development of its own reusable space transport and supporting ground equipment to proceed on an equal share basis with the US and Japan while maintaining close international cooperation. Author

N86-21563*# National Aeronautics and Space Administration, Washington, D.C.
CONTEMPORARY ACHIEVEMENTS IN ASTRONAUTICS: SALYUT-7, THE VEGA PROJECT AND SPACELAB
V. N. KUBASOV, V. M. BALEBANOV, and D. Y. GOLDOVSKIY Mar. 1986 55 p Transl. into ENGLISH from Novoye v Zhizni, Nauke, Tekhnike, Seriya: Kosmonavtika, Astronomiya (Moscow, USSR), no. 12, 1985 p 1-64 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-77712; NAS 1.15:77712) Avail: NTIS HC A04/MF A01 CSCL 22A

The latest achievements in Soviet aeronautics are described; the new stage in the space program to study Venus using Soviet automated space probes, and the next space mission by cosmonauts to the Salyut-7 station. Information is also presented on the flight of the Spacelab orbiting laboratory created by Western European specialists. Author

N86-21572# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
PARAMETER OPTIMIZATION AND ATTITUDE STABILIZATION OF A FLEXIBLE SPACECRAFT
D. C. CEBALLOS Oct. 1985 10 p refs Presented at the International Conference Space Dynamics for Geostationary Satellites, Toulouse, France, 28-30 Oct. 1985
(INPE-3680-PRE/830) Avail: NTIS HC A02/MF A01

This paper describes the synthesis and analysis of a control law for a flexible spacecraft. The control law is considered a simple proportional, integral, and derivative law together with a second order structural filter. Parameter optimization is applied for finding the controller parameters, so as to have an optimized behavior when applied to the high order model. Frequency and Laplace domain analysis are shown, which indicate the satisfactory behavior of the proposed controller. Author

N86-21996# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SPACE APPLICATIONS OF SOLAR ENERGY SYSTEMS
K. BOGUS and D. KASSING *In its* Solar Energy 85: Resources, Technologies, Economics p 153-167 Nov. 1985 refs
Avail: NTIS HC A11/MF A01

Space solar energy systems are reviewed. The European technology development program is discussed. Interactions with non-European space programs, and interactions with the development of terrestrial photovoltaics are considered.
Author (ESA)

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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.

A86-10494
NEW LIVES FOR ET
B. NOLLEY Space World (ISSN 0038-6332), vol. V-9-261, Sept. 1985, p. 13-16.

Proposed in-orbit uses for the Space Shuttle External Tanks (ETs) are discussed. The idea of using the ETs for living quarters or laboratories is suggested; however, the cleanup and outfitting of the ETs would be too difficult to accomplish in space. The melting of ETs for use as fuel for orbital transfer vehicles (OTVs) or attaching the unpressurized tanks to the Space Shuttle to serve as hangars for OTVs are described. The necessary requirements and problems encountered in using the ETs as living modules for a lunar base are explained. Adding an aft cargo compartment to the tanks to carry lightweight payloads is another use examined. A tether system which would transfer the momentum of the ETs to the Shuttle, thereby saving orbital maneuvering system propellant, is described. The breakup of the ETs is described, and a proposed technique for keeping the tanks intact for a complete revolution is considered. I.F.

A86-11401*
COMPUTERS IN AEROSPACE CONFERENCE, 5TH, LONG BEACH, CA, OCTOBER 21-23, 1985, TECHNICAL PAPERS
Conference sponsored by AIAA, Association for Computing Machinery, NASA, and IEEE. New York, AIAA, 1985, 519 p. For individual items see A86-11402 to A86-11470.

Among the topics discussed are: access control models for a distributed CAIS-conforming system; a knowledge-based advisory system for casualty procedures; and automated interactive simulation modeling system. Consideration is also given to: reusable software concepts and software development methodologies; the electronic device aspects of neutral network memories; an expert system for automated satellite anomaly resolution; and the use of automatic programming techniques for fault-tolerant computing systems. Among additional topics discussed are: systems approaches to software fault tolerance; a Space Shuttle navigation validation system; and a vision-based road following system for an autonomous land vehicle. I.H.

A86-11954
SPACE STATION REDESIGNED FOR LARGER STRUCTURAL AREA
C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, Oct. 14, 1985, p. 16-18.

The present article is concerned with a redesign of the U.S. Space Station by NASA. The redesign has the objective to provide a better zero-gravity platform for materials processing and to obtain more structure on which to mount experiments, telescopes, and upper-stage hardware. Instead of a long, tall station, the redesign will feature a wide, boxlike permanently manned structure. The changes were made in response to the concerns of science and commercial users, whose support is needed if the Space Station project is to succeed. Attention is given to the new U.S. Space Station dual keel design, safety considerations, an evaluation of development versus operating costs, station operations concepts, and operations management. G.R.

A86-12360
INTERNATIONAL DEVELOPMENTS IN SPACE STATIONS AND SPACE TECHNOLOGIES; PROCEEDINGS OF THE THIRTY-FIFTH CONGRESS, LAUSANNE, SWITZERLAND, OCTOBER 7-13, 1984
L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) Congress sponsored by IAF. New York, AIAA (IAF Series. International Advances in Space Technology. Volume 2), 1985, 384 p. For individual items see A86-12361 to A86-12363.

Opportunities for international cooperation and utilization provided by the Space Station are discussed along with the current U.S. activities related to the Space Station, the technology for a Space Station, the orbital operation of coorbiting spacecraft with a Space Station, the servicing vehicle of Columbus, and an overview of the facilities of the Space Energetics and Environment Laboratory. Attention is given to a reconfigurable common spare for colocated direct television broadcasting satellites, optical intersatellite data links with a semiconductor laser, NASA's Mobile Satellite Communications Program, and future U.S. meteorological satellite systems. Other subjects explored are related to the first dedicated life sciences Spacelab mission, finite thrust transfers, questions regarding the uniqueness of mankind in the Galaxy, large space structures ground and flight progress, orbit lifetime prediction and safety considerations, and the Radarsat SAR multibeam antenna. G.R.

A86-13076
NATIONAL SAMPE SYMPOSIUM AND EXHIBITION, 30TH, ANAHEIM, CA, MARCH 19-21, 1985, PROCEEDINGS
Symposium and Exhibition sponsored by the Society for the Advancement of Material and Process Engineering. Covina, CA, Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 30), 1985, 1698 p. For individual items see A86-13077 to A86-13093, A86-13095 to A86-13102, A86-13104 to A86-13157, A86-13159 to A86-13164, A86-13166 to A86-13181.

Among the topics discussed are novel biomedical materials, high temperature polyimides, structures and materials for space structures, pressure sensitive adhesives, materials for advanced electronics, fiber/matrix-interface technologies, composite materials' testing and analysis techniques, thermoplastic matrices, recent advancements in automated and robotic manufacturing methods, and novel polymeric materials. Also covered are surface mount assembly technology, metallic materials for automated and robotic systems, novel matrix resin technologies, surface preparation and adhesive bonding methods, spacecraft and missile material design, the application of computers to materials engineering, advancements in filament winding techniques, advanced composites' design and manufacture, and environmental management. O.C.

