NASA

Space Station Systems

A Bibliography
with Indexes

NASA SP-7056 (08)
July 1989

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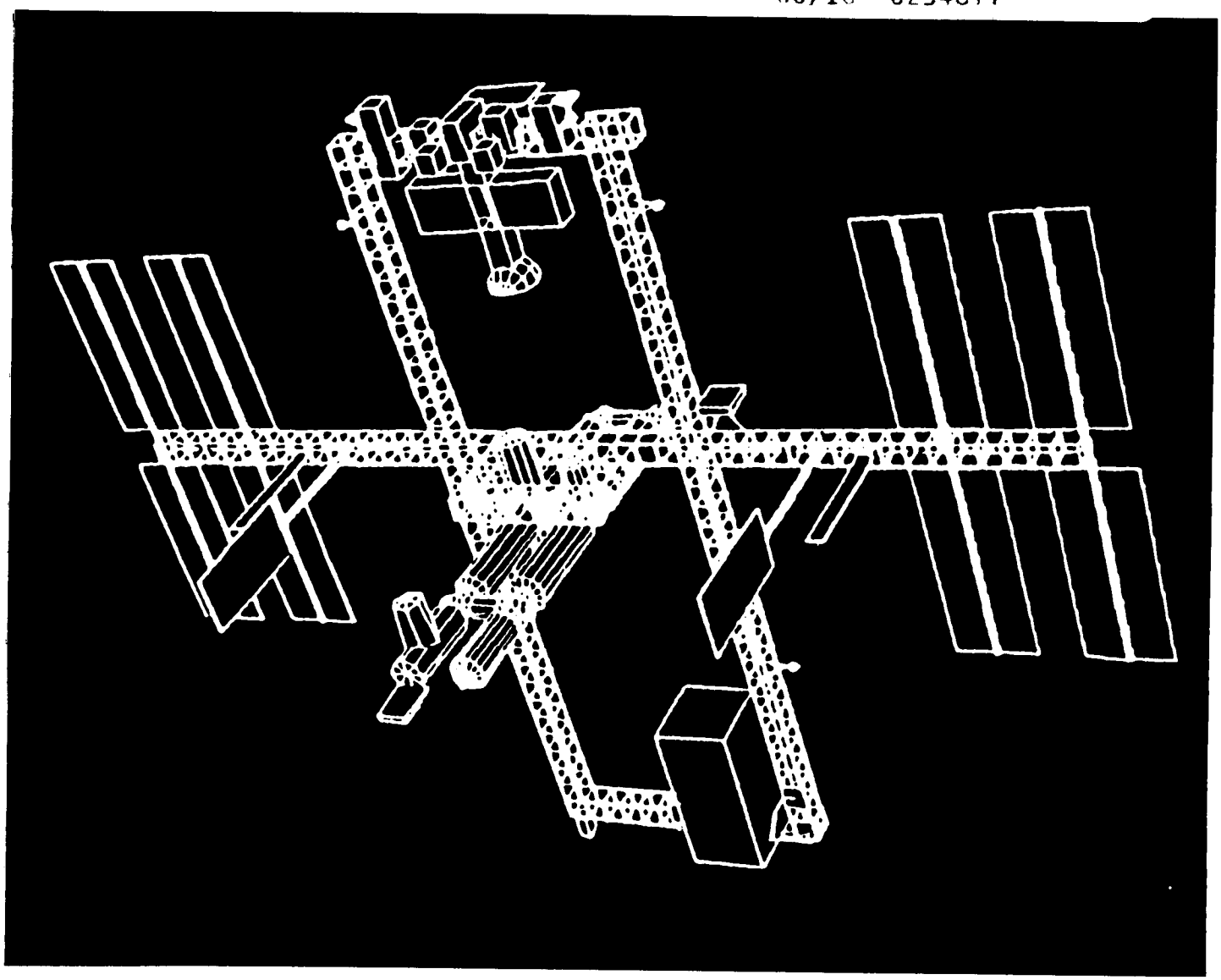

NASA SP-7056 (08)

SPACE STATION SYSTEMS

A BIBLIOGRAPHY WITH INDEXES

Supplement 8

Compiled by
Technical Library Branch
and
Edited by
Space Station Office
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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 July 1 and December 31, 1988 in

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

National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Division
Washington, DC 1989

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.

This supplement is available from the National Technical Information Service (NTIS), Springfield , Virginia 22161 at the price code A11.

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 950 reports, articles and other documents announced between July 1, 1988 and December 31, 1988 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 A88-10,000 in ascending accession number order;

(2) *STAR* entries identified by accession number series N88-10,000 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.

Robert E. Satterthwaite, *Space Station Office*
Sue K. Seward, *Technical Library Branch*

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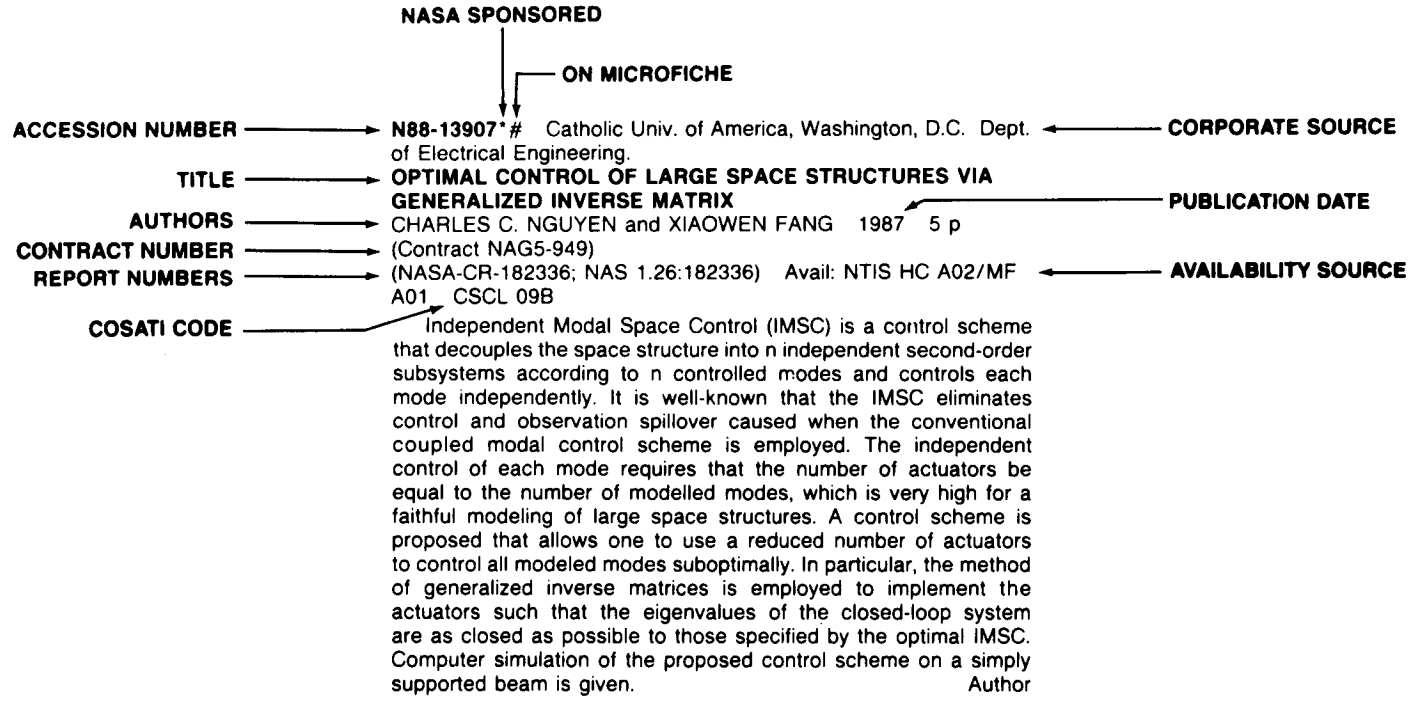
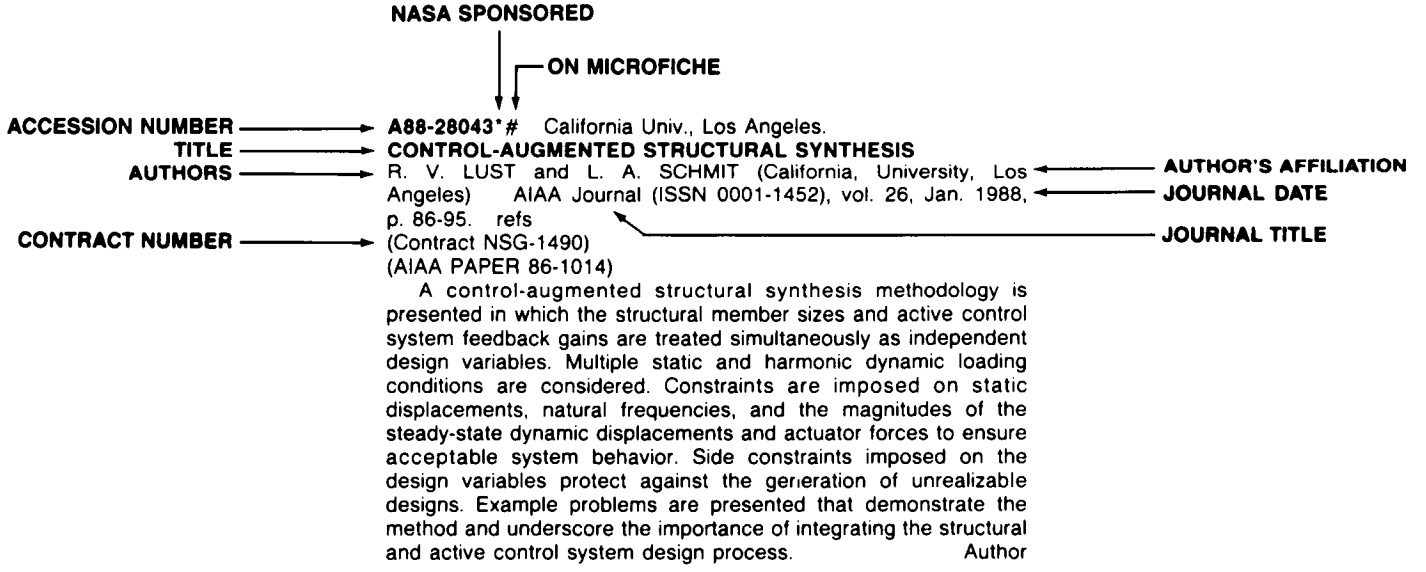
TYPICAL REPORT CITATION AND ABSTRACT



TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



SPACE STATION SYSTEMS

A Bibliography (Suppl. 8)

JULY 1989

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.

A88-22063#
A CONCEPTUAL DESIGN FOR A SINGLE-STAGE-TO-ORBIT SPACE STATION SERVICE VEHICLE
JOHN R. OLDS (North Carolina State University, Raleigh) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 10 p. refs
(AIAA PAPER 88-0089)

A single-stage-to-orbit aerospace vehicle designed to service the Space Station is described. Design restrictions included a minimum landing speed, stability at low and high speeds, and the use of LOX/LH2 propellants. The preliminary vehicle configuration has a landing speed of 131 knots at 15-deg angle of attack, a gross lift-off weight of 4,680,000 lbs, and a length of 252 ft; the payload weight fraction is 0.004274. It is noted that further investigation is needed to evaluate reentry performance, structural integrity, and thermal protection. K.K.

A88-24149
STUDIES OF IONOSPHERIC F-REGION IRREGULARITIES FROM GEOMAGNETIC MID-LATITUDE CONJUGATE REGIONS
A. S. RODGER (NERC, British Antarctic Survey, Cambridge, England) and J. AARONS (Boston University, MA) Journal of Atmospheric and Terrestrial Physics (ISSN 0021-9169), vol. 50, Jan. 1988, p. 63-72. Navy-supported research. refs

The diurnal and seasonal variations in the occurrence of F-region irregularities in geomagnetically conjugate regions during a period of high solar flux (1980-1981) are described. Scintillation data from the Boston area are used as well as spread-F data from Argentine Islands (Antarctica). The findings are discussed in terms of possible mechanisms for medium-scale irregularity formation at midlatitudes. K.K.

A88-33427
AEROBRAKE FOR THE CENTAUR AEROBRAKE FLIGHT EXPERIMENT
JOHN PORTER (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1-12. refs

A retractable aerobrake using only current technology was predesigned. It would be flown on the Centaur rocket in 1992 as the principal part of the Centaur Aerobrake Flight Experiment (CAFE). A triple pass, constant dynamic pressure (TCP) trajectory was chosen to limit peak temperature to 2 260 F, and heating to 22 Btu/s-sq ft. The brake would fly at a 12-degree nominal angle of attack (AOA). Given a + or - 2-degree uncertainty, a worst case AOA of 10 degrees, producing a lift to drag (L/D) of 0.139 for trajectory correction, was used in the analysis. A new flexible Thermal Protection System was developed and crudely tested. An 8-inch diameter wind tunnel model and a 1/20th scale functional model were built. Flyable solutions were conceived for all technical challenges. It is concluded that with a 1988 start, there are no major technical roadblocks to a 1992 CAFE flight. Author

A88-35107* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
THE CHALLENGE OF AEROBRAKING
ROBERT C. RIED (NASA, Johnson Space Center, Houston, TX) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 891-902. refs
(AAS PAPER 86-349)

The system efficiencies obtainable through the synergistic interaction of a LEO spaceport, earth-to-spaceport transportation, and a space-based, reusable aerobraking orbit transfer vehicle, are discussed with a view to NASA's next-century requirements. Attention is given to low Reynolds number hypersonic aerothermodynamic phenomena that will be encountered in aerobraking maneuvers, together with tasks of characterizing nonequilibrium chemistry and thermodynamics through ground experiments, computational chemistry, and CFD. Also noted are the requirements of an aeroassist flight experiment furnishing verification of current understanding of aerobraking vehicle design criteria. O.C.

A88-43299*#
SPACECRAFT TECHNOLOGY REQUIREMENTS FOR FUTURE NASA MISSIONS
WAYNE R. HUDSON and GORDON I. JOHNSTON (NASA, Washington, DC) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 10 p. refs
(AIAA PAPER 88-3487)

By working with advanced planners in the NASA Office of Space Science and Applications (OSSA), a spacecraft technology model has been generated that represents the predominant themes of their respective programs for the next twenty years. This set of missions serves as a base from which a few representative and challenging landmark missions have been extracted to serve as a focal point for identifying the most critical technology issues. Each mission requires significant advances in several technology disciplines in order to be feasible. The mission set selected to serve as a technology focus reflects the increased emphasis within NASA on a potential civil space leadership initiative, and include the Geostationary Earth Observing PLatform from the Planet Earth initiative and the precursor Mars Rover and Sample Return mission from the Mars Exploration Initiative. These missions are briefly described and the key technology requirements are discussed. Author

A88-43300#
DESIGNING FOR OPERATIONS PRODUCTIVITY ON THE SPACE STATION PROGRAM
G. R. BENNETT and S. G. PADDOCK (McDonnell Douglas Astronautics Co., Space Station Div., Houston, TX) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24,

1988. 8 p.
(AIAA PAPER 88-3502)

A systematic approach to operation analysis and the development of an automated Operations Management System (OMS) to enhance productivity and help minimize operation costs for the Space Station are examined. The operation analysis process works with design engineering to derive requirements based on operational need, to enhance on-orbit crew productivity, improve flexibility of systems to respond to contingencies with less ground support workarounds, and to integrate all the funtions of operation planning and execution. The OMS is a software system which will take care of routine operations both on board and at ground facilities. The OMS will develop, manage, update and execute the Short-Term Plan, monitor the status of space station systems and payloads, manage inter-system and payload testing, maintain and log the station's global configuration, activity and state information, detect and manage resource conflicts, manage the global base caution and warning, perform global base fault management and reconfiguration, support the management of commands and the uplink and downlink of data, provide a global base inventory and maintenance management system and support on-board training and simulations. R.B.

A88-43333
SYSTEM EFFECTIVENESS-A KEY TO ASSURANCE
PAUL DICK (General Electric Co., Astro-Space Div., Philadelphia, PA) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 77-85.

The increasing demands for long life and reliability performance in space for communication satellites has focused increased attention on those critical parts, materials, processes, subassemblies, assemblies, and products whose individual performance is essential to the success of the mission. Various case histories, problems, concerns, and uncertainties that arose during the design, manufacture, test, and acceptance of critical items on several communications satellite programs are reported. It is shown how they were resolved by system effectiveness activities. Subsequent corrective action taken is discussed. I.E.

A88-43953#
RECONSIDERING ARTIFICIAL GRAVITY FOR TWENTY-FIRST CENTURY SPACE HABITATS
PETER H. DIAMANDIS (MIT, Cambridge, MA) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 55-68. Research supported by the Space Studies Institute. refs

The medical bases for development of artificial gravity systems that can be incorporated by spacecraft on long duration missions, orbital habitats, and lunar and asteroidal bases are presented. After giving an account of the renal, cardiovascular, and musculoskeletal effects of weightlessness, attention is given to such considerations as how much artificial gravity is required, the physiological limits of radii and angular velocity for centrifugal artificial gravity systems, and the economic limits to radius and angular velocity. Motion sickness due to Coriolis cross-coupled accelerations is identified as a major problem. O.C.

A88-43964#
A DESCRIPTION OF THE EXPANDABLE PLATFORM
JOSEPH J. MANGAN (Aerospace Industries Association of America, Inc., Washington, DC) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 140-147.

The five regular convex polyhedrons, or Platonic solids, are presently used as the geometrical bases of structural frames that can be selected, assembled, and located by computers; they essentially represent redundant shapes that can be expanded or contracted, and are programmed for robotic construction. An account is given of how structural frames predicated on the five solids can be used on the moon and on Mars to solve numerous problems encountered in lunar and planetary base design and in their high speed transportation systems. O.C.

A88-43967#
SPACE STATION TOOL KIT
WILLIAM LEWIS (Washington, University, Seattle), DWIGHT WAHLBERG (California, University, La Jolla), and ARCHIE BREEDEN IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 167-170.

Since a module-replacement strategy cannot furnish complete coverage of all possible system failures on the NASA Space Station, an attempt is presently made to identify those tools that may be most efficiently and with the minimum possible mass employed to undertake component-level repairs and maintenance improvisation. This speculative 'tool kit' is intended to demonstrate the possibility of very general purpose tools, as well as to adumbrate the character of prospective on-orbit repairs. Electrical, electronic, piping, structural, and informational components would be encompassed by the kit. O.C.

A88-45109*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
BEYOND SIMULATION
JOHN G. DAVIS, JR. and SIDNEY C. DIXON (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, July 1988, p. 38-40, 42.

The technological breakthroughs required for the development of fully reusable launch vehicles are reviewed, with a focus on advanced materials and structures. Current proposals favor LH2 as a fuel for both conventional dual-stage rockets, vertical-launch SSTO rockets, and horizontal-launch airbreathing SSTOs; hence large cryogenic tanks and thermal protection (for descent in rockets and ascent in airbreathers) are required. Consideration is given to structural alloys and composites; thermal-protection materials; propellant-tank insulation materials; the design of light but strong tanks, wings, nose caps, and airbreathing-engine structures; and the problem of hot boundary-layer gases. The need for more accurate and efficient design codes (including dynamic loads and aerothermoelasticity) and for better ground test facilities is stressed. T.K.

A88-45632*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
WALL CATALYSIS EXPERIMENT ON AFE
DAVID A. STEWART and PAUL KOLODZIEJ (NASA, Ames Research Center, Moffett Field, CA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 11 p. refs
(AIAA PAPER 88-2674)

This paper describes the wall catalysis experiment which is planned as part of the Aeroassist Flight experiments (AFE) that will be flown from the Space Shuttle Orbiter in late 1993. Research on candidate high-catalytic efficiency overcoats for the experiment conducted in an arc-jet air stream are discussed. The temperature distribution over the AFE heat shield is also predicted using a reacting boundary layer solution that includes surface kinetics and optical properties determined from these tests. Author

A88-45713* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ATMOSPHERIC GUIDANCE CONCEPTS FOR AN AEROASSIST FLIGHT EXPERIMENT
J. D. GAMBLE, C. J. CERIMELE, T. E. MOORE (NASA, Johnson Space Center, Houston, TX), and J. HIGGINS (Charles Stark Draper Laboratory, Inc., Cambridge, MA) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 36, Jan.-June 1988, p. 45-71. refs

Three atmospheric guidance concepts proposed for an

aeroassist flight experiment are presented. The flight experiment will simulate a return from geosynchronous orbit by an aeroassisted orbital transfer vehicle and is proposed to be flown on board the Space Shuttle in 1992. The three guidance concepts include an analytic predictor/corrector, a numeric predictor/corrector, and an energy controller. The algorithms for the three guidance methods are developed and performance results are presented for the nominal case and for several cases dispersed from the nominal conditions. Author

A88-45714* Rice Univ., Houston, TX.
NEARLY-GRAZING OPTIMAL TRAJECTORIES FOR NONCOPLANAR, AEROASSISTED ORBITAL TRANSFER
A. MIELE (Rice University, Houston, TX), K. D. MEASE (Princeton University, NJ), and W. Y. LEE Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 36, Jan.-June 1988, p. 139-157. Research supported by Boeing Military Airplane Co. refs
(Contract JPL-956415)

This paper discusses aeroassisted orbital transfer maneuvers under the assumption that the terminal orbital inclinations are different. Both GEO-to-LEO and LEO-to-LEO transfers are considered in connection with a spacecraft which is controlled during the atmospheric pass via the angle of attack and the angle of bank. Within the framework of classical optimal control, the following problems are studied: the minimization of the total characteristic velocity (P1); the minimization of the time integral of the square of the path inclination (P5); and the minimization of the peak heating rate (Q1). Numerical solutions are obtained by means of the sequential gradient-restoration logarithm for optimal control problems under the conditions that, for the problem (P1), the plane change components are optimized, while for the problems (P5) and (Q1), the plane change components are kept at the levels determined for problem (P1). The engineering implications of the solutions are discussed, in order to determine the most useful solutions in the light of energy requirements and heat transfer requirements. I.S.

A88-48477*# Martin Marietta Corp., Denver, CO.
TRANSPORTATION CONCEPTS FOR MARS EXPLORATION
BENTON C. CLARK (Martin Marietta Planetary Sciences Laboratory, Denver, CO) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 7 p. refs
(Contract NAS8-37126)
(AIAA PAPER 88-3494)

The transportation aspects of astronaut travel to Mars are discussed. Alternative types of propulsion are examined, including mainline and ancillary chemical propulsion, electric propulsion, and nuclear thermal rocket propulsion. The possibility of remote propellant production is presented, focusing on the use of lunar liquid oxygen, Phobos propellants and Mars propellant production. Also, the way in which habitat models may be derived from Space Station modules or from other designs capitalizing on larger diameter payload envelopes for heavy-lift launch vehicles is considered. R.B.

A88-50266*# Georgia Inst. of Tech., Atlanta.
A NEAR OPTIMAL GUIDANCE ALGORITHM FOR AERO-ASSISTED ORBIT TRANSFER
ANTHONY J. CALISE and GYOUNG H. BAE (Georgia Institute of Technology, Atlanta) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1015-1019. refs
(Contract NAG1-660)
(AIAA PAPER 88-4175)

The paper presents a near optimal guidance algorithm for aero-assited orbit plane change, based on minimizing the energy loss during the atmospheric portion of the maneuver. The guidance algorithm makes use of recent results obtained from energy state approximations and singular perturbation analysis of optimal heading change for a hypersonic gliding vehicle. This earlier work ignored the terminal constraint on altitude needed to insure that the vehicle exits that atmosphere. Thus, the resulting guidance algorithm was only appropriate for maneuvering reentry vehicle guidance. In the context of singular perturbation theory, a constraint on final altitude gives rise to a difficult terminal boundary layer problem, which cannot be solved in closed form. This paper will demonstrate the near optimality of a predictive/corrective guidance algorithm for the terminal maneuver. Comparisons are made to numerically optimized trajectories for a range or orbit plane angles. Author

A88-50280#
PILOTED EARTH POINTING OF A SPINNING GEOSYNCHRONOUS SATELLITE
D. D. FITZGERALD, R. B. SHERWOOD, and A. B. SIMMONS (TRW, Inc., Redondo Beach, CA) AIAA, Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988. 12 p.
(AIAA PAPER 88-4130)

The development of a ground controlled earth acquisition for a geosynchronous satellite is discussed. The satellite's normal attitude control capabilities and the provision available for back-up ground commanding are examined. The theoretical approach used to implement the manual earth acquisition is presented. This implementation consists of several hours of continuous, time-critical, man-in-the-loop commanding. The refinements made to the operation as a result of knowledge gained in the hands-on rehearsals are given. R.B.

A88-50308
COMPARISON OF FIBER OPTIC AND SPACE FEED FOR LARGE APERTURE PHASED ARRAY ANTENNAS
NILS V. JESPERSEN and PETER R. HERCZFELD (Drexel University, Philadelphia, PA) IN: Optical technology for microwave applications III; Proceedings of the Meeting, Orlando, FL, May 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 88-91.

Two technologies which are potential candidates for distributing control and intelligence information in large phased array antennas, are space feeding and fiber optic corporate feeding. A comparison of the two technologies is presented in both qualitative and quantitative form. The comparison is embodied in the hypothetical cases of a V-band and an L-band spaceborne imaging radar. Size, weight, power and performance impacts of the two feeding methods are contrasted. Author

A88-50588#
LIFTING ENTRY RESCUE VEHICLE CONFIGURATION
J. PETER REDING and HAROLD O. SVENDSEN (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 114-123. refs
(AIAA PAPER 88-4342)

NASA has reviewed the need for alternative ways to provide rescue capability for the Space Station crew in the event that the Shuttle is not available. This Crew Emergency Return Vehicle would be docked to the Station and available for a variety of return or rescue missions. A lifting entry configuration concept is presented whose design is driven by the need to safely return injured, ill or deconditioned crew members. This need is a significant consideration for limiting reentry Gs, minimizing impact loads with ground or water, and reducing transport time from the station to medical care. Therefore, the capability for land-landing with ready access to medical help is highly desirable. A moderate L/D design that provides a minimum risk and is inexpensive, featuring simple geometry and structure, is shown to provide significant cross range capability combined with low reentry G load. A state-of-the-art thermal protection system and a parachute landing system are used. Author

A88-51386*# Sterling Software, Palo Alto, CA.
OPTIMUM CONFIGURATION OF HIGH-LIFT AEROMANEUVERING ORBITAL TRANSFER VEHICLES IN VISCOUS FLOW

CAROL B. DAVIES (Sterling Software, Palo Alto, CA) and CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 193-201. Previously cited in issue 17, p. 2472, Accession no. A85-37673. refs

A88-51389*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
THEORY OF IDEALIZED TWO-DIMENSIONAL BALLUTE IN NEWTONIAN HYPERSONIC FLOW
CHUL PARK (NASA, Ames Research Center, Moffett Field, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 217-224. Previously cited in issue 08, p. 986, Accession no. A86-22689. refs

A88-51397
A PRODUCTION APPROACH TO ENVIRONMENTAL ACCEPTANCE TESTING OF SPACE VEHICLE SUBSYSTEMS
ARTHUR S. JACKOLA and JOHN E. ALLEN (Rockwell International Corp., Satellite and Space Electronics Div., Seal Beach, CA) Journal of Environmental Sciences (ISSN 0022-0906), vol. 31, July-Aug. 1988, p. 26-30, 47, 48. refs

Rockwell International's Multi-Environment Test System (METS) is an environmental simulation facility for thermal cycle and thermal vacuum testing of space vehicle subsystems. The use of a central cryopump and eight radially mounted, independently controlled, test chambers provide test efficiencies not possible in single chamber test systems. Thermal cycle and thermal vacuum testing can be performed in each chamber and thereby further increase the efficiency of the test system. This article describes the Multi-Environment Test System and its configuration and control system and summarizes its use to support black-box environmental test programs. Author

A88-52331* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TECHNOLOGIES FOR PROTECTION OF THE SPACE STATION POWER SYSTEM SURFACES IN ATOMIC OXYGEN ENVIRONMENT
HENRY K. NAHRA and SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-1 to 5-8. refs

Technologies for protecting Space Station surfaces from degradation caused by atomic oxygen are discussed, stressing protection of the power system surfaces. The Space Station power system is described and research concerning the solar array surfaces and radiator surfaces is examined. The possibility of coating the solar array sufaces with a sputter deposited thin film of silicon oxide containing small concentrations of polytetrafluoroethylene is presented. Hexamethyldisiloxane coating for these surfaces is also considered. For the radiator surfaces, possible coatings include silver teflon thermal coating and zinc orthotitanate. R.B.

A88-52332
TECHNOLOGY DEVELOPMENT MISSIONS CONCEPT DEFINITION STUDY - TDMX 2066 LARGE INFLATABLE/RIGIDIZED STRUCTURES
R. E. GIUNTINI and K. M. SEISER (Wyle Laboratories, El Segundo, CA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-9 to 5-20.

A preliminary study is presented for a technology development mission (TDMX 2066) to address the definition, feasibility, and requirements for a large inflatable/rigidized hangar for payload servicing on the Space Station. The applications and technology options for inflatable/rigidized structures are examined, including Space Shuttle enhancements, Space Station elements, orbital transfer and satellite systems, and lunar habitats. The concept design, ground logistics, and support requirements for development of the hangar are discussed. STS flight requirements, on-orbit logistics/support resource requirements, and a preliminary evolutionary plan indicating the phases from development to Space Station flight are given. R.B.

N88-23824*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ON-ORBIT TECHNOLOGY EXPERIMENT FACILITY DEFINITION
RICHARD A. RUSSELL, ROBERT W. BUCHAN, and RICHARD M. GATES (Boeing Aerospace Co., Seattle, Wash.) May 1988 145 p
(NASA-TM-100614; NAS 1.15:100614) Avail: NTIS HC A07/MF A01 CSCL 22B

A study was conducted to identify on-orbit integrated facility needs to support in-space technology experiments on the Space Station and associated free flyers. In particular, the first task was to examine the proposed technology development missions (TDMX's) from the model mission set and other proposed experimental facilities, both individually and by theme, to determine how and if the experiments might be combined, what equipment might be shared, what equipment might be used as generic equipment for continued experimentation, and what experiments will conflict with the conduct of other experiments or Space Station operations. Then using these results, to determine on-orbit facility needs to optimize the implementation of technology payloads. Finally, to develop one or more scenarios, design concepts, and outfitting requirements for implementation of onboard technology experiments. Author

N88-27214* National Aeronautics and Space Administration, Washington, DC.
TECHNOLOGY FOR LARGE SPACE SYSTEMS: A BIBLIOGRAPHY WITH INDEXES (SUPPLEMENT 18)
Jun. 1988 162 p
(NASA-SP-7046(18); NAS 1.21:7046(18)) Avail: NTIS HC A07 CSCL 22B

This bibliography lists 569 reports, articles, and other documents introduced into the NASA scientific and technical information system between July 1,1987 and December 31, 1987. 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. Author

N88-28958* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
EXPANDABLE PALLET FOR SPACE STATION INTERFACE ATTACHMENTS Patent
CLARENCE J. WESSELSKI, inventor (to NASA) 23 Aug. 1988 11 p Filed 13 Nov. 1986 Supersedes N87-18597 (25 - 11, p 1446)
(NASA-CASE-MSC-21117-1; US-PATENT-4,765,114; US-PATENT-APPL-SN-929875; US-PATENT-CLASS-52-646; US-PATENT-CLASS-52-648) Avail: US Patent and Trademark Office CSCL 22B

Described is a foldable expandable pallet for Space Station interface attachments with a basic square configuration. Each pallet consists of a series of struts joined together by node point fittings to make a rigid structure. The struts have hinge fittings which are spring loaded to permit collapse of the module for stowage transport to a Space Station in the payload bay of the Space Shuttle, and development on orbit. Dimensions of the pallet are selected to provide convenient, closely spaced attachment points between the node points of the relatively widely spaced trusses of a Space Station platform. A pallet is attached to a strut at four points: one close fitting hole, two oversize holes, and a slot to allow for thermal expansion/contraction and for manufacturing tolerances. Applications of the pallet include its use in rotary or angular joints; servicing of splints; with gridded plates; as instrument mounting bases; and as a roadbed for a Mobile Service Center (MSC). Official Gazette of the U.S. Patent and Trademark Office

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.

A88-29852
VISUALIZATION OF RESISTIVE REGIONS AND ACTIVE ZONES IN NARROW CHANNELS UNDER CONDITIONS OF NON-JOSEPHSON GENERATION [VIZUALIZATSIIA REZISTIVNYKH OBLASTEI I AKTIVNYKH ZON V UZKIKH KANALAKH V REZHIME NEDZHOZEFSONOVSKOI GENERATSII]
V. N. SVETLOV, G. E. CHURILOV, V. M. DMITRIEV, A. P. ZHURAVE'L, and V. A. KONOVODCHENKO (AN USSR, Fiziko-Tekhnicheskii Institut, Kharkov, Ukrainian SSR) Fizika Nizkikh Temperatur (ISSN 0132-6414), vol. 14, Jan. 1988, p. 26-33. In Russian. refs

The resistive state of narrow superconducting channels under conditions of the onset of Josephson oscillations is investigated experimentally using laser probing. Direct experimental evidence is obtained, demonstrating that generation occurs directly in the resistive region of the phase-slip center when a certain current density is reached in this region. The structure of the resistive state is shown to be static in space. V.L.

A88-34465
COMPUTER APPLICATIONS IN SPACECRAFT DESIGN AND OPERATION
T. K. S. MURTHY, ED. (Computational Mechanics Institute, Southampton, England) and R. E. MUENCH, ED. (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) Berlin and New York, Springer-Verlag, 1987, 196 p For individual items see A88-34466 to A88-34476.

The papers presented in this volume provide an overview of the use of computer-aided design, manufacture and operation in the aerospace industry. Topics discussed include preliminary design techniques for interplanetary solar-electric propulsion spacecraft, animated computer graphics for spacecraft mission analysis, an integrated computer aided engineering system for space station design, and automatic quality control of meteorological parameters derived from Meteosat imagery. Papers are also presented on expert systems for decision support in military aircraft mission preparation and new tools in support of satellite operation. V.L.

A88-34469
AN INTEGRATED COMPUTER AIDED ENGINEERING SYSTEM FOR SPACE STATION DESIGN
R. A. WHALE (SDRC Engineering Services, Ltd., Hitchin, England), M. BAKER, H. D. CHIGER, J. A. HABERMEYER, P. J. HIPOL (SDRC, Inc., San Diego, CA) et al. IN: Computer applications in spacecraft design and operation. Berlin and New York, Springer-Verlag, 1987, p. 53-76.

A computer-aided engineering tool currently in use at NASA for system engineering and integration analysis of the space station is described. The tool combines spacecraft-specific analysis software called IDEAS (truss synthesizer, rigid body controls, plume impingement, orbital lifetime, orbit heat loads, and life support systems with general purpose interactive graphics, geometric database, solid modeller, and structural and thermal software to obtain an integrated package suitable for space station design. The capabilities and examples of the use of IDEAS are presented. V.L.

A88-43976#
COMPUTATIONAL TECHNIQUES FOR THE SELF ASSEMBLY OF LARGE SPACE STRUCTURES
ALAN H. BARR, BRIAN VON HERZEN, RONEN BARZEL, and JOHN SNYDER (California Institute of Technology, Pasadena) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 275-282. refs

We present a new computational technique, dynamic constraints, which is potentially applicable to the computer aided design, modeling, and control of the self assembly of large space structures. The technique models the dynamic behavior of mechanical elements, subject to geometric constraints on their final configuration. The constraints are met by applying external forces to the elements of the structure during assembly. The techniques are envisioned as being useful for calculating the strength of rocket impulses for automated docking maneuvers, for smoothly eliminating residual velocities and angular velocities associated with self-assembly, and for other applications where we wish to create homeostatic spatial relationships between space platforms and other structures. The technique will also be useful as a computer aided design tool for these applications. Author

A88-46406* Colorado Univ., Boulder.
COMPUTATIONAL ISSUES IN CONTROL-STRUCTURE INTERACTION ANALYSIS
K. C. PARK (Colorado, University, Boulder) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 115-131. refs
(Contract F49620-87-C-0074; NAG1-756)

This paper surveys computational issues for large-scale simulation of dynamics and controls of space structures, which involve structural elements that are capable of large combined rigid and flexible motions, accurate and efficient treatment of constraints, robust integration of both translational and large rotational motions in the equations of motion, modular interface with active control synthesis packages, and a capability from wave motions to slowly varying transient responses. A particular feature of the present survey is a partitioned solution (or divide-and-conquer) procedure that can handle the numerical solution of multidisciplinary simulation problems by relying on individual modular solution packages that treat each aspect of simulation requirements. Author

A88-46968
INTERACTIVE RADAR ENVIRONMENT SIMULATION MODEL (IRESM)
ROBERT J. HANCOCK, PAUL ANTONIK, FRANCIS G. SHERRILL, JEFFREY A. MCKAY (Simulation Technology, Inc., Greenville, TX), and JOHN C. CLEARY (USAF, Rome Air Development Center, Griffiss AFB, NY) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 272-274.