A86-14272* National Aeronautics and Space Administration, Washington, D.C.
SPACE - THE LONG RANGE FUTURE
J. VON PUTTKAMER (NASA, Office of Space Flight, Washington, DC) Spaceflight (ISSN 0038-6340), vol. 27, Nov. 1985, p. 395-400. refs

Space exploration goals for NASA in the year 2000 time frame are examined. A lunar base would offer the opportunity for continuous earth viewing, further cosmogeochemical exploration and rudimentary steps at self-sufficiency in space. The latter two factors are also compelling reasons to plan a manned Mars base. Furthermore, competition and cooperation in a Mars mission and further interplanetary exploration is an attractive substitute for war. The hardware requirements for various configurations of Mars missions are briefly addressed, along with other, unmanned missions to the asteroid belt, Mercury, Venus, Jupiter and the moons of Jupiter and Saturn. Finally, long-range technological requirements for providing adequate living/working facilities for larger human populations in Space Station environments are summarized. M.S.K.

A86-15611*# National Aeronautics and Space Administration, Washington, D.C.
THE SPACE STATION PROGRAM DEFINITION AND PRELIMINARY SYSTEMS DESIGN - RECENT DEVELOPMENTS
R. F. FREITAG (NASA, Office of Space Station, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-18)

It is pointed out that space stations represent a major vehicle for accomplishing many things mankind envisions for space activities. Thus, space stations have become necessary stepping-off points for deep-space expeditions, and it is expected that they will lead eventually to the permanent occupancy of another planet. The present paper provides a report regarding planning activities in the U.S. and in other countries which have made significant progress in making a permanent Space Station a reality. The Space Station will consist of a manned base and associated platforms, as well as collateral support equipment. The purpose of the program definition and preliminary design activities (Phase B) is to arrive at the baseline configuration before initiating actual hardware development. Details of the program plan are discussed along with user considerations in design, the commercialization of space, design issues, operations, and Space Station evolution. G.R.

A86-15619*# National Aeronautics and Space Administration, Washington, D.C.
AN OVERVIEW OF THE SPACE STATION TECHNOLOGY/ADVANCED DEVELOPMENT PROGRAM
R. F. CARLISLE, J. H. AMBRUS, and D. L. HALL (NASA, Office of Space Station, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 12 p.
(IAF PAPER 85-28)

The Advanced Technology Plan of the Fiscal Year (FY) 1986 is designed to focus on the most promising technology options applicable to the Space Station (SS), selected from the list of tasks identified by the FY 1984 Technology Program as the most critical technologies to be developed for the initial SS Initial Operating Capability. Most of the current activities are in the stages of manufacture and life tests of specific SS subsystems. Special attention is given to major technologies, which include power systems (PSs) (with emphasis on a Solar Dynamic PS concept); the thermal control system (with the focus on the 'thermal bus' concept); the environmental control and life support system; and the data management system; all are illustrated schematically. Other tasks, including dynamics, communications, extravehicular activities, mechanics, propulsion, and fluid, as well as the tasks of cost, maintainability, automation and robotics, and productivity are discussed. I.S.

A86-15901#
SPACE COMMERCIALIZATION IN THE UNITED STATES - A STATUS REPORT
J. M. LOGSDON (George Washington University, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 16 p. refs
(IAF PAPER 85-430)

The problems encountered and areas of developments in space commercialization in the U.S. are analyzed. Developments such as, reductions in projected payoffs from space commercialization, the incurred losses and increased cost to a business for space activities, the slow development of material processing in space, and the limited areas for investment, which have led to reduced interest and investment in space commercialization, are discussed. Emphasis must be placed on the process of developing the research base and infrastructure required for commercialization of space. The future use of the Space Shuttle and its pricing are investigated. The incorporation of the proper requirements into a Space Station is studied. The establishment of an Office of Commercial Programs to direct and control NASA's space commercialization policies is discussed. I.F.

A86-15914*# National Aeronautics and Space Administration, Washington, D.C.
FUNCTION, FORM, AND TECHNOLOGY - THE EVOLUTION OF SPACE STATION IN NASA
S. D. FRIES (NASA, Washington, DC) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 11 p. refs
(IAF PAPER 85-454)

The history of major Space Station designs over the last twenty-five years is reviewed. The evolution of design concepts is analyzed with respect to the changing functions of Space Stations; and available or anticipated technology capabilities. Emphasis is given to the current NASA Space Station reference configuration, the 'power tower'. Detailed schematic drawings of the different Space Station designs are provided. I.H.

A86-15941#
ANTHROPOLOGY AND THE HUMANIZATION OF SPACE
B. R. FINNEY (Hawaii, University, Honolulu) IAF, International Astronautical Congress, 36th, Stockholm, Sweden, Oct. 7-12, 1985. 16 p. refs
(IAF PAPER 85-497)

The role of anthropology in the colonization of space is studied. Some problems that would be encountered in space living such as, isolation from earth, family, and friends, small living space, psychological strain, and interaction of heterogenous groups are

described. The understanding of various cultures in order to have successful space living is discussed; the need for good cross-cultural relations in heterogenous space crews and the use of earth practices and institutions in space is analyzed. New cultures and societies will evolve to adapt to extraterrestrial environments once man settles space; the problems of reproduction and demographics are investigated. The application of anthropology to human expansion into space, taking into account possible contact with extraterrestrials, is discussed. I.F.

A86-17301* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATIONS AND SPACE PLATFORMS - CONCEPTS, DESIGN, INFRASTRUCTURE, AND USES
I. BEKEY, ED. and D. HERMAN, ED. (NASA, Washington, DC) New York, American Institute of Aeronautics and Astronautics (Progress in Astronautics and Aeronautics. Volume 99), 1985, 402 p. For individual items see A86-17302 to A86-17314.

Topics discussed include space infrastructures and early Space Station and platform planning. Consideration is given to the supportive role of the Space Station and platform in future astronomy, earth observation, planetary, and communication space missions. Papers are presented on the history of the Space Station and space platform concepts, potential designs of space stations and space platforms, and long-range plans for space research. I.F.

A86-17307*# National Aeronautics and Space Administration, Washington, D.C.
INTRODUCTION - SPACE STATION AND PLATFORM ROLES IN SUPPORTING FUTURE SPACE ENDEAVORS
D. H. HERMAN (NASA, Office of Space Station, Washington, DC) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 85-88.

The function of the Space Station and a platform is studied. The development of an earth observing instrument platform in a near-polar geosynchronous orbit to provide data about the earth is examined. The establishment of a permanently manned Space Station will allow development of commercial laboratories. Architectural requirements for servicing, transportation, and assembly on the Space Station are analyzed. The study of physiological and psychological effects due to weightlessness can be conducted on the Space Station. Developments in space knowledge and technology that are possible with the Space Station are discussed. I.F.

A86-17313#
SPACE STATION AND SPACE PLATFORM CONCEPTS - A HISTORICAL REVIEW
J. M. LOGSDON (George Washington University, Washington, DC) and G. BUTLER (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Space stations and space platforms - Concepts, design, infrastructure and uses . New York, American Institute of Aeronautics and Astronautics, 1985, p. 203-263. refs

The design of the United States Space Station system, which will include both manned and unmanned elements, can draw upon over 75 years of thinking and planning with respect to a permanent human outpost in space. This paper reviews the evolution of space station and space platform concepts, from the ideas of space pioneers, such as Tsiolkovsky, Oberth, and von Braun, through the increasingly more detailed engineering studies of the post-Sputnik period. The various space station and space platform studies sponsord by NASA from the early 1960's until the early 1980's are summarized. Author

A86-17315* National Aeronautics and Space Administration, Washington, D.C.
PERMANENT PRESENCE - MAKING IT WORK; PROCEEDINGS OF THE TWENTY-SECOND GODDARD MEMORIAL SYMPOSIUM, GREENBELT, MD, MARCH 15, 16, 1984
I. BEKEY, ED. (NASA, Washington, DC) Symposium sponsored by AAS. San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 60), 1985, 188 p. For individual items see A86-17316 to A86-17324.

Among the topics discussed are: electrophoresis operations in space for pharmaceutical processing; Space Station program operations; and Space Station platform configurations. Consideration is also given to: the human role in future space systems; EVA operations; spherical shell applications; and a container material for alloy processing in near-zero gravity. Among additional topics discussed are: Space Station platform thermal control; environmental control and life support for an evolving capability manned Space Station; and the commercial prospects of the Space Station. I.H.

A86-18626
SPACE SCIENCE, SPACE TECHNOLOGY AND THE SPACE STATION
J. A. VAN ALLEN (Iowa, University, Iowa City) Scientific American (ISSN 0036-8733), vol. 254, Jan. 1986, p. 32-39.

It is argued that the Space Station program will seriously diminish the opportunities for advancing space science and technology if it proceeds as planned, and that most national goals in space are better realized by robot spacecraft. The inadequacy of manned missions to meet primary goals of the space program is considered, stressing the number of useful unmanned missions that have been cancelled in order to keep the Space Shuttle program going. Various arguments made in favor of manned missions are stated and dismissed, generally on the grounds that the objectives are of questionable value or could be attained more cheaply on earth. C.D.

A86-19523* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
THE NATIONAL SYMPOSIUM AND WORKSHOP ON OPTICAL PLATFORMS, HUNTSVILLE, AL, JUNE 12-14, 1984, PROCEEDINGS
C. L. WYMAN, ED. (NASA, Marshall Space Flight Center, Huntsville, AL) Symposium and Workshop sponsored by SPIE - The International Society for Optical Engineering, NASA, and OSA. Bellingham, WA, SPIE - The International Society for Optical Engineering (SPIE Proceedings. Volume 493), 1984, 471 p. For individual items see A86-19524 to A86-19574.
(SPIE-493)

The present conference is concerned with space-based observatories (including future systems), interplanetary observation platforms, Space Station optical utilization, orbital earth viewing systems, and Spacelab's use as an observations platform. Attention is given to the pointing system for the Space Telescope, the Advanced X-ray Astrophysics Facility, the conceptual definition of the Space IR Telescope Facility's spacecraft, satellite servicing in light of the Solar Maximum Repair Mission, a large deployable reflector telescope concept, moon-based astronomical observatories, Space Station-based remote sensing of the earth, optical systems is geosynchronous orbit, multispectral linear array detector technology, Spacelab-based space plasma and materials processing investigations, and space construction technology for large space observatories. Also discussed are military optical platforms for sea, land and air stationing. O.C.

A86-20591
HAVE FACTORY, WILL LAUNCH
M. REGISTER Space World (ISSN 0038-6332), vol. W-1, Jan. 1986, p. 11-13.

The design of the Industrial Space Facility (ISF) is described. The ISF, which will be powered by solar arrays, consists of a 35 ft long facility module for manufacturing and a 6 or 12 ft supply module. The ISF is to be fully operational when it is deployed in

a 230-nautical-mile orbit inclined to 28.5 degrees. The equipping of the factory to meet the requirements of its users is discussed. The stabilization and stationkeeping systems for the ISF are analyzed. The agreement with NASA that does not require any payments prior to launching of the factory is examined. I.F.

A86-20726
SPACE NUCLEAR POWER SYSTEMS 1984; PROCEEDINGS OF THE FIRST SYMPOSIUM, ALBUQUERQUE, NM, JANUARY 11-13, 1984. VOLUMES 1 & 2
M. S. EL-GENK, ED. and M. D. HOOVER, ED. (New Mexico, University, Albuquerque) Symposium sponsored by the University of New Mexico, DOE, USAF, et al., Malabar, FL, Orbit Book Co., Inc., 1985. Vol. 1, 313 p.; vol. 2, 300 p. For individual items see A86-20727 to A86-20776.

Various papers on space nuclear power systems are presented. The general topics addressed are: programmatics, power systems integration and control, systems concepts, reactors, materials and energy conversion, thermal management, and safety and reliability. Individual papers on subjects such as the past, present, and future of space nuclear power programs, space systems architecture, and civilian and military applications of space nuclear power are also presented. C.D.

A86-21519* National Aeronautics and Space Administration, Washington, D.C.
NASA DEVELOPS SPACE STATION
R. F. FREITAG (NASA, Washington, DC) Space (ISSN 0267-954X), vol. 1, June 1985, p. 18-20.

The NASA Space Station program's planning stage began in 1982, with a view to development funding in FY1987 and initial operations within a decade. An initial cost of $8 billion is projected for the continuously habitable, Space Shuttle-dependent system, not including either operational or scientific and commercial payload-development costs. As a customer-oriented facility, the Space Station will be available to foreign countries irrespective of their participation in the development phase. O.C.

A86-21826
SYMPOSIUM GYRO TECHNOLOGY 1984; PROCEEDINGS OF THE SYMPOSIUM, UNIVERSITAET STUTTGART, WEST GERMANY, SEPTEMBER 11, 12, 1984
H. SORG, ED. (Stuttgart, Universitaet, West Germany) Stuttgart/Duesseldorf, Universitaet Stuttgart/Deutsche Gesellschaft fuer Ortung und Navigation, 1984, 455 p. For individual items see A86-21827 to A86-21843.

Among the topics discussed are: drift and scale factor tests on the SEL fiber gyro; integrated optical rate sensor development; and the beam geometry of a ring laser gyro in relation to its performance. Consideration is also given to: a fast filtering technique for measuring random walk in a laser gyro; vibratory gyroscopic sensors; a redundant strapdown reference for advanced aircraft flight control systems; and a low-cost piezoelectric rate/acceleration sensor. Additional topics include: an inertial guidance system for a Low-Earth-Orbit (LEO) vehicle; and signal disturbance effects in a strapdown northfinder. I.H.

A86-21876
EASCON '84; PROCEEDINGS OF THE SEVENTEENTH ANNUAL ELECTRONICS AND AEROSPACE CONFERENCE, WASHINGTON, DC, SEPTEMBER 10-12, 1984
Conference sponsored by IEEE and DOD. New York, Institute of Electrical and Electronics Engineers, 1984, 334 p. For individual items see A86-21877 to A86-21891.

U.S. national Command, Control, Communication (CCC) activities are discussed, taking into account the Nationwide Emergency Telecommunications System (NETS), an outlook on national CCC systems, the improvement of the national military command systems, the Air Force communications commands family of technical initiatives for information systems Air Force-wide, a game plan for the new joint tactical CCC agency, and strategic communications using ELF. Other subjects explored are related to distributed CCCI, NATO CCCI, civilian/government information systems, DOD terrestrial communications networks, DOD communication technology, emerging telecommunications policy issues, national security/emergency preparedness telecommunications, advanced high frequency communications, government and commercial space communications, and the Space Station. Attention is also given to advanced concepts in space communications, technology and policy aspects of commercial satellite communications, commercial space applications, information systems, technology transfer, and space systems. G.R.

A86-22249
POWER-INDUSTRY ORBITAL COMPLEXES OF THE 21ST CENTURY
L. LESKOV Space Policy (ISSN 0265-9646), vol. 1, Feb. 1985, p. 84, 85.

Global industrialization of space is examined. The manufacturing of semiconductor materials, metals, alloys, and biomedical products is discussed. Space solar power stations, which would supply the earth with up to 100 million kW of electric power, are proposed. The development of a global system of orbital objects which will control the placement of space vehicles in geostationary, solar-synchronous and other orbits is investigated. The use of the system to establish a space power base and improve the illumination of some areas on the earth is described. I.F.