A radar simulation computer program to evaluate various radar system designs and a comprehensive program to evaluate various large aperture antenna designs have been integrated into the Interactive Radar Environment Simulation Model (IRESM). This simulation has been used to evaluate a number of different surface-based radar systems. The IRESM and its components are examined. A detailed signal simulation is presented, which models radar signals as they are generated, propagated through the environment, reflected by scatterers, and processed. A program for the evaluation of electronically-scanned phased array antennas is discussed, which enables the user to perform quick and accurate analyses on a variety of antenna designs. R.B.

A88-50264*# Vigyan Research Associates, Inc., Hampton, VA.
ADAPTIVE GUIDANCE FOR AN AERO-ASSISTED BOOST VEHICLE
BANDU N. PAMADI (Vigyan Research Associates, Inc., Hampton, VA), LAWRENCE W. TAYLOR, JR., and DOUGLAS B. PRICE (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC,

American Institute of Aeronautics and Astronautics, 1988, p. 995-1005. refs
(Contract NAS1-17919)
(AIAA PAPER 88-4173)

An adaptive guidance system incorporating dynamic pressure constraint is studied for a single stage to low earth orbit (LEO) aero-assist booster with thrust gimbal angle as the control variable. To derive an adaptive guidance law, cubic spline functions are used to represent the ascent profile. The booster flight to LEO is divided into initial and terminal phases. In the initial phase, the ascent profile is continuously updated to maximize the performance of the boost vehicle enroute. A linear feedback control is used in the terminal phase to guide the aero-assisted booster onto the desired LEO. The computer simulation of the vehicle dynamics considers a rotating spherical earth, inverse square (Newtonian) gravity field and an exponential model for the earth's atmospheric density. This adaptive guidance algorithm is capable of handling large deviations in both atmospheric conditions and modeling uncertainties, while ensuring maximum booster performance. Author

A88-50265*# Texas Univ., Austin.
AN APPROXIMATE ATMOSPHERIC GUIDANCE LAW FOR AEROASSISTED PLANE CHANGE MANEUVERS
JASON L. SPEYER and EDWIN Z. CRUES (Texas, University, Austin) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1006-1014. refs
(Contract JPL-956414)
(AIAA PAPER 88-4174)

An approximate optimal guidance law for the aeroassisted plane change problem is presented which is based upon an expansion of the Hamilton-Jacobi-Bellman equation with respect to the small parameter of Breakwell et al. (1985). The present law maximizes the final velocity of the reentry vehicle while meeting terminal constraints on altitude, flight path angle, and heading angle. The integrable zeroth-order solution found when the small parameter is set to zero corresponds to a solution of the problem where the aerodynamic forces dominate the inertial forces. Higher order solutions in the expansion are obtained from the solution of linear partial differential equations requiring only quadrature integration. R.R.

N88-24192*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
KNOWLEDGE BASED SYSTEM VERIFICATION AND VALIDATION AS RELATED TO AUTOMATION OF SPACE STATION SUBSYSTEMS: RATIONALE FOR A KNOWLEDGE BASED SYSTEM LIFECYCLE
KEITH RICHARDSON and CARLA WONG *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 25-30 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

The role of verification and validation (V and V) in software has been to support and strengthen the software lifecycle and to ensure that the resultant code meets the standards of the requirements documents. Knowledge Based System (KBS) V and V should serve the same role, but the KBS lifecycle is ill-defined. The rationale of a simple form of the KBS lifecycle is presented, including accommodation to certain critical KBS differences from software development. Author

N88-28083# Societe Nationale Industrielle Aerospatiale, Cannes (France).
LITERAL DYNAMIC MODELING [MODELISATION DYNAMIQUE LITTERALE]
C. GARNIER, P. RIDEAU, and Y. PAPEGAY (Nice Univ., France) 14 Jan. 1988 15 p In FRENCH
(REPT-881-440-114; ETN-88-92878) Avail: NTIS HC A03/MF A01

A computer program to create the literal dynamic model of systems composed of articulated flexible structures is presented. The procedure is characterized by the fact that the computing power is used to manipulate equations and algebra expressions till the end, without using numerical approximations. At this stage of development, the program deals with tree structures only. This type of structure is easier to study. The procedure is used to model large space structures of complex geometry. ESA

N88-29358*# Alabama Univ., Huntsville. Dept. of Management Information Systems and Management Science.
A KNOWLEDGE-BASED DECISION SUPPORT SYSTEM FOR PAYLOAD SCHEDULING
STEPHEN FLOYD and DONNIE FORD *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 69-78 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The role that artificial intelligence/expert systems technologies play in the development and implementation of effective decision support systems is illustrated. A recently developed prototype system for supporting the scheduling of subsystems and payloads/experiments for NASA's Space Station program is presented and serves to highlight various concepts. The potential integration of knowledge based systems and decision support systems which has been proposed in several recent articles and presentations is illustrated. Author

N88-29385*# Martin Marietta Aerospace, Denver, CO. Space Station Program.
INTELLIGENT RESOURCE MANAGEMENT FOR LOCAL AREA NETWORKS: APPROACH AND EVOLUTION
ROGER MEIKE *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 319-324 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The Data Management System network is a complex and important part of manned space platforms. Its efficient operation is vital to crew, subsystems and experiments. AI is being considered to aid in the initial design of the network and to augment the management of its operation. The Intelligent Resource Management for Local Area Networks (IRMA-LAN) project is concerned with the application of AI techniques to network configuration and management. A network simulation was constructed employing real time process scheduling for realistic loads, and utilizing the IEEE 802.4 token passing scheme. This simulation is an integral part of the construction of the IRMA-LAN system. From it, a causal model is being constructed for use in prediction and deep reasoning about the system configuration. An AI network design advisor is being added to help in the design of an efficient network. The AI portion of the system is planned to evolve into a dynamic network management aid. The approach, the integrated simulation, project evolution, and some initial results are described. Author

N88-29389*# Boeing Computer Support Services, Inc., Huntsville, AL.
GENERIC SUPERVISOR: A KNOWLEDGE-BASED TOOL FOR CONTROL OF SPACE STATION ON-BOARD SYSTEMS
J. R. CARNES and R. NELSON (Boeing Aerospace Co., Huntsville, Ala.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 355-362 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The concept of a generic module for management of onboard systems grew out of the structured analysis effort for the Space Station software. Hierarchical specification of subsystems software revealed that nontrivial supervisory elements are required at all levels. The number of supervisors (and subsequent software) required to implement the hierarchical control over onboard functions comprise a large portion of the Space Station software. Thus, a generic knowledge based supervisory module significantly reduces the amount of software developed. This module, the Generic Supervisor, depends on its knowledge of control to provide direction for subordinates and feedback to superiors within a specific subsystem area. The Generic Supervisor provides an

adaptable and maintainable control system. A portion of the Space Station Environmental Control and Life Support System (ECLSS) was implemented as a hierarchy of supervisors. This prototype implementation demonstrates the feasibility of a generic knowledge based supervisor, and its facility to meet complex mission requirements. Author

N88-29414*# Martin Marietta Aerospace, Denver, CO.
BLACKBOARD ARCHITECTURES AND THEIR RELATIONSHIP TO AUTONOMOUS SPACE SYSTEMS
ALLISON THORNBRUGH *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 583-589 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The blackboard architecture provides a powerful paradigm for the autonomy expected in future spaceborne systems, especially SDI and Space Station. Autonomous systems will require skill in both the classic task of information analysis and the newer tasks of decision making, planning and system control. Successful blackboard systems have been built to deal with each of these tasks separately. The blackboard paradigm achieves success in difficult domains through its ability to integrate several uncertain sources of knowledge. In addition to flexible behavior during autonomous operation, the system must also be capable of incrementally growing from semiautonomy to full autonomy. The blackboard structure allows this development. The blackboard's ability to handle error, its flexible execution, and variants of this paradigm are discussed as they apply to specific problems of the space environment. Author

N88-29417*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.
A NONLINEAR FILTERING PROCESS DIAGNOSTIC SYSTEM FOR THE SPACE STATION
RAYMOND R. YOEL, M. BUCHNER, K. LOPARO, and ARIF CUBUKCU (Case Western Reserve Univ., Cleveland, Ohio.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 601-604 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

A nonlinear filtering process diagnostic system, terrestrial simulation and real time implementation studies is presented. Possible applications to Space Station subsystem elements are discussed. A process diagnostic system using model based nonlinear filtering for systems with random structure was shown to provide improvements in stability, robustness, and overall performance in comparison to linear filter based systems. A suboptimal version of the nonlinear filter (zero order approximation filter, or ZOA filter) was used in simulation studies, initially, with a pressurized water reactor model and then with water/steam heat exchanger models. Finally, a real time implementation for leak detection in a water/steam heat exchanger was conducted using the ZOA filter and heat exchanger models. 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.

A88-21243
AN ANTIMONY-RELATED ELECTRONIC LEVEL IN ISOVALENTLY DOPED BULK GAAS
W. C. MITCHEL (USAF, Materials Laboratory, Wright-Patterson AFB, OH) and P. W. YU (Wright State University, Dayton, OH) Journal of Applied Physics (ISSN 0021-8979), vol. 62, Dec. 15, 1987, p. 4781-4785. refs
(Contract F33615-84-C-1423)

Temperature-dependent Hall-effect and photoluminescence measurements have been performed on a series of antimony-doped bulk GaAs samples that were otherwise undoped. A new donor level located 0.48 eV below the conduction-band edge has been detected by both experiments in all antimony-doped samples studied. This level reduces the resistivity of antimony-doped material below the semiinsulating limit. Comparison with known intrinsic levels in undoped material have been made, and it is shown that the 0.48-eV donor is distinct from any of these. It is concluded that the defect responsible for the 0.48-eV donor involves an impurity antisite Sb(Ga) either isolated or in a complex with intrinsic defects. Author

A88-24672
ESTIMATION OF RESIDUAL STRESSES IN PROTECTIVE COATINGS ON MODELS OF GAS-TURBINE BLADES [OTSENKA OSTATOCHNYKH NAPRIAZHENII V ZASHCHITNYKH POKRYTIIAKH NA MODELIAKH LOPATOK GTD]
K. P. BUISKIKH (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), Dec. 1987, p. 56-59. In Russian. refs

The thermal-cycle fatigue behavior of gas-turbine blade models of ZhS6U alloy with various protective coatings is investigated with emphasis on the effect of process-related residual stresses and coating type. In particular, calculations are carried out for vacuum vapor deposited coatings of the systems Ni-Co-Cr-Al-Y, Ni-Cr-Al-Y, and Co-Cr-Al-Y. An analysis of the results obtained shows that it is essential that both the thermal loading conditions and the residual stresses be taken into account. V.L.

A88-33018
DESIGN, FABRICATION, AND TESTING OF ROLLED CARBON/EPOXY STRUTS FOR SPACE STATION APPLICATION
RUDY LUKEZ, DAVID R. NELSON (Morton Thiokol, Inc., Brigham City, UT), VOLKER B. TELLER, and HARLEY J. ROCKOFF (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: International SAMPE Technical Conference, 19th, Crystal City, VA, Oct. 13-15, 1987, Proceedings. Covina, CA, Society for the Advancement of Material and Process Engineering, 1987, p. 536-544.

High-quality carbon/epoxy struts applicable to the proposed NASA Space Station's space structure in virtue of their high stiffness, low voids-content, and low production cost, have been manufactured by means of a novel 'tape-rolling' process.In this process, aluminum foil overwraps serving as protection for the epoxy in the space environment can be easily incorporated. Alternative fabrication methods which were considered and rejected include filament-winding, braiding, and pultrusion. O.C.

A88-33433
LARGE SPACE SYSTEM ASSEMBLY OPTIONS
MICHAEL K. BAILY (Martin Marietta Corp., Denver, CO) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 61-74.

Methods and techniques used to display various large space structure assembly sequence alternatives are discussed. The launch vehicle performance and requirements definition of the major elements to be assembled and delivered and assembled in orbit are considered along with logistics and module outfitting requirements. A Space Station manifest for each mission, the Shuttle performance parameters, and the dynamic requirements for Station weight, altitude, and system are considered. C.D.

A88-34486
STRUCTURAL MECHANICS OF OPTICAL SYSTEMS II; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 13-15, 1987

ALSON E. HATHEWAY, ED. (Alson E. Hatheway, Inc., Pasadena, CA) Conference sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 748), 1987, 242 p. For individual items see A88-34487 to A88-34508.
(SPIE-748)

The present conference discusses the support structure for the optics of the Multiple Mirror Telescope (MMT), cophasing and coaligning the MMT, the 11.3-m optical telescope of the Columbus project, CAD techniques for a space-based optical system, solid optics for small and complex optical systems, and optical path-length calculations using finite elements. Also discussed are optomechanical analysis strategies, active vibration suppression methods for a large optical system, a conceptual design for the active control of a large optical system, the flexural rigidity characteristics of lightweight mirrors, the structural analysis of a lightweight aluminum foam core mirror, and the response of large optical mirrors to thermal distributions. O.C.

A88-34491
STRUCTURAL INNOVATIONS IN THE COLUMBUS PROJECT - AN 11.3 METER OPTICAL TELESCOPE
WARREN B. DAVISON (Steward Observatory, Tucson, AZ) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 31-37.

The goal of the Steward Observatory's Columbus Project is the construction of an 11.3-m effective aperture telescope by the 500th aniversary of the discovery of America in 1992. The configuration of the telescope is projected to consist of two 8-m diameter F:1 primary mirrors with 14-m center separation; these two mirrors can be supported with a relatively lightweight and simple structure that will facilitate the achievement of high servo performance with modest technology and costs. O.C.

A88-34498
LARGE SPACE OPTICAL SYSTEM ACTIVE VIBRATION SUPPRESSION
L. W. HODGE and J. A. BREAKWELL (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 106-113.

Large space optical system vibration suppression is presently undertaken through the assembly of an integrated optics/structures/controls simulation, in order to test the performance of the primary control system. This high authority control/low authority control (HAC/LAC) system's simulated performance for a defined suppression requirement encompassed a partially validated FEM model, the requisite optical performance algorithms, and a closed loop HAC/LAC model. The specified -40 dB requirements are met with actuators of minimal, 0.5-lb weight at eight locations, which cause no significant changes in either modal frequency or shape. O.C.

A88-34613#
MODAL TESTING R&D AT THE COMMUNICATIONS RESEARCH CENTRE
Y. SOUCY, F. R. VIGNERON, and T. STEELE (CDC, Communications Research Centre, Ottawa, Canada) (Canadian Symposium on Aerospace Structures and Materials, 3rd, Ottawa, Canada, June 9-11, 1986) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 34, March 1988, p. 38-47. refs

In the last ten years, novel methods of parameter identification have been developed and modal testing technology has rapidly expanded, primarily as a result of the availability of low-cost, high-performance minicomputers and test equipment. Modal tests are broadly characterizable as phase-resonance and mode-separation methods; attention is presently given to the latter, in which one or more excitation devices are used to induce structure motions that contain all structural modes of interest. Projects of this kind that are presently discussed include the step-relaxation and driven-base excitation techniques for space structure parameter estimation, the testing of large, flexible space structures, and the evaluation of a substructure coupling method. O.C.

A88-34736
TIME OPTIMAL SLEWING OF FLEXIBLE SPACECRAFT
JOSEPH BEN-ASHER, JOHN A. BURNS, and EUGENE M. CLIFF (Virginia Polytechnic Institute and State University, Blacksburg) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 524-528. refs
(Contract AF-AFOSR-85-0287)

The time-optimal slewing problem of flexible spacecraft is considered. The system is discretisized by the assumed-modes method, and the problem is solved for a linearized model in reduced state space by parameter optimization. Optimality is verified by the maximal principle. The linear solution is used to obtain time-optimal solutions for the nonlinear problem. I.E.

A88-34737
APPROXIMATION IN DISCRETE-TIME BOUNDARY CONTROL OF FLEXIBLE STRUCTURES
J. S. GIBSON (California, University, Los Angeles) and I. G. ROSEN (Southern California, University, Los Angeles, CA) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 535-540. refs
(Contract AF-AFOSR-84-0309; AF-AFOSR-84-0393)

The authors consider discrete-time LQG (linear quadratic Guassian) optimal control of flexible structures with boundary control and what normally are unbounded measurement operators. The application of recently developed approximation theory for infinite-dimensional discrete-time LQG problems to this problem is discussed. Numerical results are given for control of a flexible beam. I.E.

A88-34805* Brown Univ., Providence, RI.
PARAMETER IDENTIFICATION TECHNIQUES FOR THE ESTIMATION OF DAMPING IN FLEXIBLE STRUCTURE EXPERIMENTS
H. T. BANKS, Y. WANG (Brown University, Providence, RI), D. J. INMAN, and H. CUDNEY, JR. (New York, State University, Buffalo) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1392-1395. refs
(Contract NAG1-517; AF-AFOSR-84-0398; AF-AFOSR-85-0220; NSF MSM-83-51807; AF-AFOSR-85-01)

The use of spline-based inverse procedures to estimate damping coefficients for flexible structures in distributed-parameter systems is reported. Damping models involving viscous (air) damping and Kelvin-Voigt damping in an Euler-Bernoulli framework are used to analyze data from vibration experiments with composite material beams. I.E.

A88-34812
TIME OPTIMAL SLEWING OF A RIGID BODY WITH FLEXIBLE APPENDAGES
G. SINGH, P. T. KABAMBA, and N. H. MCCLAMROCH (Michigan, University, Ann Arbor) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1441, 1442. refs

The control problem of time-optimal, rest-to-rest, slewing of a rigid body with flexible appendages through a large angle is considered. A finite-dimensional time-optimal slewing problem is proposed as a relaxation of an ill-posed infinite-dimensional time-optimal slewing problem. The optimal control history is shown to have an important time symmetry property. The switching times, final time, and costates at midmaneuver are shown to satisfy a system of nonlinear algebraic equations. I.E.

A88-34813
STABILITY AND EQUILIBRIA OF DEFORMABLE SYSTEMS
ANTHONY M. BLOCH (Michigan, University, Ann Arbor) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1443, 1444. refs
(Contract NSF DMS-87-01574; AF-AFOSR-ISSA-87-0077)

The stability of the equilibrium states of a deformable body, consisting of a rigid body with attached flexible rod is considered. By the so-called Energy-Casimir method formal stability is proved for the nontrivial equilibrium with lowest angular velocity. I.E.

A88-34914
MODELLING AND STABILIZATION OF FLEXIBLE SPACECRAFT UNDER THE INFLUENCE OF ORBITAL PERTURBATION
N. U. AHMED and SANG S. LIM (Ottawa, University, Canada) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2331-2336. refs

The problem of modelling of large flexible spacecraft and their stabilization under the influence of orbital (radial) perturbation is considered. The dynamics of the flexible spacecraft is derived using Hamilton's principle. The equations of motion consist of a coupled system of ordinary differential equations and partial differential equations. The asymptotic stability of the system is proved using Lyapunov's approach. Simple feedback controls are suggested for the stabilization of the system. For illustration, numerical simulations are carried out. I.E.

A88-34916* Rensselaer Polytechnic Inst., Troy, NY.
MODEL REFERENCE CONTROL OF THE NASA SCOLE PROBLEM
HOWARD KAUFMAN and ABRAHAM MUSALEM (Rensselaer Polytechnic Institute, Troy, NY) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2341-2343.
(Contract NAG1-515)

Model reference controllers have been developed and applied to the linearized Spacecraft Control Laboratory Experiment (SCOLE) roll beam mode equation. When a large- but finite-dimensional approximation to the partial differential equation is used, the resulting control will be finite-dimensional, but possibly not adequately representative for the actual distributed-parameter system. To date the theory for such model reference controllers has been developed; here it is applied to a 16th-order finite-dimensional representation of the flexible and rigid body modes of the SCOLE. Results of the analysis and some preliminary simulation studies are presented. I.E.

A88-34917
COMPUTING THE TRANSMISSION ZEROS OF LARGE SPACE STRUCTURES
TREVOR WILLIAMS (NASA, Langley Research Center, Hampton, VA) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2344, 2345. SERC-supported research. refs

The transmission zeros of a large space structure can be computed by the general-purpose algorithm of A. Emami-Naeini and P. Van Dooren (1982). However, careful use of the special form of the equations of motion of structural dynamics leads to a new method that is about twice as fast as theirs when applied to a damped structure, and at least 60 times as fast for an undamped one. I.E.

A88-35115* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LARGE SPACE SYSTEMS REQUIREMENTS, DEPLOYABLE CONCEPTS, AND TECHNOLOGY ISSUES
U. M. LOVELACE and L. B. GARRETT (NASA, Langley Research Center, Hampton, VA) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1019-1034. refs
(AAS PAPER 86-394)

This paper summarizes some of the future civil missions requiring large space systems technologies. Antenna, collector, and reflector missions are generalized to define a similar set of system requirements and characteristics. Although many concepts exist for both deployable and space assemblable large structures, four technically mature deployable concepts are reviewed. Two of these concepts are probably applicable to only antenna/collector missions, whereas the other two employ continuous trusses which can be configured for a broad range of planar, linear, or curved structures. Finally, technology problems or needs associated with large deployable systems are reviewed to highlight additional research and development, both analytical and experimental, required to reduce mission risk. Author

A88-35116* Martin Marietta Corp., Denver, CO.
MEMBER VIBRATION EFFECTS ON LSS BEHAVIOR
CHARLES W. WHITE (Martin Marietta Corp., Denver, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1035-1049. refs
(Contract NAS1-7551)
(AAS PAPER 86-396)

This paper evaluates the sensitivity of modal characteristics of large deployable lattice-type space structures to joint boundary conditions. The evaluation of joint rotational boundary conditions is accomplished by a review of modal strain energy among elements of the analytic dynamic model. This review shows that space structure designs having no bending energy in lattice members in the low frequency range are insensitive to joint rotational boundary conditions in that frequency range. Evaluation of joint translation boundary conditions is accomplished by the 'modal freeplay method' which is described in this paper. The modal freeplay method relates modal frequency to joint translational freeplay and to amplitude of applied forces. Author

A88-35117
DISTRIBUTED AND CONCURRENT COMPUTATION FOR SPACE STRUCTURES
JOHN E. HERSHEY, ROBERT F. KUBICHEK, and JAMES E. SCHROEDER (BDM Corp., Boulder, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1051-1055.
(AAS PAPER 86-397)

An evaluation is made of the development status and prospects of distributed/concurrent real-time computation methods in the control of large space structures, with attention to the subtle interplay between hardware, algorithm, and computer architecture design factors. Current efforts are noted to be developing in distinct, microparallelization and macroparallelization directions. It appears doubtful that any single processor will be sufficient to handle the real-time computational loads associated with such structures. O.C.

A88-35526
RECENT TRENDS IN AEROELASTICITY, STRUCTURES, AND STRUCTURAL DYNAMICS; PROCEEDINGS OF THE R. L. BISPLINGHOFF MEMORIAL SYMPOSIUM, UNIVERSITY OF FLORIDA, GAINESVILLE, FL, FEB. 6, 7, 1986
PRABHAT HAJELA, ED. (Florida, University, Gainesville) Symposium sponsored by NSF, USAF, and MIT;. Gainesville, FL, University Presses of Florida, 1987, 424 p. For individual items see A88-35527 to A88-35547.
(Contract NSF ECE-86-02170)

The papers contained in this volume provide an overview of the state of the art in the field of aeroelasticity and aeronautical structures, including surveys of well-developed fields of study and

new contributions in emerging areas of technology. The subject areas covered include fixed and rotary wing aeroelasticity; aeroelastic considerations in rotating machinery; aeroelastic problems in bridge design; structural analysis and structural dynamics in aerospace applications; aeroservoelastic considerations; and the emerging discipline of optimal structural design. Papers are presented on the whirl flutter of swept tip propfans; aeroelasticity of very light aircraft; structural stability in turbulent flow; and structural tailoring of aircraft performance. V.L.

A88-35541
INTERACTIVE STRUCTURAL AND CONTROLLER SYNTHESIS FOR LARGE SPACECRAFT
S. C. MCINTOSH, JR. (McIntosh Structural Dynamics, Inc., Palo Alto, CA) and M. A. FLOYD (Integrated Systems, Inc., Palo Alto, CA) IN: Recent trends in aeroelasticity, structures, and structural dynamics; Proceedings of the R. L. Bisplinghoff Memorial Symposium, Gainesville, FL, Feb. 6, 7, 1986. Gainesville, FL, University Presses of Florida, 1987, p. 283-297. refs
(Contract F49620-84-C-0025)

A technique is developed for least-weight optimal design of a tubular-truss space structure, subject to constraints on its natural frequencies and its open-loop disturbance-rejection properties. The disturbance-rejection properties of the structure are measured by disturbance-to-regulated-variable grammians. It is shown how this technique can be embedded in a model-reduction scheme based on internal balancing. The procedure is applied to to a simple 'dumbbell' model and CSDL Model No. 1. Author

A88-35543
DYNAMIC RESPONSES OF ORTHOTROPIC PLATES UNDER MOVING MASSES
O. P. AGRAWAL (Southern Illinois University, Carbondale, IL) and SUNIL SAIGAL (Worcester Polytechnic Institute, MA) IN: Recent trends in aeroelasticity, structures, and structural dynamics; Proceedings of the R. L. Bisplinghoff Memorial Symposium, Gainesville, FL, Feb. 6, 7, 1986. Gainesville, FL, University Presses of Florida, 1987, p. 313-333. refs

The problem considered is that of heavy masses moving on lightweight rectangular plates of orthotropic materials, slated for use in space structures. The dynamic equation of motion for orthotropic plates which contains singularities in both space and time variables is first presented. The response is expressed as a summation of double series of eigenfunctions. The equation of motion is transformed into an integro-differential equation for modal amplitudes using the Green's function. The Green's function is chosen to satisfy the initial conditions, the boundary conditions, and the transient conditions due to the moving masses. The solution series exhibits a good convergence. The effect of orthotropicity on natural frequencies and dynamic responses is demonstrated. Author

A88-35940#
SPACE STATION ERECTABLE TRUSS JOINT EVALUATION
J. H. PEEBLES and K. B. KEMPSTER (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 9 p.
(AIAA PAPER 88-2448)

The structural and functional suitability of five different joint concepts developed and fabricated as part of an advanced development project for the Space Station program is evaluated. The joints were tested in axial tension and compression to determine their inherent stiffness, damping, and nonlinear characteristics which may have a strong influence on the dynamic behavior of a Space Station or other large space structures such as those proposed for SDI concepts. Ease of operation, maintainability, and reliability of the joint concepts are also addressed. Underwater test results for two of the joints are also described. C.D.

A88-35941#
PERFORMANCE ENHANCEMENT OF PASSIVELY DAMPED JOINTS FOR SPACE STRUCTURES
JACKY C. PRUCZ and C. C. SPYRAKOS (West Virginia University, Morgantown) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 23 p. refs
(AIAA PAPER 88-2450)

This paper presents a theoretical performance analysis of different configurations for passively damped joints that could be used as alternatives to the conventional double-lap configuration. A rational approach is described for predicting the effects of structural interactions between various constituents of a passively damped joint on some of its performance characteristics, including weight, damping, strength, and stiffness in the load transfer direction. Numerical results are described for a rhomblike geometry where the viscoelastic adhesive is enclosed by the elastic joint measurements, and for the application of lateral pressure-tension to the outer adherends of a double-lap jont. A rational methodology for developing innovative joining concepts for space structure is described which can provide enhanced dissipation of vibrational energy without serious penalties in strength, stiffness, or weight characteristics. C.D.

A88-35942#
DESIGNING SPACE STATION STRUCTURE FOR ASSEMBLY
F. DAVID RIEL (McDonnell Douglas Astronautics Co., Space Station Div., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 7 p.
(AIAA PAPER 88-2453)

The principal factors influencing the design of the Space Station, which will be approximately 650 feet wide by 350 feet tall when fully deployed, are examined. In particular, the design of the primary truss structure to be assembled in space is described, and it is shown how the design decisions have been influenced by assembly considerations. The decisions discussed include those related to incremental growth, maintenance, Orbiter capability, EVA capability, and test and verification methods. V.L.

A88-35944#
SPACE STATION TRUSS STRUT TUBE DESIGN
KARL B. KEMPSTER and HANK W. BABEL (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 6 p.
(AIAA PAPER 88-2471)

The paper describes the rationale that led to the current Space Station truss strut tube design. The system-level and derived requirements and the design options developed to satisfy them are discussed. The designs addressed both material and construction options. The selection criteria for evaluating the design options are reviewed and the recommended truss strut tube design is described. Author

A88-37000
DAMPING MATERIALS FOR SPACECRAFT VIBRATION CONTROL
JUN FUJIMOTO, RYOSUKE UGO (NEC Corp., Kawasaki, Japan), YOHZOH YAMAMOTO (Mitsui Petrochemical Research Center, Ichihara, Japan), and KAZUHIDE TODOME (NEC Corp., Space Development Div., Yokohama, Japan) IN: International Conference on Composite Materials, 6th, and European Conference on Composite Materials, 2nd, London, England, July 20-24, 1987, Proceedings. Volume 5. London and New York, Elsevier Applied Science, 1987, p. 5.134-5.143. refs

Newly developed constrained shear damping materials for spacecraft vibration control are epoxy based polymers. These materials show high damping capability (tan delta max=1.3-1.8) and have low outgassing (TML less than 1 percent) in a space environment. Damping material SS-37 was applied to the 'Yo-Yo' bracket in the 11th scientific satellite ASTRO-C (Japan). Author

A88-37278#
METHODS FOR SPACECRAFT SIMULATION IN VIBRO-ACOUSTIC ENVIRONMENTS
P. G. BREMNER and D. C. RENNISON (Vipac Pty., Ltd., Australia) IN: National Space Engineering Symposium, 3rd, Canberra, Australia, June 30-July 2, 1987, Preprints of Papers. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co., 1987, p. 232-237. refs

Seemingly quite different modelling approaches to spacecraft design are emerging for acoustic and random vibration environments. The authors endeavor to unify these methods as a single vibro-acoustics field. A good understanding of the theory is necessary to make decisions on cost-effective spacecraft analysis and test strategies. The paper describes three modelling strategies, their inter-relationships and their relative merits or realm of suitability. These are Finite Element Methods, Statistical Energy Analysis and the Power Flow Method. Original work by the authors is presented to demonstrate the application to aerospace structural design problems. Particular attention is drawn to the accuracy and useable frequency range of the different methods, including validation exercises using test data. Test facilities are proposed for the cost-effective simulation of vibro-acoustic environments in a manner appropriate to Australian needs. Author

A88-37466
USE OF MODAL ENERGY DISTRIBUTION IN THE DESIGN OF HONEYCOMB SANDWICH DECKS
M. SAMBASIVA RAO, P. S. NAIR (Indian Space Research Organization, Satellite Centre, Bangalore, India), and S. DURVASULA (Indian Institute of Science, Bangalore, India) Computers and Structures (ISSN 0045-7949), vol. 28, no. 6, 1988, p. 737-743. refs

Through the example of a spacecraft equipment deck, which is generally made of honeycomb sandwich construction, it is shown that modal energy distribution can be used as an effective guideline in improving the deck's frequencies to meet the restrictions imposed upon it. The kinetic energy distribution is employed as a basis for redistributing various packages on the deck. Strain energy distribution is used to identify areas which can be stiffened by bonding 'doublers' on the face sheets and the doubler thickness is obtained from a sensitivity analysis. Author

A88-38389#
DYNAMICS OF VISCOELASTIC STRUCTURES
K. J. BUHARIWALA and J. S. HANSEN (Toronto, University, Canada) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 220-227. refs

A general method is presented for model material damping in dynamical systems. The work is primarily concerned with a dissipation model based on viscoelastic assumptions. Motion equations are formulated in operator form for a structure constructed from an anisotropic, viscoelastic material. The mass, damping, and stiffness operators are developed consistently in the formulation. Basic operator properties are discussed, and orthonormality conditions are derived for the viscoelastic system. Modal identities are derived for a constrained viscoelastic structure. These identities provide useful criteria in order reduction of finite-element models. An example of a viscoelastic beam in pure flexure is illustrated. Author

A88-38390#
EXPERIMENTAL STUDY OF TRANSIENT WAVES IN A PLANE GRID STRUCTURE
WILLIAM L. HALLAUER, JR. and DINESH J. TRIVEDI (Virginia Polytechnic Institute and State University, Blacksburg) (Structures, Structural Dynamics, and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 888-899) AIAA Journal (ISSN 0001-1452), vol. 26, Feb. 1988, p. 228-234. Previously cited in issue 14, p. 2174, Accession no. A87-33741. refs
(Contract F49620-85-C-0024; NSF CME-80-14059)

A88-38689*# PRC Kentron, Inc., Hampton, VA.
SENSITIVITY ANALYSIS OF A DEPLOYABLE THREE LONGERON TRUSS BEAM DESIGNED FOR MINIMUM MEMBER LOADS DURING DEPLOYMENT
DIRK B. WARNAAR (PRC Kentron, Inc., Hampton, VA) and JERROLD M. HOUSNER (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, ASCE, and AHS, Structures, Structural Dynamics and Materials Conference, 29th, Williamsburg, VA, Apr. 18-20, 1988. 9 p. refs
(AIAA PAPER 88-2436)

The significant design variables of a deployable three longeron truss beam, designed for minimum member loads during deployment, are identified and the sensitivity of the load level in the members of the truss beam due to variations of the design variables is established. The analysis of the deployment models, developed in this paper, is carried out using a commercially available computer code, called DADS. Based on the results of the analysis, guidelines are formulated for the design of a deployable three longeron truss beam to achieve minimum loads in the members during deployment. The paper concludes with a brief discussion of the applicability of the approach, taken in this paper, to other truss configurations. Author

A88-39724
DISTRIBUTED SENSORS AND ACTUATORS FOR VIBRATION CONTROL IN ELASTIC COMPONENTS
J. E. HUBBARD, JR. (Charles Stark Draper Laboratory, Inc.; MIT, Cambridge, MA) IN: NOISE-CON 87; Proceedings of the National Conference on Noise Control Engineering, State College, PA, June 8-10, 1987. Poughkeepsie, NY, Noise Control Foundation, 1987, p. 407-412.

The paper presents data pertaining to the design and implementation of distributed sensing and actuation for one-dimensional structural components which may be used in the design of large space structures for active vibration control. The results apply to an active damper developed at the Massachusetts Institute of Technology which involves the use of polyvinylidene. The system made up of a sensing film, a beam structure, and an actuation film represents an autonomous structure which may be combined with closed loop control strategies to yield 'smart' structural members in more complex systems. K.K.

A88-40251
1987 SEM SPRING CONFERENCE ON EXPERIMENTAL MECHANICS, HOUSTON, TX, JUNE 14-19, 1987, PROCEEDINGS
Conference sponsored by SEM. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, 981 p. For individual items see A88-40252 to A88-40301.

The papers presented in this volume provide an overview of current research in the field of experimental mechanics. Topics discussed include composites, photoelasticity, optical methods in experimental mechanics, fracture, and modal testing and analysis. Other topics include identification of large structures, gaskets and bolted assemblies, strain gage applications, hybrid techniques in fracture and stress analysis, and wave propagation studies using optical techniques. V.L.

A88-40261
INSTRUMENTATION FOR MODAL TESTING OF LARGE SPACE STRUCTURES
DOUGLAS A. HENDERSON and WAYNE YUEN (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 122-127. refs

Instrumentation and modal parameter survey requirements for two 12-m truss beams are described, and problems associated with the ground testing of large space structures are identified. In particular, attention is given to transducer selection and data measurement requirements. Piezoelectric, piezoresistive, and LED sensors are found to meet frequency, dynamic range, and practical usage requirements. Future transducer requirements are reviewed,

emphasizing the requirements for low mass velocity sensors, greater proximity probe gap sizes, and improved fiber optics methods. V.L.

A88-40773*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
ANALYTIC REDUNDANCY MANAGEMENT FOR SYSTEMS WITH APPRECIABLE STRUCTURAL DYNAMICS
RAYMOND C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) International Association for Mathematics and Computers in Simulation, World Congress on Scientific Computation, 12th, Paris, France, July 18-22, 1988, Paper. 4 p. refs

This paper deals with analytic redundancy management of systems that have appreciable structural dynamics and require active control. The class of systems considered is large, lightweight spacecraft that have large numbers of distributed sensors and actuators. Both preliminary design and on-line operations are studied. For the preliminary design we deal with the placement of the sensor and actuator components on a highly flexible spacecraft. For on-line operation an analytic redundancy management system based on examination of the residuals of a Kalman filter is considered. A large, flexible grid made of overlapping aluminum bars is used to experimentally evaluate this analytic redundancy management system. Results of the experimental evaluation are included in the paper. Author

A88-41038
A CONTINUUM MODEL FOR THE NONLINEAR ANALYSIS OF BEAM-LIKE LATTICE STRUCTURES
D. B. MCCALLEN (Lawrence Livermore National Laboratory, Livermore, CA) and K. M. ROMSTAD (California, University, Davis) Computers and Structures (ISSN 0045-7949), vol. 29, no. 2, 1988, p. 177-179, 181-197. refs

A simple equivalent continuum model has been developed for the geometrically nonlinear analysis of beam-like lattice structures. Two important features of the model are the simplicity of the calculation of the continuum properties and the ability of the continuum to accurately predict the behavior of rigid-joint as well as pin-joint lattices. The equivalence of the continuum and lattice is established by requiring the strain energy of the continuum to equal the strain energy of the lattice for a finite set of assumed deformation modes. It is shown that an additional strain energy term not found in classical Timoshenko beam theory must be included in the continuum strain energy function in order to accurately approximate the behavior of rigid-joint frames. A finite element discretization is applied to the continuum to obtain numerical solutions for the continuum model. By comparison with discrete finite element results for the lattice, the accuracy of the continuum methodology is demonstrated for both static and dynamical problems. For the nonlinear problems studied, the continuum solutions were found to require only a small fraction of the CPU time needed for the discrete finite element solutions. Author

A88-41885
MANUFACTURING OF DAMAGE-RESISTANT COMPOSITE STRUCTURES FOR AEROSPACE APPLICATIONS
ASHOK K. MUNJAL (Aerojet Strategic Propulsion Co., Sacramento, CA) IN: Advanced composites III: Expanding the technology; Proceedings of the Third Annual Conference, Detroit, MI, Sept. 15-17, 1987. Metals Park, OH, ASM International, 1987, p. 53-56. refs

The present discussion of emerging manufacturing methods for the production of damage-resistant composite structures addresses impact, fatigue, and creep damage resistance effects obtainable by identifiable design, materials formulation, and fabrication practices. Damage containment methods encompass stitching of layup plies, interleafing, three-dimensional reinforcements, hybrid materials, and the incorporation of external protection materials. Attention is given to the effects of strength, modulus, strain-to-failure, fracture toughness, and resistance to environmental temperature and humidity. O.C.

A88-42574
STRUCTURAL VIBRATION OF SPACE POWER STATION SYSTEMS
M. J. CROCKER, P. K. RAJU, E. CHRISTENSEN, N. H. MADSEN, E. GUINDON (Auburn University, AL) et al. IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 205-224. Research supported by Auburn University and SDIO. refs
(Contract DNA001-85-C-0183)

A new approach to the control of active vibration in large flexible structures based on wave cancellation techniques is reported. A finite element model of the vibratory response of large flexible spacecraft truss structures to systems of applied forces representing machinery forces and maneuvers is developed. Predictions regarding the pointing accuracy and tip displacement of such structures to the assumed force inputs are presented. The optimization of the structures to minimize dynamic response is addressed, and interfacial damping in composite structures is modeled and subjected to finite element analysis. C.D.

A88-44839#
A SELF-CONSISTENT TENSION SHELL STRUCTURE FOR APPLICATION TO AEROBRAKING VEHICLE AND ITS AERODYNAMIC CHARACTERISTICS
TAKASHI ABE (Institute of Space and Astronautical Science, Sagamihara, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p. refs
(AIAA PAPER 88-3405)

A new method determining a tension shell structure for an application to an aerobraking vehicle is proposed. In this method, the tension shell configuration can be determined self-consistently in that the pressure distribution which is used to determine the shell configuration can be consistent with the one appearing on the configuration. The aerodynamic characteristics of the tension shell is also investigated numerically. Author

A88-45227* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
OPTIMAL EXPERIMENT DESIGN FOR IDENTIFICATION OF LARGE SPACE STRUCTURES
D. S. BAYARD, F. Y. HADAEGH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and D. R. MELDRUM (Stanford University, CA) Automatica (ISSN 0005-1098), vol. 24, May 1988, p. 357-364. refs

The optimal experiment design for on-orbit identification of modal frequency and damping parameters in large flexible space structures is discussed. The main result is a separation principle for D-optimal design which states that under certain conditions the sensor placement problem is decoupled from the input design problem. This decoupling effect significantly simplifies the overall optimal experiment design determination for large MIMO structural systems with many unknown modal parameters. The error from using the uncoupled design is estimated in terms of the inherent damping of the structure. A numerical example is given, demonstrating the usefulness of the simplified criteria in determining optimal designs for on-orbit Space Station identification experiments. Author

A88-46041* Brown Univ., Providence, RI.
THE IDENTIFICATION OF A DISTRIBUTED PARAMETER MODEL FOR A FLEXIBLE STRUCTURE
H. T. BANKS (Brown University, Providence, RI), S. S. GATES (Charles Stark Draper Laboratory, Inc., Cambridge, MA), I. G. ROSEN, and Y. WANG (Southern California, University, Los Angeles, CA) SIAM Journal on Control and Optimization (ISSN 0363-0129), vol. 26, July 1988, p. 743-762. Previously announced in STAR as N87-19760. refs
(Contract NSF MCS-85-04316; AF-AFOSR-84-0398; AF-AFOSR-84-0393; NAG1-517; NAS1-17070; NAS1-18107)

A computational method is developed for the estimation of parameters in a distributed model for a flexible structure. The

structure we consider (part of the RPL experiment) consists of a cantilevered beam with a thruster and linear accelerometer at the free end. The thruster is fed by a pressurized hose whose horizontal motion effects the transverse vibration of the beam. The Euler-Bernoulli theory is used to model the vibration of the beam and treat the hose thruster assembly as a lumped or point mass dashpot spring system at the tip. Measurements of linear acceleration at the tip are used to estimate the hose parameters (mass, stiffness, damping) and a Voigt-Kelvin viscoelastic structural damping parameter for the beam using a least squares fit to the data. Spline based approximations are considered to the hybrid (coupled ordinary and partial differential equations) systems; theoretical convergence results and numerical studies with both simulation and actual experimental data obtained from the structure are presented and discussed. Author

A88-46402* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTINUUM MODELING OF LARGE LATTICE STRUCTURES - STATUS AND PROJECTIONS
AHMED K. NOOR and MARTIN M. MIKULAS (NASA, Langley Research Center, Hampton, VA) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 1-34. Previously announced in STAR as N88-14115. refs
(Contract NAG1-740)

The status and some recent developments of continuum modeling for large repetitive lattice structures are summarized. Discussion focuses on a number of aspects including definition of an effective substitute continuum; characterization of the continuum model; and the different approaches for generating the properties of the continuum, namely, the constitutive matrix, the matrix of mass densities, and the matrix of thermal coefficients. Also, a simple approach is presented for generating the continuum properties. The approach can be used to generate analytic and/or numerical values of the continuum properties. Author

A88-46403
NONLINEARITIES IN THE DYNAMICS AND CONTROL OF SPACE STRUCTURES - SOME ISSUES FOR COMPUTATIONAL MECHANICS
S. N. ATLURI and M. IURA (Georgia Institute of Technology, Atlanta) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 35-70. USAF-SDIO-supported research. refs

Semidiscrete computational methods for the dynamical analysis of large space structures (LSSs) and the design of passive or active LSS controllers are described and demonstrated. Strategies for reduced-order structural-dynamic modeling of beam and shell LSSs undergoing large deformation are developed analytically, representing the LSSs as equivalent elastic continua, and applied to truss-and-frame lattice-type LSSs. Particular attention is given to sample problems involving a 12-bay space truss subjected to axial loads, a framed dome loaded at the crown point, and a beam-column lined with piezoelectric material. Extensive diagrams, graphs, and tables of numerical data are provided. T.K.

A88-46404* Purdue Univ., West Lafayette, IN.
MODAL COST ANALYSIS FOR SIMPLE CONTINUA
A. HU, R. E. SKELTON, and T. Y. YANG (Purdue University, West Lafayette, IN) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 71-94. refs
(Contract NAG1-642)

The most popular finite element codes are based upon appealing theories of convergence of modal frequencies. For example, the popularity of cubic elements for beam-like structures is due to the rapid convergence of modal frequencies and stiffness properties. However, for those problems in which the primary consideration is the accuracy of response of the structure at specified locations, it is more important to obtain accuracy in the modal costs than in the modal frequencies. The modal cost represents the contribution of a mode in the norm of the response vector. This paper provides a complete modal cost analysis for simple continua such as beam-like structures. Upper bounds are developed for mode truncation errors in the model reduction process and modal cost analysis dictates which modes to retain in order to reduce the model for control design purposes. Author

A88-46405
ON THE TRANSIENT DYNAMICS OF FLEXIBLE ORBITING STRUCTURES
V. J. MODI and A. M. IBRAHIM (British Columbia, University, Vancouver, Canada) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 95-114. refs
(Contract NSERC-G-1547)

Complex interactions between deployment, attitude dynamics and flexural rigidity are reviewed using a rather general formulation applicable to a large class of space platforms with flexible, extensible members. The governing nonlinear, nonautonomous and coupled hybrid set of equations 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 several dynamical situations of contemporary interest involving beam type appendages. Both transient as well as postdeployment phases are considered. Results suggest significant influence of flexibility, inertia, deployment time history and orbital parameters on the system stability. The presence of free molecular and solar radiation induced environmental forces may further accentuate this tendency. The information has relevance to the design of control systems for the next generation of communications satellites with large solar panels; the Orbiter-based experiments such as SAFE, COFS, NASA/CNR tethered subsatellite system, etc.; as well as constructional and operational phases of the proposed space station. Author

A88-47964#
TWO-DIMENSIONAL DEPLOYABLE TRUSS STRUCTURES FOR SPACE APPLICATIONS
JUNJIRO ONODA (Tokyo, University, Japan) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 109-116. refs

A variable-length diagonal (VLD) member-employing truss that can be folded by elongation of some members and a sliding-hinge, double-fold (SHDF) truss that can be folded upon sliding some of its hinge assemblies are presently compared to existing deployable truss alternatives. It is established that the number of mechanical elements which must be actuated and locked during VLD and SHDF deployment is only about half as many as the number involved in double-fold and biaxial double-fold types. The neccessary conditions for the trusses' folding/deployment are formulated, and the design flexibility of each concept in the formation of a globally curved surface is investigated. O.C.

A88-49271* Commonwealth Scientific and Industrial Research Organization, Epping (Australia).
SUPERNOVA 1987A - A RADIOSPHERE RESOLVED WITH VLBI FIVE DAYS AFTER THE NEUTRINO BURST
D. L. JAUNCEY (CSIRO, Div. of Radiophysics, Epping, Australia), A. KEMBALL (Hartebeesthoek Radio Astronomy Observatory, Johannesburg, Republic of South Africa), N. BARTEL, I. I. SHAPIRO (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA), A. R. WHITNEY, A. E. E. ROGERS (Haystack Observatory, Westford, MA), R. A. PRESTON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and T. A. CLARK (NASA, Goddard Space Flight Center, Greenbelt, MD) Nature (ISSN 0028-0836), vol. 334, Aug. 4, 1988, p. 412-415. NSF-supported research. refs

The results of VLBI observations of SN1987A are reported. No emission from the supernova above a level of about 20 percent of the supernova's total flux density was detected, although signals were detected from two calibrator sources with amplitudes roughly equal to those determined in earlier VLBI observations. It is inferred that the supernova's radiosphere was resolved, and a lower bound on the radiosphere's radius of 2.2 mas is estimated from an epoch 5.2 days after the neutrino burst. Given the photometric data from

the supernova, a distance to the LMC of 50 + or - 5 kpc, and an apparent expansion velocity that varied systematically with time from 18,000-16,000 km/s, as estimated from the blue-shifted H-alpha absorption lines on the days preceding the observations, it is concluded that 5.2 days after the neutrino burst the supernova's radiosphere was at least 2.5 times larger than the inferred blackbody photosphere, and at least as large as the H-alpha line-forming region. C.D.

A88-49658
DYNAMIC ANALYSIS OF FINITELY STRETCHED AND ROTATED THREE-DIMENSIONAL SPACE-CURVED BEAMS
M. IURA and S. N. ATLURI (Georgia Institute of Technology, Atlanta) Computers and Structures (ISSN 0045-7949), vol. 29, no. 5, 1988, p. 875-889. refs
(Contract F49620-87-C-0064)

The problem of transient dynamics of highly flexible three-dimensional space-curved beams undergoing large rotations and stretches, is treated. The case of conservative force loading, which may also lead to configuration-dependent moments on the beam, is considered. Using the three parameters associated with a conformal rotation-vector representation of finite rotations, a well-defined Hamilton functional is established for the flexible beam undergoing finite rotations and stretches. A Newmark time-integration scheme is used to integrate the semi-discrete finite-element equations in time. Several examples of transient dynamic response of highly flexible beam-like structures including those in free flight, are presented to illustrate the validity of the theoretical methodology. Author

A88-50168#
A DISTURBANCE MODEL FOR THE OPTIMIZATION OF CONTROL/STRUCTURE INTERACTIONS FOR FLEXIBLE DYNAMIC SYSTEMS
G. L. SLATER (Cincinnati, University, OH) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 57-63. USAF-supported research. refs
(AIAA PAPER 88-4058)

This paper deals with a technique for the integrated optimization of structure and control in the design of flexible spacecraft and other flexible systems. This current approach uses the response to dynamic inputs and constraint limits to establish trade-offs between control energy and structural mass. This approach gives a concise variational approach to total system optimization and eliminates the need to specify rather arbitrary trade-offs between control energy and structural mass. Results give an explicit dependency between structural stiffness (hence mass), disturbance magnitude, control energy available and deflection constraints. For the special case of linear controls and quadratic constraints the problem reduces to a standard LQG problem plus a structure optimization. The method is general, however, and can be extended to more general problems such as output feedback, nonlinear controls, and slew optimization. Author

A88-50169*# DYNACS Engineering Co., Inc., Clearwater, FL.
EFFECTS OF NONLINEAR DAMPING IN FLEXIBLE SPACE STRUCTURES
ANREN HU (DYNACS Engineering Co., Inc., Clearwater, FL) and LAWRENCE W. TAYLOR (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 64-73. refs
(AIAA PAPER 88-4059)

The classical Krylov-Bogoliubov 'averaging' technique is used to study a class of nonlinear damping models, for which the damping force is proportional to the product of positive integer or fractional power of absolute values of displacement and that of velocity. The results are compared with linear viscous damping models. The amplitude decrement of free vibration for a single mode system with nonlinear models depends not only on damping ratio, but also on the initial amplitude, the time to measure the response, frequency of the system, and the powers of displacement and velocity. For the distributed system, the action of nonlinear damping is found to reduce energy of the system as well as to pass energy to higher modes. Experimental evidence such as in Spacecraft Control Laboratory Experiment seems to support the need for nonlinear models. Author

A88-50246#
SYSTEM IDENTIFICATION AND CONTROL OF THE TRUSS EXPERIMENT - A RETROSPECTIVE
MICHAEL S. LUKICH (TRW, Inc., Redondo Beach, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 821-831. refs
(AIAA PAPER 88-4152)

Research on an experimentally validated system identification and control technology for large space structures is reviewed. Brief synopses of theoretical developments in system identification, multivariable control system design, and passive/active control are given. The emphasis is on the the results of the truss experiment and the lessons learned from them. C.D.

A88-50367#
A SLEW MANEUVER EXPERIMENT OF MISSION FUNCTION CONTROL
HIRONORI FUJII (Tokyo Metropolitan Institute of Technology, Hino, Japan) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 130-134. refs
(AIAA PAPER 88-4226)

A control algorithm, named 'The Mission Function Control', is experimentally demonstrated and verified its validity on slew maneuver of a flexible space structure model. The mission function control algorithm is to use a Liapunov-type function consists of generalized energy functions. The model is a rigid main body equipped with a flexible beam and is controlled to slew in a horizontal plane by a torque motor attached to the main body. The vibrational motion of the flexible beam is sensed by strain gages as bending moment and shearing force at the root of the beam after analytical reduction of the algorithm. Results of the experiment show simple implementation of the algorithm and such an excellent controlled behavior of the slew maneuver as control robustness. Author

A88-50383#
ANALYTICAL EXPRESSIONS FOR VIBRATORY DISPLACEMENTS OF DEPLOYING APPENDAGES
A. K. MISRA (McGill University, Montreal, Canada) and S. KALAYCIOGLU IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 270-277. refs
(AIAA PAPER 88-4250)

For beam-type appendages, solutions are presented for uniform extension rate, exponential extension and deployment where the square of the length varies linearly with time. For tethered systems, an analytical solution is presented for the common exponential deployment (or retrieval). The analytical solutions seem to be quite close to the more expensive numerical solutions. If the length changes, the amplitude of transverse vibration varies as L(exp 1/2) for beam-type and L(exp - 1/4) for tether-type appendages. Author

A88-50385#
A POLE PLACEMENT TECHNIQUE FOR VIBRATION SUPPRESSION OF FLEXIBLE STRUCTURES
NELSON G. CREAMER (General Research Corp., Arlington, VA) and JOHN L. JUNKINS (Texas A & M University, College Station) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug.

15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 286-293. refs
(AIAA PAPER 88-4254)

A novel pole placement technique is developed for stabilizing an initially undamped (or lightly damped) structure using symmetric 'structural' feedback. The feedback matrices are expressed in terms of prescribed symmetric, positive semi-definite submatrices and unknown scale factors (gain elements). The gain elements are designed to place a set of target eigenvalues at (or near) their desired locations by imposing state space orthogonality conditions which the closed-loop structure must satisfy. A standard linear programming problem is formulated which not only places the target eigenvalues but also minimizes the modal dissipation and potential energy of the target modes and satisfies actuator force limits. In addition, the untargeted, higher frequency modes are guaranteed to be stable due to the positivity of the gain submatrices. Author

A88-50428#
A FORMULATION FOR STUDYING DYNAMICS OF INTERCONNECTED BODIES WITH APPLICATION

A. C. NG and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 660-668. refs
(Contract NSERC-58-0029)
(AIAA PAPER 88-4303)

A relative general formulation for studying the dynamics of spacecraft with interconnected flexible bodies is presented accounting for thermal deformations and transverse vibrations of the structural members. In addition, the shift in the center of mass of the system and the slewing maneuvers of the members are incorporated. The formulation can be applied to study the U.S. proposed Space Station as well as a large class of present and future spacecraft. An example illustrates application of the formulation. The model under study is a satellite with a central rigid body and a pair of beam-type appendages. The librational and vibrational responses of the system with and without thermal deformation are compared. The results show that in circular orbits, under a critical combination of system parameters and initial conditions, thermal deformation can lead to instability. Author

A88-50429#
A DYNAMICAL STUDY OF THE PROPOSED SPACE STATION TYPE CONFIGURATION

A. SULEMAN and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 669-680.
(Contract NSERC-A-2181)
(AIAA PAPER 88-4304)

The planar libration-vibration interaction dynamics of the proposed Space Station is investigated using a simplified model where the keel and solar panels are represented as beams and the central pressurized modules as a rigid body. Following a Lagrangian analysis of the governing nonlinear nonautonomous and coupled equations of motion, a finite element analysis is used to study the first seven system modes and associated frequencies. A parametric analysis of the system librational and vibrational response is then presented. Finally, a closed-form solution of the simplified nonlinear problem is obtained using the variation of parameters method. R.R.

A88-50432#
ACTIVE CONTROL EXPERIMENT USING PROOF MASS ACTUATORS

T. CRISTLER and R. A. CALICO (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 695-703.
(AIAA PAPER 88-4307)

An experimental investigation of a vertically suspended cantilevered beam was performed in order to study the control of large space structures. In the present experimental arrangement, control forces were provided by linear proof mass actuators and structural motion was measured using peizoelectric accelerometers. The structure provided six vibration modes in the designated control bandwidth. The simultaneous operation of separate controllers while maintaining overall system stability was demonstrated, along with suppression of a mode from one of the controllers. Although the proof mass actuators were shown to be viable structural control devices, they have limited force output at low frequencies. R.R.

A88-50809
IDENTIFICATION OF A COMPLEX SATELLITE MODEL BY MEANS OF MODAL SYNTHESIS

WERNER SACHS (DFVLR, Institut fuer Aeroelastik, Goettingen, Federal Republic of Germany) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 468-475. refs

A study conducted in order to answer many of the open questions in the field of modal synthesis, with particular attention given to practical applicability, is summarized. The design of the interfaces, test condition of the substructures, sensitivity of the procedure dependent on the measuring errors, convergence acceleration, interface loading, and damping influences are considered. A new representation of the synthesis algorithm used here is introduced. C.D.

A88-50862
LARGE TRUSS STRUCTURES

M. SIERRA (Sener-Ingenieria y Sistemas, S.A., Las Arenas, Spain) and M. FUENTES (Sener-Ingenieria y Sistemas, S.A., Madrid, Spain) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1091-1097.

The possible use of deployable structures that reach their final configuration in orbit is discussed. The existing concepts of deployable structures are classified into groups. The dynamic behavior of these structures in the fully stowed condition, during the intermediate deployment sequence, and in the fully deployed condition are examined. Four specific deployable trusses from a study made by the ESA are presented and analyzed. R.B.

A88-50873
COMPARISON OF THEORETICAL AND EXPERIMENTAL MODAL ANALYSIS RESULTS OF A RECTANGULAR THREE DIMENSIONAL FRAME

R. SAMUEL, R. K. RAMANATHAN, S. SHANKARNARAYANAN, and K. H. NAVALGUND (ISRO, Satellite Centre, Bangalore, India) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1214-1218.

The spacecraft structures are qualified using base excitation on a shaker system whereas experimental modal analysis is done using Single Point Random (SPR) method. Experimental (SPR and base excitation) and theoretical results show good agreement for a simple three dimensional frame with fixed boundary condition and these results are presented in this paper. Author

A88-50891
BEAM MODIFICATIONS OF STRUCTURAL SYSTEMS UTILIZING THE RECEPTANCE APPROACH WITH STATIC FLEXIBILITY

R. R. LIN, A. B. PALAZZOLO, R. M. ALEXANDER, and C. H. GERHOLD (Texas A & M University, College Station) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1557-1564. refs

Structural modification algorithms were developed for reanalyzing a structure subjected to a local change. The goal is

to predict the modified system modal parameters using only the experimental data from the original system. Most structural modification methods are based on the eigensolution derivative concept. In this research the modification algorithm consists of adding a beam element to the structure and then predicting not only the new natural frequencies, but also the damping ratios. Two different algorithms were examined: a damped receptance approach and an eigensolution derivative approach. The results of these two algorithms were compared to those from an ANSYS finite element model. In addition, the effects of including static flexibility in the receptance approach were examined. Experimental tests on a cantilever beam were conducted. The results of the receptance method were excellent, especially when the static deflections were utilized; however, the results of the eigensolution derivative approach were poor if the local modification was large. Author

A88-50892* Howard Univ., Washington, DC.
FREQUENCY OPTIMIZATION OF REPETITIVE LATTICE BEAM-LIKE STRUCTURES USING A CONTINUUM MODEL
ROBERT REISS (Howard University, Washington, DC) and K. JAYARAMAN IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1565-1572. refs
(Contract NAG1-383)

A new method for obtaining the maximum frequency design of a beam-like repetitive lattice structure is presented. Using existing techniques, the lattice is first modeled as an equivalent anisotropic Timoshenko beam. The computation of the stiffness and inertial properties of the beam, determined by matching the strain and kinetic energies of the beam with those of the lattice, is facilitated by the repetitive nature of the lattice. The optimum design is obtained by maximizing Rayleigh's quotient using methods of variational calculus. For the problem selected, results show excellent agreement with those obtained by traditional finite-element methods. Moreover, unlike FE methods, cpu time is relatively unaffected by the size of the truss. Author

A88-50897
IDENTIFICATION OF MULTIPLE-INPUT MODAL PARAMETERS FROM MULTIPLE-FREQUENCY RESPONSE FUNCTION
RUIYAN LIU (National University of Defense Technology, Changsha, People's Republic of China) and ZIJIE FAN IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1645-1650. refs

In this paper a new concept of multiple frequency response function-MFRF is presented. The identification model of multiple-input modal parameters is established from MFRF, and the calculating formula and process are given. The analytical results of two examples show that the proposed method has the advantages of accuracy, consistency and separating closely-space modes, etc. The method can be used perfectly for experimental modal analysis of large or complicated structures. Author

A88-50899
SPATIAL DISTRIBUTION OF MODEL ERROR BASED ON ANALYTICAL/EXPERIMENTAL FREQUENCY DISCREPANCIES
G. DUDLEY SHEPARD (Lowell, University, MA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1665-1668. refs

The intent of modal analysis is to develop a reliable dynamic model of a structure by determining and comparing the analytical and experimental modal properties of frequency, damping and mode shape. In addition to identifying these modal properties it would be desirable to determine spatially which parts of the structure are modeled poorly or well. This information could be used to improve the finite element model. It could also point to faults in the structure and hence help to evaluate mechanical integrity. This paper shows how the pattern of discrepancies in the analytical and experimental test values for the pole and zero frequencies of a structure can be linked to discrepancies in the mass or stiffness of the structural elements. Author

A88-50980
AEROELASTIC INTERACTIONS WITH FLIGHT CONTROL OF TRANSATMOSPHERIC VEHICLES
ROBERT L. SWAIM (Oklahoma State University, Stillwater) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 574-581. refs

The research needed on structural dynamics interactions with rigid body dynamics and stability augmentation systems to allow confidence in vehicle design are discussed. This includes high-temperature-gradient effects on two- and three-dimensional total-vehicle elastic mode shapes and natural frequencies; robust control laws tolerant of wide uncertainties in elastic mode data; and compatible mathematical models for dynamic analysis of structures exhibiting low-frequency shell-type elastic modes. The expected use of metal matrix and carbon-carbon composite materials and ceramics with internally circulated cooling fluid will greatly complicate proper modeling and analysis of these interactions. I.E.

A88-52639
DYNAMICS ANALYSIS OF A SYSTEM OF HINGE-CONNECTED FLEXIBLE BODIES
MADELEINE PASCAL (Paris VI, Universite, France) Celestial Mechanics (ISSN 0008-8714), vol. 41, no. 1-4, 1987/88, p. 253-274. Research supported by Matra Espace. refs

The subject of this work is the dynamics of flexible space vehicles modeled by a chain of rigid and elastic bodies with tree structure. The aim is to obtain an impedance matrix giving (in the frequency domain) the response of the structure to external forces. It is possible to obtain an expansion of this impedance matrix in terms of an infinite set of modal frequencies (termed constrained modes) and an expansion of the inverse of this impedance matrix in terms of another set of modes. The work is a generalization of the theory of Hugues (1974) and others for systems with star structure. Author

A88-53126#
ADVANCED COMPOSITES FOR MAGELLAN SPACECRAFT
D. A. STANG (Martin Marietta Corp., Astronautics Group, Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 4 p.
(AIAA PAPER 88-3031)

Over 100 composite tubes were built for truss members for the Magellan spacecraft which is to orbit and radar-map the planet Venus. Materials used were unidirectional and woven E-glass, S-2 glass, high-strength high modulus graphite. All were used in the form of epoxy preimpregnated broadgoods. Tube diameters ranged from 1 to 4 inches, and tube construction ranged from five to 21 layers. All tubes were fabricated and cured on aluminum mandrels. Each truss member assembly was proofloaded in axial compression prior to final vehicle assembly. This presentation will focus on the design, fabrication, and testing of three of the graphite/epoxy tube configuration. Author

A88-53420
LOAD DEPENDENT SUBSPACE REDUCTION METHODS FOR STRUCTURAL DYNAMIC COMPUTATIONS
PIERRE LEGER (McGill University, Montreal, Canada) Computers and Structures (ISSN 0045-7949), vol. 29, no. 6, 1988, p. 993-999. refs

The evaluation of the dynamic response analysis of large structures by vector superposition requires in its traditional formulation the solution of a large and expensive eigenvalue problem. A new method of dynamic analysis using load-dependent transformation vectors for systems subjected to fixed spatial distribution of dynamic loads was introduced by Wilson et al. (1982) as an economic alternative to the usual mode-superposition

method. Here, new computational variants to generate a load-dependent transformation basis for arbitrary transient loading which are a function of space and time are presented. Numerical applications on a simple structural system are used to show the relative efficiency of the proposed solution procedure over classical solution methods using mode-displacement, mode-acceleration, or the original (fixed) load-dependent reduction method. Author

A88-53785
NECESSARY CONDITIONS OF GEOMETRICAL STABILITY IN TRUSSES WHICH INCLUDE ONE-FORCE MEMBERS
CARL C. VON STETTEN (Stubbins Associates, Inc., Cambridge, MA) SAWE, Annual Conference, 46th, Seattle, WA, May 18-20, 1987. 26 p. refs
(SAWE PAPER 1776)

Trusses may include three distinct types of members: either compressionally or tensionally stressed one-force members, and two-force members that bear stresses both compressionally and tensionally. Attention is presently given to the nature of those conditions which, according to both theoretical and pragmatic criteria, are more advantageous when trusses are allowed to include one-force members rather than two-force members exclusively. It is found that many systems of joints can be stabilized entirely with one-force members, with negligible effect on the number of members required. O.C.

A88-54532* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
RAPID MULTI-FLEXIBLE-BODY MANEUVERING EXPERIMENTS
JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1009-1014. refs

Progress at the NASA Langley Research Center in the area of rapid multiple-flexible-body maneuvering experiments is described. The experiments are designed to verify theoretical analyses using control theory for the control of flexible structures. The objective of the maneuvering experiments is to demonstrate slewing of flexible structures in multiple axes while simultaneously suppressing vibration to have acceptable motion at the end of the maneuver. The status of some research activities oriented primarily to the experimental methods for control of flexible structures is presented. I.E.

A88-54533
DEVELOPMENT OF A CONTROL ORIENTED MODEL OF A CANTILEVERED BEAM WITH END-MASS
UMIT OZGUNER and ERIC BREITFELLER (Ohio State University, Columbus) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1015-1020. USAF-supported research.

A cantilevered beam configuration with a disk at the end is considered. Active vibration damping is to be accomplished with two sets of double proof-mass actuators mounted on the disk. A mathematical model is developed for control studies, based on a combination of analytical modeling of both the structure and the actuators, with experimental validation and adjustment. I.E.

A88-54572* Air Force Wright-Patterson Aeronautical Labs., Wright-Patterson AFB, OH.
ADVANCED CONTROL EVALUATION FOR STRUCTURES (ACES) PROGRAMS
JEROME PEARSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) and HENRY WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1448-1452.

The ACES programs are a series of past, present, and future activities at the Marshall Space Flight Center (MSFC) Ground facility for Large Space Structure Control Verification (GF/LSSCV). The main objectives of the ACES programs are to implement control techniques on a series of complex dynamical systems, to determine the control/structure interaction for the control techniques, and to provide a national facility in which dynamics and control verification can be effected. The focus is on these objectives and how they are implemented under various engineering and economic constraints. Future plans that will be effected in upcoming ACES programs are considered. I.E.

A88-54573* Control Dynamics Co., Huntsville, AL.
ACES PROGRAM - LESSONS LEARNED
VICTORIA L. JONES, SALLY C. RICE (Control Dynamics Co., Huntsville, AL), and HENRY B. WAITES (NASA, Marshall Space Flight Center, Huntsville, AL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1453-1455.

The ACES Program involved the experimental evaluation of three LSS (large space structures) control design techniques at the LSS GTF (ground test facility) at NASA/MSFC. The three techniques were developed under the ACOSS (active control of space structures) Program specifically for application to LSS. The techniques included FAMESS (filter accommodated model error sensitivity suppression), HAC/LAC (high authority control/low authority control), and positivity. Some of the lessons that have been learned during the course of the ACES program are examined. I.E.

A88-54574
APPLICATION OF FAMESS TO A LARGE SPACE STRUCTURE GROUND TEST FACILITY
R. DENNIS IRWIN (Ohio University, Athens) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1456-1461.

Filter accommodated model error sensitivity suppression (FAMESS) is applied to the problem of regulating the line-of-sight (LOS) of a laser beam pointing system mounted on a 13-m flexible beam, which is the current configuration of the Marshall Space Flight Center Large Space Structure Ground Test Verification Facility (LSS/GTV). The configuration of the LSS/GTV exhibits many of the pathologies usually associated with large space structures (LSS). The collection of techniques commonly known as FAMESS is used to accomplish the design of the LOS regulating control system for the LSS/GTV. These techniques include decentralization, alpha shifting techniques, model error sensitivity suppression, and filter accommodation. Representative test results are presented and illustrate the dramatic degradation of performance which can be expected when significant system behavior is unmodeled. I.E.

A88-54577
IDENTIFICATION OF A FLEXIBLE TRUSS STRUCTURE USING LATTICE FILTERS
MARIBETH D. ROESLER, MICHAEL S. LUKICH (TRW, Inc., Control Systems Engineering Dept., Redondo Beach, CA), FARYAR JABBARI (California, University, Irvine), and J. S. GIBSON (California, University, Los Angeles) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1474-1482. refs

The size and complexity of next-generation space structures present a formidable challenge for online (adaptive) identification methods. The methods must accommodate a variety of structural changes resulting from on-orbit assembly, spacecraft docking, and time-varying disturbance, which affect the order of the structural system's model. TRW's flexible truss structure was used to demonstrate the feasibility of the least-squares lattice filter for the identification of both a time-invariant and a time-varying system. The results, including natural frequency estimates, frequency responses, and one-step-ahead predictions, show that the lattice filters provide accurate and timely estimates for the different

configurations considered, in particular for a two-input two-output plant and a time-varying system. I.E.

A88-54587* National Taiwan Univ., Taipei.
DECENTRALIZED MODEL REFERENCE ADAPTIVE CONTROL OF LARGE FLEXIBLE STRUCTURES
FU-MING LEE, I-KONG FONG (National Taiwan University, Taipei, Republic of China), and YU-HWAN LIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1538-1543. Sponsorship: National Science Council of the Republic of China. refs
(Contract NSC-77-0404-E002-28)

A decentralized model reference adaptive control (DMRAC) method is developed for large flexible structures (LFS). The development follows that of a centralized model reference adaptive control for LFS that have been shown to be feasible. The proposed method is illustrated using a simply supported beam with collocated actuators and sensors. Results show that the DMRAC can achieve either output regulation or output tracking with adequate convergence, provided the reference model inputs and their time derivatives are integrable, bounded, and approach zero as t approaches infinity. I.E.

A88-54603
ON THE CALTECH EXPERIMENTAL LARGE SPACE STRUCTURE
GARY J. BALAS and JOHN C. DOYLE (California Institute of Technology, Pasadena) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1701, 1702. Research supported by California Institute of Technology and TRW, Inc.

A large-space-structure experiment developed at the California Institute of Technology is reported. The main thrust of the experiment is to address the identification and robust control issues associated with large space structures by capturing their characteristics in the laboratory. The design, modeling, indentification, and control objectives are discussed. I.E.