A86-22250* National Aeronautics and Space Administration, Washington, D.C.
THE CHALLENGE OF THE US SPACE STATION
J. M. BEGGS (NASA, Washington, DC) Space Policy (ISSN 0265-9646), vol. 1, Feb. 1985, p. 85-90.

The U.S. Space Station program is described. The objectives of the present national space policy are reviewed. International involvement and commercial use of space are the two strategies involved in the development of the Space Station. The Space Station is to be a multifunctional, modular, permanent facility with manned and unmanned platforms. The functions of the Space Station for space research projects, such as material processing and electrophoresis, are examined. The infrastructure required for commercialization of space is analyzed. NASA's space policy aimed at stimulating space commerce is discussed. NASA's plans to reduce the financial, institutional, and technical risks of space research are studied. I.F.

A86-22267
SATELLITE LEASING - CHEAP ACCESS TO SPACE
R. MAEHL (RCA, Astro-Electronics Div., Princeton, NJ) Space (ISSN 0267-954X), vol. 1, Dec. 1985-Feb. 1986, p. 10, 11, 17.

The role of satellite leasing arrangements in marketing commercial ventures in space is considered. The most recent examples of leased space platforms are described, including Leasat: ESA's EURECA; Omnistar; and Leasecraft. It is shown that because of NASA Shuttle pricing policies, leasing room for commercial payloads on board space platforms will become an increasingly attractive way of financing space ventures in which capital investments are often at risk. The development of the first large-scale commercial space platform for the Electrophoresis in Space (EOS) program is also discussed. I.H.

A86-22393
SPACE STATION RELIABILITY
C. R. BIRDSALL and H. J. FRANK (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Annual Reliability and Maintainability Symposium, Philadelphia, PA, January 22-24, 1985, Proceedings . New York, Institute of Electrical and Electronics Engineers, 1985, p. 197-202.

This paper addresses the complex reliability issues of a permanent manned space station. Space station development concepts for a space vehicle service station demand state of the art approaches to crew safety, automation, Space Shuttle support, and maintenance. The paper describes a preliminary approach to application of reliability technology to future manned space systems. An effective approach to minimal cost is a difficult issue.

A nearly failure free system is within the available technology, but the initial cost is high. Lower reliability, more frequent failure, more maintenance and logistic support raise operational support cost. The solution is shown to lie between the extremes of the reliability alternatives. Author

A86-23741
A NEW TILT ON COMPUTER GENERATED SPACE STATION DISPLAYS
J. P. YORCHAK, J. E. ALLISON, and V. S. DODD (Martin Marietta Corp., Denver, CO) IN: Human Factors Society, Annual Meeting, 28th, San Antonio, TX, October 22-26, 1984, Proceedings. Volume 2 . Santa Monica, CA, Human Factors Society, 1984, p. 894-898. refs

In theory, globes appear to make excellent maps. There are, however, drawbacks which make them difficult to use. It became, therefore, necessary to project a map of the earth on a flat surface. In connection with air and space travel, there is now a need for accurate 'three-dimensional' projections. The considered projections are not true 3D, but rather '3D-looking', perspective 2D map displays. Computer representations of space situations provide flat two-dimensional maps and three-dimensional globe displays. However, none of these display techniques are entirely satisfactory in all situations. An investigation of alternate display techniques was, therefore, conducted, taking into account a display, called the '3D' hybrid display. Pilot studies were performed with the aim to assess the advantages of the hybrid display for depicting satellite situations. It was found that the subjects prefer the hybrid display over the flat 2D display even though it does not significantly aid their performance. G.R.

A86-23967* National Aeronautics and Space Administration, Washington, D.C.
THE US SPACE STATION PROGRAM
R. F. FREITAG (NASA, Office of Space Station, Washington, DC) British Interplanetary Society, Journal (Space Stations) (ISSN 0007-084X), vol. 39, Feb. 1986, p. 80-84.

International participation in the U.S. Space Station program is examined. Proposed Space Station mission studies to be conducted by Canada, Japan, and Europe are described; the establishment and implementation of these programs is discussed. The use of the Space Station as a laboratory, test center, and manufacturing area, and the commercial applicability of the Space Station are analyzed. I.F.

A86-24104
SHUTTLE LAUNCHES OF SATELLITES ARE MAKING SPACE A BOTTOMLINE BUSINESS
G. MIGLICCO (Peat, Marwick, Mitchell and Co., Houston, TX) Commercial Space (ISSN 8756-4831), vol. 1, Summer 1985, p. 36-39.

Factors affecting the levels of private investment in commercial projects in space are considered. Attention is given to tax uncertainties; the long lag time between investment and payoff; and government regulation costs. Some of the attributes of an attractive space venture are discussed including: high investment/return ratio; investment-to-payoff lag time of 1-5 years; and relaxed tax requirements. The opportunities for limited partnerships in R&D for space projects are briefly outlined. I.H.

A86-24110
SPACE STATION MANAGER'S NEXT BIG JOB IS TO DRUM UP BUSINESS
E. H. KOLCUM Commercial Space (ISSN 8756-4831), vol. 1, Summer 1985, p. 81, 83-85.

A progress report on the development of Space Station is given. The Phase B design definition study now under way is described in detail. Phase B consists of four separate mission design studies involving the selection of designs for the command modules structural framework, power sources and free-flying servicing vehicles. Contracts will be awarded for the development of Space Station hardware during Phase C, and Phase D will be the assembly of the Station in orbit. A photograph of a full scale mock-up of a Space Station command module is provided. I.H.

A86-24117
SPACE INDUSTRIES IS MAKING PLANS WITH NASA FOR A SPACE FACILITY
M. FAGET Commercial Space (ISSN 8756-4831), vol. 1, Fall 1985, p. 40, 41, 44.

The development of a privately funded space facility as the base of operation for commercial space projects is examined. The 35 foot long and 14.5 foot wide facility is to contain automatic material processing equipment, which will be periodically serviced by the Shuttle crew. The benefits of NASA's deferred payment agreement, which will allow the facility to be established with no payment required until revenue is generated by the project, are described. The building and assembly of the industrial space facility, and the designing of the docking module are analyzed. Potential projects for the facility include: (1) the development of organic films that use light to carry information, (2) the manufacturing of semiconductor materials, and (3) a biological space medicines processing system. I.F.

A86-24776
INTERSOCIETY ENERGY CONVERSION ENGINEERING CONFERENCE, 20TH, MIAMI BEACH, FL, AUGUST 18-23, 1985, PROCEEDINGS. VOLUMES 1, 2, & 3
Conference sponsored by SAE, AChS, AIAA, et al. Warrendale, PA, Society of Automotive Engineers, Inc., 1985. Vol. 1, 760 p.; vol. 2, 965 p.; vol. 3, 912 p. For individual items see A86-24777 to A86-24929.
(SAE P-164)

Topics related to aerospace power are discussed, taking into account trends and issues of military space power systems technology, space station power system advanced development, the application and use of nuclear power for future spacecraft, the current status of advanced solar array technology development, the application of a parabolic trough concentrator to space station power needs, life test results of the Intelsat-V nickel-cadmium battery, and metal hydride hydrogen storage in nickel hydrogen batteries. Other subjects explored are concerned with alternative fuels, biomass energy, biomedical power, coal gasification, electric power cycles, and electric propulsion. Attention is given to an advanced terrestrial vehicle electric propulsion systems assessment, fuel cells as electric propulsion power plants, a sinewave synthesis for high efficiency dc-ac conversion, steam desulfurization of coal, leadless transfer of energy into the body to power implanted blood pumps, oil production via entrained flow pyrolysis of biomass, and a New Zealand synthetic gasoline plant. G.R.