A88-54989#
TRANSFER MATRIX ANALYSIS OF CABLE-STIFFENED HOOP PLATFORMS
R. G. LOEWY (Rensselaer Polytechnic Institute, Troy, NY) and C. L. ZARETZKY Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 45-52. refs
(Contract AF-AFOSR-83-0348)

A transfer matrix methd is applied to the free-vibration analysis of a series of cable-stiffened hoop platforms, which are often encountered as subassemblies in large space antennas. The method takes advantage of the cyclic symmetry of the structures to reduce significantly the amount of computations necessary to determine natural frequencies and the associated mode shapes. Numerical difficulties, which often arise in transfer matrix analyses of periodic structures, are not encountered with the method presented. Free-vibration characteristics are calculated for equilateral hoop assemblies with from 5 to 11 segments. Properties are chosen to allow comparison with the earlier experiments and calculations of Belvin, and good agreement is shown for that specific, hexagonal hoop platform. Running time comparisons indicate that the transfer matrix approach provides a promising alternative to finite-element methods for the dynamic analysis of spacecraft structures characterized by slender substructures and repetitive geometry. Author

A88-55088*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SINE DWELL OR BROADBAND METHODS FOR MODAL TESTING
JAY-CHUNG CHEN and BEN K. WADA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2B, p. 998-1004) AIAA Journal (ISSN 0001-1452), vol. 26, June 1988, p. 733-737. Previously cited in issue 14, p. 2113, Accession no. A87-33752. refs

A88-55371#
CONTROL OF LARGE SPACE STRUCTURES USING REDUCED ORDER MODELS
JAYANT V. RAMAKRISHNAN (Dynacs Engineering Co., Inc., Clearwater, FL), S. VITTAL RAO, and LESLIE R. KOVAL (Missouri-Rolla, University, Rolla) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p. refs
(IAF PAPER 88-272)

Two reduced-order system modeling methods, the balanced-realization method and the multivariable Routh method, are considered in the context of the control of large space structures via reduced-order controllers. Results of simulations are presented to demonstrate that controllers based on reduced-order models provide efficient control performance, with good correlation between suboptimal and optimal responses. It is noted, however, that the method of model reduction is often problem dependent and that some methods may be more amenable than others for a class of problems. V.L.

A88-55375*# Howard Univ., Washington, DC.
EFFECT OF NATURAL DAMPING ON THE DYNAMICS AND CONTROL OF A CLASS OF OPTIMALLY DESIGNED STRUCTURES
K. SATYANARAYANA and M. BAINUM (Howard University, Washington, DC) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. Research supported by Howard University and NASA. refs
(IAF PAPER 88-288)

In this study the vibration control of large space structures with structural damping is investigated. Emphasis is made on the control of both a class of optimally designed (stepped) structures and also the corresponding uniform structures using a cantilever beam as an example. The open loop and closed loop dynamics are compared and the transient responses are determined to study the effect of damping on the control system design. Author

A88-55378#
GENERIC MODEL LABORATORY TESTS FOR LARGE FLEXIBLE STRUCTURE CONTROL
THOMAS LANGE (DFVLR, Wessling, Federal Republic of Germany) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 8 p.
(IAF PAPER 88-294)

A generic model testing concept for large flexible structures is developed which involves a two-stage test procedure based on the 'ideal' and 'realistic' approaches. The 'ideal' test approach addresses the fundamental problems of structural dynamics vs. control interaction, with hardware imperfections excluded as far as possible. The 'realistic' approach covers unpredicted hardware constraints interfering with the overall system dynamics and is implemented in software in a real-time processor in addition to external filtering and noise suppression. Based on results obtained for a hanging plate, it is suggested that a systematic sequence of tests be developed which approaches, step by step, the expected generic features of large space structures. V.L.

A88-55379*# Houston Univ., TX.
IDENTIFICATION OF LARGE STRUCTURES ON ORBIT - A SURVEY
EUGENE E. DENMAN (Houston, University, TX), JER-NAM JUANG (NASA, Langley Research Center, Hampton, VA), JOHN L. JUNKINS (Texas A & M University, College Station), MANOHAR KAMAT (Georgia Institute of Technology, Atlanta), T. K. HASSELMAN et al. IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. USAF-supported research. refs
(IAF PAPER 88-295)

This paper seeks to provide a brief overview of the somewhat unfamiliar concept underlying system identification especially as it applies to large flexible space structures. Having elaborated on the concept, the authors provide a detailed description of the identification process including model development, its experimental validation and final certification. This discussion is followed by a classification of the different identification methods and a brief evaluation of the potential of existing methodology to address special circumstances of large flexible space structures. The paper concludes by making a few recommendations that are deemed necessary to meet the enormous challenges posed by the deployment or erection of large space structures. Author

A88-55386#
OPTIMAL DEPLOYMENT OF SPACECRAFT APPENDAGES
A. K. MISRA (McGill University, Montreal, Canada) and S. KALAYCIOGLU IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p. refs
(IAF PAPER 88-307)

The existing dynamical analyses of axially moving beams assume a given deployment scheme (usually, uniform deployment rate) and determine the corresponding vibratory response. The present paper, however, attempts to determine deployment schemes so that the vibrations during deployment are minimized. The minimization is carried out using Pontriagin's principle. In this, deployment of a beam-type appendage from a given initial length to a desired final length within a specified duration of time is considered and the square of the displacement, integrated over the length and over the given duration, is minimized. The two point boundary value problem obtained is solved numerically. The vibration during this optimum deployment scheme is much smaller than that during uniform or exponential deployment. Author

A88-55391#
DYNAMICS OF INTERCONNECTED FLEXIBLE MEMBERS IN THE PRESENCE OF ENVIRONMENTAL FORCES - A FORMULATION WITH APPLICATIONS
V. J. MODI and A. C. NG (British Columbia, University, Vancouver, Canada) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. refs
(Contract NSERC-G-1547)
(IAF PAPER 88-318)

A relatively general formulation for studying the dynamics of spacecraft with interconnected flexible bodies is presented accounting for thermal deformations and transverse vibrations of the structural members. In addition, the shift in the center of mass of the system and the slewing maneuvers of the members are incorporated. The formulation can be applied to study the U.S. proposed Space Station as well as a large class of present and future spacecraft. An example illustrates application of the formulation. The model under study is a satellite with a central rigid body and a pair of appendages. The satellite response is investigated numerically over a range of system parameters and effect of the thermal deformations assessed. An approximate closed-form (analytical) solution of the problem is also obtained to quickly assess trends and gain better physical appreciation of response characteristics. Author

N88-21190*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A 60-METER ERECTABLE ASSEMBLY CONCEPT FOR A CONTROL OF FLEXIBLE STRUCTURES FLIGHT EXPERIMENT
JUDITH J. WATSON and WALTER L. HEARD, JR. Feb. 1988 20 p
(NASA-TM-100497; NAS 1.15:100497) Avail: NTIS HC A03/MF A01 CSCL 22B

A flight experiment which proposes to use a 60-m deployable/retractable truss beam attached to the Space Shuttle to study dynamic characterization and control of flexible structures is being studied by NASA. The concept requires a relatively complex mechanism for deploying and retracting the truss on-orbit. Development of such a mechanism having a high degree of reliability will be expensive. An alternative method for constructing the truss is discussed requiring no new technology development or complex mechanisms and has already been demonstrated on-orbit. The alternative method proposes an erectable truss beam which can be assembled by two astronauts in EVA. The EVA crew would have to manually assemble the beam from 468 struts and 165 nodes, and install 7 instrumentation platforms with signal and power cabling. The predicted assembly time is 3 hr and 23 min. The structure would also have to be disassembled and restowed following testing, thus 2 EVA days would be required. To allow 25 hr for data collection (probably a bare minimum to accomplish meaningful tests), current Shuttle operations policy dictates a 9-day mission. The design, assembly procedure and issues associated with the alternative concept are discussed.
Author

N88-21201# Fokker B.V., Amsterdam (Netherlands).
THE DEVELOPMENT STATUS OF THE STRONGBACK ARRAY
R. ZWANENBURG *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 65-71 Dec. 1987
Avail: NTIS HC A14/MF A01

A lifesize model of the strongback array (STAR) was built. The model demonstrates the feasibility of this deployable and retractable support structure. Deployment analyses show good correspondence with the test results. The measured bending stiffness of the mast in deployed condition is between 50,000 to 200,000 Nmsq. Stiffness depends on the preload condition and the considered load environment. Mast stiffness may decrease significantly if the mast shape deviates from the ideal deployed condition. A very simple mast layout without a bottom sliding rail is possible for deployments of experiment payloads. ESA

N88-21202# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
A SEQUENTIALLY DEPLOYABLE STRUCTURE FOR SPACE APPLICATIONS
F. PANIN, M. EIDEN, M. SIERRA, and J. RIVACOBA (Sener S.A., Las Arenas, Spain) *In its* Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 73-82 Dec. 1987
Avail: NTIS HC A14/MF A01

A large truss structure which deploys sequentially from the spacecraft was designed, and the deployment was simulated using the Automatic Dynamic Analysis of Mechanical Systems package. The development model of the deployable truss is formed by three bays. When in the deployed configuration, each bay is a cube of 1 m side formed of 2 battens connected by struts. By the use of joints in the middle and at the end of struts, the bay can be folded to a very reduced length. Actuation is achieved by torsional springs in the joints and the deployment is controlled according to a chosen law by the release of retaining cables.
ESA

N88-21472*# AEC-Able Engineering Co., Inc., Goleta, CA.
THERMALLY STABLE DEPLOYABLE STRUCTURE
COLLEEN M. KEGG *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium, p 45-57 May 1988
Avail: NTIS HC A18/MF A01 CSCL 20K

A deployable structure which meets stringent thermal and strength requirements in a space environment was developed. A mast with a very low coefficient of thermal expansion (CTE) was required to limit the movement from thermal distortion over the temperature range of -200 C to 80 C to .064 cm (.025 in). In addition, a high bending strength over the temperature range and weight less than 18.1 kg (40 lbs) was needed. To meet all of the requirements, a composite, near-zero CTE structure was developed. The measured average CTE over the temperature range for the mast was .70 x .000001/C (.38 x .000001/F). The design also has the advantage of being adjustable to attain other specific CTE if desired. Author

N88-21473*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE X-BEAM AS A DEPLOYABLE BOOM FOR THE SPACE STATION
LOUIS R. ADAMS *In its* The 22nd Aerospace Mechanisms Symposium, p 59-66 May 1988
Avail: NTIS HC A18/MF A01 CSCL 22B

Extension of antennas and thrust modules from the primary structure of the space station will require deployable beams of high stiffness and strength, as well as low mass and package volume. A square boom cross section is desirable for interface reasons. These requirements and others are satisfied by the X-beam. The X-beam folds by simple geometry, using single-degree-of-freedom hinges at simple angles, with no strain during deployment. Strut members are of large diameter with unidirectional graphite fibers for maximum beam performance. Fittings are aluminum with phosphor bronze bushings so that compliance is low and joint lifetime is high. The several beam types required for different applications on the space station will use the same basic design, with changes in strut cross section where necessary. Deployment is by a BI-STEM which pushes the beam out; retraction is by cables which cause initial folding and pull the beam in. Author

N88-21474*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MOTION SYNCHRONIZATION OF A MECHANISM TO DEPLOY AND RESTOW A TRUSS BEAM
M. LUCY *In its* The 22nd Aerospace Mechanisms Symposium, p 67-85 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13E

The functions of the Control of Flexible Structures I (COFS I) deployer and retractor assembly (DRA) are primarily to deploy and retract the Mast I beam, and secondarily to latch, unlatch, and restow the DRA mechanism. The problems associated with the diagonal folding mechanism that retracts the beam is presented, the synchronization requirements critical to the process of restowing the beam is discussed, and a proposed solution to the problem of synchronization between the mechanical systems is presented. In addition, a detailed description is presented of the design and functioning of the DRA. Author

N88-22066# WEA, Cambridge, MA.
WAVE PROPAGATION AND DYNAMICS OF LATTICE STRUCTURES Final Report, 1 Sep. 1985 - 30 Sep. 1987
JAMES H. WILLIAMS, JR. 1 Oct. 1987 40 p
(Contract F49620-85-C-0148)
(AD-A190037; AFOSR-88-0062TR) Avail: NTIS HC A03/MF A01 CSCL 22B

One of the most attractive structural configurations for large space structures (LSS) for outer space applications is the repetitive lattice concept. Achieving the operational requirements of such structures will necessitate considerable knowledge of the dynamics, control, materials and nondestructive evaluation (NDE) of these structural systems. Wave propagation analyses provide potentially valuable perspectives from which to consider this broad range of analysis, design and synthesis issues. The theoretical and experimental results of a two-year research program on the wave propagation and dynamics of LSS are briefly reviewed. Potential benefits of wave propagation analyses in the vibration, parameter identification, dynamic failure, control and NDE of lattice structures have been identified and are summarized in this report. GRA

N88-22070# Clarkson Univ., Potsdam, NY.
NONLINEAR ANALYSIS AND OPTIMAL DESIGN OF DYNAMIC MECHANICAL SYSTEMS FOR SPACECRAFT APPLICATION Final Technical Report, 1 Feb. 1984 - 31 Jul. 1987
K. D. WILLMERT and M. SATHYAMOORTHY Sep. 1987 103 p
(Contract AF-AFOSR-0076-84)
(AD-A190644; AFOSR-87-2008TR) Avail: NTIS HC A06/MF A01 CSCL 22B

Analysis and optimal design procedures for planar as well as spatial mechanisms frequently used in space structures are developed. A nonlinear finite element procedure, developed originally for planar mechanisms during the initial stages of this research, has been modified considerably to handle complex mechanisms with sliding masses and mechanisms operating at relatively high speeds. The analysis takes into account the effects of geometric and material nonlinearities, vibrational effects and coupling of deformations. Numerical results have been reported for certain mechanism examples. The effects of nonlinearities on the dynamic behavior of mechanisms are significant. Considerable progress has been made in developing a nonlinear finite element procedure for 3-D mechanisms. Numerical results obtained for some example problems show the validity of the current 3-D formulation. A new optimization algorithm has also been developed based on the Gauss method to handle various types of nonlinear constraints with the goal of reducing the number of analyses required to obtain and optimal design. Details of the nonlinear finite element procedures as well as the optimization technique are available in published papers, copies of which are included. goal of reducing the number of analyses required to obtain an optimal design. Complete details of the nonlinear finite element procedures as well as the optimization technique are available in published papers, copies of which are included here in the Appendix. GRA

N88-22378# Weidlinger Associates, New York, NY.
VIBRATIONS OF STRUCTURES WITH PARAMETRIC UNCERTAINTIES Final Report, Jan. 1984 - Sep. 1987
HAYM BENAROYA 31 Oct. 1987 75 p
(Contract F49620-84-C-0009)
(AD-A190400; AFOSR-87-1734TR) Avail: NTIS HC A04/MF A01 CSCL 22A

The focus of this research effort has been the study of structural dynamics with parameter and environmental uncertainties. The motivation for this study rests with the need to understand the dynamics and control of large space structures. Stochastic stability and output stationarity are also studied. GRA

N88-22924# Technische Hogeschool, Delft (Netherlands). Faculty of Aerospace Engineering.
MAXIMUM LIKELIHOOD PARAMETER IDENTIFICATION OF FLEXIBLE SPACECRAFT
QI PING CHU Mar. 1987 264 p
(LR-508; B8733287; ETN-88-92456) Avail: NTIS HC A12/MF A01

Identifying parameters of a flexible spacecraft model from in-orbit measurements is discussed, emphasizing mathematical modelling of a flexible spacecraft, using finite element analysis, and maximum likelihood parameter estimation, based on system models of reduced order with correlated process and measurement noise. It is shown that finite element analysis can be used to develop mathematical models of finite order of three-dimensional flexible spacecraft in arbitrary orbits. The following parameters in the flexible spacecraft model may be estimated from dynamic response measurements: Young's elasticity modulus, the Poisson ratio, the inertia matrix of the rigid main body and the jet input amplitudes. ESA

N88-22928# Virginia Univ., Charlottesville. Dept. of Electrical Engineering.
VIBRATION CONTROL OF LARGE STRUCTURES Final Technical Report, 1 Jan. - 31 Dec. 1986
ANTHONY K. AMOS Sep. 1987 33 p
(Contract F49620-86-K-0009)
(AD-A191358; UVA/525673/MAE88/101; AFOSR-88-0007TR)
Avail: NTIS HC A03/MF A01 CSCL 22A

This is a study of vibration control for large space structures. Advantage is taken of the limiting performance characteristics of dynamic systems. This approach permits large problems with constraints to be analyzed. A modal formulation for the limiting performance was developed in order to enhance the applicability of limiting performance to large structural systems. One effort to develop an optimal control system is based on the limiting

performance approach in combination with classical/optimal control theory. A limiting-performance/minimum-time solution was formulated to achieve the goal of rapid suppression of disturbances. Classical/optimal control studies show that a position loop might be useful in taking care of constraint controllers, such as proof-mass dampers. Finally, to derive feedback control law based on the limiting performance characteristics, parameter identification technique has been under investigation. GRA

N88-23226*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
LEWIS STRUCTURES TECHNOLOGY, 1988. VOLUME 1: STRUCTURAL DYNAMICS
May 1988 463 p Symposium held in Cleveland, Ohio, 24-25 May 1988
(NASA-CP-3003-VOL-1; E-3970-VOL-1; NAS 1.55:3003-VOL-1) Avail: NTIS HC A20/MF A01 CSCL 20K

The specific purpose of the symposium was to familiarize the engineering structures community with the depth and range of research performed by the Structures Division of the Lewis Research Center and its academic and industrial partners. Sessions covered vibration control, fracture mechanics, ceramic component reliability, parallel computing, nondestructive testing, dynamical systems, fatigue and damage, wind turbines, hot section technology, structural mechanics codes, computational methods for dynamics, structural optimization, and applications of structural dynamics.

N88-23265# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Direction Scientifique de la Resistance des Structures.
A NONLINEAR COMPUTATION FOR COMPOSITE STRUCTURES Final Report [UN MODULE DE CALCUL NON LINEAIRE POUR LES STRUCTURES COMPOSITES]
R. GIRARD Mar. 1987 40 p In FRENCH
(Contract DRET-86-34-001)
(ONERA-RT-15/3542-RY-062-R; ETN-88-92141) Avail: NTIS HC A03/MF A01

A procedure based on total Lagrangian implementation, where the nonlinear problem is solved numerically by increment and iteration (Newton method with load increments) is presented. The finite element model is general enough to allow the analysis of large structures built with composite materials. Algorithms and computation strategies are compared. ESA

N88-23819# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
TRAVELLING WAVE CONCEPTS FOR THE MODELING AND CONTROL OF SPACE STRUCTURES Final Report, 1 Mar. 1986 - 31 Oct. 1987
A. H. VONFLOTOW and S. R. HALL 31 Jan. 1988 442 p
(Contract F49620-86-C-0039)
(AD-A191235; AFOSR-88-0278TR) Avail: NTIS HC A19/MF A01 CSCL 22A

This report summarizes 20 months of research into Travelling Wave Concepts for the Modelling and Control of Space Structures. A good portion of the research has focused upon the development of techniques for the modelling of structural response in terms of disturbance propagation. Such models are of interest for several reasons: (1) Understanding the mechanisms that govern the propagation of disturbances through an elastic structure is useful for building intuition, for structural design and for design of active control, (2) Disturbance propagation models have the potential for providing high-fidelity analysis capabilities in response regimes where other techniques are inapplicable. Of considerable interest to the researchers at MIT is the response of elastic spacecraft to disturbances with significant spectral content at frequencies including many (even hundreds) of the spacecraft natural modes of structural vibration; and (3) Elastic disturbance propagation is a classic area of research in applied mechanics, having application in acoustics, seismology, microwave electronics, transducer design, biological fluid mechanics, design of mechanisms and machines, and many other areas. GRA

N88-23826*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
LDR STRUCTURAL EXPERIMENT DEFINITION
RICHARD A. RUSSELL and RICHARD M. GATES (Boeing Aerospace Co., Seattle, Wash.) Jun. 1988 51 p
(NASA-TM-100618; NAS 1.15:100618) Avail: NTIS HC A04/MF A01 CSCL 22B

A study was performed to develop the definition of a structural flight experiment for a large precision segmented reflector that would utilize the Space Station. The objective of the study was to use the Large Deployable Reflector (LDR) baseline configuration for focusing on experiment definition activity which would identify the Space Station accommodation requirements and interface constraints. Results of the study defined three Space Station based experiments to demonstrate the technologies needed for an LDR type structure. The basic experiment configurations are the same as the JPL baseline except that the primary mirror truss is 10 meters in diameter instead of 20. The primary objectives of the first experiment are to construct the primary mirror support truss and to determine its structural and thermal characteristics. Addition of the optical bench, thermal shield and primary mirror segments and alignment of the optical components occur on the second experiment. The structure will then be moved to the payload pointing system for pointing, optical control and scientific optical measurement for the third experiment. Author

N88-23995 Purdue Univ., West Lafayette, IN.
CONTINUUM MODELING AND DYNAMIC ANALYSIS OF LARGE TRUSS STRUCTURES Ph.D. Thesis
BRAHIM NECIB 1987 163 p
Avail: Univ. Microfilms Order No. DA8729772

Truss Structures such as large space structures consist of a large number of truss members. Full scale finite element analysis which accounts for every member is computationally very expensive. In practice only the lower modes of vibration are of interest; the truss structure may be effectively represented by a continuous model. An extended Timoshenko beam model is derived to represent large truss structures where the extensional, flexural and shear deformations are coupled. Procedures for evaluating the equivalent continuum beam stiffnesses based on a substructure of the original system are presented. A higher order beam finite element based on the Timoshenko beam model is developed. Using this model, a number of truss structures is studied for free and forced vibration. Forces in the individual members obtained using the continuum model are compared with the full scale finite element solution applied to the original structure. Experiments are conducted on a scaled down truss model. Strain responses in members of the truss model due to impact force are measured. Comparison of the experimental results and the Timoshenko beam model is very accurate. Dissert. Abstr.

N88-24665# Innovative Sciences, Inc., San Leandro, CA.
ELECTROMAGNETIC DAMPING AND VIBRATION ISOLATION OF SPACE STRUCTURES Final Report, 1 Feb. - 30 Sep. 1987
J. K. HULBERT and BRUCE W. MAXFIELD 5 Aug. 1987 66 p
(Contract F49620-87-C-0029)
(AD-A191492; AF080722A.DOC; AFOSR-88-0063TR) Avail: NTIS HC A04/MF A01 CSCL 10A

Structures used in the vacuum, zero gravity environment of space are quite different from earth-bound system. Vibrations induced in a space structure by the operation of equipment internal to the structure should, to the greatest extent possible, be dissipated through heat generation so that this vibrational energy is not simply redistributed throughout the structure. The usual restricted fluid flow dashpot damping system has several serious drawbacks when operating within a space environment. Phase 1 proposed the quantitative assessment of electromagnetic damping that results when conducting but non-magnetic body moves through a region of localized magnetic field. It was shown theoretically in the Phase 1 proposal that this damping should depend quadratically upon both the velocity and the magnetic field seen by the moving conducting body. From this, it follows that electromagnetic damping (ED) has the potential for both large energy and power dissipation.

Although our initial approximate theoretical estimate predicted strong damping under ideal circumstances, the appropriate partial differential equations (PDE) had not been solved at the onset of Phase 1. Consequently, one could not calculate the damping magnitude that might be realized under practical conditions.
GRA

N88-24667 State Univ. of New York, Buffalo.
LOW AUTHORITY CONTROL OF LARGE SPACE STRUCTURES USING A CONSTRAINED THRESHOLD CONTROL FORMULATION Ph.D. Thesis
DAVID C. ZIMMERMAN 1987 208 p
Avail: Univ. Microfilms Order No. DA8727761

A new active control strategy for the vibration control of large space structures is presented. In this Low Authority-Threshold Control (LATC) method, the total energy requirement of the active controller is minimized by use of a threshold control formulation and by determining the control which minimizes an appropriate cost functional. The minimization results in a piecewise constant feedback control law and is suited for a distributed processing architecture because the designer is free to choose the allowable feedback structure. LATC is developed for single- and multi-degree of freedom structural models. The necessary conditions which define the optimal control law are determined using variational methods. Closed form and quasi-closed form solutions are developed to aid in the determination of the optimal control. The effect of observer-induced errors on LATC are investigated. The robustness of the control method in light of modelling errors is addressed. Finally, LATC has been compared with and contrasted to other similar control methods. Dissert. Abstr.

N88-25244*# Old Dominion Univ., Norfolk, VA. Dept. of Mechanical Engineering and Mechanics.
SINGLE-MODE PROJECTION FILTERS FOR MODAL PARAMETER IDENTIFICATION FOR FLEXIBLE STRUCTURES Final Report, for period ending 31 Dec. 1987
JEN-KUANG HUANG and CHUNG-WEN CHEN Feb. 1988 73 p
(Contract NAG1-655)
(NASA-CR-182680; NAS 1.26:182680) Avail: NTIS HC A04/MF A01 CSCL 12A

Single-mode projection filters are developed for eigensystem parameter identification from both analytical results and test data. Explicit formulations of these projection filters are derived using the orthogonal matrices of the controllability and observability matrices in the general sense. A global minimum optimization algorithm is applied to update the filter parameters by using the interval analysis method. The updated modal parameters represent the characteristics of the test data. For illustration of this new approach, a numerical simulation for the MAST beam structure is shown by using a one-dimensional global optimization algorithm to identify modal frequencies and damping. Another numerical simulation of a ten-mode structure is also presented by using a two-dimensional global optimization algorithm to illustrate the feasibility of the new method. The projection filters are practical for parallel processing implementation. Author

N88-26693*# Old Dominion Univ., Norfolk, VA. Dept. of Civil Engineering.
EXPERIMENTAL AND THEORETICAL INVESTIGATION OF PASSIVE DAMPING CONCEPTS FOR MEMBER FORCED AND FREE VIBRATION Progress Report, period ending 31 Dec. 1987
ZIA RAZZAQ and DAVID W. MYKINS Dec. 1987 125 p
(Contract NAG1-336)
(NASA-CR-183082; NAS 1.26:183082) Avail: NTIS HC A06/MF A01 CSCL 20K

Potential passive damping concepts for use in space structures are identified. The effectiveness of copper brush, wool swab, and silly putty in chamber dampers is investigated through natural vibration tests on a tubular aluminum member. The member ends have zero translation and possess partial rotational restraints. The silly putty in chamber dampers provide the maximum passive damping efficiency. Forced vibration tests are then conducted with one, two, and three damper chambers containing silly putty. Owing to the limitation of the vibrator used, the performance of these dampers could not be evaluated experimentally until the forcing function was disengaged. Nevertheless, their performance is evaluated through a forced dynamic finite element analysis conducted as a part of this investigation. The theoretical results based on experimentally obtained damping ratios indicate that the passive dampers are considerably more effective under member natural vibration than during forced vibration. Also, the maximum damping under forced vibration occurs at or near resonance.
Author

N88-27183# California Univ., Berkeley. Electronics Research Lab.
NUMERICAL OPTIMIZATION, SYSTEM THEORETIC AND SOFTWARE TOOLS FOR THE INTEGRATED DESIGN OF FLEXIBLE STRUCTURES AND THEIR CONTROL SYSTEMS Annual Technical Report, 30 Sep. 1986 - 29 Sep. 1987
E. POLAK 11 Apr. 1988 6 p
(Contract AF-AFOSR-86-0116)
(AD-A192927; AFOSR-88-0405TR) Avail: NTIS HC A02/MF A01 CSCL 01C

This research was motivated by a growing consensus that design specifications for projected controlled flexible aerospace structures, which are becoming larger and more flexible while performance requirements are becoming more stringent, can only be satisfied through an integrated design approach in which one determines simultaneously both structural and control system parameters. The work dealt with nonsmooth optimization techniques for the integrated design of flexible structures and their control systems. Nonsmooth optimization is an ideal tool for integrated design because it allows dynamic constraints and imposes no distinction between control system and structural variables. Major accomplishment include the development and testing of an optimal control algorithm which can be used to solve both free and fixed time optimal control problems, such as the problem of moving a flexible structure, modeled by a partial differential equation, from an in initial to a final position in minimum time, while guaranteeing upper bounds on the controls and deformations of the structure over the entire maneuver; and laying the ground-work for the frequency domain design of finite dimensional feedback controllers for flexible structures, without resorting to modal truncation and suffering the resulting spillover effects.
GRA

N88-27233# Martin Co., Denver, CO. Astronautics Group.
DAMPING CHARACTERISTICS OF METAL MATRIX COMPOSITES Quarterly Letter Progress Report No. 7, 11 Aug. - 9 Dec. 1987
MOHAN S. MISRA 9 Dec. 1987 7 p
(Contract N00014-85-C-0857)
(AD-A193144; MCR-85-721) Avail: NTIS HC A02/MF A01 CSCL 11D

Objectives of Present Research: Metal Matrix Composites (MMC) with enhanced material damping can be potential structural materials to improve significantly the stability, control and reliability of space structures. Objectives of this investigation are: - Identify the mechanisms and sources of damping in continuous fiber reinforced MMC (Gr/Al and Gr/Mg) using in situ characterization techniques. - Determine the role of microstructural parameters (fiber volume, fiber orientation, interfiber spacing, grain size, precipitate morphology) in damping. - Define the role of the fiber matrix interface in damping. - Develop high damping structural materials for space applications.
GRA

N88-27587# European Nuclear Energy Agency, Paris (France).
VIBRATION CONTROL OF LARGE STRUCTURES Final Report, 1 Jan. 1986 - 31 Dec. 1987
WALTER D. PILKEV 1 Mar. 1988 46 p
(Contract F49620-86-K-0009)
(AD-A193317; UVA/525673/MAE88/103; AFOSR-88-0369TR)
Avail: NTIS HC A03/MF A01 CSCL 13M

This is a study of some fundamental aspects of the structural dynamics and vibration control of large structures. One focus is the development of a limiting performance formulation with minimum settling time which can accept multiple design objectives efficiently. This new formulation is intended to meet the need of rather comprehensive design objectives for the control of large space structures. Another objective of the study is to develop a systematic way of designing a control system based on the limiting performance characteristics. An indirect synthesis method is proposed. It is shown that closed loop control laws can be based on the optimal response trajectories in the time domain. The method is successfully applied to the control of proof-mass actuators. GRA

N88-27640# Societe Nationale Industrielle Aerospatiale, Cannes (France).
SPACE PHOTOVOLTAIC GENERATORS. STATE OF THE ART, TRENDS [PHOTOVOLTAIQUE SPATIAL. ETAT DE'LART, TENDANCES]
M. ZILANI and L. PELENC 6 Apr. 1987 13 p In FRENCH Presented at the Agence Francaise pour la Maitrisede l'Energie Seminaire d'Evaluation des Conventions et Contrats de Recherche Conversion Photovoltaique, Nov. 1986
(REPT-881-440-106; ETN-88-92875) Avail: NTIS HC A03/MF A01

Different aspects of space photovoltaic generators are discussed, including useful range of power, specifications, life, manufacturing procedures, and limitations. It is shown that they are the choice generators for geosynchronous satellites requiring few kilowatts generated. It is thought that AsGa devices will expand the space applications due to longer life and powers going up to hundreds of kW. ESA

N88-29794# Iowa Univ., Iowa City. Center for Computer Aided Design.
DYNAMICS OF ARTICULATED AEROSPACE STRUCTURES Final Report, 1 Dec. 1985 - 30 Nov. 1987
EDWARD J. HAUG 22 Apr. 1988 9 p
(Contract AF-AFOSR-0082-86)
(AD-A195685; AFOSR-88-0670TR) Avail: NTIS HC A02/MF A01 CSCL 20K

A unified variational approach to dynamics of flexible multibody systems has been developed and demonstrated on several test problems, including a deployable space structure, flexible manipulators with feedback control, spinning blades, impacting elastic bodies, and variety of mechanisms. A new recursive formulation was developed for dynamics of flexible multibody systems. This new formulation demonstrated in excess of an order of magnitude speed up in computation, compared to the Cartesian coordinate approach, with comparable accuracy and improved stability. A substructuring formulation that accounts for geometrically nonlinear deformation effects in spinning blades and large space structures was developed and demonstrated, using both the Cartesian coordinate and recursive relative coordinate formulations. The substructure technique was further extended to account for contact-impact effects between structural components. A new formulation of translational joints between flexible bodies was developed, to account for deformation due to sliding contacts. GRA

N88-30130*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CLEVIS JOINT FOR DEPLOYABLE SPACE STRUCTURES Patent Application
MARVIN D. RHODES, inventor (to NASA) 28 Jul. 1988 13 p
(NASA-CASE-LAR-13898-1; NAS 1.71:LAR-13898-1; US-PATENT-APPL-SN-225427) Avail: NTIS HC A03/MF A01 CSCL 13K

This invention relates generally to pin clevis joints, and more particularly, to zero play pin clevis joints for connecting structural members of a deployable space structure. A joint includes a pin, a tang, and a shackle. The pin is tapered at the same angle as the bores extending through the projections of the shackle and the tang. A spring washer biases the tang onto the tapered sidewall of the pin. The invention solves the free play problem associated with deployable space structures by using a tapered pin which is held in tapered holes by the spring washers. NASA

04

THERMAL CONTROL

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

A88-20347#
STATISTICAL AND FUNCTIONAL REPRESENTATIONS OF THE PATTERN OF AURORAL ENERGY FLUX, NUMBER FLUX, AND CONDUCTIVITY
D. A. HARDY, M. S. GUSSENHOVEN, R. RAISTRICK (USAF, Geophysics Laboratory, Hanscom AFB, MA), and W. J. MCNEIL (Radex, Inc., Carlisle, MA) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12275-12294. refs
(AD-A193886; AFGL-TR-88-0074)

The global pattern of the height-integrated Hall and Pedersen conductivities produced by precipitating auroral electrons for several levels of geomagnetic activity as measured by K(p) is determined. These conductivities are found to vary smoothly in magnetic local time and corrected geomagnetic latitude, typically displaying a single peak conductivity value at each magnetic local time (MLT). There are generally two maxima for the conductivities in the nightside auroral oval, one near midnight and another several hours postmidnight. The peak Hall and Pedersen conductivities decrease with MLT away from midnight on both the morningside and eveningside of the oval, with the lowest peak conductivities seen in the postnoon sector. The global patterns for the height-integrated Hall and Pedersen conductivities as well as the integral energy flux and the integral number flux are found to be better fitted by Epstein functions than by a spherical harmonic expansion. C.D.

A88-21237
COMPETITION BETWEEN SECOND HARMONIC GENERATION AND ONE- AND TWO-PHOTON ABSORPTION IN THE ANTHRACENE/9,10-DIHYDROANTHRACENE MIXED CRYSTAL
A. BREE, A. LEYDERMAN (British Columbia, University, Vancouver, Canada), and C. TALIANI (CNR, Istituto di Molecolare Spettroscopia, Bologna, Italy) Journal of Applied Physics (ISSN 0021-8979), vol. 62, Dec. 15, 1987, p. 4662-4667. NSERC-CNR-supported research. refs

A88-29395* Cornell Univ., Ithaca, NY.
UPPER HYBRID AND LANGMUIR TURBULENCE IN THE AURORAL E REGION
MICHAEL C. KELLEY and GREGORY D. EARLE (Cornell University, Ithaca, NY) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, March 1, 1988, p. 1993-1996. refs
(Contract NSG-6020; NGT-33-010-802)

Oscillations at a frequency between the local upper hybrid and plasma frequencies have been detected in the upper E region of the morning auroral oval. The emission occurs in a narrow band of frequencies when the dipole antenna is nearly perpendicular to B but broadens when the antenna has a component parallel to B. The waves have a low-altitude cutoff at about 125-130 km, and their intensity increases in regions of low plasma density. No theoretical explanation yet exists for these waves, which may be the manifestation of a plasma instability process due to the suprathermal electron flux which accompanies collisional ionization in the auroral E region. Author

A88-36982
MEASUREMENTS OF THERMAL CONDUCTIVITY AND THERMAL CONTACT RESISTANCE IN COMPOSITE MATERIALS FOR SPACE APPLICATIONS
M. GIOMMI, F. R. TORRISI (Selenia Spazio S.p.A., Rome, Italy), M. MARCHETTI, and P. TESTA (Roma I, Universita, Rome, Italy) IN: International Conference on Composite Materials, 6th, and European Conference on Composite Materials, 2nd, London, England, July 20-24, 1987, Proceedings. Volume 4. London and New York, Elsevier Applied Science, 1987, p. 4.323-4.334. refs

In the study reported here, a specially designed apparatus was used to measure the thermal conductivity and thermal contact resistance of stainless steel, aluminum, copper, and glass/epoxy and carbon/epoxy composites at pressures up to 28 x 10 to the 6th Pa in the temperature range 30-90 C. The thermal conductivity of the composites tested is found to be essentially independent of the applied pressure; in the range studied, temperature does not play an important role. Thermal contact conductance, however, is found to increase with the applied load. V.L.

A88-41414#
CALORIMETRIC MEASUREMENTS OF THERMAL CONTROL SURFACES AT GEOSYNCHRONOUS ORBIT
C. C. ANDERSON and M. M. HATTAR (Aerojet ElectroSystems Co., Azusa, CA) Journal of Thermophysics and Heat Transfer (ISSN 0887-8722), vol. 2, April 1988, p. 145-151. Previously cited in issue 19, p. 2956, Accession no. A87-43082. refs
(Contract F04701-84-C-0034)

A88-42441* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LONG-LIVED THERMAL CONTROL MATERIALS FOR HIGH TEMPERATURE AND DEEP SPACE APPLICATIONS
ROBIN WHITT and TIM O'DONNELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1773-1786.
(Contract NAS7-918)

Considerable effort has been put into developing thermal-control materials for the Galileo space-craft. This paper presents a summary of these findings to date with emphasis on requirements, testing and results for the post-Challenger Galileo mission. Polyimide film (Kapton), due to its inherent stability in vacuum, UV, and radiation environments, combined with good mechanical properties over a large temperature range, has been the preferred substrate for spacecraft thermal control materials. Composite outer layers, using Kapton substrates, can be fabricated to meet the requirements of severe space environments. Included in the processing of Kapton-based composite outer layers can be the deposition of metal oxide, metallic and/or polymeric thin-film coatings to provide desirable electrical, optical and thermo-optical properties. In addition, reinforcement of Kapton substrates with fabrics and films is done to improve mechanical properties. Also these substrates can be filled with varying amounts of carbon to achieve particular electrical properties. The investigation and material development reported on here has led to improved thermo-gravimetric stability, surface conductivity, RF transparency, radiation and UV stability, flammability and handle-ability of outer layer thermal control materials for deep space and near-sun spacecraft. Designing, testing, and qualifying composite thermal-control film materials to meet the requirements of the Galileo spacecraft is the scope of this paper. Author

A88-42829
INTERNATIONAL SYMPOSIUM ON THERMAL PROBLEMS IN SPACE-BASED SYSTEMS, BOSTON, MA, DEC. 13-18, 1987, PROCEEDINGS
FLAVIO DOBRAN, ED. (New York University, NY) and MURRAY IMBER, ED. (New York, Polytechnic University, Brooklyn) Symposium sponsored by ASME and SDIO. New York, American Society of Mechanical Engineers, 1987, 143 p. For individual items see A88-42830 to A88-42843.

The present conference discusses fluid mechanics and heat transfer problems pertaining to space-based systems. Particular attention is given to super heat pipe design considerations for application to space-based systems, an experimental investigation of low gravity two-phase flow behavior, and the response of a double wall artery heat pipe to pulsed heat loads. Also considered are the Marangoni convection on a germanium float zone, gas liquid flow at microgravity conditions, and ascent and reentry heat rejection concepts for the Hermes space plane. Other topics include conjugating binary solutions for spacecraft thermal control, the application of two-phase thermal transport systems to space platforms, and two-dimensional thermal conduction effects in high-power CW laser target plates. R.R.

A88-42830#
SUPER HEAT PIPE DESIGN CONSIDERATIONS FOR APPLICATIONS TO SPACE-BASED SYSTEMS
F. DOBRAN (New York University, NY) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 1-12. refs

Current high heat-transfer-performance heat pipes are reviewed, and a super heat pipe designed to meet the reliability and heat transfer requirements of space-based systems is proposed. It is found that the axial heat transport capacity depends on the working fluid, the vapor flow area, the methods for both vapor introduction into the main core flow of the evaporator and vapor withdrawal from the condenser, and on the lengths of the evaporator, adiabatic, and condensor regions. Methods to suppress the axial heat transport limits are identified, in addition to design considerations for optimal boiling and wicking limits in heat pipes. R.R.

A88-42842#
APPLICATION OF TWO-PHASE THERMAL TRANSPORT SYSTEMS TO SPACE PLATFORMS
C. E. BRAUN, J. E. FREDLEY, V. J. GILBERTI, and K. HARTSHORN (RCA Aerospace and Defense, RCA Astro-Space Div., Princeton, NJ) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 125-134. refs

Increasingly stringent thermal requirements are projected for future spacecraft. Compliance with these requirements necessitates the development of thermal control techniques with capabilities far exceeding those in current use. A fundamental consideration is a heat acquisition, transport and rejection system capable for simultaneously accommodating large heat loads, high heat density sources, long transport distances, and varying operational parameters. This paper presents an overview of two-phase thermal transport systems and major components being developed for implementation in the forth-coming space platform era. Author

A88-42843#
ORBITAL REPLACEABLE UNIT-COLD PLATE DRY THERMAL INTERFACE CONCEPT AND TEST MEASUREMENTS
D. NIKANPOUR (British Aerospace, PLC, Space and Communications Div., Stevenage, England), H. K. SILL, and H. KREEB (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IN: International Symposium on Thermal Problems in Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 135-139. ESA-supported research. refs

A cold plate to an ORU dry thermal interface design that would meet both the joint thermal performance of 5000 W/sq m K and allow easy replacement in space during repeated in-orbit servicing is proposed. The present concept involves a cylindrical arrangement of flexible outer heat pipes which are pneumatically forced onto a central inner heat pipe. A thin coating of a low melting point alloy on the heat pipes provides a detachable continuous thermal path across the joint and allows the

performance requirements to be achieved even in the case of failure of the pressure. R.R.

A88-43743#
A FLEXIBLE VARIABLE CONDUCTANCE HEAT PIPE DESIGN FOR TEMPERATURE CONTROL OF SPACECRAFT EQUIPMENT
HAN HWANGBO and T. E. JOOST (MRJ, Inc., Oakton, VA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 7 p.
(AIAA PAPER 88-2680)

The paper describes a variable conductance heat pipe design with a flexible joint. The heat pipe is developed for temperature control of high power electronics using a deployable space radiator. The evaporator section of the heat pipe is attached to the baseplate of the electronics. The condenser section of the heat pipe and the reservoir of noncondensible gas are attached to the deployable radiator. During the ascent phase of the flight the radiator is stowed for minimum heat rejection. During the final orbit period the radiator is deployed for full operation. An analytical thermal model of a Flexible Variable Conductance Heat Pipe (FVCHP) is developed to predict the heat transport capacity and the location of the noncondensible gas front in the heat pipe. Also, transient performance of the FVCHP in an orbital environment with electrical feedback temperature control is predicted. The analysis results indicate that a FVCHP radiator can reject at least twice the heat of a single sided fixed radiator of the same size. Results also indicate that control of the evaporator within 75 + or - 5 F is feasible for a unit with 100 W dissipation using the FVCHP radiator design presented. Author

A88-43752#
THERMAL DESIGN OF THE SPACE STATION FREE-FLYING PLATFORMS
C. E. BRAUN, K. HARTSHORN, and S. D. PERGAMENT (General Electric Co., Astro-Space Div., Princeton, NJ) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 10 p.
(AIAA PAPER 88-2698)

The requirements and mechanical configuration of the thermal control subsystem (TCS) on the free-flying platforms of the Space Station are discussed. Requirements influencing the TSC design include modularity, high heat flux, precise temperature control, and the ability to perform without the need for thermal system redesign in numerous orbital environments with payload sets varying in power level and configuration. The polar platform flies in a 98.5 deg inclination with operating altitude ranging from 500 to 900 km. Studies have lead to a hybrid TCS design in which the central core fluid loop is used for thermal control of the payload experiments while the subsystems such as power, communications, and data management are housed in orbital replacement units and are independently regulated. R.B.

A88-43753#
TWO-PHASE AMMONIA THERMAL BUS PERFORMANCE
TED J. KRAMER, DONALD L. MYRON, and MICHAEL P. MCHALE (Boeing Aerospace Co., Seattle, WA) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 13 p. refs
(AIAA PAPER 88-2701)

This paper describes the results of a series of tests that explored the performance of an ammonia heat transport system being developed for future spacecraft applications. It was found that the self-controlling system maintained stable evaporative cold plate temperatures over a wide range of heat loads and heat sink temperatures. The ability of the system to control heat load temperatures during burst power inputs to the evaporator was demonstrated. It was shown that the system required no thermal conditioning or special procedures to start; and reached set point control temperatures within 3.5 minutes of startup under heat load. It was also shown that set point temperatures could be changed and set point control maintained during system operation. Author

A88-43754*# OAO Corp., Greenbelt, MD.
A HIGH POWER SPACECRAFT THERMAL MANAGEMENT SYSTEM
J. KU, E. J. KROLICZEK (OAO Corp., Greenbelt, MD), M. E. MCCABE, JR. (NASA, Goddard Space Flight Center, Greenbelt, MD), and S. M. BENNER (TS Infosystems, Inc., Lanham, MD) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 12 p. refs
(AIAA PAPER 88-2702)

This paper describes the design and test results of an ammonia hybrid capillary pumped loop thermal control system. As a hytbrid, the system can operate as either a passive, capillary pumped loop, or, as a mechanically pumped system. The system is comprised of an evaporator section, a condenser section, 10 meters of liquid and vapor transport lines, a mechanical pump, and a reservoir. In the evaporator section, four capillary pumps are each integrated into three cold plates. The mechanical pump is installed in the liquid line and is in series with the capillary pumps. Testing has demonstrated that in the capillary pumped mode, the HPSTM can acquire and transport a total heat load of between 120 W and 24 kW, with a maximum heat flux density of 4.3 W/sq cm in the evaporator section. In the mechanically pumped configuration, a heat acquisition potential of 50 kW (9 W/sq cm heat flux density) has been demonstrated. The hybrid system still retains the proven capillary capabilities of temperature control, heat load sharing and fluid flow control between evaporator plates, rapid power cycling, and pressure priming recovery of deprimed evaporators. Author

A88-44785#
ROTATING SOLID RADIATIVE COOLANT SYSTEM FOR SPACE NUCLEAR REACTORS
WALTER J. APLEY (Pacific Northwest Laboratory, Richland, WA) and ALBERT L. BABB (Washington, University, Seattle) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 7 p. refs
(Contract DE-AC06-76RL-01830)
(AIAA PAPER 88-3189)

The RING power system described in this paper is proposed as a primary or emergency heat rejection system for advanced space reactor power applications. The system employs a set of four (4) counter-rotating, 90 degree offset, coolant-carrying rings. The rings (segmented, corrugated, finned, thin-walled pipes, filled with liquid lithium) pass through a cavity heat exchanger and re-radiate the absorbed heat to the space environment. Author

A88-48479#
CRITIQUE OF THE THERMAL DESIGN VERIFICATION PROGRAM FOR A HIGH-POWER COMMUNICATIONS SPACECRAFT
P. C. WISE (General Electric Co., Astro-Space Div., Princeton, NJ), W. H. KELLY (COMSAT Laboratories, Clarksburg, MD), and S. P. SHARMA (COMSAT, Space Communications Div., Princeton, NJ) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 8 p.
(AIAA PAPER 88-2648)

This paper describes the programmatic and technical trade-offs used to define a thermal-control-subsystem verification-test program for a high-power communications spacecraft employing heat pipes. Benefits derived from a qualification thermal/mechanical model are critically reviewed. An overview of requirements for and constraints on unit- and spacecraft-level testing involving the use of heat pipes is presented. Finally, the test techniques used to measure thermal distortion of the deployed antenna reflector dish are described. Author

N88-21492*# Lockheed Missiles and Space Co., Sunnyvale, CA.
AMMONIA TRANSFER ACROSS ROTATING JOINTS IN SPACE
MARK H. WARNER *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 341-353 May 1988
Avail: NTIS HC A18/MF A01 CSCL 20D

Thermal control of future large space facilities, such as the space station, will require the transfer of anhydrous ammonia across

rotating joints with near zero leakage. Anhydrous ammonia is the primary heat transfer fluid aboard the station, providing critical thermal management of habitat and payload systems. The solar radiator joints, as well as the various payload pointing systems, are obvious examples of the need for a reliable fluid transfer device. Low weight, tight temperature control, low parasitic drag torque, long life, and high reliability, in addition to near zero leakage, are important characteristics necessary for the successful operation of such a device. In late 1986, Lockheed initiated a project to develop a Rotary Transfer Coupling (RTC) directed toward space station requirements. Fabrication and assembly of this device is now complete and testing is scheduled. The design and development of the face seal-type rotary fluid coupling that utilizes a unique cover gas concept (an inert gas such as nitrogen) to provide full containment of the ammonia was addressed. Author

N88-22321# Boeing Aerospace Co., Seattle, WA.
FLOSIN: A FLUID LOOP ANALYZER FOR SINDA
STEVEN M. LUNDE 1988 11 p Presented at the SAE 18th Intersociety Conference on Environment Systems
Avail: NTIS HC A03/MF A01

High-power heat transport systems for large space platforms require the use of complex fluid loops to effectively and efficiently move waste heat energy from source to sink. In particular, use of two-phase heat acquisition and transport systems offers significant advantages such as reduction of pump power, automation of control systems, constant sink temperatures at the load, and flexible load placement. Analytical tools are needed for design analysis and performance prediction of these systems. Moreover, environmental considerations and insulation systems need to be taken into account, especially when subcooling and superheating become important parameters in the overall design. The development and use of FLOSIN, a system-level, two-phase fluid loop analyzer, are discussed. Explained are the modeling approach for systems utilizing Rotary Fluid Management Device (RFMD), Back Pressure Regulating Valve (BPRV), and cavitating venturis. Described are the unique components and special subroutines for processing input and output, for handling flow splits, and for generating Systems Improved Numerical Differencing Analyzer (SINDA) thermal networks. Author

N88-22458*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
DEVELOPMENT OF AN INTEGRATED HEAT PIPE-THERMAL STORAGE SYSTEM FOR A SOLAR RECEIVER
E. S. KEDDY, J. T. SENA, M. A. MERRIGAN, G. HEIDENREICH (Sundstrand Advanced Technology Group, Rockford, Ill.), and S. JOHNSON 1987 10 p Presented at the Thermophysics Conference, San Antonio, Tex., 27 Jun. 1987
(Contract W-7405-ENG-36)
(NASA-TM-101099; NAS 1.15:101099; DE88-003153; LA-UR-87-3950; CONF-8706254-1) Avail: NTIS HC A02/MF A01 CSCL 10A

The Organic Rankine Cycle (ORC) Solar Dynamic Power System (SDPS) is one of the candidates for Space Station prime power application. In the low Earth orbit of the Space Station approximately 34 minutes of the 94-minute orbital period is spent in eclipse with no solar energy input to the power system. For this period the SDPS will use thermal energy storage (TES) material to provide a constant power output. An integrated heat-pipe thermal storage receiver system is being developed as part of the ORC-SDPS solar receiver. This system incorporates potassium heat pipe elements to absorb and transfer the solar energy within the receiver cavity. The heat pipes contain the TES canisters within the potassium vapor space with the toluene heater tube used as the condenser region of the heat pipe. During the insolation period of the Earth orbit, solar energy is delivered to the heat pipe in the ORC-SDPS receiver cavity. The heat pipe transforms the non-uniform solar flux incident in the heat pipe surface within the receiver cavity to an essentially uniform flux at the potassium vapor condensation interface in the heat pipe. During solar insolation, part of the thermal energy is delivered to the heater tube and the balance is stored in the TES units. During the eclipse period of the orbit, the balance stored in the TES units is transferred by the potassium vapor to the toluene heater tube. DOE

N88-23182*# Grumman Aerospace Corp., Bethpage, NY.
SOLAR DYNAMIC HEAT REJECTION TECHNOLOGY. TASK 2: HEAT PIPE RADIATOR DEVELOPMENT Final Report
MARK LEAGUE and JOE ALARIO May 1988 46 p
(Contract NAS3-24665)
(NASA-CR-182141; NAS 1.26:182141) Avail: NTIS HC A03/MF A01 CSCL 20D

This report covers the design, fabrication, and test of several dual slot heat pipe engineering development units. The following dual-slot heat pipes were fabricated and tested: two 6-ft. aluminum heat pipes; a 20-ft. aluminum heat pipe; and a 20-ft. aluminum heat pipe with a four-leg evaporator section. The test results of all four test articles are presented and compared to the performance predicted by the design software. Test results from the four-leg article are incomplete. The methodology for fabricating stainless steel dual slot heat pipes was also studied by performing a tool life test with different single point cutters, and these results are also presented. Although the dual-slot heat pipe has demonstrated the potential to meet the requirements for a high capacity radiator system, uncertainties with the design still exist. The startup difficulties with the aluminum test articles must be solved, and a stainless steel/methanol heat pipe should be built and tested. Author

N88-24332# Texas A&M Univ., College Station. Dept. of Nuclear Engineering.
A THERMAL EQUILIBRIUM MODEL FOR MULTI-MEGAWATT SPACE PLATFORMS
MARK DAVID DEHART *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 335-338 1987 Sponsored by DOE, Washington, D.C.
Avail: NTIS HC A22/MF A01

Due to the current research under the SDI and the SP-100 Project, much work is being done to determine the optimum design for a space based nuclear powered platform. The problem of thermal equilibrium temperature distributions which would be experienced on a multimegawatt platform using a nuclear reactor driven thermodynamic cycle for production of several megawatts of electrical power over extended periods of time, the temperatures to which electronics packages on the platform would be subjected, and what measures needed to ensure that such electronics could survive is addressed. Anticipated electronics used on such a platform may be able to withstand steady state temperatures of up to 600 K, while current high temperature electronics are limited to 475 K. Therefore, an effort is made to determine the conditions and requirements to be imposed on a platform that would result in temperatures at critical locations between 475 and 600 K. A numerical model was developed to estimate outer surface temperatures and radioisotopes based on radiation heat transfer. In this model, the effects of space, Earth, and Sun are represented by an averaged sink temperature of 250 K. Author

N88-24416# Sandia National Labs., Albuquerque, NM. Advanced Nuclear Power Systems Safety Div.
THE EFFECT OF MAXIMUM ALLOWABLE PAYLOAD TEMPERATURE ON THE MASS OF A MULTIMEGAWATT SPACE BASED PLATFORM
DEAN DOBRANICH *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 205-208 1988
(Contract DE-AC04-76DP-00789)
Avail: NTIS HC A99/MF A01

Two separate computer programs were used in conjunction to estimate the mass of a multimegawatt (MMW) platform as a function of the maximum allowable payload operating temperature. It was concluded that increasing the maximum allowable payload temperature results in a significant decrease in the platform mass for both the Brayton and Rankine cycle platforms. Author

N88-24754*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ARC-TEXTURED METAL SURFACES FOR HIGH THERMAL EMITTANCE SPACE RADIATORS
BRUCE A. BANKS, SHARON K. RUTLEDGE, MICHAEL J. MIRTICH, TRACY BEHREND, DEBORAH HOTES, MICHAEL KUSSMAUL, JENNIFER BARRY, CURTIS STIDHAM, THOMAS STUEBER, and FRANK DIFILIPPO (Case Western Reserve Univ., Cleveland, Ohio.) 1988 11 p Presented at the International Conference on Metallurgical Coatings, San Diego, Calif., 11-15 Apr. 1988; sponsored by the American Vacuum Society
(NASA-TM-100894; E-4135; NAS 1.15:100894) Avail: NTIS HC A03/MF A01 CSCL 11F

Carbon arc electrical discharges struck across the surfaces of metals such as Nb-1 percent Zr, alter the morphology to produce a high thermal emittance surface. Metal from the surface and carbon from the arc electrode vaporize during arcing, and then condense on the metal surface to produce a microscopically rough surface having a high thermal emittance. Quantitative spectral reflectance measurements from 0.33 to 15 microns were made on metal surfaces which were carbon arc treated in an inert gas environment. The resulting spectral reflectance data were then used to calculate thermal emittance as a function of temperature for various methods of arc treatment. The results of arc treatment on various metals are presented for both ac and dc arcs. Surface characterization data, including thermal emittance as a function of temperature, scanning electron microscopy, and atomic oxygen durability, are also presented. The ac arc texturing was found to increase the thermal emittance at 800 K from 0.05 to 0.70.
Author

N88-25477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MOVING BELT RADIATOR DEVELOPMENT STATUS
K. ALAN WHITE Jul. 1988 24 p Presented at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored in part by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100909; E-4140; NAS 1.15:100909) Avail: NTIS HC A03/MF A01 CSCL 22A

Development of the Moving Belt Radiator (MBR) as an advanced space radiator concept is discussed. The ralative merits of Solid Belt (SBR), Liquid Belt (LBR), and Hybrid Belt (HBR) Radiators are described. Analytical and experimental efforts related to the dynamics of a rotating belt in microgravity are reviewed. The development of methods for transferring heat to the moving belt is discussed, and the results from several experimental investigations are summarized. Limited efforts related to the belt deployment and stowage, and to fabrication of a hybrid belt, are also discussed. Life limiting factors such as seal wear and micrometeroid resistance are identified. The results from various MBR point design studies for several power levels are compared with advanced Heat Pipe Radiator technology. MBR designs are shown to compare favorable at both 300 and 1000 K temperature levels. However, additional effort will be required to resolve critical technology issues and to demonstrate the advantage of MBR systems.
Author

N88-26389*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DESIGN AND TESTING OF A HIGH POWER SPACECRAFT THERMAL MANAGEMENT SYSTEM
MICHAEL E. MCCABE, JR., JENTUNG KU, and STEVE BENNER (TS Infosystems, Lanham, Md.) Jun. 1988 109 p Sponsored in part by AF
(Contract NAS5-28626)
(NASA-TM-4051; REPT-88B0167; NAS 1.15:4051) Avail: NTIS HC A06/MF A01 CSCL 22B

The design and test results are presented of an ammonia hybrid capillary pumped loop thermal control system which could be used for heat acquisition and transport on future large space platforms and attached payloads, such as those associated with the NASA Space Station. The High Power Spacecraft Thermal Management System (HPSTM) can operate as either a passive, capillary pumped two phase thermal control system, or, when additional pressure head is required, as a mechanically pumped loop. Testing has shown that in the capillary mode, the HPSTM evaporators can acquire a total heat load of between 600 W and 24 kW, transported over 10 meters, at a maximum heat flux density of 4.3 W/sq cm. With the mechanical pump circulating the ammonia, a heat acquisition potential of 52 kW was demonstrated for 15 minutes without an evaporator failure. These results represent a significant improvement over the maximum transport capability previously displayed in other capillary systems. The HPSTM system still retains the proven capillary capabilities of heat load sharing and flow control between evaporator plates, rapid power cycling, and nonuniform heating in both the capillary and hybrid operating modes.
Author

N88-27507*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TEMPERATURE RISE IN SUPERFLUID HELIUM PUMPS
PETER KITTEL Jul. 1988 8 p
(NASA-TM-100997; A-88172; NAS 1.15:100997) Avail: NTIS HC A02/MF A01 CSCL 20D

The temperature rise of a fountain effect pump (FEP) and of a centrifugal pump (CP) are compared. Calculations and estimates presented here show that under the operating conditions expected during the resupply of superfluid helium in space, a centrifugal pump will produce a smaller temperature rise than will a fountain effect pump. The temperature rise for the FEP is calculated assuming an ideal pump, while the temperature rise of the CP is estimated from the measured performance of a prototype pump. As a result of this smaller temperature rise and of the different operating characteristics of the two types of pumps, transfers will be more effective using a centrifugal pump.
Author

N88-29128# Societe Nationale Industrielle Aerospatiale, Cannes (France).
DEVELOPMENT OF A SPACE DEPLOYABLE RADIATOR USING HEAT PIPES
M. AMDIEU, B. MOSCHETTI, and M. B. TATRY (Centre National d'Etudes Spatiales, Toulouse, France) 25 Mar. 1988 7 p
(SNIAS-881-440-104; ETN-88-92874) Avail: NTIS HC A02/MF A01

A space radiator using heat pipes prototype model with a deployable radiator connected to a rotating thermal joint was designed, built, and tested. Performance tests were conducted on the model to measure deployment torque, and verifiy the thermal performance (globally and for each of the components). The good results of these tests show that this radiator can be adapted to all kinds of satellites and space platforms.
ESA

N88-30552# Contraves Corp., Zurich (Switzerland). Space Dept.
FAR INFRARED SPECTROSCOPY TELESCOPE (FIRST) INFLATABLE THERMAL SHIELD, PHASE 1 Final Report
S. KOSE Paris, France ESA Jun. 1987 197 p
(Contract ESA-6324/85-NL-PB(SC))
(SR/FIS/108(87)CZ; ESA-CR(P)-2568; ETN-88-93017) Avail: NTIS HC A09/MF A01

Inflatable space rigidized structures (ISRS) were assessed for the FIRST satellite thermal shield. The baseline shield configuration, the so called obliquely cut cylindrical shield configuration, has a diameter of 10 m, a maximum height of 10 m, and a cut angle of 30 deg. This shield consists of an ISRS skeleton of tubes of diameter 0.45 m carrying the thermal control layers. The stringent requirements on the thermal control can be met by a 6-layer multilayer insulation, consisting of 2 layers of SAK (1 Mil) and 4-layers of DAM (0.25 Mil). Using the BF3 catalyst, the ISRS structure can be cured in 3 preselected positions with respect to Sun within 9 hr. Curing without catalyst is also possible, but in this case a 90 deg tilt of the satellite and longer cure times (24 hr) must be faced. The first eigenfrequency of the baseline thermal shield in deployed configuration is 2.15 Hz, thus the stiffness requirement is fulfilled. The thermal shield can survive the thermal

stresses introduced during the worst operational case. The total mass lies comfortably within the specified limit of 220 kg. The shield can be well stowed in the allowable volume of the Ariane 4 shroud. ESA

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.

A88-35133
THE ROLE OF SPACE STATION LIFE SCIENCES EXPERIMENTS IN THE DEVELOPMENT OF A CELSS
NANCY SEARBY, PAUL DOLKAS, and S. SCHWARTZKOPF (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1313-1318.
(AAS PAPER 86-340)

A plan for integrating supporting research for NASA's Controlled Ecological Life Support System (CELSS) with the development and operation of the Space Station laboratory equipment is outlined. Functional descriptions are given for the CELSS plant holding facility, animal metabolic measuring system, waste processing system, recycling loops (between the heterotrophic and autotrophic components of the system), and variable gravity research centrifuge. Applicable experiments are discussed, and the use of existing technology for the development of the CELSS is considered. R.R.

A88-35452
HANDGRIP STRENGTH WITH THE BARE HAND AND IN THE NASA SPACESUIT GLOVE
J. RICHARD ROESCH (Human Factors Applications, Inc., Panama City, FL) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 786-790. refs

This study examined handgrip strength with the bare and spacesuit-gloved hand, in three hand- and two elbow positions. Sixteen subjects from the suited-subject pool at NASA/Johnson Space Center gripped a hand dynamometer encased in a vacuum chamber designed to simulate the pressure differential of the spacesuit in space. With the bare hand (at one atmosphere), there was an effect for hand position and a hand-position x elbow-position interaction. With the spacesuit-gloved hand, there was only an effect for hand position. Two different pressure differentials were used; the glove at 0.5 psid was responsible for a 35 percent grip decrement (when compared to bare handgrip); the glove at 4.3 psid (normal operating pressure) was responsible for a 42 percent grip decrement. Bare and gloved-handgrips were positively correlated with hand size, body weight, height, and forearm circumference. Post hoc, subjects were grouped by hand size; the four subjects in the XL hand-size group lost an average of 17 percent in grip in the glove at 4.3 psid (when compared to the glove at 0.5 psid); the L group lost 12 percent; the M group lost 9 percent; and the S hand-size group lost less than 1 percent. Author

A88-45628
SIMPLIFIED INTEGRATED TEST OF A BREADBOARD REGENERATIVE ECLSS
J. GREG MCALLISTER (Martin Marietta Corp., Denver, CO) SAE, Intersociety Conference on Environmental Systems, 17th, Seattle, WA, July 13-15, 1987. 10 p.
(SAE PAPER 871455)

NASA-Marshall has undertaken a program of technology evaluation and feasibility testing for the system and subsystem hardware of a regenerative ECLSS. The breadboard ECLSS simulator developed for this task encompasses facility instrumentation and data acquisition systems, subsystem control electronics, a Sabatier reactor, a thermoelectric integrated membrane evaporator, a solid-amine water desorber, and a solid polymer electrolyte water electrolysis system. O.C.

A88-50998
HUMAN FACTORS ANALYSIS OF EXTRAVEHICULAR SERVICING OF PAYLOADS WITHIN THE SPACE STATION SERVICING FACILITY
RAY A. REAUX, REBECCA L. SHANNON, and SYLVIA B. SHEPPARD (Computer Technology Associates, Inc., McLean, VA) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 784-788. refs

A series of studies on extravehicular (EV) servicing of payloads was performed for the space station on-orbit assembly, maintenance, and servicing project at Goddard Space Flight Center (GSFC). The studies covered three types of servicing that could be performed in the space station servicing facility: change-out of orbital replacement units (ORUs), on-orbit assembly, and fluid replenishment. Servicing activities were decomposed into functions, subfunctions, and tasks. The tasks were allocated to EV, intravehicular (IV), and ground personnel. The temporal flow of the tasks was described using the computer-human operational requirements analysis system (CHORAS), an inhouse graphic tool that models the role of the human operator in a complex system. Once tasks were defined, detailed analyses were performed to identify the cognitive, sensory, and motor skills, information (data flows), and equipment needed to perform each task. The results of the studies include: a detailed operations concept for space station-based payload servicing, work performance issues, and design recommendations for procedures, equipment, and performance aids. In particular, recommendations for the design of the space station servicing facility and related servicing equipment were specified. I.E.

A88-55486
SPACE STATION - HOME AND WORKPLACE IN ORBIT
JERRY GOLDMACHER and JOHN MOCKOVCIAK, JR. (Grumman Corp., Bethpage, NY) Horizons (ISSN 0095-7615), vol. 24, no. 1, 1988, p. 10-15, 17.

The design of the Space Station is examined, focusing on plans for the living quarters. The process for building the station in space is outlined and the construction of a mockup of the habitation module are considered. Problems in designing the living quarters include accounting for the size range of astronauts, providing privacy, noise reduction, creating an area suitable for exercise, and allowing enough storage space. Plans for maintaining a sterile laboratory and providing equipment for personal hygiene are presented. The ability to repair all of the Space Station equipment in place and plans for dealing with emergency situations are discussed. R.B.

N88-25372*# Anacapa Sciences, Inc., Santa Barbara, CA.
SPACE STATION HABITABILITY RECOMMENDATIONS BASED ON A SYSTEMATIC COMPARATIVE ANALYSIS OF ANALOGOUS CONDITIONS
JACK W. STUSTER Washington NASA Sep. 1986 209 p
(Contract NAS2-11690)
(NASA-CR-3943; NAS 1.26:3943) Avail: NTIS HC A10/MF A01 CSCL 06K

Conditions analogous to the proposed NASA Space Station are systematically analyzed in order to extrapolate design guidelines and recommendations concerning habitability and crew productivity. Analogous environments studied included Skylab, Sealab, Tektite,

submarines, Antarctic stations and oil drilling platforms, among others. These analogues were compared and rated for size and composition of group, social organization, preparedness for mission, duration of tour, types of tasks, physical and psychological isolation, personal motivation, perceived risk, and quality of habitat and life support conditions. One-hundred design recommendations concerning, sleep, clothing, exercise, medical support, personal hygiene, food preparation, group interaction, habitat aesthetics, outside communications, recreational opportunities, privacy and personal space, waste disposal, onboard training, simulation and task preparation, and behavioral and physiological requirements associated with a microgravity environment, are provided. Author

N88-27755*# Life Systems, Inc., Cleveland, OH.
VAPOR COMPRESSION DISTILLATION SUBSYSTEM (VCDS) COMPONENT ENHANCEMENT, TESTING AND EXPERT FAULT DIAGNOSTICS DEVELOPMENT, VOLUME 2 Final Report
E. S. MALLINAK Dec. 1987 75 p
(Contract NAS9-16374)
(NASA-CR-172076; NAS 1.26:172076; LSI-TR-471-26-VOL-2)
Avail: NTIS HC A04/MF A01 CSCL 06K

A wide variety of Space Station functions will be managed via computerized controls. Many of these functions are at the same time very complex and very critical to the operation of the Space Station. The Environmental Control and Life Support System is one group of very complex and critical subsystems which directly affects the ability of the crew to perform their mission. Failure of the Environmental Control and Life Support Subsystems are to be avoided and, in the event of failure, repair must be effected as rapidly as possible. Due to the complex and diverse nature of the subsystems, it is not possible to train the Space Station crew to be experts in the operation of all of the subsystems. By applying the concepts of computer-based expert systems, it may be possible to provide the necessary expertise for these subsystems in dedicated controllers. In this way, an expert system could avoid failures and extend the operating time of the subsystems even in the event of failure of some components, and could reduce the time to repair by being able to pinpoint the cause of a failure when one cannot be avoided. Author

N88-29380*# Martin Marietta Aerospace, Denver, CO. Space Station Program.
ARGES: AN EXPERT SYSTEM FOR FAULT DIAGNOSIS WITHIN SPACE-BASED ECLS SYSTEMS
DAVID W. PACHURA, SALEM A. SULEIMAN, and ANDREW P. MENDLER *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 277-282 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

ARGES (Atmospheric Revitalization Group Expert System) is a demonstration prototype expert system for fault management for the Solid Amine, Water Desorbed (SAWD) CO2 removal assembly, associated with the Environmental Control and Life Support (ECLS) System. ARGES monitors and reduces data in real time from either the SAWD controller or a simulation of the SAWD assembly. It can detect gradual degradations or predict failures. This allows graceful shutdown and scheduled maintenance, which reduces crew maintenance overhead. Status and fault information is presented in a user interface that simulates what would be seen by a crewperson. The user interface employs animated color graphics and an object oriented approach to provide detailed status information, fault identification, and explanation of reasoning in a rapidly assimulated manner. In addition, ARGES recommends possible courses of action for predicted and actual faults. ARGES is seen as a forerunner of AI-based fault management systems for manned space systems. Author

N88-30298# Selskapet for Industriell og Teknisk Forskning, Trondheim (Norway). Div. of Medical Technology.
STUDY OF HUMAN FACTORS ENGINEERING CRITERIA FOR EXTRAVEHICULAR ACTIVITY (EVA) SYSTEMS, VOLUME 1 Final Report
A. O. BRUBAKK, B. HOLAND, G. BOLSTAD, A. PASCHE, T. SYVERSEN, O. BJORSETH, H. RYVARDEN, H. FATHI, B. BREKKE, O. I. MOLVAER et al. Paris, France ESA 8 Dec. 1987 333 p Sponsored in part by the Royal Norwegian Council for Scientific and Industrial Research, Trondheim, Norway
(Contract ESTEC-7016/87-NL-PP(SC))
(STF23-F87025-VOL-1; ESA-CR(P)-2572-VOL-1; ETN-88-93020)
Avail: NTIS HC A15/MF A01

Human factors engineering for EVA: anthropometry; physiological and biochemical parameters at 1g conditions; physiological effects of the space environment; structural considerations; procedures; EVA suit design recommendations; EVA airborne support equipment; and EVA operational support equipment was reviewed. Design guidelines for man-machine interfaces for EVA systems are presented. Guidelines for astronaut training for EVA are suggested. Simulation techniques for EVA development studies and training are considered. Training systems; neutral buoyancy facilities; and water tanks and diver test systems are discussed. ESA

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.