A86-26451
SPACE: THE COMMERCIAL OPPORTUNITIES; PROCEEDINGS OF THE INTERNATIONAL BUSINESS STRATEGY CONFERENCE, LONDON, ENGLAND, OCTOBER 31, NOVEMBER 1, 1984
Pinner, England, Online Publications, 1984, 191 p. For individual items see A86-26452 to A86-26465.

Among the topics discussed are: insurance in space risk management; legal issues in planning commercial space activities; and the potential market for commercial launch vehicles. Consideration is also given to: the position of Ariane in the world launch vehicle market; the economic advantages of reusable systems like Shuttle; and the growth of the satellite communications market; and European perspectives on the U.S. Space Station proposal. Additional topics include spin-off investments in space for small and medium-size investors; the market potential of remote sensing imagery; a general overview of risks and rewards in space investments. I.H.

A86-26460* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION - THE NEXT LOGICAL STEP
T. T. FINN and J. D. HODGE (NASA, Office of Space Station, Washington, DC) IN: Space: The commercial opportunities; Proceedings of the International Business Strategy Conference, London, England, October 31, November 1, 1984 . Pinner, England, Online Publications, 1984, p. 113-124.

NASA is committed to the development of a permanently manned Space Station within a decade, in concert with European and Japanese space agencies. In addition to continuing scientific research, the Space Station will proceed with applied science and industrialization experiments. International cooperation opportunities arise within the Space Station program for users (in the definition of missions), for builders (in the development of station resources and capabilities), and operators (in the orbital maintenance of the Space Station). O.C.

A86-27876
SPACE, OUR NEXT FRONTIER; PROCEEDINGS OF THE CONFERENCE, DALLAS, TX, JUNE 7, 8, 1984
G. MUSGRAVE, ED. (National Center for Policy Analysis, Dallas, TX) Conference sponsored by the National Center for Policy Analysis. Dallas, TX, National Center for Policy Analysis, 1985, 344 p. For individual items see A86-27877 to A86-27897.

The present conference on space development encompasses space commercialization, legislative, legal, and insurance-related factors in current space programs, political aspects of space militarization and governmental control, the military future uses of space and their consequences, command and control issues arising in space, economic influences on space policy, and recent developments in space solar power generation concepts. Attention is given to public opinion surveys concerning the scientific, military, and economic uses of space, the 'Leasecraft' orbital industrial infrastructure concept, capitalism and democracy in space development, the current status of space law on commercialization topics, the nature of Ballistic Missile Defense, the Soviet Space threat, the High Frontier concept for space defense, lunar solar power systems, solar power satellites, and the utilization of lunar resources for the reduction of lunar base construction costs. Such specific technical issues as microgravity crystal growth and directional solidification, electrophoresis operations for pharmaceuticals, and technical barriers to commericial access to space, are also noted. O.C.

A86-28581* National Aeronautics and Space Administration, Washington, D.C.
SPACE STATION PLANNING
R. F. FREITAG (NASA, Office of Space Station, Washington, DC) IN: Europe/United States space activities . San Diego, CA, Univelt, Inc., 1985, p. 85-96.
(AAS 85-111)

An overview of NASA Space Station planning activities is given. Among the specific topics addressed are: the role of private contractors in the construction and operation of Space Station; international cooperation in planning Space Station configurations; and optimum management strategies for Space Station planning activities. The division of work packages for the preliminary design definition phase of the Space Station program is described. I.H.

A86-28778
POLITICAL ACCEPTABILITY OF MARS EXPLORATION - POST-1981 OBSERVATIONS
L. DAVID (National Space Institute, Washington, DC) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 35-48. refs
(AAS 84-152)

A survey is given of space policy events which have followed the first symposium, 'The Case for Mars I', in 1981. Now that an orbiting Space Station facility is supported by the President, this country can assure a leadership position in space and reestablish a human presence on the moon - and, for the first time, points beyond. Motivations for expanding space activity include: seeking lucrative manufacturing enterprises that can only be carried on in space; assuring national security; building enhanced international collaboration; and pursuing new horizons (exploring). The last of these may be the most important in as much as it represents a drive deeply rooted in the human psyche. Views of program supporters and detractors in the government are noted. D.H.

A86-28779
THE CIVILIAN SPACE PROGRAM - A WASHINGTON PERSPECTIVE
R. H. WARE (Cooperative Institute for Research in Environmental Sciences, Boulder, CO) and P. P. CHANDLER (Office of Technology Assessment, Washington, DC) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 49-64.
(AAS 84-153)

The rationale is discussed for obtaining additional space infrastructure (spacecraft - including Space Stations and launch and transportation systems) to move forward in America's second quarter century of space activities, and the broader policy questions arising from NASA's proposal for obtaining a particular constellation of infrastructure elements are examined. A table of possible hardware options is included; possible long-term goals are presented, and objectives are formulated to reach toward those goals. The types of infrastructure that these objectives demand, and the associated cost, schedule and financing, are examined. A suggestion is offered for future roles that other nations, the private sector, and NASA might play in space. D.H.

A86-28786* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
SPACE STATION - THE FIRST STEP
H. C. MANDELL, JR. (NASA, Johnson Space Center, Houston, TX) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 157-170.
(AAS 84-160)

The United States Space Station program, begun in Fiscal Year 1985 under significant cost constraints, should cause all those involved in the planning of manned interplanetary flight to revise their impressions of the cost and practicality of planetary missions. The presence of the Space Shuttle, as well as arrival of a capable Space Station, will provide a major impetus to planetary programs, both by removing most of the real barriers to extended manned space flights and by proving that significant manned space ventures may be performed very economically. Author

A86-28787* National Aeronautics and Space Administration, Washington, D.C.
BEYOND THE SPACE STATION
J. VON PUTTKAMER (NASA, Office of Space Flight, Washington, DC) IN: The case for Mars II . San Diego, CA, Univelt, Inc., 1985, p. 171-206. refs
(AAS 84-161)

The significance of the Space Station is examined with regard to the possibilities it will open. The Space Station, as a unique R&D facility, operation base, and transportation node, will not only enhance deeper-space ventures but also enable entirely new initiatives for man's advancement in space not possible before. One large goal enabled by the Space Station could be a manned Mars landing mission as a major national objective some time beyond the year 2000. Since its principal themes would be joint exploration and advancement of mankind in space, its scientific, technical and sociological benefits would be of unprecedented scope and magnitude. The Space Station should be regarded as having a 'beachhead' role in supporting multiple goals and multiple users. Commonalities and possible synergisms between program and mission systems, elements, and technologies of large new initiatives beyond the Space Station should be assessed. D.H.

A86-29494
PRIVATE FUNDS WILL BOLSTER TAX DOLLARS IN THE JOB OF FINANCING THE STATION
D. C. WALKLET (Terra-Mar, Mountain View, CA) Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 41-43, 46-48.

The NASA Space Station, although originally intended solely as a research facility, is now committed to commercial activity as well and thereby invites consideration as a substantially privately funded industrial park in space. Investors must assess risks posed by technical, financial, and political uncertainties. Possible financing methods include venture capital, limited partnership, and project financing; each of these is appropriate under different circumstances, as detailed in the present discussion. Assuming that commercial applications become a significant factor in the planning process, a strategy must be implemented that will accomodate differing user requirements for orbiting facilities. Space Station design and financing should accordingly be structured around its individual components, rather than the facility as a whole. O.C.