A88-22071*# California Univ., Los Angeles.
MODELING OF LIQUID JETS INJECTED TRANSVERSELY INTO A SUPERSONIC CROSSFLOW
S. D. HEISTER, T. T. NGUYEN, and A. R. KARAGOZIAN (California, University, Los Angeles) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 11 p. NASA-supported research. refs
(AIAA PAPER 88-0100)

Analytical/numerical modeling of the behavior of a single nonreacting liquid jet in compressible (high subsonic and supersonic) crossflows is described here. Inviscid, compressible flow about the elliptical cross-section of the jet is solved numerically, using a procedure modeled after that of Godunov. External boundary layer analysis along the surface of the elliptical cross-section allows determination of an effective drag associated with the jet, which balances centripetal forces resulting from jet deflection. Mass and momentum balances performed along the jet, with and without the inclusion of mass loss due to droplet shedding, are then incorporated so that liquid jet trajectories and bow shock penetration may be calculated. Comparisons of the predictions are made with experimental results. Author

A88-24666
DETERMINATION OF THE LOCAL STRUCTURE OF GRAPHITE INTERCALATION COMPOUNDS WITH NICL2 AND NI USING EXAFS SPECTROSCOPY [OPREDELENIE LOKAL'NOI STRUKTURY SLOISTYKH SOEDINENII GRAFITA S NICL2 I NI METODOM EXAFS-SPEKTROSKOPII]
A. T. SHUVAEV, B. IU. KHEL'MER, V. L. KRAIZMAN, T. A. LIUBEZNOVA, A. S. MIRMIL'SHTEIN (AN SSSR, Institut Elementoorganicheskikh Soedinenii, Moscow; Rostovskii Gosudarstvennyi Universitet, Rostov-on-Don, USSR) et al. Akademiia Nauk SSSR, Doklady (ISSN 0002-3264), vol. 297, no. 6, 1987, p. 1433-1437. In Russian. refs

A88-24673
FINITE ELEMENT ANALYSIS OF AXISYMMETRIC SHELLS WITH A BRANCHING MERIDIAN [K RASCHETU OSESIMMETRICHNYKH OBOLOCHEK S VETVIASHCHIMSIA MERIDIANOM METODOM KONECHNYKH ELEMENTOV]
A. P. NIKOLAEV, N. G. BANDURIN, and IU. V. KLOCHKOV

(Volgogradskii Sel'skokhoziaistvennyi Institut, Volgograd, USSR) Problemy Prochnosti (ISSN 0556-171X), Dec. 1987, p. 66-69. In Russian. refs

A finite element algorithm for calculating axisymmetric shell structures is proposed which makes it possible to exactly satisfy both kinematic and equilibrium conditions at the junction of several shells. The meridional and normal displacements in a shell element are approximated by Hermite polynomials of fifth and seventh degrees, respectively. An example of calculations is presented. V.L.

A88-24674
DEFORMATION DYNAMICS OF AN ELASTIC-PLASTIC LAYER IN THE CASE OF PULSED ENERGY RELEASE [DINAMIKA DEFORMIROVANIIA UPRUGOPLASTICHESKOGO SLOIA PRI IMPUL'SNOM ENERGOVYDELENII]
M. M. BELOVA, S. S. PROTSENKO, and A. V. IVANOV (Kievskii Gosudarstvennyi Universitet, Kiev, Ukrainian SSR; Moskovskii Aviatsionnyi Institut, Moscow, USSR) Problemy Prochnosti (ISSN 0556-171X), Dec. 1987, p. 87-91. In Russian. refs

The paper is concerned with the dynamics of the formation of an elastic-plastic layer in a target irradiated by a homogeneous pulsed flux of high-energy electrons. The pulse duration is assumed to be comparable with the time required for an elastic wave to cover a distance equal to the layer thickness; the free path of the particles in the target is assumed to be less than the layer thickness. Three critical flux intensities are identified which correspond to qualitative changes in deformation dynamics. It is shown that quasi-static deformation effects increase with irradiation time. V.L.

A88-33446*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SYNTHESIS OF FINE-POINTING CONTROL SYSTEMS FOR LARGE, FLEXIBLE SPACECRAFT
SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 171-176. refs

This paper considers the problem of designing attitude control systems for large space structures (LSS). The difficulties in control systems design, which arise because of special dynamic characteristics of LSS, are described, and methods for overcoming them using two types of controllers are presented. The first type of controller considered is a model-based compensator (MBC), and the second is the 'dissipative' controller which employs output feedback. Based on the numerical and analytical results obtained, the MBC can offer good performance under normal conditions, while the dissipative controller offers more robustness but perhaps reduced performance in situations involving large uncertainties. Author

A88-34501
MULTIVARIABLE CONTROL LAW ANALYSIS FOR A LARGE SPACE ANTENNA
DALE F. ENNS and DANIEL J. BUGAJSKI (Honeywell Systems and Research Center, Minneapolis, MN) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 136-145. refs

This paper will discuss control laws for a large space antenna. The discussion will focus on analysis of the multivariable, closed loop system with respect to nominal performance, robust stability, and robust performance. The analysis employs singular values and structured singular values of multivariable frequency responses. Consistency between the frequency response analysis and time simulations is also presented. A simplified model of a large flexible space antenna was used for the analysis. Author

A88-34502
AN EXPERIMENTAL TEST-BED FOR VALIDATION OF CONTROL METHODOLOGIES IN LARGE SPACE OPTICAL STRUCTURES
DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Structural mechanics of optical systems II; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 146-155. refs

This paper reviews an optics/vibration experiment involving the Harris Deployable Multi-Hex Prototype - a reflector structure comprising a seven-panel array. Design considerations needed to ensure the emulation of vibration pathologies characteristic of SDI systems are discussed. The key aspects of dynamic complexity, deployability and proper combination of generically distinct vibration suppression methods are emphasized. We describe the experimental setup which follows as a consequence of these considerations. The projected test plan emphasizes combined orchestration of active and passive methods. Author

A88-34790#
MOVING BANK MULTIPLE MODEL ADAPTIVE ESTIMATION APPLIED TO FLEXIBLE SPACE STRUCTURE CONTROL
DREW A. KARNICK and PETER S. MAYBECK (USAF, Institute of Technology, Wright-Patterson AFB, OH) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1249-1257. refs

The feasibility of applying moving-bank multiple-model adaptive estimation algorithms to flexible-space-structure control is investigated. Moving-bank multiple-model adaptive estimation control is an attempt to reduce the computational load associated with the implementation of a full-scale multiple-model adaptive estimator/controller. It is shown that although the use of a moving bank can provide improved state estimation and control performance, similar performance can be obtained from a fixed-bank estimator with fewer filters than a full bank, accomplished through a coarse discretization that covers the range of parameter variation. I.E.

A88-34791
AN ADAPTIVE CONTROL SYSTEM FOR FINE POINTING OF FLEXIBLE SPACECRAFT
T. E. ELIAZOV (Bell Communications Research, Inc., Red Bank, NJ) and F. E. THAU (City College, New York) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1258-1262. refs

A least-squares algorithm is used to identify simultaneously the unknown states and parameters of a discrete-time lumped-parameter model of the flexible structure. The identified states and parameters form the input to a bang-off-bang control law that, in conjunction with the identification algorithm, results in an adaptive system whose response closely approximates that of a system with known parameters. Simulation studies demonstrate the response achievable with the proposed approach. I.E.

A88-34792
SYSTEM IDENTIFICATION FOR SPACE CONTROL LABORATORY EXPERIMENT (SCOLE) USING DISTRIBUTED PARAMETER MODELS
S. A. HOSSAIN and K. Y. LEE (Pennsylvania State University, University Park) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1263-1268. refs

An infinite-dimensional identification scheme to determine system parameters in large flexible structures in space is presented. The method retains the distributed nature of the structure throughout the development of the algorithm and a finite-element approximation is used only to implement the algorithm. This approach eliminates any problems associated with model truncation used in other methods of identification. The identification problem

is formulated in Hilbert spaces and an optimal control technique is used to minimize weighted least squares of error between the actual and the model data. Computer simulation studies are conducted using a shuttle-attached antenna configuration, more popularly known as the Space Control Laboratory Experiment (SCOLE), as an example. Numerical results show a close match between the estimated and true values of the parameters. I.E.

A88-34794
ROTATIONAL MANEUVER AND STABILIZATION OF AN ELASTIC SPACECRAFT
SAHJENDRA N. SINGH (Nevada, University, Las Vegas) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1275-1280. refs

The question of attitude control and elastic mode stabilization of a spacecraft (orbiter) with beam/tip-mass-type payloads is considered. A three-axis moment control law is derived to control the attitude of the spacecraft. The derivation of the control moments acting on the spacecraft does not require any information on the system dynamics. The control law includes a reference model and a dynamic compensator in the feedback path. For damping out the elastic motion excited by the slewing maneuver, an elastic mode stabilizer is designed. The stabilization is achieved by modal velocity feedback using force and torque actuators located at the payload end of the elastic beam. Collocated actuators and sensors provide robust stabilization. I.E.

A88-34796*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
CONTROLLER SYNTHESIS FOR FLEXIBLE SPACECRAFT USING MULTIVARIABLE LOOP-SHAPING AND FACTORIZATION METHODS
SURESH M. JOSHI (NASA, Langley Research Center, Hampton, VA) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1288, 1289. refs

The problem of designing fine-pointing controllers is considered for large, flexible space structures using modern multivariable synthesis methods. The first method is an iterative procedure which utilizes frequency-domain singular-value techniques, and is found to yield satisfactory performance and robustness. For the second method, which is based on coprime factorizations, a particular bicoprime is obtained, and the steps in the design process are described. This method is still under development. I.E.

A88-34891
DESIGN OF A CONTROLLER FOR MECHANICAL SYSTEMS BY THE GENERALIZED ENERGY FUNCTION
SHINTARO ISHIJIMA (Tokyo Metropolitan Institute of Technology, Hino, Japan), HISATO KOBAYASHI (Hosei University, Koganei, Japan), and ETSUJIRO SHIMEMURA (Waseda University, Okubo, Japan) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2186-2190. refs

A mechanical system with proportional dynamics is considered. Its dynamics are described by a matrix second-order differential equation; the coefficient matrices have properties such as symmetry and positivity. These properties are used to synthesize a better controller for such a system. The potential and kinetic energy of the system are considered. A concept called a generalized energy function is introduced and used as the basis for discussing observability and controllability. The problem of attitude control using position feedback is treated. I.E.

A88-34905
ON THE QUANTITATIVE CHARACTERIZATION OF APPROXIMATE DECENTRALIZED FIXED MODES USING TRANSMISSION ZEROS
A. F. VAZ and E. J. DAVISON (Toronto, University, Canada) IN: IEEE Conference on Decision and Control, 26th, Los Angeles, CA, Dec. 9-11, 1987, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 2283-2288. refs
(Contract NSERC-A-4396)

The coordinate invariant distance between the open-loop eigenvalues and a set of transmission zeros is used to quantify the difficulty of shifting different modes in a system. It is shown that eigenvalues have an affinity for transmission zeros that lie nearby. Consequently, large controller gains are required to move eigenvalues away from such transmission zeros. This type of result is particularly useful for systems such as large flexible space structures, which have transmission zeros in the neighborhood of some system eigenvalues and manifest a great disparity in the mobility of their eigenvalues. Since not all systems have transmission zeros, a second measure of eigenvalue assignability that applies to all systems is introduced. This measure is based on the minimum singular value of a set of transmission zero matrices. The price of this generality is that the measure becomes coordinate-dependent. I.E.

A88-35104* Martin Marietta Corp., Denver, CO.
CONTROL SYSTEMS FOR AUTONOMOUS OPERATION OF THE MAGELLAN SPACECRAFT
WHITTAK H. HUANG (Martin Marietta Corp., Denver, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 815-830. refs
(Contract JPL-956700)
(AAS PAPER 86-286)

The Magellan low cost interplanetary mission spacecraft, scheduled for flight in 1989, employs a computer-based Attitude and Articulation Control System (AACS) that interfaces with spacecraft sensors and actuators. The sensors include two attitude reference units, a star-scanner unit, two digital sun sensors, and a tachometer. The actuators encompass three reaction wheels, a total of 12 attitude control thrusters, eight attitude-control engines, a solar array drive assembly, and an input-output drive assembly. A detailed account is given of the AACS's onboard computer architecture. O.C.

A88-36123
SECULAR EFFECTS IN THE TRANSLATIONAL-ROTATIONAL MOTION OF AN ORBITAL STATION WITH ARTIFICIAL GRAVITY [VEKOVYE EFFEKTY V POSTUPATEL'NO-VRASHCHATEL'NOM DVIZHENII ORBITAL'NOI STANTSII, OBLADAIUSHCHEI ISKUSSTVENNOI TIAZHEST'IU]
D. Z. KOENOV (Tadzhikskii Gosudarstvennyi Universitet, Dushanbe, Tadzhik SSR) Akademiia Nauk Tadzhikskoi SSR, Doklady (ISSN 0002-3469), Vol. 30, no. 7, 1987, p. 417-420. In Russian.

Attention is given to an orbital station which has the form of two spheres of the same radius connected with a long tether; the spheres rotate about an axis passing through their common center of mass. Formulas are derived which show that the form of this station has a substantial effect on the translational motion of the station around the earth. The form of the station does not have any secular effect on the rotational motion of the station about the nutation axis. B.J.

A88-40269* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A COMPARATIVE OVERVIEW OF MODAL TESTING AND SYSTEM IDENTIFICATION FOR CONTROL OF STRUCTURES
JER-NAN JUANG and RICHARD S. PAPPA (NASA, Langley Research Center, Hampton, VA) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 250-259. refs

This paper presents a comparative overview of the disciplines of modal testing used in structural engineering and system identification used in control theory. A list of representative

references from both areas is given and the basic methods are briefly described. Recent progress on the interaction of modal testing and control disciplines is discussed. It is concluded that combined efforts of researchers in both disciplines are required for unification of modal testing and system identification methods for control of flexible structures. Author

A88-40292* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SHAPES - SPATIAL, HIGH-ACCURACY, POSITION-ENCODING SENSOR FOR MULTI-POINT, 3-D POSITION MEASUREMENT OF LARGE FLEXIBLE STRUCTURES
N. M NERHEIM (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1987 SEM Spring Conference on Experimental Mechanics, Houston, TX, June 14-19, 1987, Proceedings. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 596-601.

An electro-optical position sensor for precise simultaneous measurement of the 3-D positions of multiple points on large space structures is described. The sensor data rate is sufficient for most control purposes. Range is determined by time-of-flight correlation of short laser pulses returned from retroreflector targets using a streak tube/CCD detector. Angular position is determined from target image locations on a second CCD. Experimental verification of dynamic ranging to multiple targets is discussed. Author

A88-40489
ROBUST CONTROL OF FLEXIBLE STRUCTURES - A CASE STUDY
J. BONTSEMA, R. F. CURTAIN (Groningen, Rijksuniversiteit, Netherlands), and J. M. SCHUMACHER (Centrum voor Wiskunde en Informatica, Amsterdam, Netherlands) Automatica (ISSN 0005-1098), vol. 24, March 1988, p. 177-186. Research supported by the Stichting voor de Technische Wetenschappen. refs

A comparison is made between three partial differential equation models for a flexible beam with different types of damping and varying parameter values. Robust controllers can be designed to stabilize all linear systems whose transfer functions lie within a ball in the L-infinity norm. Given a nominal model for the flexible beam the sets of models that can be stabilized by the same finite-dimensional robust controller are calculated. Author

A88-42576
MINIMUM-TIME CONTROL OF LARGE SPACE STRUCTURES
ROBERT L. KOSUT, ANTONIO M. PASCOAL (Integrated Systems, Inc., Santa Clara, CA), MICHAEL L. WORKMAN (IBM, San Jose, CA), and GENE F. FRANKLIN (Stanford University, CA) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 230-241. SDIO-sponsored research. refs

An Extended Proximate Time-Optimal Servomechanism (XPTOS) is developed for the control of a flexible structure with a single structural mode. The resulting control system is closed-loop, and embodies in its structure the characteristics of a time-optimal control law and the fine tracking properties of a properly tuned linear regulator. Simulation results demonstrate the performance of the XPTOS, and its robustness in the face of uncertain plant parameters. Author

A88-42577
EXPERIMENTAL INVESTIGATIONS IN ACTIVE VIBRATION CONTROL FOR APPLICATION TO LARGE SPACE SYSTEMS
DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 242-253.

Vibration control experiments were designed on the basis of a recent survey of large space system concepts and the identified characteristics of ground-based experiments needed to demonstrate capability for future systems. The experiments involve a progression of structural configurations ranging from relatively simple one- and two-dimensional systems to a large-aperture multisegment optical structure. The following experiments are described in detail: (1) the Pendulum Experiment, (2) the Plate Experiment, and (3) the Multihex Prototype Experiment. K.K.

A88-42582
DYNAMICS AND CONTROL OF LARGE SPACE PLATFORMS AND SMALL EXPERIMENTAL PAYLOADS
J. E. COCHRAN, JR., N. G. FITZ-COY, K. KUMAR, and T. S. NO (Auburn University, AL) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 282-296. refs
(Contract DNA001-85-C-0183)

A capability developed to study the dynamics and control of space platforms in connection with the generation, conversion and utilization of power in space is described. It is based on the use of both rigid and flexible models of platform configurations which may be rather arbitrary. The principal part of the capability is a digital simulation code which uses the results of analyses of finite element models of platforms to account for their flexibilities. By using the code, the general motion of fairly complex configurations including rotating components may be simulated. The control of gross attitude motion is accomplished via a minimum impulse limit cycle controller. Examples of gross attitude motion and 'fine' motion due to flexibility are presented. Also, to illustrate the versatility of the code, results are presented of simulations of the motion of a small, suborbital, experimental payload which has deployable booms. Another aspect of the overall capability is spotlighted through an example of the attitude dynamics of the experiment carrying suborbital vehicle during boom deployment. Author

A88-43030#
NEW APPROACH TO THE ANALYSIS AND CONTROL OF LARGE SPACE STRUCTURES
G. ADOMIAN (General Analytics Corp., Roswell, GA) AIAA Journal (ISSN 0001-1452), vol. 26, March 1988, p. 377-380.
(Contract F49620-87-C-0098)

Orbiting space stations' thermal and structural analysis difficulties arise from the severe requirements of large size, low weight, high stiffness, and minimum mechanical and thermal distortion (millimetric tolerances). Attention is presently given to a decomposition method which solves the systems of multidimensional nonlinear stochastic partial differential equations (or ordinary differential equations, or integrodifferential, or delay differential equations) in space and time, without linearization, discretization, or perturbation. O.C.

A88-43203#
INPUT SELECTION FOR A SECOND-ORDER MASS PROPERTY ESTIMATOR
ROBERT F. RICHFIELD (U.S. Army, Redstone Arsenal, AL), BRUCE K. WALKER (Cincinnati, University, OH), and EDWARD V. BERGMANN (Charles Stark Draper Laboratory, Inc., Cambridge, MA) (Guidance, Navigation and Control Conference, Williamsburg, VA, Aug. 18-20, 1986, Technical Papers, p. 57-67) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 207-212. Previously cited in issue 23, p. 3425, Accession no. A86-47409. refs

A88-43206*# State Univ. of New York, Buffalo.
MICROPROCESSOR CONTROLLED FORCE ACTUATOR
D. C. ZIMMERMAN, D. J. INMAN (New York, State University, Buffalo), and G. C. HORNER (NASA, Langley Research Center, Hampton, VA) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 1, p. 243-251) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 230-236. Previously cited in issue 18, p. 2617, Accession no. A86-38827. refs
(Contract NGT-33-183-801; NSF MEA-83-51807; AF-AFOSR-85-0220)

A88-43211*# Illinois Univ., Urbana.
VARIABLE-STRUCTURE CONTROL OF SPACECRAFT ATTITUDE MANEUVERS
THOMAS A. W. DWYER, III and HEBERTT SIRA-RAMIREZ (Illinois, University, Urbana) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 262-270. refs
(Contract NAG1-436; NSF ECS-85-16445; N00014-84-C-0149)

A variable-structure control approach is presented for multiaxial spacecraft attitude maneuvers. Nonlinear sliding surfaces are proposed that result in asymptotically stable, ideal linear decoupled sliding motions of Cayley-Rodrigues attitude parameters, as well as of angular velocities. The resulting control laws are interpreted as more easily implemented and more robust versions of those previously obtained by feedback linearization. Author

A88-43212#
ACTIVE VIBRATION CONTROL SYNTHESIS FOR THE CONTROL OF FLEXIBLE STRUCTURES MAST FLIGHT SYSTEM
BONG WIE (Texas, University, Austin) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 271-277. Previously cited in issue 22, p. 3549, Accession no. A87-50443. refs

A88-43215#
EVALUATION OF IMAGE STABILITY OF A PRECISION POINTING SPACECRAFT
HARI B. HABLANI (Rockwell International Corp., Seal Beach, CA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, May-June 1988, p. 283-286.

A discrete Fourier transform presentation is given for a 'clutter leakage metrics' device, which is a Fourier-integral form available in the electrooptics literature for the evaluation of image stability in precision-pointing telescopes. The metrics encompass the Fourier spectrum of the pointing error, an integration interval, and a differencing operation; these are presently demonstrated for the case of a telescope whose image stability during landmark tracking is disturbed by a neighboring solar array. O.C.

A88-46401
LARGE SPACE STRUCTURES: DYNAMICS AND CONTROL
SATYA N. ATLURI, ED. (Georgia Institute of Technology, Atlanta) and ANTHONY K. AMOS, ED. (USAF, Office of Scientific Research, Bolling AFB, Washington, DC) Berlin and New York, Springer-Verlag, 1988, 373 p. For individual items see A88-46402 to A88-46414.

Recent advances in the dynamical design and control theory of large space structures (LSSs) are examined in chapters contributed by leading experts. Topics addressed include continuum modeling of large lattice structures, computational aspects of nonlinearities in the dynamics and control of LSSs, modal cost analysis for simple continua, the transient dynamics of flexible LSSs, control-LSS interaction analysis, the dynamical response of an LSS to pulse excitation, and modeling techniques for open- and closed-loop LSS dynamics. Consideration is given to dynamic friction, control of distributed structures, the acoustic limit of structural-dynamic control, active control for vibration damping, a unified theory of reduced-order robust control design, adaptive control of LSSs, and unified optimization of structures and controllers. T.K.

A88-46408
CONTROL OF DISTRIBUTED STRUCTURES
LEONARD MEIROVITCH (Virginia Polytechnic Institute and State University, Blacksburg) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 195-212. refs

The modal or direct-feedback control of distributed structures is considered theoretically, summarizing the results of the author's recent investigations (Meirovitch, 1980, 1987, and 1988; Meirovitch and Baruh, 1983 and 1985; Meirovitch and Silverberg, 1983). The derivations of the equation of motion for a distributed structure and the modal equations are outlined; mode controllability and observability are defined; the closed-loop modal equations are obtained; and particular attention is given to independent modal-space control, pole allocation, optimal control, control by point actuators, control spillover, observation spillover, feedback control, and proportional damping. The optimal choice of gain is shown to be a critical problem in both modal and feedback controls. T.K.

A88-46410
ACTIVE CONTROL FOR VIBRATION DAMPING
P. J. LYNCH (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 239-261. refs

Active control laws are developed for an LSS-type structure to damp vibrations. High frequency modeling uncertainties lead to the necessity for a robust control design. The Linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR) control design technique is a particular robust design technique selected for use in designing a damping control system. A summary of LQG/LTR is given and numerical example using a two bay truss is presented. Author

A88-46411
OPTIMAL PROJECTION FOR UNCERTAIN SYSTEMS (OPUS) - A UNIFIED THEORY OF REDUCED-ORDER, ROBUST CONTROL DESIGN
DENNIS S. BERNSTEIN and DAVID C. HYLAND (Harris Corp., Government Aerospace Systems Div., Melbourne, Florida) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 263-302. refs
(Contract F49620-86-C-0002; F49620-86-C-0038)

Recent advances in the numerical solution of active-vibration-control problems for large flexible structures are examined in an analytical review, with a focus on the optimal-projection algorithm OPUS (Bernstein, 1986). The fundamental principles of vibration suppression are recalled; the linear-quadratic-Gaussian (LQG) design technique is described; and the operation of OPUS is characterized in detail and illustrated with extensive diagrams and flow charts. In OPUS, the LQG approach is generalized in two different ways to permit simultaneous development of low-order and robust controllers, employing the efficient homotropy algorithm of Richter (1987) in the solution of pairs of Riccati and Liapunov equations coupled by optimal projection and uncertainty terms, respectively. Such an approach is shown to account for all major tradeoffs in the design of practical controllers for large space structures. T.K.

A88-46412
ADAPTIVE CONTROL OF LARGE SPACE STRUCTURES - UNCERTAINTY ESTIMATION AND ROBUST CONTROL CALIBRATION
ROBERT L. KOSUT (Integrated Systems, Inc., Santa Clara, CA) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 303-321. refs
(Contract F49620-85-C-0094)

An approach is presented to the problem of designing a robust control using on-line measurements. The idea is to use standard methods of parametric system identification to obtain a nominal estimate of the plant transfer function. Nonparametric spectral methods are then used to obtain a frequency domain expression for model uncertainty. If the model uncertainty exceeds a specified frequency bound, which has been predetermined from the nominal model and the performance criteria, then data filters used in the system identification are modified and the procedure is repeated. An analysis is presented which establishes conditions under which the procedure will actually converge to a satisfactory robust design. An example is provided which illustrates the method and supporting analysis. Author

A88-46413
UNIFIED OPTIMIZATION OF STRUCTURES AND CONTROLLERS
J. L. JUNKINS and D. W. REW (Texas A & M University, College

Station) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 323-353. refs
(Contract F49620-86-K-0014)

The theoretical basis and performance of methods for the solution of high-dimensional structural control problems are examined, reviewing the results of recent investigations. The emphasis is on robust eigenstructure-assignment methods and optimization methods in which both the controller and selected structural parameters are readjusted to improve robustness. Families of designs displaying the inherent tradeoffs between robustness, small control errors, and small controller inputs are generated, and the use of homotopy methods is shown to improve the convergence of iterative numerical procedures. Diagrams, graphs, and tables of numerical data are provided. T.K.

A88-46414
AN INTEGRATED APPROACH TO THE MINIMUM WEIGHT AND OPTIMUM CONTROL DESIGN OF SPACE STRUCTURES
N. S. KHOT (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) IN: Large space structures: Dynamics and control. Berlin and New York, Springer-Verlag, 1988, p. 355-363. refs

Two procedures for the simultaneous optimization of a structural design for both minimum weight and active vibration control are characterized analytically in a brief review. The equations of motion for a typical system are derived, and the formulations of methods based on (1) minimum-weight design with constraints on the closed-loop eigenvalues and (2) minimum-weight design with constraints on the control gain norm are outlined. Numerical results for sample problems analyzed using the active-control algorithm ACOSS-FOUR (Strunce et al., 1980) are presented in tables. T.K.

A88-47462#
GAME THEORY APPROACH FOR THE INTEGRATED DESIGN OF STRUCTURES AND CONTROLS
S. S. RAO (Purdue University, West Lafayette, IN), V. B. VENKAYYA, and N. S. KHOT (USAF, Wright-Patterson AFB, OH) AIAA Journal (ISSN 0001-1452), vol. 26, April 1988, p. 463-469. USAF-supported research. refs

The problem of design of actively controlled structures subject to constraints on the damping parameters of the closed-loop system is formulated as a multiobjective optimization problem. The structural weight and the controlled system energy are considered as objective functions for minimization with cross-sectional areas of members as design varibles. A computational procedure is developed for solving the multiobjective optimization problem using cooperative game theory. The feasibility of the procedure is demonstrated through the design of two truss structures. Author

A88-50095
METHOD FOR THE EXPERIMENTAL DETERMINATION OF THE FREQUENCY CHARACTERISTICS OF AN ELASTIC FLIGHT VEHICLE WITH A DIGITAL CONTROL SYSTEM [METODY EKSPERIMENTAL'NOGO OPREDELENIIA CHASTOTNYKH KHARAKTERISTIK UPRUGOGO LETATEL'NOGO APPARATA S TSIFROVOI SISTEMOI UPRAVLENIIA]
V. M. KUVSHINOV TsAGI, Uchenye Zapiski (ISSN 0321-3429), vol. 17, no. 6, 1986, p. 54-68. In Russian. refs

Several frequency-analyzer-based techniques for determining the frequency characteristics of flight vehicles with a digital control system in the elastic-vibration frequency range of the structure are examined. Errors due to the finite measurement time are assessed, and simple relationships for choosing the appropriate measurement time are proposed. B.J.

A88-50165*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
POLE/ZERO CANCELLATIONS IN FLEXIBLE SPACE STRUCTURES
TREVOR WILLIAMS and JER-NAN JUANG (NASA, Langley Research Center, Hampton, VA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 33-40. refs
(AIAA PAPER 88-4055)

A practical objective in the control of flexible space structures is to minimize the effects of vibrational dynamics at certain specified points on a structure. State feedback can be used to address this question by creating closed-loop modes which are unobservable at these points, and so do not contribute to the measured response. In the frequency domain, such modes correspond to pole/zero cancellations in the closed loop system. This paper analyzes the problem of pole/zero cancellation in flexible structures, making full use of the second-order form of such systems. An explicit expression is derived for the unique state feedback gain with minimum norm which cancels all open-loop zeros. Furthermore, the properties of the residual poles that remain observable in the closed-loop system are studied, and their stability proven for the case of colocated sensors and actuators. Author

A88-50167#
SENSORS, ACTUATORS, AND HYPERSTABILITY OF STRUCTURES
MICHAEL E. STIEBER (CDC, Communications Research Centre, Ottawa, Canada) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 51-56. refs
(AIAA PAPER 88-4057)

The design of robust adaptive controllers for large space flexible structures with poorly known time-varying nonlinear dynamics is considered in an analytical review, with a focus on the hyperstability (HS) criterion (guaranteeing stability of interconnected systems) and the selection and placement of sensors and actuators. A definition of HS is presented; the properties of hyperstable systems are listed; sufficient and necessary conditions for HS are outlined; conditions on sensor types and placement are summarized; and problems involving absolute positioning, asymptotic HS, and the use of 'nonallowed' sensors are briefly considered. Colocation of sensors and actuators is found to be preferable because it is sufficient (although not necessary) for HS. T.K.

A88-50170#
MODELING OF NON-COLLOCATED STRUCTURAL CONTROL SYSTEMS
V. A. SPECTOR (TRW, Inc., Redondo Beach, CA) and H. FLASHNER (Southern California, University, Los Angeles) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 74-83. Research supported by TRW, Inc. refs
(Contract NSF MSM-85-05331)
(AIAA PAPER 88-4060)

The generic properties of structural modeling pertinent to structural control are discussed, with emphasis on noncollocated systems. Analysis is performed on a representative example of a pinned-free Euler-Bernoulli beam with end-point inertia and distributed sensors. Analysis in the wavenumber plane highlights the crucial qualitative characteristics common to all structural systems. High sensitivity of the transfer-function zeros to errors in model parameters and sensor locations is demonstrated. The existence of finite right-half-plane zeros in noncollocated systems, along with this high sensitivity, further complicates noncollocated control design. A numerical method for accurate computation of the transfer-function zeros in proposed. Author

A88-50189*# Ohio State Univ., Columbus.
TWO CONTROLLER DESIGN APPROACHES FOR DECENTRALIZED SYSTEMS
U. OZGUNER, F. KHORRAMI, and A. IFTAR (Ohio State University, Columbus) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 237-244. Research supported by Lawrence

Livermore National Laboratory. refs
(Contract NAG1-720)
(AIAA PAPER 88-4083)

Two different philosophies for designing the controllers of decentralized systems are considered within a quadratic regulator framework which is generalized to admit decentralized frequency weighting. In the first approach, the total system model is examined, and the feedback strategy for each channel or subsystem is determined. In the second approach, separate, possibly overlapping, and uncoupled models are analyzed for each channel, and the results can be combined to study the original system. The two methods are applied to the example of a model of the NASA COFS Mast Flight System. R.R.

A88-50191#
A DISTRIBUTED FINITE ELEMENT MODELING AND CONTROL APPROACH FOR LARGE FLEXIBLE STRUCTURES
K. DAVID YOUNG (Lawrence Livermore National Laboratory, Livermore, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 253-263. refs
(Contract W-7405-ENG-48)
(AIAA PAPER 88-4085)

A framework for the design of decentralized controllers for large flexible structures is proposed which integrates the finite element modeling and control design phases. The integrated modeling and control design tasks are distributed among the individual components from which the large flexible structure is contructed using the Controlled Component Synthesis method. The method allows controlled components to be built and assembled into a controlled flexible structure that meets performance specifications. Connections are made between controlled component synthesis and existing large scale system model reduction and decomposition techniques. R.R.

A88-50209*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
NASA OFFICE OF SPACE SCIENCES AND APPLICATIONS STUDY ON SPACE STATION ATTACHED PAYLOAD POINTING
R. A. LASKIN, J. M. ESTUS, Y. H. LIN, J. T. SPANOS, and C. M. SATTER (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 430-443. refs
(AIAA PAPER 88-4105)

A study has been conducted to determine the articulated-pointing requirements of a suite of instruments carried by the NASA Space Station, and define a pointing system architecture accomodating those requirements. It is found that these pointing requirements are sufficiently exacting, and the Space Station's disturbance environment sufficiently severe, to preclude the successful use of a conventional gimbal-pointing system; a gimbaled system incorporating an isolation stage is judged capable of furnishing the requisite levels of pointing performance. O.C.

A88-50233*# Texas Univ., Austin.
A NEW MOMENTUM MANAGEMENT CONTROLLER FOR THE SPACE STATION
B. WIE, K. W. BYUN, V. W. WARREN (Texas, University, Austin), D. GELLER, D. LONG, and J. SUNKEL (NASA, Johnson Space Center, Houston, TX) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 677-687. refs
(AIAA PAPER 88-4132)

A new approach to CMG (control moment gyro) momentum management and attitude control of the Space Station is developed. The control algorithm utilizes both the gravity-gradient and gyroscopic torques to seek torque equilibrium attitude in the presence of secular and cyclic disturbances. Depending upon mission requirements, either pitch attitude or pitch-axis CMG momentum can be held constant; yaw attitude and roll-axis CMG momentum can be held constant, while roll attitude and yaw-axis CMG momentum cannot be held constant. As a result, the overall attitude and CMG momentum oscillations caused by cyclic aero-dynamic disturbances are minimized. A state feedback controller with minimal computer storage requirement for gain scheduling is also developed. The overall closed-loop system is stable for + or - 30 percent inertia matrix variations and has more than + or - 10 dB and 45 deg stability margins in each loop. Author

A88-50247*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADAPTIVE CONTROL EXPERIMENT WITH A LARGE FLEXIBLE STRUCTURE
CHE-HANG CHARLES IH, DAVID S. BAYARD, SHYH JONG WANG, and DANIEL B. ELDRED (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 832-851. refs
(AIAA PAPER 88-4153)

A large space antenna-like ground experiment structure has been developed for conducting research and validation of advanced control technology. A set of proof-of-concept adaptive control experiments for transient and initial deflection regulation with a small set of sensors and actuators were conducted. Very limited knowledge of the plant dynamics and its environment was used in the design of the adaptive controller so that performance could be demonstrated under conditions of gross underlying uncertainties. High performance has been observed under such stringent conditions. These experiments have established a baseline for future studies involving more complex hardware and environmental conditions, and utilizing additional sets of sensors and actuators. Author

A88-50261#
GUIDANCE AND CONTROL FOR COOPERATIVE TETHER-MEDIATED ORBITAL RENDEZVOUS
DALE G. STUART (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 964-974. refs
(AIAA PAPER 88-4170)

This paper presents a viable guidance algorithm for performing a tether-mediated rendezvous, optimizing the rendezvous state such that the minimum total maneuvering effort is required of two vehicles performing the rendezvous. The algorithm's feasibility and practicality are analyzed under near-realistic operating conditions by simulating perturbations of a free-flying pursuit vehicle (PV) from its nominal rendezvous trajectory and then observing the capability of the algorithm to determine corrective maneuvers that would lead to a successful rendezvous. Fuel requirements, time spent within proximity of the target, and thruster failure tolerances are considered. Results indicate that the algorithm performs well even with large PV perturbations. The resulting total fuel cost for both vehicles is less than what would be required by having one vehicle alone perform the rendezvous maneuvers. C.D.

A88-50263#
LIBRATION DAMPING OF A TETHERED SATELLITE USING RATE ONLY CONTROL
W. R. DAVIS and A. K. BANERJEE (Lockheed Missiles and Space Co., Sunnyvale, CA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 984-994. refs
(AIAA PAPER 88-4172)

A control law specifying tether reel in/out rate based on measurement of tether libration angles and their rates has been formulated and evaluated using a simple model of a tethered satellite. The results indicate that both out-of-plane and in-plane

librations can be damped by varying the length of the tether by about 10 percent of its length. Time required to reduce out-of-plane librations by a factor of 10 is less than seven orbital periods. Significant improvement in control of in-plane librations are shown in that these are damped in less than one orbit period. Control of the damped configuration to a nominal desired length is also included. A FORTRAN code for the control logic is given.
Author

A88-50339#
OPTIMAL STRUCTURAL DESIGN WITH CONTROL GAIN NORM CONSTRAINT
N. S. KHOT, V. B. VENKAYYA (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH), H. OZ (Ohio State University, Columbus), R. V. GRANDHI (Wright State University, Dayton, OH), and F. E. EASTEP (Dayton, University, OH) AIAA Journal (ISSN 0001-1452), vol. 26, May 1988, p. 604-611. Previously cited in issue 08, p. 1144, Accession no. A87-22363. refs

A88-50352
AIAA/AAS ASTRODYNAMICS CONFERENCE, MINNEAPOLIS, MN, AUG. 15-17, 1988, TECHNICAL PAPERS
Conference sponsored by AIAA and AAS. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, 760 p. For individual items see A88-50353 to A88-50407, A88-50409 to A88-50439.

Papers are presented on precise orbit computations of Lageos, an ideal reference frame for perturbed orbital motion, the celestial mechanics of gravity assist, and a slew maneuver experiment of mission function control. Also considered are an error analysis for a Mars landing, a collision matrix for LEO satellites, Galilean satellite ephemeris improvement using Galileo tour encounter information, and low-thrust power-limited transfer for a pole squatter. Other topics include navigating Neptune, long-term revisit coverage using multisatellite constellations, optimal payload lofting with tethers, and double lunar swingby trajectory design. Papers are also presented on explicit guidance along an optimal space curve, analytical models for relative motion under constant thrust, and a GPS constellation buildup plan. R.R.

A88-50384*# Howard Univ., Washington, DC.
THE DYNAMICS AND CONTROL OF THE ORBITING SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) DURING STATION KEEPING
PETER M. BAINUM and CHEICK M. DIARRA (Howard University, Washington, DC) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 278-285. refs
(Contract NSG-1414)
(AIAA PAPER 88-4252)

A mathematical model is developed to predict the dynamics of the proposed orbiting Spacecraft Control Laboratory Experiment during the station keeping phase. The Shuttle as well as the reflector are assumed to be rigid, the mast is flexible and is assumed to undergo elastic displacements very small as compared with its length. The equations of motion are derived using a Newton-Euler formulation. The model includes the effects of gravity, flexibility, and orbital dynamics. The control is assumed to be provided to the system through the Shuttle's three torquers, and through six actuators located by pairs at two points on the mast and at the mass center of the reflector. At each of the locations, an actuator acts parallel to the roll axis while the other one acts parallel to the pitch axis. It is seen that, in the presence of gravity-gradient torques in the system dynamics, the system assumes a new equilibrium position about which the equations must be linearized, primarily due to the offset in the mast attachment point to the reflector. The linear regulator theory is used to derive control laws for the linear model of the SCOLE including the first four flexible modes. Numerical results confirm the robustness of this control strategy for station keeping with maximum control efforts significantly below saturation levels.
Author

A88-50386#
AN OPTIMAL MANEUVER CONTROL METHOD FOR THE SPACECRAFT WITH FLEXIBLE APPENDAGES
D. LIU, D. M. YANG, W. P. ZHANG (Harbin Institute of Technology, People's Republic of China), and J. XI IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 294-300. Research sponsored by the National Natural Science Foundation of China. refs
(AIAA PAPER 88-4255)

A maneuver control method for a system of rigid and flexible bodies is presented which can suppress the elastic vibration mode and avoids the two point boundary value problem. The method requires that vibration parameters be determined before optimal controls are applied to the system. The method can be used to restrict or eliminate elastic vibration, liquid sloshing, or pendulum oscillation. The approach can be developed to suppress two of these vibrations simultaneously. R.B.

A88-50430#
INTEGRATED STRUCTURAL/CONTROLLER OPTIMIZATION OF LARGE SPACE STRUCTURES
SCOT K. MORRISON, YINYU YE, CHARLES Z. GREGORY, JR., ROBERT L. KOSUT (Integrated Systems, Inc., Santa Clara, CA), and MARC E. REGELBRUGGE (Lockheed Research Laboratories, Palo Alto, CA) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 681-688. refs
(Contract F29601-86-C-0243)
(AIAA PAPER 88-4305)

A method for optimizing the closed-loop disturbance rejection capabilities of a large-space-structure is presented herein. The procedure uses two levels of model reduction, one to an evaluation model, and another to a controlled subspace. The line-of-sight pointing error of optical elements mounted on the spacecraft is used to evaluate the system performance. Optimization results are obtained for both the open-loop and closed-loop system, with several different sets of constraints. The results indicate that combined structural/controller optimization yields superior disturbance rejection qualities than open-loop optimization followed by optimal control implementation. Author

A88-50438*# Columbia Univ., New York, NY.
A MATHEMATICAL THEORY OF LEARNING CONTROL FOR LINEAR DISCRETE MULTIVARIABLE SYSTEMS
MINH PHAN and RICHARD W. LONGMAN (Columbia University, New York) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 740-746. refs
(Contract NAG1-649)
(AIAA PAPER 88-4313)

When tracking control systems are used in repetitive operations such as robots in various manufacturing processes, the controller will make the same errors repeatedly. Here consideration is given to learning controllers that look at the tracking errors in each repetition of the process and adjust the control to decrease these errors in the next repetition. A general formalism is developed for learning control of discrete-time (time-varying or time-invariant) linear multivariable systems. Methods of specifying a desired trajectory (such that the trajectory can actually be performed by the discrete system) are discussed, and learning controllers are developed. Stability criteria are obtained which are relatively easy to use to insure convergence of the learning process, and proper gain settings are discussed in light of measurement noise and system uncertainties. Author

A88-50440#
ACCOMMODATION OF KINEMATIC DISTURBANCES DURING A MINIMUM-TIME MANEUVER OF A FLEXIBLE SPACECRAFT
YAAKOV SHARONY and LEONARD MEIROVITCH (Virginia

Polytechnic Institute and State University, Blacksburg) AIAA and AAS, Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988. 17 p. refs
(Contract F33615-86-C-3233)
(AIAA PAPER 88-4253)

This paper is concerned with control of the perturbations experienced by a flexible spacecraft during a minimum-time maneuver. The spacecraft is modeled as a flexible appendage attached to a rigid hub. The perturbations consist of rigid-body deviations and elastic vibration. The vibration is described by a linear, time-varying set of ordinary differential equations subjected to piecewise-constant disturbances caused by inertial forces resulting from the maneuver. The control is carried out during the maneuver period, which is relatively short, and it uses an observer that estimates the controlled state and part of the disturbance vector. The controller is divided into an optimal finite-time linear quadratic regulator for the reduced-order model and a disturbance-accommodation control that minimizes a weighted norm spanning the full modeled state. The controller is designed to mitigate the effects of control and observation spillover, as well as of modeling errors. The developments are illustrated by means of a numerical example. Author

A88-50818
SPACE STATION DYNAMIC ANALYSIS

PREM B. D'CRUZ (Structural Dynamics Research Corp., Milford, OH) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 544-547. refs

This paper describes an application example of computer aided engineering techniques used to investigate the structural dynamnic characteristics of one of NASA's proposed Space Station configurations. The example investigations involved predicting vibration levels due to orbit reboost, Space Shuttle berthing and the unbalance force of the control moment gyro. Component mode synthesis was used to assemble and solve the system model of the Space Station. A numerical comparison of two popular component mode synthesis modeling methods, the fixed interface Craig-Bampton method and the free interface residual flexibility method was also performed for this application. Using the systems approach helps to predict and resolve many of the difficult and costly problems due to system level effects early in the product design cycle. SDRC I-DEAS and MSC/NASTRAN, software packages were used for the analysis. Author

A88-50836
EXPONENT DIAGRAM ANALYSIS OF FEEDBACK CONTROL SYSTEMS INCLUDING FLEXIBLE STRUCTURES

HUBERT HAHN IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 785-798.

Techniques for the analysis and design of feedback controllers for hydraulic or pneumatic test facilities (for applications such as earthquake, vehicle, and spacecraft testing) are developed and demonstrated. The method is designed to incorporate the effects of structural flexibility and provide better insight into the physics of system behavior; it comprises three main steps: symbolic computation of a characteristic polynomial, exponent-diagram analysis of the symbolic characteristic equation, and higher-order root-locus computation. These steps are described in detail and illustrated with extensive diagrams, graphs, and tables of numerical data for two sample problems. T.K.

A88-50863
SPACE STATION DYNAMIC ANALYSIS METHODS

MARY BAKER and PAUL BLELLOCH (SDRC, Inc., San Diego, CA) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 2. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 1098-1105.

Space Station dynamic characteristics have been studied using realistic Space Station models. With these characteristics as a guide, methods are presented for simultaneously modeling the effects of structural modes, any number of linear continuous time control systems, discrete passive dampers, and spinning bodies. The approach presented includes application of a structural analogy to controls which makes it possible to simulate all the above effects within s single structural dynamics code which is one module of the NASA/SDRC software, IDEAS. Author

A88-51715#
PROBLEMS AND SOLUTIONS FOR GPS USE BEYOND THE 12-HOUR ORBIT

STANLEY C. MAKI (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 187-193. refs

Eight different technological approaches for improving availability of GPS satellites at GEO are evaluated. These approaches are high-gain antenna systems, GPS channel coding, low-noise preamp, filter optimization, GPS satellite acquisition and selection, accurate on-board clock, mission planning, and earth-based GPS transmitters. Three options which stand out as possible solutions are analyzed and simulated: the combination of a high-gain antenna system with an accurate on-board clock, the use of earth-based GPS transmitters, and filter optimization. Performance improvement results and implementation are presented. C.D.

A88-51716*# Mayflower Communications Co., Inc., Wakefield, MA.
FEASIBILITY OF USING GPS MEASUREMENTS FOR OMV ATTITUDE UPDATE

TRIVENI N. UPADHYAY, HARLEY RHODEHAMEL (Mayflower Communications Co., Inc., Wakefield, MA), and A. WAYNE DEATON (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Institute of Navigation, National Technical Meeting, Santa Barbara, CA, Jan. 26-29, 1988, Proceedings. Washington, DC, Institute of Navigation, 1988, p. 194-200. refs
(Contract NAS8-36363)

This paper presents the results of a feasibility study to determine whether the measurements from GPS satellites can be used to estimate the OMV attitude to an accuracy comparable to the onboard sun sensors, i.e., better than 0.5 degree in each axis. The results documented in this paper demonstrate that OMV attitude can be estimated to an accuracy of 0.1 - 0.5 degree in each axis by processing GPS measurements in an onboard integrated, 17-state GPS/inertial navigation filter. The result is particularly significant for missions of short duration burns where accurate attitude information is needed to minimize guidance and control errors. It is shown that the GPS attitude technique described in this paper can be easily implemented in the current OMV navigation system design. Results reported in this paper are expected to support the goal of developing a fault-tolerant guidance, navigation, and control system offering an improved total navigation performance for the OMV. Author

A88-52355
REAL-TIME FAULT MANAGEMENT FOR LARGE-SCALE SYSTEMS

H. BIGLARI (Boeing Aerospace Co., Huntsville, AL), C. CHENG, and G. VACHTSEVANOS (Georgia Institute of Technology, Atlanta) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 9-63 to 9-69. refs

A priori knowledge of failure modes of a system is an indispensable information for design of robust decentralized hierarchical control schemes. In particular inclusion of system faults as part of the process under control provides greater flexibility for self diagnosis and maintenance of real-time systems. By assigning discrete states to the process under control, an 'artificial consciousness' can be created within the controller which allows the controller to exercise selective actions for each given discrete state. This concept has been implemented to control the utility systems of the Space Station Laboratory Simulator. Author

A88-53681
LABORATORY FACILITY FOR FLEXIBLE STRUCTURE CONTROL EXPERIMENTS
UMIT OZGUNER, STEPHEN YURKOVICH (Ohio State University, Columbus), JOSEPH W. MARTIN, and PAUL T. KOTNIK (Battelle Memorial Institute, Columbus, OH) (Virginia Polytechnic Institute and State University and AIAA, Symposium on Dynamics and Control of Large Space Structures, 6th, Blacksburg, VA, June 1987) IEEE Control Systems Magazine (ISSN 0272-1708), vol. 8, Aug. 1988, p. 27-33. Research supported by the Digital Equipment Corp. refs
(Contract NSF DMC-85-06143)

A laboratory facility to study various control problems related to flexible mechanical structures is described. Computer, interfacing, and software issues are discussed. A novel proof-mass actuator is presented. A free-free suspended-beam experiment and a skewing-beam experiment are described. Three additional experimental setups at various stages of development are briefly considered. I.E.

A88-54401
1988 AMERICAN CONTROL CONFERENCE, 7TH, ATLANTA, GA, JUNE 15-17, 1988, PROCEEDINGS. VOLUMES 1, 2, & 3
Conference sponsored by the American Automatic Control Council. New York, Institute of Electrical and Electronics Engineers, 1988, p. Vol. 1, 863 p.; vol. 2, 919 p.; vol. 3, 841 p. For individual items see A88-54402 to A88-54676.

Various papers on control are presented. The general topics considered include: simulation and computational methods; linear systems and control; control of flexible structures; intelligent control systems; industrial control systems; computer-aided control engineering; robust adaptive control; frequency-domain methods; filtering, estimation, and tracking; optimization of discrete event systems; trajectory control of robot manipulators; digital signal processsing in process control; control of batch processes; robustness of state space models; stable factorization; aircraft and spacecraft guidance; model order reduction; computer networking of real-time control; and advances in automatic control education. Also addressed are: implementation of adaptive and self-tuning controls in machining, eigenvalue/eigenstructure assignment, robust nonlinear control of manipulators, redundant robot control, fault detection, ACES control theory and verification, decentralized control, damage-tolerant flight control systems, neural networks in control, distributed parameter and time-delay systems, and robust stabilization and control. C.D.

A88-54410
PROJECTIVE CONTROLS FOR DISTURBANCE ATTENUATION IN LSS SYSTEMS
R. A. RAMAKER, J. MEDANIC, and W. R. PERKINS (Illinois, University, Urbana) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 89-94. refs
(Contract N00014-84-C-0149)

A design methodology is presented which addresses three main issues in the control of large space structures: improving the disturbance attenuation of the system, implementing the design as a low-order output feedback controller, and ensuring that the controller is robust to modeling uncertainty. The method developed to solve this problem makes use of projective controls. A frequency-domain characterization of the disturbance attenuation properties of projective controllers is developed to use design freedoms in the controllers to achieve robust disturbance attenuation. A 20-mode example demonstrates the use of this methodology. I.E.

A88-54423
IMPROVED METHODS FOR LINEARIZED FLEXIBILITY MODELS IN MULTIBODY DYNAMICS AND CONTROL
R. JONES, W. CIMINO, and W. RUSSELL (Boeing Aerospace Co., Seattle, WA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 189-194. refs

Simulation of structural response of multi-flexible-body systems by linearized flexible motion combined with nonlinear rigid motion is discussed. The advantages and applicability of such an approach for accurate simulation with reduced computational costs and turnaround times are briefly described, restricting attention to a control design environment. Requirements for updating the linearized flexibility model to track large angular motions are discussed, several update approaches are compared, and an approach that improves on previously published methods is recommended. A simple system undergoing large rotations is used for numerical illustration. I.E.

A88-54425
FAULT TOLERANT INTELLIGENT CONTROLLER FOR SPACE STATION SUBSYSTEMS
H. BIGLARI (Boeing Aerospace Co., Huntsville, AL), C. CHENG, and G. VACHTSEVANOS (Georgia Institute of Technology, Atlanta) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 202-207. refs

A priori knowledge of failure modes of a system is an indispensable information for design of robust decentralized hierarchical control schemes. In particular, inclusion of system faults as part of the process under control provides greater flexibility for self diagnosis and maintenance of real-time systems. By assigning discrete states to the process under control, an artificial consciousness can be created within the controller which allows the controller to exercise selective actions for each given discrete state. This concept has been implemented to control the utility systems of the Space Station Laboratory simulator. I.E.

A88-54529* Georgia Inst. of Tech., Atlanta.
OPTIMAL REENTRY GUIDANCE FOR AEROASSISTED ORBIT TRANSFER VEHICLES
ANTHONY J. CALISE and GYOUNG H. BAE (Georgia Institute of Technology, Atlanta) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 990-995. refs
(Contract NAG1-660)

A three-state model is presented for analyzing the problem of optimal changes in heading with minimum energy loss for a hypersonic gliding vehicle. A further model order reduction to a single state model is examined using singular perturbation theory. The optimal solution for the reduced problem defines an optimal altitude profile dependent on the current energy of the vehicle. A separate boundary-layer analysis is used to account for altitude and flight path angle dynamics, and to obtain lift and bank angle control solutions. By considering alternative approximations to solve the boundary-layer problem, three guidance laws are obtained, each having a feedback form. The guidance laws are evaluated for a hypothetical vehicle, and compared to an optimal solution obtained using a multiple shooting algorithm. I.E.

A88-54576
RECENT RESULTS IN IDENTIFICATION AND CONTROL OF A FLEXIBLE TRUSS STRUCTURE
R. LANE DAILEY and MICHAEL S. LUKICH (TRW, Inc., Redondo Beach, CA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 1468-1473. refs

Results are presented from an ongoing laboratory experiment in identification and feedback control of TRW's flexible truss structure. H(infinity) and mu-synthesis design methods were used to design high-performance MIMO (multi-input, multioutput) digital control laws for the six-input, four-output system. Noncollated feedback has reduced RMS structural vibration (as measured by the four sensors) by a factor of 48:1 open-loop versus closed-loop (60:1 on specific outputs). Frequency domain system identification,

using FFT (first Fourier transform) transfer function measurements and a Chebyshev polynomial curve fitting method, was the crucial factor in achieving these high performance levels. I.E.

A88-54639
H(INFINITY) ROBUST CONTROL SYNTHESIS FOR A LARGE SPACE STRUCTURE
M. G. SAFONOV, R. Y. CHIANG, and H. FLASHNER (Southern California, University, Los Angeles, CA) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 3. New York, Institute of Electrical and Electronics Engineers, 1988, p. 2038-2045. Research supported by TRW, Inc. refs

In a design study involving the use of H(infinity) optimal control theory, an 11-state control law is generated for a 116-state model of a large flexible space structure. A combination of colocated rate feedback, modal truncation, and optimal Hankel-norm model techniques is found to lead to a vastly simplified four-state model for the structure which, by singular-value theory, is proved to be satisfactory for design of a controller whose bandwidth exceeds the natural frequencies of all of the modes of the original 116-state model. Specifications regarding disturbance attenuation, bandwidth, and stability robustness are quantitatively expressed as weighting functions in a mixed-sensitivity H(infinity) optimal-control synthesis problem, the solution to which is computed using the LINF program of Chiang and Safonov (1987). I.E.

A88-54973#
OPTIMIZATION OF ACTIVELY CONTROLLED STRUCTURES USING MULTIOBJECTIVE PROGRAMMING TECHNIQUES
SINGIRESU S. RAO (Purdue University, West Lafayette, IN) IN: Developments in Mechanics. Volume 14(c) - Midwestern Mechanics Conference, 20th, West Lafayette, IN, Aug. 31-Sept. 2, 1987, Proceedings. West Lafayette, IN, Purdue University, 1987, p. 1215-1221. refs

The design of minimum weight structures with constraints on the damping parameters of the closed loop system in the design of an active control system is considered using multiobjective optimization techniques. The cross sectional areas of the members are treated as design variables. The structural weight and the controlled system energy are considered as objective functions for minimization. The goal programming and game theory approaches are used for the solution of the multiobjective optimization problems. The feasibility of the approaches is demonstrated through the design of two-bar and twelve-bar truss structures. Author

A88-55063#
THEORETICAL AND EXPERIMENTAL INVESTIGATION OF SPACE-REALIZABLE INERTIAL ACTUATION FOR PASSIVE AND ACTIVE STRUCTURAL CONTROL
DAVID W. MILLER and EDWARD F. CRAWLEY (MIT, Cambridge, MA) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Sept.-Oct. 1988, p. 449-458. refs
(Contract F49620-84-K-0010)

Inertial reaction devices are investigated for use as passive vibration absorbers and active control actuators for flexible space structures. Absorbers are designed for one- and two-degree-of-freedom structural representations using three parameter optimization techniques. All three yield nearly identical designs and indicate that inertial devices should be tuned to the lowest mode intended to receive increased damping. The optimal passive components of the control actuator are found to be those of the optimal passive vibration absorber. Proof-of-concept laboratory tests were performed on a quasi-free-free beam using inertial reaction devices that are space-realizable, i.e., conceptually capable of functioning in the space environment. The inertial devices were used as both passive absorbers and tuned actuators. Damping was significantly increased using both passive and passive/active techniques. Additional tests indicated the benefits and limitations of actuator tuning and the necessity of performing realistic experiments using space-realizable hardware. Author

A88-55393*# Howard Univ., Washington, DC.
RAPID SLEWING OF THE ORBITING SPACECRAFT CONTROL LABORATORY EXPERIMENT (SCOLE) USING LQR TECHNIQUES
CHEICK M. DIARRA and PETER M. BAINUM (Howard University, Washington, DC) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 9 p. refs
(Contract NSG-1414)
(IAF PAPER 88-320)

The rotational equations of motion, describing the dynamics of the (rigidized) proposed orbiting Spacecraft Control Laboratory Experiment (SCOLE) during the station keeping phase, are derived using the Eulerian formulation. When the attitude angles (roll, pitch, and yaw) are assumed small, a stability analysis is conducted for the system. It is seen that the pitch equation decouples from the roll and yaw equations when the interface between the mast on the reflector is not offset or the offset is only along the Shuttle roll axis. When a second offset is introduced along the pitch axis of the system and when the gravity-gradient torques are present in the dynamics, the system assumes a new equilibrium position. The linear regulator theory is used to derive a control law for the linear model of the rigidized SCOLE. This law is applied to the nonlinear model of the same configuration of the system and preliminary single axis slewing maneuvers (20 deg amplitude) are simulated. Author

N88-20902# Lawrence Livermore National Lab., CA.
ROBUST DECENTRALIZED CONTROL OF LARGE FLEXIBLE STRUCTURES
S. C. LU, I. K. FONG, S. H. WANG, and S. BUMPUS 17 Nov. 1987 48 p Prepared in cooperation with California Univ., Davis.
(Contract W-7405-ENG-48)
(DE88-005416; UCRL-15980) Avail: NTIS HC A03/MF A01

This report studies the problem of controlling a large flexible structure with robust decentralized feedback control. A decentralized optimal control algorithm is applied to compute the parameters of the robust controller. The proposed method is tested on the ACOSS Model No. 2, which is a realistic evaluation model for active structure control methods. Twelve co-located sensors and actuators are applied in order to suppress vibrations which are caused by two external disturbances. It is demonstrated that the proposed method can stabilize the closed-loop system via decentralized feedback. Other performance measures are also discussed. DOE

N88-21230# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (Germany, F.R.).
EVOLUTION OF LARGE MOMENTUM AND REACTION WHEELS
H. HEIMEL *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 297-302 Dec. 1987
Avail: NTIS HC A14/MF A01

Momentum and reaction wheels with diameters of 45 and 60 cm producing angular momentum ceilings of 300 and 1000 Nms are presented. For the 1000 Nms wheel, an engineering model is being built and tested. Design and expected performance data are given. A modular family of flywheels with momentums between 1 and 1000 Nms is also presented. ESA

N88-21240# Instituto de Pesquisas Espaciais, Sao Jose dos Campos (Brazil).
A FEEDBACK DOUBLE PATH COMPENSATING CONTROL STRUCTURE FOR THE ATTITUDE CONTROL OF A FLEXIBLE SPACECRAFT
DECIO CASTILHO CEBALLOS Feb. 1988 8 p Presented at the 5th IFAC/IFIP Symposium on Software for Computer Control, South Africa, 26-28 Apr. 1988
(INPE-4464-PRE/1239) 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 modeling errors are present. Parameter optimization is applied for finding the controller so as

to have optimized behavior for a high-order model. The fourth-order FDPC controller was tested for the one-axis attitude control of a spacecraft with flexible appendages, whose dynamics were approximated by a fourteenth-order linear invariant model. The FDPC controller was compared with a low-order controller and is shown to be less sensitive to modeling errors. Author

N88-22065# California Univ., Los Angeles. School of Engineering and Applied Science.
OPTIMAL CONTROL AND IDENTIFICATION OF SPACE STRUCTURES Final Report, 15 Aug. 1984 - 14 Dec. 1987
J. S. GIBSON 21 Dec. 1987 84 p
(Contract AF-AFOSR-0309-84)
(AD-A190033; AFOSR-88-0173TR) Avail: NTIS HC A05/MF A01 CSCL 22B

The focus of this research was to develop theoretical and computational tools for optimal control and adaptive parameter identification and control and adaptive parameter systems, primarily large flexible space structures. Approximation results for optimal control of infinite-dimensional systems were drived along with numerical results. Also developed was an approximation theory for discrete-time optimal regulator problems, which included problems with flexible structures as a particular example. GRA

N88-22068# Department of the Air Force, Washington, DC. Directorate of Studies and Analysis.
FEEDBACK CONTROL OF DISTRIBUTED PARAMETER SYSTEMS WITH APPLICATIONS TO LARGE SPACE STRUCTURES Final Progress Report, 28 Dec. 1983 - 1 Sep. 1987
MARK J. BALAS 15 Oct. 1987 27 p
(Contract AF-AFOSR-0124-83)
(AD-A190536; AFOSR-87-2034TR) Avail: NTIS HC A03/MF A01 CSCL 22B

Large space structures exhibit distributed parameter behavior in their dynamics and thus must be described on infinite-dimensional state-spaces. However, the controller algorithm must be finite-dimensional to be implemented. The focus of this research has been to make finite-dimensional approximations of infinite-dimensional controllers which stabilize the distributed parameter system. The investigator has shown conditions under which Galerkin approximation schemes can yield finite-dimensional stabilizing controllers for linear distributed parameter systems. GRA

N88-24666# Oklahoma Univ., Norman. Dept. of Mathematics.
ESTIMATION AND CONTROL OF DISTRIBUTED MODELS FOR CERTAIN ELASTIC SYSTEMS ARISING IN LARGE SPACE STRUCTURES Final Report, 1 Jul. 1984 - 30 Sep. 1987
LUTHER W. WHITE 30 Sep. 1987 62 p
(Contract AF AFOSR-0271-84)
(AD-A192120; AFOSR-88-0245TR) Avail: NTIS HC A04/MF A01 CSCL 22B

The goal of this research was to study estimation and control of elastic systems composed of beams and plates. Specifically, the research considered the problem of locating the optimal placement of controllers on a beam or plate and the problem of controlling general three-dimensional elastic models that incorporate nonlinear friction and contact laws on the boundary conditions. This final report summarizes those results. GRA

N88-24989# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Aerospace and Ocean Engineering.
EXPERIMENTAL STUDY OF ACTIVE VIBRATION CONTROL Final Technical Report, 30 Jan. 1986 - 31 Aug. 1987
WILLIAM L. HALLAUER, JR. 31 Aug. 1987 71 p
(Contract F49620-85-C-0024)
(AD-A191454; AFOSR-88-0060TR) Avail: NTIS HC A04/MF A01 CSCL 22B

Complementary experimental-theoretical studies were conducted on the following subjects related to the dynamics and control of flexible large spacecraft structures: 1) Transient wave propagation - Extensive results are presented for traveling waves in a laboratory structure excited by suddenly applied oscillatory point forces; 2) The dynamics of a thin-walled grid with a ridgid body slewing degree of freedom - The design, theoretical analysis, experimental testing, and experimental, and experimental-theoretical correlation are reported. Even after much refinement, the finite element model of the relatively simple structure did not satisfactorily predict the measured dynamic behavior; and 3) Active damping and control the slewing gird with the use of structure-borne accelerometers and reaction wheel actuators - The results of an active vibration damping experiment are presented. Also discussed are the serious practical problems encountered in this research and the potential for future experiments with simultaneous control of maneuvering and vibration. GRA

N88-26143 Rensselaer Polytechnic Inst., Troy, NY.
ADAPTIVE RESIDUAL MODE FILTER CONTROL OF DISTRIBUTED PARAMETER SYSTEMS FOR LARGE SPACE STRUCTURE APPLICATIONS Ph.D. Thesis
JANG JAMES OUYANG 1987 129 p
Avail: Univ. Microfilms Order No. DA8729317

Modal control is often proposed as a way to design stabilizing low order controllers for Distributed Parameter Systems (DPS). However, it is well known that such controllers, designed from a reduced order modal model, do not necessarily stabilize the actual DPS. It is proved that exponential closed-loop stability can always be achieved by the addition of a very low order Residual Mode Filter (RMF). Due to the uncertainty of modal data for the Large Space Structure (LSS), a real-time adaptive controller was designed and tested successfully via computer simulation. The controller, implemented in a digital minicomputer, consists of a modal Reduced-Order Model (ROM) controller, a bank of RMFs, and a bank of Frequency Locked Loops (FLLs) with associated bandpass filters for real-time parameter identification. Three DPS examples: a simply supported Euler-Bernoulli beam, a telegraph equation, and a Space Based Laser (SBL) beam expander are presented to illustrate the application of this concept. Dissert. Abstr.

N88-26390# Groningen Rijksuniversiteit (Netherlands). Subfaculteit Wiskunde en Informatica.
L(SUB INFINITY SYMBOL)-APPROXIMATIONS OF COMPLEX FUNCTIONS AND ROBUST CONTROLLERS FOR LARGE FLEXIBLE SPACE STRUCTURES
R. F. CURTAIN 1987 24 p
(PB88-186226; TW-281) Avail: NTIS HC A03/MF A01 CSCL 22B

A survey is presented of a theory for a frequency domain design of robust controllers for infinite dimensional systems using L sub infinity approximations. Applications to large flexible space structures are discussed. Author

N88-27180*# Axiomatix, Los Angeles, CA.
SPACECRAFT APPLICATIONS OF ADVANCED GLOBAL POSITIONING SYSTEM TECHNOLOGY Final Report
GAYLORD HUTH, JAMES DODDS, SERGEI UDALOV, RICHARD AUSTIN, PETER LOOMIS, and I. NEWTON DUBORAW, III (Motorola, Inc., Chicago, Ill.) 31 May 1988 147 p
(Contract NAS9-17681)
(NASA-CR-172055; NAS 1.26:172055; R8805-5) Avail: NTIS HC A07/MF A01 CSCL 17G

The purpose of this study was to evaluate potential uses of Global Positioning System (GPS) in spacecraft applications in the following areas: attitude control and tracking; structural control; traffic control; and time base definition (synchronization). Each of these functions are addressed. Also addressed are the hardware related issues concerning the application of GPS technology and comparisons are provided with alternative instrumentation methods for specific functions required for an advanced low earth orbit spacecraft. B.G.

N88-29850*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STRUCTURE (DYNAMICS AND CONTROL) THEME DEVELOPMENT
RICHARD A. RUSSELL and RICHARD M. GATES (Boeing Aerospace Co., Seattle, Wash.) Aug. 1988 32 p
(NASA-TM-100597; NAS 1.15:100597) Avail: NTIS HC A03/MF A01 CSCL 22B

A study was made to define the long-range technical objectives and goals for the Space Structure (Dynamics and Control) theme area. The approach was to evaluate ongoing and proposed technology activities such that the technology gaps and voids could be identified. After the technology needs were identified, a set of recommended experimental activities was defined including the technical objectives of each and their relationship. Author

N88-29851# California Univ., Los Angeles.
THEORY OF FILTERING AND CONTROL WITH APPLICATION TO CONTROL OF LARGE SPACE STRUCTURES Final Report, 1 Sep. 1983 - 31 Aug. 1987
A. V. BALAKRISHNAN 30 Mar. 1988 8 p
(Contract AF-AFOSR-0318-83)
(AD-A195500; AFOSR-88-0666TR) Avail: NTIS HC A02/MF A01 CSCL 22B

This report summarizes accomplishments under a grant to study modeling. Identification, and control of flexible structures and to study random fields with applications to laser beam distortion in a turbulent field. Research in flexible structures focused on deriving continuum models base upon partial differential equations and derived methods for the solution of the resulting boundary control problems. A robust controller for stabilization based upon the abstract Hilbert-space semigroup formulation was derived as was a stochastic control theory for partial differential equations. A white noise theory for random fields was derived which has applications to laser beam propagation in the atmosphere; in particular, it is used to model the turbulent field. GRA

N88-30124# State Univ. of New York, Albany. Research Foundation.
LASER SENSING FOR IDENTIFICATION AND CONTROL OF DISTRIBUTED PARAMETER SYSTEMS Final Report, 1 Dec. 1986 - 30 Nov. 1987
DANIEL J. INMAN 1 May 1988 17 p
(Contract AF-AFOSR-0099-87)
(AD-A195886; AFOSR-88-0654TR) Avail: NTIS HC A03/MF A01 CSCL 14B

This instrumentation award funded the purchase of a laser vibrometer system, mass computer data storage and data acquisition equipment. This equipment used in conjunction with existing vibration testing and control facilities provides a sophisticated low frequency velocity measurement system for use in identifying the coefficients in partial differential equation models of distributed mass structures. In addition, the vibrometer system provides straightforward and direct velocity feedback for such systems. These flexible structures characteristically have very low natural frequencies which cannot be detected by accelerometers. This system has and is being used to perform tests on models and sub-assemblies of large space structures for the purpose of evaluating existing identification and control strategies as well as to stimulate new research in the area of control, observers (estimators) and identification. Several intense experiments using the laser vibrometer were performed to measure the response of a quasi isotropic cantilevered beam with a removable tip mass excited by an impulse at various locations. This data was collected, stored, and sent to AFOSR researchers at Brown University transmitted using BITNET. The data was analyzed using a spline based estimation procedure, starting with a partial differential equation model of the structure. A clear advantage over modal methods based on a finite dimensional model of the same system was observed. GRA

N88-30134*# Catholic Univ. of America, Washington, DC. Dept. of Electrical Engineering.
ROBUST DESIGN OF DISTRIBUTED CONTROLLERS FOR LARGE FLEXIBLE SPACE STRUCTURES Final Technical Report
CHARLES C. NGUYEN Sep. 1988 33 p
(Contract NAG5-949)
(NASA-CR-183202; NAS 1.26:183202) Avail: NTIS HC A03/MF A01 CSCL 13I

Independent Modal Space Control (IMSC) method avoids control spillover generated by conventional control schemes such as Coupled Modal Control by decoupling the large flexible space structure into independent subsystems of second order and controlling each mode independently. The IMSC implementation requires that the number of actuators be equal to that of modeled modes, which is in general very huge. Consequently the number of required actuators is unrealizable. Two methods are proposed for the implementation of IMSC with reduced number of actuators. In the first method, the first m modes are optimized, leaving the last (n-m) modes unchanged. In the second method, generalized inverse matrices are employed to design the feedback controller so that the control scheme is suboptimal with respect to IMSC. The performance of the proposed methods is tested by performing computer simulation on a simply support beam. Simulation results are presented and discussed. Author

07

POWER

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

A88-21245
EVIDENCE FOR WEAK LINK AND ANISOTROPY LIMITATIONS ON THE TRANSPORT CRITICAL CURRENT IN BULK POLYCRYSTALLINE Y1BA2CU3OX
J. W. EKIN (NBS, Electromagnetic Technology Div., Boulder, CO), A. I. BRAGINSKI, A. J. PANSON, M. A. JANOCKO (Westinghouse Research and Development Center, Pittsburgh, PA), D. W. CAPONE, II (Argonne National Laboratory, IL) et al. (International Cryogenic Materials Conference, Saint Charles, IL, June 17, 1987) Journal of Applied Physics (ISSN 0021-8979), vol. 62, Dec. 15, 1987, p. 4821-4828. NBS-supported research. refs
(Contract DE-AI01-84ER-52113; F49620-85-C-0043; W-31-109-ENG-38)

Measurements of the transport critical-current density (Jc), magnetization Jc, and magnetoresistance in a number of bulk sintered samples of Y1Ba2Cu3Ox from several different laboratories indicate that the transport Jc is limited by weak-link regions between high Jc regions. The weak-link Jc has a Josephson character, decreasing by two orders of magnitude as the magnetic field is increased from 0.1 to 10 mT at 77 K. An examination of the grain-boundary region in Y1Ba2Cu3Ox shows no observable impurities or second phases to the scale of the 001-line-oriented lattice planes (about 12 A). The effect of intrinsic conduction anisotropy is discussed. A current-transfer model is proposed in which weak conduction along the c axis plays a role in limiting Jc at grain boundaries. Orienting the grains in the powder state during processing may result in enhanced transport Jc in bulk conductors. Author

A88-28942
FLOW IN THE INTER-PROFILE SURFACE OF THE BLADE PASSAGE OF A TURBINE CASCADE
E. G. NAREZHNYI, A. A. CHERNYSH, and B. V. SUDAREV (Leningradskii Korablestroitel'nyi Institut, Leningrad, USSR) (Teploenergetika, vol. 34, no. 6, 1987, p. 6-9) Thermal Engineering (ISSN 0040-6015), vol. 34, June 1987, p. 291-295. Translation. refs

The kinematic characteristics of flow and heat exchange at the interprofile surface of a blade passage in a two-dimensional model of a turbine cascade are studied. The boundary layer forming at the interprofile surface is of moderate thickness. The thickness of the boundary layer and of the longitudinal and transverse velocity oscillations within it decrease steadily downstream toward the throat of the passage; nonetheless, it remains turbulent all over. K.K.