A86-29495
SHUTTLE ACCIDENT POINTS TO THE NEED FOR BETTER KNOWLEDGE OF LAWS ON LIABILITY
J. W. ANDERSON (Wilson, Elser, Moskowitz, Edelman and Dicker, New York) Commercial Space (ISSN 8756-4831), vol. 1, Winter 1986, p. 50, 51.

A86-29696
STATUS OF SPACE COMMERCIALIZATION IN THE USA
J. M. LOGSDON (George Washington University, Washington, DC) Space Policy (ISSN 0265-9646), vol. 2, Feb. 1986, p. 9-15. refs

Positive and negative developments affecting space commercialization in the USA are discussed. A 75 percent reduction for one year in the potential revenue from space activities, a decrease in the amount of private investment, a financial loss by space commercialization investors, an increase in insurance premium costs, and the slow advancement of material processing in space are described as factors which have hindered space commercialization activities. Progress has been achieved in the formation of a research base and the infrastructure required for the realization of the economic potential of space activities. The future use of the Space Shuttle and its pricing policy, the development and operation of a Space Station, NASA's Commercial Space Policy, and the activities of the Office of Commercial Programs are examined. I.F.

N86-13233# Committee on Appropriations (U. S. Senate).
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, AND CERTAIN OTHER INDEPENDENT AGENCIES APPROPRIATIONS FOR FISCAL YEAR 1986, PART 1
Washington GPO 1985 877 p refs Hearings on H.R. 3629 before the Comm. on Appropriations, 99th Cong., 1st Sess., 14 Mar. 1985
(S-HRG-99-221-PT-1; GPO-43-660) Avail: Subcommittee of the Committee on Appropriations

James Beggs, NASA Administrator, presented his 1986 Fiscal Budget to the Senate Committee on Appropriations (99th Congress), during hearings on 14 May 1985, the Honorable Jake Garn presiding. The NASA request was $7.9 billion of which 2.9 billion is for research and development, including $354 million for aeronautical research and technology; $3.5 billion for space flight, control, and data communications; $149 million for construction of facilities; and $1.3 billion for research and program management. This was followed by a University of California (California Space Institute) report on Automation and Robotics, and Volumes 1 (executive Overview) and 2 (Technical Report) of NASA's Advanced Technology Advisory Committee (ATAC), entitled, Advancing Automation and Robotics Technology for the Space Station and the U.S. Economy.

N86-13234# Committee on Appropriations (U. S. Senate).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
In its Dept. of HUD, and Certain Independent Agencies Appropriations for Fiscal Year 1986, Pt. 1 p 1-407 1985 refs Avail: Subcommittee of the Committee on Appropriations

In response to Public Law 98-371, dated July 18, 1984, the NASA Advanced Technology Advisory Committee (ATAC) has studied automation and robotics for use in the Space Station and prepared this report to the House and Senate Committees on Appropriations. The report is divided into two volumes: the Executive Overview, Volume 1, presents the major findings of the study and recommends to NASA principles for advancing automation and robotics technologies for the benefit of the Space Station and of the U.S. economy in general; the Technical Report, Volume 2, provides background information on automation and robotics technologies and their potential. As a result of its study, the Advanced Technology Advisory Committee believes that a key element of technology for the Space Station is extensive use of advanced general-purpose automation and robotics. This could include many systems and devices (such as computer vision, expert systems, and dexterous manipulators) that have been made possible by recent advances in artificial intelligence, robotics, computer science, and microelectronics. Author

N86-14078*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
THE 1983 NASA/ASEE SUMMER FACULTY FELLOWSHIP RESEARCH PROGRAM RESEARCH REPORTS Final Reports
W. J. HORN, ed. (Texas A&M Univ., College Station) and M. B. DUKE, ed. Sep. 1983 409 p refs Program held in College Station, Tex., 1983
(Contract NGT-44-001-800)
(NASA-CR-171904; NAS 1.26:171904) Avail: NTIS HC A18/MF A01 CSCL 05I

The 1983 NASA/ASEE Summary Faculty Fellowship Research Program was conducted by Texas A&M University and the Lyndon B. Johnson Space Center (JSC). The 10-week program was operated under the auspices of the American Society for Engineering Education (ASEE). The basic objectives of the programs, which began in 1965 at JSC and in 1964 nationally, are (1) to further the professional knowledge of qualified engineering and science faculty members, (2) to stimulate an exchange of ideas between participants and NASA, (3) to enrich and refresh the research and teaching activities of participants' institutions, and (4) to contribute to the research objectives of the NASA Centers. The faculty fellows spent 10 weeks at JSC engaged in a research project commensurate with their interests and background. They worked in collaboration with a NASA/JSC colleague. This document is a compilation of final reports on their research during the summer of 1983.

N86-14161# Joint Publications Research Service, Arlington, Va.
ARCHITECT DISCUSSES SPACE HABITAT DESIGNS
S. ZIGUNENKO *In its* USSR Rept.: Space (JPRS-USP-85-005) p 75-77 30 Sep. 1985 Transl. into ENGLISH from Pravda (Moscow), 4 Dec. 1984 p 3
Avail: NTIS HC A08

General considerations for the interior design of spacecraft intended for long duration space flight were reviewed from a human factors engineering standpoint. It is important that those responsible for spacecraft design not allow their work to be overshadowed by their sense of gravity and the general restrictions of a terrestrial environment. G.L.C.

N86-14213*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EMERGING AEROSPACE TECHNOLOGIES
W. F. BALLHAUS, JR. and L. A. MILOV Sep. 1985 16 p refs (NASA-TM-86837; REPT-85409; NAS 1.15:86837) Avail: NTIS HC A02/MF A01 CSCL 05D

The United States Government has a long history of promoting the advancement of technology to strengthen the economy and national defense. An example is NASA, which was formed in 1958

to establish and maintain U.S. space technology leadership. This leadership has resulted in technological benefits to many fields and the establishment of new commercial industries, such as satellite communications. Currently, NASA's leading technology development at Ames Research Center includes the Tilt Rotor XV-15, which provides the versatility of a helicopter with the speed of a turboprop aircraft; the Numerical Aerodynamic Simulator, which is pushing the state of the art in advanced computational mathematics and computer simulation; and the Advanced Automation and Robotics programs, which will improve all areas of space development as well as life on Earth. Private industry is involved in maintaining technological leadership through NASA's Commercial Use of Space Program, which provides for synergistic relationships among government, industry, and academia. The plan for a space station by 1992 has framed much of NASA's future goals and has provided new areas of opportunity for both domestic space technology and leadership improvement of life on Earth.
Author

N86-15157*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
R AND D PRODUCTIVITY: NEW CHALLENGES FOR THE US SPACE PROGRAM
O. W. BASKIN, ed. (Houston Univ., Clear Lake) and L. J. SULLIVAN, ed. 1985 596 p refs Conference held in Houston, Tex., 10-11 Sep. 1985; sponsored in cooperation with NASA. Johnson Space Center, Houston Univ., AIAA, and the American Productivity Center
(NASA-TM-87520; NAS 1.15:87520) Avail: NTIS HC A25/MF A01 CSCL 05A

Various topics related to research and development activities applicable to their U.S. space program are discussed. Project management, automatic control technology, human resources, management information systems, computer aided design, systems engineering, and personnel management were among the topics covered.

N86-15166*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, Tex.
GOVERNMENT-TO-GOVERNMENT COOPERATION IN SPACE STATION DEVELOPMENT
S. H. NASSIFF *In its* R and D Productivity: New Challenges for the US Space Program p 88-108 1985
Avail: NTIS HC A25/MF A01 CSCL 05A

A memoranda of understanding was recently signed between the United States (NASA) and three international Space Station partners - Canada, European Space Agency (ESA), and Japan. The international partners are performing parallel Phase B preliminary design studies, concurrent with the U.S., on their proposed elements/systems for possible integration and operation with the U.S. Space Station System complex. During the 21-month Space Station Phase B study, a large amount of technical interface data will have to be transferred between the U.S. and the international partners. Scheduled bilateral technical coordination meetings will also be held. The coordination and large number of interfaces required to integrate the international requirements into the Space Station require a clean interface management organizational structure and operation procedures to accomplish the integration task. The international coordination management organizational structure, management tools, and communications network are discussed including the proposed international elements/systems being studied by the international partners.
Author

N86-15171*# McDonnell-Douglas Technical Services Co., Inc., Houston, Tex.
TECHNICAL AND MANAGEMENT INFORMATION SYSTEM: THE TOOL FOR PROFESSIONAL PRODUCTIVITY ON THE SPACE STATION PROGRAM
G. MONTOYA and P. BOLDON *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 149-164 1985 refs
Avail: NTIS HC A25/MF A01 CSCL 05A

The Space Station Program is highly complex not only in its technological goals and requirements but also in its organizational structure. Eight Contractor teams supporting four NASA centers plus Headquarters must depend on effective exchange of information--the lifeblood of the program. The Technical and Management Information System (TMIS) is the means by which this exchange can take place. Value of the TMIS in increasing productivity comes primarily from its ability to make the right information available to whomever needs it when it is needed. Productivity of the aerospace professional and how it can be enhanced by the use of specifically recommended techniques and procedures for information management using the TMIS are discussed.
Author

N86-15191*# McDonnell-Douglas Technical Services Co., Inc., Houston, Tex.
APPLICATION OF MODERN TOOLS AND TECHNIQUES TO MAXIMIZE ENGINEERING PRODUCTIVITY IN THE DEVELOPMENT OF ORBITAL OPERATIONS PLANS FOR THE SPACE STATION PROGRM
J. S. MANFORD and G. R. BENNETT *In* NASA. Johnson (Lyndon B.) Space Center R and D Productivity: New Challenges for the US Space Program p 383-393 1985
Avail: NTIS HC A25/MF A01 CSCL 05A

The Space Station Program will incorporate analysis of operations constraints and considerations in the early design phases to avoid the need for later modifications to the Space Station for operations. The application of modern tools and administrative techniques to minimize the cost of performing effective orbital operations planning and design analysis in the preliminary design phase of the Space Station Program is discussed. Tools and techniques discussed include: approach for rigorous analysis of operations functions, use of the resources of a large computer network, and providing for efficient research and access to information.
E.A.K.

N86-17265*# National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, Fla.
RESEARCH AND TECHNOLOGY Annual Report, 1985
Nov. 1985 62 p
(NASA-TM-83099; NAS 1.15:83099) Avail: NTIS HC A04/MF A01 CSCL 05A

As the NASA Center responsible for assembly, checkout, servicing, launch, recovery, and operational support of Space Transportation System elements and payloads, Kennedy Space Center is placing increasing emphasis on the Center's research and technology program. In addition to strengthening those areas of engineering and operations technology that contribute to safe, more efficient, and more economical execution of our current mission, we are developing the technological tools needed to execute the Center's mission relative to Space Station and other future programs. The Engineering Development Directorate encompasses most of the laboratories and other Center resources that are key elements of research and technology program implementation and is responsible for implementation of the majority of the projects in this Kennedy Space Center 1985 Annual Report. The report contains brief descriptions of research and technology projects in major areas of Kennedy Space Center's disciplinary expertise.
Author

N86-17266*# National Aeronautics and Space Administration, Washington, D.C.
THE NINTH DR. ALBERT PLESMAN MEMORIAL LECTURE: THE FUTURE OF SPACE FLIGHT
J. W. MOORE 1984 61 p Lecture held in Delft, Netherlands, 26 Oct. 1984
(NASA-TM-87558; NAS 1.15:87558) Avail: NTIS HC A04/MF A01 CSCL 05D

The history of space flight is reviewed and major NASA programs (Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz, Science and Applications, Space Shuttle, Space Station) are summarized. Developments into the early 21st century are predicted.
Author (ESA)

N86-17372*# National Academy of Sciences - National Research Council, Washington, D. C. Ad Hoc Committee on Space Station Engineering and Technology Development.
SPACE STATION ENGINEERING AND TECHNOLOGY DEVELOPMENT. PROCEEDINGS OF THE PANEL ON PROGRAM PERFORMANCE AND ONBOARD MISSION CONTROL
1985 72 p Proceedings held in Washington, D.C., 6-7 Aug. 1985
(Contract NASW-4003)
(NASA-CR-176484; NAS 1.26:176484) Avail: NTIS HC A04/MF A01 CSCL 22B

An ad-hoc committee was asked to review the following questions relevant to the space station program: (1) onboard maintainability and repair; (2) in-space research and technology program and facility plans; (3) solar thermodynamic research and technology development program planning; (4) program performance (cost estimating, management, and cost avoidance); (5) onboard versus ground-based mission control; and (6) technology development road maps from IOC to the growth station. The objective of these new assignments is to provide NASA with advice on ways and means for improving the content, performance, and/or effectiveness of these elements of the space station program.
G.L.C.

N86-17380 Johns Hopkins Univ., Laurel, Md. Chemical Propulsion Information Agency.
THE 1985 JANNAF PROPULSION MEETING, VOLUME 1
K. L. STRANGE, ed. Apr. 1985 522 p refs Meeting held in San Diego, Calif., 9-12 Apr. 1985 6 Vol.
(Contract N00024-85-C-5301)
(AD-A161084; CPIA-PUBL-425) Avail: Chemical Propulsion Information Agency, Johns Hopkins Road, Laurel, Md. 20707 HC $78.98 CSCL 21H

The Propulsion Meeting is sponsored by the Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee on an approximately annual basis. The objective of the meeting is to promote the exchange of technical information among the organizations active in the fields of missile, space, and gun propulsion technology. This is the first volume of a six-volume proceedings containing the unclassified, public-release papers presented at the 1985 JANNAF Propulsion Meeting. Topics include satellite propulsion technology, oxygen/hydrogen engines, solid motor component design and evaluation, and liquid propellant compatibility.

N86-19335# Mitre Corp., Bedford, Mass.
NATIONAL SECURITY ISSUES SYMPOSIUM, 1984. SPACE, NATIONAL SECURITY, AND C3I (COMMAND, CONTROL, COMMUNICATIONS AND INTELLIGENCE) HELD AT BEDFORD, MASSACHUSETTS ON 25-26 OCTOBER 1984 Final Report
S. ROLPH, D. COURTOY, B. DONOVAN, S. GILBERT, and T. KEELEY May 1985 134 p Symp. held at Bedford, Mass., 25-26 Oct. 1984
(Contract F19628-84-C-0001)
(AD-A160356; MITRE-M85-3; ESD-TR-85-267) Avail: NTIS HC A07/MF A01 CSCL 22A

The following topics were discussed at the National Security Issues Symposium held at Bedford, Mass., 25-26 Oct. 1984: The U.S. Use of Space; The U.S.S.R. Use of Space; Treaties and Legal Issues; A Defense Department Perspective; The U.S. Air Force Space Program; The U.S. Navy Space Program; The U.S. Army Space Program; An Industrial Perspective; Space Challenges; Practical Perspectives on a Space Defense Program; An Air Force Perspective; Space Defense; The Space Station; The Potential for Arms Control; Verification; The Impact of New Technologies; The Strategic Defense Initiative; and A European Perspective.
GRA

N86-19349*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
SOLAR TERRESTRIAL OBSERVATORY SPACE STATION WORKSHOP REPORT
W. T. ROBERTS, ed. Washington Jan. 1986 41 p refs Workshop held in Huntsville, Ala., 6 Jun. 1985
(NASA-CP-2411; M-505; NAS 1.55:2411) Avail: NTIS HC A03/MF A01 CSCL 14B

In response to a need to develop and document requirements of the Solar Terrestrial Observatory at an early time, a mini-workshop was organized and held on June 6, 1985. The participants at this workshop set as their goal the preliminary definition of the following areas: (1) instrument descriptions; (2) placement of instrumentation on the IOC Space Station; (3) servicing and repair assessment; and (4) operational scenarios. This report provides a synopsis of the results of that workshop.

N86-20176# Committee of Conference (U. S. Congress).
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION ACT, 1986
Washington GPO 19 Nov. 1985 18 p Rept. to accompany H.R. 1714 presented by the Committee of Conference to the 99th Congression, 1st Session, Nov. 1985
(H-REPT-99-379; GPO-54-684) Avail: US Capitol, House Document Room

Appropriations to NASA for research and development, space flight, control and data communications, construction of facilities, and research and program management are discussed. Shuttle pricing policies for commercial and foreign users are also described.
B.G.

N86-21420*# National Aeronautics and Space Administration, Washington, D.C.
NASA: 1986 LONG-RANGE PROGRAM PLAN
Aug. 1985 269 p
(NASA-TM-87560; NAS 1.15:87560) Avail: NTIS HC A12/MF A01 CSCL 05A

For the years beyond FY 1986, the plan consists of activities that are technologically possible and considered to be in the national interest. Its implementation will ensure logical and continued progress in reaching the Nation's goals in aeronautics and space, consistent with the responsibilities assigned NASA by the National Aeronautics and Space Act of 1958, as amended. The major features of the programs are described in detail and the nature of the aeronautics and space programs beyond the year 2000 are projected. The abbreviations and acronyms that appear in this report are listed. The status of NASA's plans are summarized at the time of its preparation.
Author

N86-21453# Committee on Science and Technology (U. S. House).
ASSURED ACCESS TO SPACE DURING THE 1990'S
Washington GPO 1986 187 p Joint Hearings on HASC-99-9 before the Subcommittee on Space Science and Applications of the Committee on Science and Technology and the Subcommittee on Research and Development of the Committee on Armed Services, 99th Congress, 1st Session, no. 51, 23-25 Jul. 1985
(GPO-53-617) Avail: Subcommittee on Space Science and Applications

The Subcommittees on Space Science and applications, and the subcommittee on research and development held joint hearings on assured access to space during the 1990's. Topics discussed include: space transportation systems, launch vehicle requirements

of the Space Station Program during the 1990's, commercial payloads and satellite launches, strategic defense initiative, DOD launch plans through the 1990's, space launch vehicle capacity, complementary expendable launch vehicles (CELV), and adequacy of the orbiter fleet to meet the launch requirements through the 1990's. E.A.K.

N86-22435# Committee on Science and Technology (U. S. House).

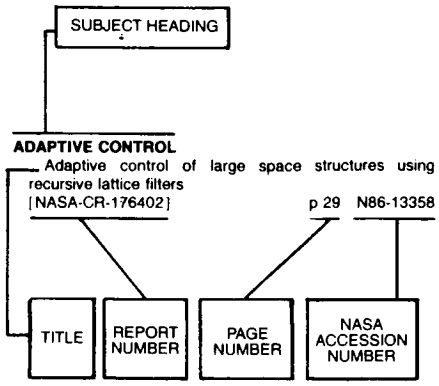
NASA'S LONG RANGE PLANS

Washington GPO 1986 224 p Hearings before the Subcommittee on Space Science and Applications of the Committee on Science and Technology, 99th Congress, 1st Session, no. 57, 17, 19, 1985

(GPO-55-035) Avail: Subcommittee on Space Science and Applications

The long range planning schedule for NASA programs is reviewed. Objectives are summarized for programs in space flight, space science and applications, space stations, space technology, and Space tracking and Data Systems. B.G.

Typical Subject Index Listing



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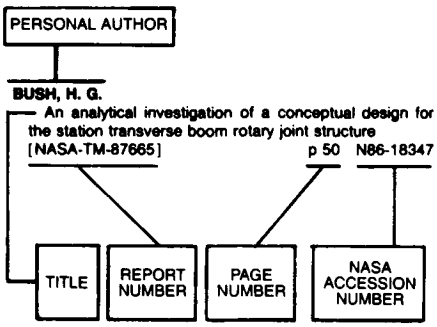

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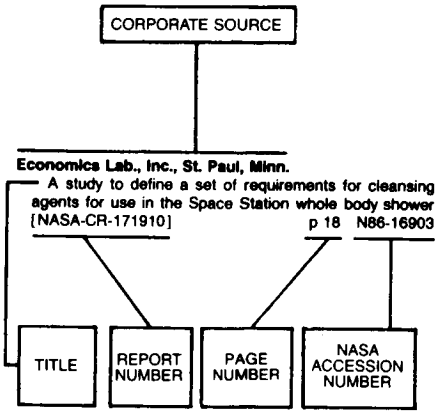

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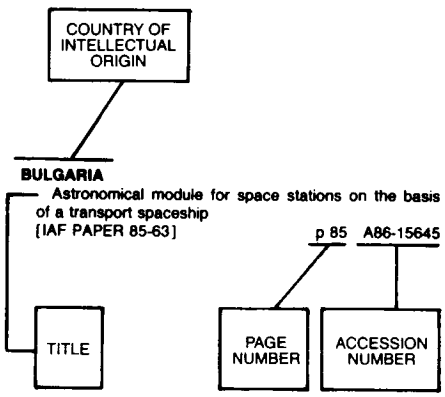

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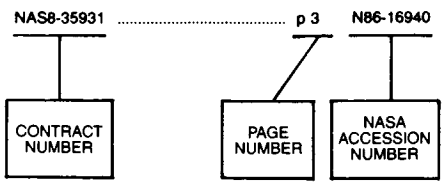

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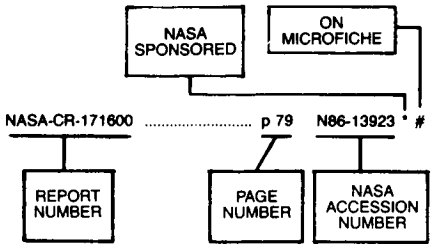

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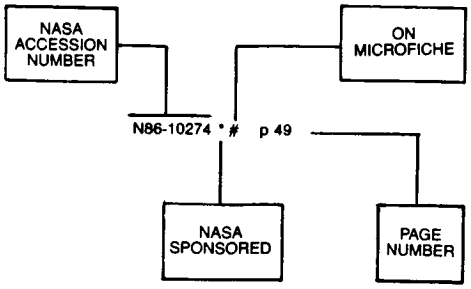

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16. Abstract

This bibliography lists 780 reports, articles and other documents introduced into the NASA scientific and technical information system between January 1, 1986 and June 30, 1986. Its purpose is to provide helpful information to the researcher, manager, and designer in technology development and mission design according to system, interactive analysis and design, structural and thermal analysis and design, structural concepts and control systems, electronics, advanced materials, assembly concepts, propulsion, and solar power satellite systems. 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.

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