A88-34093
ELECTRIC POWER GENERATION AND CONDITIONING FOR SPACECRAFT DYNAMIC ISOTOPE POWER SYSTEMS
KAPAL GANDIKOTA and WILLIAM R. OWENS (Sundstrand Advanced Technology Group, Rockford, IL) IN: NAECON 87; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1987. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 492-499. refs

The electrical power conditioning and control of a power conversion system employing an organic Rankine cycle (ORC) using toluene as the working fluid has been described. Electric power is generated by an ac homopolar alternator and conditioned by a three-phase Graetz bridge. Speed control of the turbine-alternator is the responsibility of the parasitic load regulator, while control of the excitation provides voltage regulation at the point of regulation. This is a departure from past spacecraft electric power system practice, in which a shunt regulator has been used to regulate voltage. A multiply redundant dual microprocessor controller is used to furnish adequate computational resources for control, protection, and reconfiguration of the dynamic isotope power system power conversion assembly. I.E.

A88-34312* Spectrolab, Inc., Sylmar, CA.
DEVELOPMENT OF 8 CM X 8 CM SILICON GRIDDED BACK SOLAR CELL FOR SPACE STATION
D. R. LILLINGTON, J. R. KUKULKA, S. M. BUNYAN, G. F. J. GARLICK (Spectrolab, Inc., Sylmar, CA), and B. SATER (NASA, Lewis Research Center, Cleveland, OH) IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 489-493.
(Contract NAS3-24672)

The 8-cm x 8-cm gridded back cell being developed for the space station photovoltaic array is described. Modeling studies show that the beginning of life power output of 1.039 W per cell may be met by several different configurations, the most promising being either a fielded or nonfielded 2 ohm-cm planar 8-mil cell. Experimental data are presented which show that a thermal alpha of 0.63 is achievable on a planar cell but at the expense of some Isc. Planar cells are found to possess short-circuit currents which are 9 percent lower than on textured cells due to the loss of near-IR radiation by transmission through the cell. Preliminary modeling shows that the efficiency of the textured cell exceeds the planar cell by approximately 9 percent at 25 C but the situation is reversed in orbit due to the high thermal alpha of textured cells (0.82). Experimental data show that the IR absorption in textured cells can be reduced by about 3 alpha points without loss of efficiency by controlling the doping concentration in the diffused layers, thus increasing the efficiency in orbit. I.E.

A88-34320* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A VERIFIED TECHNIQUE FOR CALIBRATING SPACE SOLAR CELLS
BRUCE ANSPAUGH (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 542-547.

Solar cells have been flown on high-altitude balloons for over 24 years, to produce solar cell standards that can be used to set the intensity of solar simulators. The events of a typical balloon calibration flight are reported. These are: the preflight events, including the preflight cell measurements and the assembly of the flight cells onto the solar tracker; the activities at the National Scientific Balloon Facility in Palestine, Texas, including the preflight calibrations, the mating of the tracker and cells onto the balloon, preparations for launch, and the launch; the payload recovery, which includes tracking the balloon by aircraft, terminating the flight, and retrieving the payload. In 1985, the cells flow on the balloon were also flown on a shuttle flight and measured independently. The two measurement methods are compared and shown to agree within 1 percent. I.E.

A88-34418* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEMPERATURE CHARACTERISTICS OF SILICON SPACE SOLAR CELLS AND UNDERLYING PARAMETERS
B. E. ANSPAUGH, RAM KACHARE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and G. F. J. GARLICK IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1194-1200. refs

Silicon space cells, 2 cm x 2 cm, with 10 ohm-cm p-base resistivity, 8-mil base thickness, and no back-surface fields have been investigated over the temperature range from 301 to 223 K by measurements of dark forward and reverse current-voltage characteristics and current-voltage relations under illumination. From dark forward bias data, the first and second diode saturation currents, I01 and I02, are determined and hence the base diffusion length and lifetime of minority carriers as functions of temperature. Lifetime increases exponentially with temperature and is explained by a Shockley-Read-Hall model with deep recombination levels 0.245 eV above the valence band. The I02 variation with temperature follows the Sah-Noyce-Shockley-Choo model except at low temperature where extra transitions raise the value above the predicted level. Reverse bias current at low voltage is a thermally assisted tunneling process via deep levels which are observed in base recombination at higher temperatures. The tunneling effects tend to become independent of temperature in the low-temperature region. These results demonstrate the ability to deduce basic parameters such as lifetime from simple measurements and show that back-surface fields offer no advantage at temperatures below 230 K. The analysis also explains the fall in lifetimes observed as the base conductivity increases, attributing it to native defects (perhaps carbon-oxygen-vacancy complexes) rather than the concentration of base dopant. I.E.

A88-34448
FLIGHT QUALIFICATION TESTING OF ULTRATHIN SOLAR CELLS
R. D. WILLIAMS, S. W. GELB, L. J. GOLDHAMMER, and G. S. GOODELLE (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA) IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1490, 1491.

Characterization and flight qualification testing has been conducted on ultrathin (0.0025-inch) production solar cells. Cells qualified by this test program and subsequently used in the fabrication of a Hughes HS 376 communications satellite represent the first ultrathin production solar cells to be used as the primary power source of a commercial satellite. Systems tests conducted on that satellite, including the solar panel, recently have been successfully completed. Significant results of the testing included verification of the mechanical integrity of the ultrathin solar cell and confirmation of improved radiation hardness. Improved resistance to radiation degradation is most pronounced at lower fluences, however the superior current collection efficiency of the ultrathin cell design is maintained in significant degree throughout the lifetime of a typical 10-year geosynchronous mission. I.E.

A88-34456
DOPING AND ALLOYING AMORPHOUS SILICON USING SILYL COMPOUNDS
B. FIESELMANN, M. MILLIGAN, A. WILCZYNSKI, J. PICKENS,

and C. R. DICKSON (Solarex Corp., Thin Film Div., Newtown, PA) IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1510, 1511.

An approach to alloying and doping amorphous silicon is presented in which the gas-phase starting materials are chosen with the desired chemical structure built-in prior to deposition to enhance the electronic and optical properties films. This is achieved by bonding silyl groups to the alloying or doping element to form the feedstock material. Superior a-SiC:H p-layers are produced using silylmethanes instead of methane, and Similarly for a-SiGe:H alloys produced using silylgermane. Results are presented for high-performance solar cells produced using these silyl compounds. I.E.

A88-35099
THE USE OF ELECTRODYNAMIC TETHERS FOR GENERATING POWER AND THRUST IN SPACE
D. E. HASTINGS and MANUEL MARTINEZ-SANCHEZ (MIT, Cambridge, MA) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 701-716.
(AAS PAPER 86-366)

The concept of an electrodynamic tether is introduced. Such a tether works by inducing a current flow through the tether which closes in the ionosphere. It is shown that an electrodynamic tether used to generate power and thrust compares favorably with fuel cells and rockets. Some of the outstanding physical questions associated with operation of a tether are outlined and recent theoretical work reviewed. Author

A88-35945*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MAST MATERIAL TEST PROGRAM (MAMATEP)
MICHAEL L. CIANCONE and SHARON K. RUTLEDGE (NASA, Lewis Research Center, Cleveland, OH) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 12 p. refs
(AIAA PAPER 88-2475)

The MAMATEP program, which is aimed at verifying the need for and evaluating the performance of various protection techniques for the solar array assembly mast of the Space Station photovoltaic power module, is discussed. Coated and uncoated mast material samples have been environmentally tested and evaluated, before and after testing, in terms of mass and bending modulus. The protective coatings include CV-1144 silicone, a Ni/Al/InSn eutectic, and an open-weave Al braid. Long-term plasma asher results from unprotected samples indicate that, even though fiberglass-epoxy samples degrade, a protection technique may not be necessary to ensure structural integrity. A protection technique, however, may be desirable to limit or contain the amount of debris generated by the degradation of the fiberglass-epoxy. V.L.

A88-37293#
SOLAR-DYNAMIC ENERGY SUPPLY SYSTEMS FOR SPACE SYSTEMS
ALBERT FRITZSCHE and WOLF-JUERGEN DENNER Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 41-43.

Solar-dynamic spacecraft power-supply systems combine technically known processes of terrestrial power supply systems with a primary solar energy collector suitable for the 1.37 kW/sq m-intensity solar flux. An autonomous solar-dynamic module will encompass a parabolic solar collector, a receiver cavity for heat transfer to a working fluid, a thermal storage system, a thermomechanical converter, a cooler/preheater for use of waste heat, a radiator, an electrical generator, an energy conditioning system, and heliostatic mechanisms for pointing the concentrator. O.C.

A88-40564
THE EMERGING OPPORTUNITIES FOR SOLAR SPACE POWER
PETER E. GLASER (Arthur D. Little, Inc., Cambridge, MA) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 5-11. refs

The expansion of space activities in an increasing number of countries and developing capabilities to pursue these activities are described in relation to emerging opportunities for solar space power. The evolution of a space indusrial infrastructure based on the development of space stations and platforms that is opening up opportunities for space power projects is described. The need for a viable power supply to service the space infrastructure is emphasized. The space shuttle, space station, and the solar power satellite - and their relation to the development of a space infrastructure and the inherent commercial opportunities - are also described. The policy considerations to enable space mission planning and the development of systems and supporting technologies are cited. Finally, projections of space power markets in support of space activities are made, and a positive view of the achievable economic returns from space endeavors is emphasized. Author

A88-40566
DESIGN OF A SOLAR POWER SATELLITE FOR CONSTRUCTION FROM LUNAR MATERIALS
GREGG E. MARYNIAK (Space Studies Institute, Princeton, NJ) and BRIAN TILLOTSON (Space Research Associates, Redmond, WA) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 27-36. refs

Solar power satellites may be constructed from materials mined on the moon and transported into free space by means of an electromagnetic catapult called a mass-driver. Both the mass-driver and the chemical processing techniques required to obtain construction materials from lunar soil have been demonstrated in the laboratory. A solar power satellite has been designed for construction from lunar materials. This design requires only 1 percent of its mass from the earth. Author

A88-40567
THE SPS TRANSMITTER DESIGNED AROUND THE MAGNETRON DIRECTIONAL AMPLIFIER
WILLIAM C. BROWN (Microwave Power Transmission Systems, Inc., Weston, MA) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 37-49. refs

During the US Department of Energy (DOE)/NASA study of Satellite Power Systems (SPS) an assessment of the magnetron as the microwave generator was made. This paper reviews important findings and updates those findings with more recent technology. The magnetron, when combined with a passive device to make it into an amplifier and then fitted with a phase locked control loop to provide high gain while preserving phase lock between input and output, meets the many severe requirements imposed upon the microwave generator by the SPS transmitter. These include high efficiency, passive dissipation of waste heat, low noise, long life, low cost, low specific mass, and ability to interface with solar photovoltaic array with minimal power conditioning. Author

A88-40568
PROSPECTS OF INTERCALATED GRAPHITE FIBRE USE FOR ELECTRICAL POWER TRANSMISSION IN SOLAR POWER SATELLITES
SERGE FLANDROIS, CLAUDE MESCHI, and PIERRE DELHAES (CNRS, Centre de Recherche Paul Pascal, Talence, France) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 51-56. Research supported by Electricite de France. refs

The properties of different-source carbon fibers which can be used for intercalation with metal chlorides are discussed together with the characteristics (relevant for electrical power transmission) of various intercalated fibers. Special attention is given to the experimental results obtained on graphite fibers intercalated with $CuCl_2$, $AlCl_3$, $InCl_3$, $GaCl_3$, $SbCl_5$, $CdCl_2$, and $PdCl_2$. The products were characterized by SEM, Raman microprobe spectroscopy, and

X-ray diffraction, in addition to electrical resistivity measurements, stress-strain traction experiments, and current density tests. The conductivity losses were determined in air and high vacuum at temperatures below 200 C. The results showed that the electrical conductivity of intercalated graphite fibers is below that of Al and Cu. It is considered however that, owing to their superior stability, low density, and good mechanical properties, intercalated carbon fibers have good prospects for power transmission, particularly in solar power satellites. I.S.

A88-40569
SILICON RIBBON FOR SPACE SOLAR CELLS
CHRISTIAN BELOUET (Compagnie Generale d'Electricite, Marcoussis, France) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 57-67. refs

The classical approach based on flat solar arrays using crystalline silicon solar cells 50 microns thick is one of the approaches which has been considered for the achievement of space photovoltaic systems. The preparation of this silicon sheets in the 50-micron range is a difficult operation which can be obviated by means of ribbon growth technologies, such as the RAD process developed at the Laboratoires de Marcoussis. The purpose of this article is to present the RAD process and to discuss its ability to produce a material appropriate for space solar cells. It is shown that the RAD material may closely approach the performances of single crystalline silicon, if the growth process and the cell fabrication are optimized for space cell applications. A 15.5-percent AMI conversion efficiency has always been demonstrated in the laboratory, despite the polycrystalline texture of the material, with a conventional n(+)/p/p(+) structure. Author

A88-40570
A POLAR ORBIT SOLAR POWER SATELLITE
JOHN W. FREEMAN, JR. (Rice University, Houston, TX) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 69-73.

A proposal is suggested for placing the solar power satellite (SPS) in a polar elliptic orbit with apogee over the North Pole and placing the rectenna at a high latitude location. The satellite's long dwell time near apogee would allow it to follow the circumpolar motion of the rectenna for a large fraction of an orbit period. The long distance between the rectenna and the consumer could be accommodated by energy storage such as the conversion of elecricity to hydrogen. The advantages of this scheme are that it would confine the microwave beam near the earth to the polar regions which are sparsely populated and it would permit a total power requirement of less than 5 GW for early versions of the SPS, since the geostationary orbit distance would no longer be mandatory. Author

A88-42547
SPACE STRUCTURES, POWER, AND POWER CONDITIONING; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 11-13, 1988
RAYMOND F. ASKEW, ED. (Auburn University, AL) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 871), 1988, 368 p. For individual items see A88-42548 to A88-42590. (SPIE-871)

Various papers on space structures, power, and power conditioning are presented. Among the topics discussed are: heterogeneous gas core reaction for space nuclear power, pulsed gas core reactor for burst power, fundamental considerations of gas core reactor systems, oscillating thermionic conversion for high-density space power, thermoelectromagnetic pumps for space nuclear power systems, lightweight electrochemical converter for space power applications, ballistic acceleration by superheated hydrogen, laser-induced current switching in gaseous discharge, electron-beam-controlled semiconductor switches, laser-controlled semiconductor closing and opening switch. Also addressed are: semiconductor-metal eutectic composites for high-power switching, optical probes for the characterization of surface breakdown, 40 kV/20 kA pseudospark switch for laser applications, insulation direction for high-power space systems, state space simulation of spacecraft power systems, structural vibration of space power station systems, minimum-time control of large space structures, novel fusion reaction for space power and propulsion, repetition rate system evaluations, cryogenic silicon photoconductive switches for high-power lasers, multilevel diamondlike carbon capacitor structure, surface breakdown of prestressed insulators, C-Mo and C-Zr alloys for space power systems, magnetic insulation for the space environment. C.D.

A88-43746*# Los Alamos National Lab., NM.
DEVELOPMENT OF AN INTEGRATED HEAT PIPE-THERMAL STORAGE SYSTEM FOR A SOLAR RECEIVER
E. KEDDY, J. TOM SENA, M. MERRIGAN (Los Alamos National Laboratory, NM), GARY HEIDENREICH (Sundstrand Corp., Rockford, IL), and STEVE JOHNSON (NASA, Lewis Research Center, Cleveland, OH) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 6 p. (AIAA PAPER 88-2683)

An integrated heat pipe-thermal storage system was developed as part of the Organic Rankine Cycle Solar Dynamic Power System solar receiver for space station application. The solar receiver incorporates potassium heat pipe elements to absorb and transfer the solar energy within the receiver cavity. The heat pipes contain thermal energy storage (TES) canisters within the vapor space with a toluene heater tube used as the condenser region of the heat pipe. During the insolation period of the earth orbit, solar energy is delivered to the heat pipe. Part of this thermal energy is delivered to the heater tube and the balance is stored in the TES units. During the eclipse period of earth orbit, the stored energy in the TES units is transferred by the potassium vapor to the toluene heater tube. A developmental heat pipe element was constructed that contains axial arteries and a distribution wick connecting the toluene heater and the TES units to the solar insolation surface of the heat pipe. Tests were conducted to demonstrate the heat pipe, TES units, and the heater tube operation. The heat pipe element was operated at design input power of 4.8 kW. Thermal cycle tests were conducted to demonstrate the successful charge and discharge of the TES units. Axial power flux levels up to 15 watts/sq cm were demonstrated and transient tests were conducted on the heat pipe element. Details of the heat pipe development and test procedures are presented. Author

A88-43974#
A MICROWAVE POWERED ORBITING INDUSTRIAL PARK SYSTEM
WILLIAM C. BROWN (Microwave Power Transmission Systems, Weston, MA) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 242-250. refs

The concept of orbiting industrial parks characterized by large physical size and large electrical power demands is noted to be compatible with existing 2.45-GHz microwave power transmission technology. Attention is given to one such system located on the earth's equatorial plane and employing 14 microwave power transmitters, emphasizing the key transmitter and rectenna technologies required to vindicate the present contention of near-term, low-cost implementability. The projected 10-year cost of the system, pased on 14 transmitters and a single industrial park in orbit, is $2.50/kW-hr. O.C.

A88-43975*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
BEAMED ENERGY FOR SPACE CRAFT PROPULSION - CONCEPTUAL STATUS AND DEVELOPMENT POTENTIAL
JOEL C. SERCEL and ROBERT H. FRISBEE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC,

American Institute of Aeronautics and Astronautics, 1987, p. 251-265. refs

This paper outlines the results of a brief study that sought to identify and characterize beamed energy spacecraft propulsion concepts that may have positive impact on the economics of space industrialization. It is argued that the technology of beamed energy propulsion systems may significantly improve the prospects for near-term colonization of outer space. It is tentatively concluded that, for space industrialization purposes, the most attractive near-term beamed energy propulsion systems are based on microwave technology. This conclusion is reached based on consideration of the common features that exist between beamed microwave propulsion and the Solar Power Satellite (SPS) concept. Laser power beaming also continues to be an attractive option for spacecraft propulsion due to the reduced diffraction-induced beam spread afforded by laser radiation wavelengths. The conceptual status and development potential of a variety of beamed energy propulsion concepts are presented. Several alternative space transportation system concepts based on beamed energy propulsion are described. Author

A88-45452#
THE HIPPARCOS SOLAR PANELS [DE ZONNEPANELEN VAN HIPPARCOS]
T. KONINK (Fokker Space and Systems, Amsterdam, Netherlands) Ruimtevaart, vol. 37, April 1988, p. 12-14. In Dutch.

The design and test performance of the solar panels for the ESA Hipparcos astrometric satellite are reviewed. The panels are of the type used on MARECS and ECS: 2240 180-micron-thick back-surface-reflecting solar cells are mounted on each 1.69 x 1.29 x 0.023-m Al-honeycomb/CFRP panel, electrically insulated with a 50-micron layer of kapton, and shielded from micrometeorites by a 150-micron protective layer. Three panels are attached with hinges to three of the six side faces of the Hipparcos spacecraft and unfolded after it attains GEO. The cells operate at a fixed voltage of 53 V and produce total power of about 450 W. The panels have passed qualification tests including temperature changes between -170 and +85 C, mechanical loads of 45 g, and impact tests of the hinges, as well as vibration and acoustic tests as part of the Hipparcos flight model. T.K.

A88-49750
PERFORMANCE OF FOCUSING MIRROR SYSTEMS FOR THE SOLAR DYNAMIC ENERGY SUPPLY OF SPACE STATIONS [ZUR LEISTUNG KONZENTRIERENDER SPIEGELSYSTEME FUER DIE SOLARDYNAMISCHE ENERGIE VERSORGUNG VON RAUMSTATIONEN]
R. KOEHNE (DFVLR, Institut fuer technische Thermodynamik, Stuttgart, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, May-June 1988, p. 197-201. In German. refs

Solar dynamic systems consisting of focusing solar collectors and heat engines are attracting increasing interest for space stations because of their high efficiencies. The optical and thermal performances of various collecting mirrors and collecting mirror systems is determined by computer modeling and the effect of manufacturing and tracking errors is indicated. Sufficiently high thermal collector efficiencies from 60 to 75 percent over a 600-1200 C temperature range can be attained with low total error below 4 mrad. C.D.

A88-52333* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE STATION PHOTOVOLTAIC POWER MODULES
CHARLES A. TATRO (NASA, Lewis Research Center, Cleveland, OH) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-21 to 5-33. refs

Silicon cell Photovoltaic (PV) power modules are key components of the Space Station Electrical Power System (EPS) scheduled to begin deployment in 1994. Four PV power modules, providing 75 KWe of user ac power, form the cornerstone of the EPS; which is comprised of Photovoltaic (PV) power modules, Solar Dynamic (SD) power modules, and the Power Management and Distribution (PMAD) system. The PV modules are located on rotating outboard sections of the Space Station (SS) structure and each module incorporates its own nickel-hydrogen energy storage batteries, its own thermal control system, and some autonomous control features. The PV modules are a cost-effective and technologically mature approach for providing reliable SS electrical power and are a solid base for EPS growth, which is expected to reach 300 KWe by the end of the Space Station's 30-year design lifetime. Author

A88-53779
ADVANCED SPACE POWER SYSTEMS
V. L. TEOFILO (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA) SAWE, Annual Conference, 46th, Seattle, WA, May 18-20, 1987. 11 p.
(SAWE PAPER 1762)

A review of electrical power source concepts for application to near term space missions is presented along with a comparison of their weight and area estimates. The power sources reviewed include photovoltaic solar arrays, solar concentrators, radioisotopic thermoelectric generators (RTG), Dynamic Isotope Power Subsystems (DIPS) and nuclear reactors. The solar arrays are found to be the lightest systems in the 1-6 kWe range for a 10 year mission life but they have the largest area of the practicable sources. Solar dynamics has the smallest area of the solar systems and has the lightest mass above 20 kWe of all the solar sources when a closed Brayton cycle power conversion system is used. The DIPS is the lightest weight system from 6 to 11 kWe above which the thermionic reactor is the lightest assuming a 38 foot boom is used to minimize shield weight. Author

A88-54696
DIGITAL SEQUENTIAL SHUNT REGULATOR FOR SOLAR POWER CONDITIONING OF ENGINEERING TEST SATELLITE (ETS-V)
SABURO KUWAJIMA, TETSUO SATO, MOTOHIRO KOBAYASHI, TOSHIO OKAMURA (National Space Development Agency of Japan, Tsukuba), NAOKI TSUYA (Mitsubishi Electric Corp., Kamakura, Japan) et al. IN: PESC '88 - Annual IEEE Power Electronics Specialists Conference, 19th, Kyoto, Japan, Apr. 11-14, 1988, Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 619-625. refs

A digital sequential shunt regulator is presented that regulates the bus voltage of the high-power ETS-V by controlling solar array segments sequentially in an on-off switching manner. To reduce EMI generated from switching surge current, a current-limiting circuit has been designed, and its effectiveness is verified experimentally. Static and dynamic characteristics of the voltage regulation loop are analyzed, and results are in good agrement with experimental results. I.E.

A88-54988*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ATOMIC-OXYGEN DURABILITY OF IMPACT-DAMAGED SOLAR REFLECTORS
DANIEL A. GULINO (NASA, Lewis Research Center, Cleveland, OH) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 39-44. Previously cited in issue 08, p. 1062, Accession no. A87-22417. refs

A88-55363#
DEVELOPMENT OF A GENERALIZED COST MODEL FOR LARGE SPACE POWER SYSTEMS
ALBIN D. KAZANOWSKI (Aerospace Corp., Los Angeles, CA) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 6 p. refs
(IAF PAPER 88-219)

A model for estimating weights and costs of large space electrical power systems is developed. It is valid for solar dynamic systems in the 50-150 kWe range and nuclear systems in the

50-500 kWe range. The model is expected to reduce the cost uncertainty of large space power systems from a factor of 5 to a range on the order of + or - 30 to 50 percent. K.K.

N88-20361*# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
SOLAR DYNAMIC POWER SYSTEM DEFINITION STUDY Final Report
WAYNE E. WALLIN and JERRY M. FRIEFELD Mar. 1988 322 p Prepared for presentation at the National Aerospace and Electronics Conf., Dayton, Ohio, 18-22 May 1987
(Contract NAS3-24864)
(NASA-CR-180877; NAS 1.26:180877; RI/RD87-250) Avail: NTIS HC A14/MF A01 CSCL 10B

The solar dynamic power system design and analysis study compared Brayton, alkali-metal Rankine, and free-piston Stirling cycles with silicon planar and GaAs concentrator photovoltaic power systems for application to missions beyond the Phase 2 Space Station level of technology for all power systems. Conceptual designs for Brayton and Stirling power systems were developed for 35 kWe and 7 kWe power levels. All power systems were designed for 7-year end-of-life conditions in low Earth orbit. LiF was selected for thermal energy storage for the solar dynamic systems. Results indicate that the Stirling cycle systems have the highest performance (lowest weight and area) followed by the Brayton cycle, with photovoltaic systems considerably lower in performance. For example, based on the performance assumptions used, the planar silicon power system weight was 55 to 75 percent higher than for the Stirling system. A technology program was developed to address areas wherein significant performance improvements could be realized relative to the current state-of-the-art as represented by Space Station. In addition, a preliminary evaluation of hardenability potential found that solar dynamic systems can be hardened beyond the hardness inherent in the conceptual designs of this study. Author

N88-21249*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED SENSIBLE HEAT SOLAR RECEIVER FOR SPACE POWER
TIMOTHY J. BENNETT (Sverdrup Technology, Inc., Cleveland, Ohio.) and DOVIE E. LACY 1988 12 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ASC and AIChE
(NASA-TM-100847; E-4008; NAS 1.15:100847) Avail: NTIS HC A03/MF A01 CSCL 10B

NASA Lewis, through in-house efforts, has begun a study to generate a conceptual design of a sensible heat solar receiver and to determine the feasibility of such a system for space power applications. The sensible heat solar receiver generated in this study uses pure lithium as the thermal storage medium and was designed for a 7 kWe Brayton (PCS) operating at 1100 K. The receiver consists of two stages interconnected via temperature sensing variable conductance sodium heat pipes. The lithium is contained within a niobium vessel and the outer shell of the receiver is constructed of third generation rigid, fibrous ceramic insulation material. Reradiation losses are controlled with niobium and aluminum shields. By nature of design, the sensible heat receiver generated in this study is comparable in both size and mass to a latent heat system of similar thermal capacitance. The heat receiver design and thermal analysis was conducted through the combined use of PATRAN, SINDA, TRASYS, and NASTRAN software packages. Author

N88-21250*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
SPACE STATION SOLAR CONCENTRATOR MATERIALS RESEARCH
DANIEL A. GULINO May 1988 15 p
(NASA-TM-100862; E-4074; NAS 1.15:100862) Avail: NTIS HC A03/MF A01 CSCL 10B

The Space Station will represent the first time that a solar dynamic power system will be used to generate electrical power in space. In a system such as this, sunlight is collected and focused by a solar concentrator onto the receiver of a heat engine which converts the energy into electricity. The concentrator must be capable of collecting and focusing as much of the incident sunlight as possible, and it must also withstand the atomic oxygen bombardment which occurs in low Earth orbit (LEO). This has led to the development of a system of thin film coatings applied to the concentrator facet surface in a chamber designed especially for this purpose. The system of thin film coatings employed gives both the necessary degree of reflectance and the required protection from the LEO atomic oxygen environment. Author

N88-21251*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POWER TRANSMISSION STUDIES FOR TETHERED SP-100
DAVID J. BENTS 1988 16 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ASC and AIChE
(NASA-TM-100864; E-4081; NAS 1.15:100864) Avail: NTIS HC A03/MF A01 CSCL 10B

The tether and/or transmission line connecting the SP-100 to space station presents some unorthodox challenges in high voltage engineering, power transmission, and distribution. The line, which doubles as a structural element of this unusual spacecraft, will convey HVDC from SP-100 to the platform in low Earth orbit, and environment where the local plasma is sufficient to cause breakdown of exposed conductors at potentials of only a few hundred volts. Its anticipated several years operation, and continuously accumulating exposure to meteoroids and debris, raises an increasing likelihood that mechanical damage, including perforation, will be sustained in service. The present concept employs an array of gas insulated solid wall aluminum coaxial tubes; a conceptual design which showed basic feasibility of the SP-100 powered space station. Practical considerations of launch, deployment and assembly have lead to investigation of reel deployable, dielectric insulated coaxial cables. To be competitive, the dielectric would have to operate reliably in a radiation environment under electrical stresses exceeding 50 kV/cm. The SP-100 transmission line high voltage interfaces are also considered. Author

N88-21374*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
POWER COMPONENTS FOR THE SPACE STATION 20-KHZ POWER DISTRIBUTION SYSTEM
DAVID D. RENZ 1988 10 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100866; E-4092; NAS 1.15:100866) Avail: NTIS HC A02/MF A01 CSCL 09C

Since 1984, NASA Lewis Research Center was developing high power, high frequency space power components as part of The Space Station Advanced Development program. The purpose of The Advanced Development program was to accelerate existing component programs to ensure their availability for use on the Space Station. These components include a rotary power transfer device, remote power controllers, remote bus isolators, high power semiconductor, a high power semiconductor package, high frequency-high power cable, high frequency-high power connectors, and high frequency-high power transformers. All the components were developed to the prototype level and will be installed in the Lewis Research Center Space Station power system test bed. Author

N88-21375*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
MULTI-HUNDRED KILOWATT ROLL RING ASSEMBLY EVALUATION RESULTS
DAVID D. RENZ 1988 10 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference,

Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100865; E-4091; NAS 1.15:100865) Avail: NTIS HC A02/MF A01 CSCL 13B

NASA Lewis Research Center has been evaluating low loss multi-hundred-kilowatt Roll Ring assemblies (an 8 circuit and a 4 circuit) for use on Space Station as the rotating joint power transfer device. In this device ac or dc power is transferred across the rotating joint through compressed rotating flexures. Results and conclusions of the evaluation program are presented. Author

N88-22075# Oak Ridge National Lab., TN.
THERMAL ANALYSIS OF HEAT STORAGE CANISTERS FOR A SOLAR DYNAMIC, SPACE POWER SYSTEM
R. P. WICHNER, A. D. SOLOMON, J. B. DRAKE, and P. T. WILLIAMS 1988 11 p Presented at the 10th Annual American Society of Mechanical Engineers Solar Energy Conference, Denver, Colo., 10 Apr. 1988
(Contract DE-AC05-84OR-21400)
(DE88-004199; CONF-880457-2) Avail: NTIS HC A03

A thermal analysis was performed of a thermal energy storage canister of a type suggested for use in a solar receiver for an orbiting Brayton cycle power system. Energy storage for the eclipse portion of the cycle is provided by the latent heat of a eutectic mixture of LiF and CaF2 contained in the canister. The chief motivation for the study is the prediction of vapor void effects on temperature profiles and the identification of possible differences between ground test data and projected behavior in microgravity. The first phase of this study is based on a two-dimensional, cylindrical coordinates model using an interim procedure for describing void behavior in 1-g and microgravity. The thermal analysis includes the effects of solidification front behavior, conduction in liquid/solid salt and canister materials, void growth and shrinkage, radiant heat transfer across the void, and convection in the melt due to Marangoni-induced flow and, in 1-g, flow due to density gradients. A number of significant differences between 1-g and 0-g behavior were found. This resulted from differences in void location relative to the maximum heat flux and a significantly smaller effective conductance in 0-g due to the absence of gravity-induced convection. DOE

N88-22225# Joint Publications Research Service, Arlington, VA.
SOLAR CELL COVER GLASSES FOR SATELLITES
TOKIO KIMURA *In its* JPRS Report: Science and Technology. Japan p 31-37 3 Mar. 1988 Transl. into ENGLISH from Ceramics Japan (Tokyo, Japan), Apr. 1987 p 303-308
Avail: NTIS HC A05/MF A01

Since the world's first artificial satellite, Vostok 1, was launched in October 1957, many artificial satellites were launched for many purposes. It is not generally known that such satellites incorporate glass parts which play important roles. Such glass parts include the cover glasses for solar cell systems attached to satellites and the thermal control mirrors for the satellite proper. These glass parts are used to protect satellites from radiation and heat, enabling them to function properly in space where environmental severity is beyond the imagination. Cover glasses will be examined. First, the space environment will be described in connection with the use of cover glasses. Then, the purposes of using cover glasses and the functions required of them covered. Finally, the actual cover glasses are described and the cover glass reliability management explained. Author

N88-22406*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
STRUCTURAL ASSESSMENT OF A SPACE STATION SOLAR DYNAMIC HEAT RECEIVER THERMAL ENERGY STORAGE CANISTER
R. L. THOMPSON, T. W. KERSLAKE, and M. T. TONG (Sverdrup Technology, Inc., Cleveland, Ohio.) *In its* Lewis Structures Technology, 1988. Volume 2: Structural Mechanics p 281-294 May 1988 Previously announced in IAA as N88-31396
Avail: NTIS HC A14/MF A01 CSCL 20K

The structural performance of a space station thermal energy storage (TES) canister subject to orbital solar flux variation and engine cold start up operating conditions was assessed. The impact of working fluid temperature and salt-void distribution on the canister structure are assessed. Both analytical and experimental studies were conducted to determine the temperature distribution of the canister. Subsequent finite element structural analyses of the canister were performed using both analytically and experimentally obtained temperatures. The Arrhenius creep law was incorporated into the procedure, using secondary creep data for the canister material, Haynes 188 alloy. The predicted cyclic creep strain accumulations at the hot spot were used to assess the structural performance of the canister. In addition, the structural performance of the canister based on the analytically determined temperature was compared with that based on the experimentally measured temperature data. Author

N88-22935*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN INTEGRATED AND MODULAR DIGITAL MODELING APPROACH FOR THE SPACE STATION ELECTRICAL POWER SYSTEM DEVELOPMENT
FRANK J. GOMBOS (Rockwell International Corp., Canoga Park, Calif.) and NARAYAN DRAVID 1988 9 p Presented at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored in part by ASME, AIAA, ANS, SAE, IEEE, ACS, and AIChE
(NASA-TM-100904; E-4155; NAS 1.15:100904) Avail: NTIS HC A02/MF A01 CSCL 10B

An electrical power system for the Space Station was designed, developed and built. This system provides for electrical power generation, conditioning, storage, and distribution. The initial configuration uses photovoltaic power generation. The power system control is based on a hierarchical architecture to support the requirements of automation. In the preliminary design and technology development phase of the program, various modeling techniques and software tools were evaluated for the purpose of meeting the Space Station power system modeling requirements. Rocketdyne and LeRC jointly selected the EASY5 simulation software, developed by Boeing Computer Services, as a system level modeling tool. The application of the selected analytical modeling approach to represent the entire power system is described. Typical results of model predictions are also summarized. The equipment modeled includes solar arrays, dc to ac converters, resonant inverters, battery storage system, alternator, transmission line, switch gear, and system level microprocessor controls. During the advanced development phase of this program, several models were developed using this approach. Author

N88-22939*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THE APPLICATION OF HIGH TEMPERATURE SUPERCONDUCTORS TO SPACE ELECTRICAL POWER DISTRIBUTION COMPONENTS
PAUL R. ARON and IRA T. MYERS 1988 8 p Proposed for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, ANS, SAE, IEEE, ACS and AIChE
(NASA-TM-100901; E-4153; NAS 1.15:100901) Avail: NTIS HC A02/MF A01 CSCL 10B

Some important space based electrical power distribution systems and components are examined to determine what might be achieved with the introduction of high temperature superconductors (HTS). Components that are compared in a before and after fashion include transformers, transmission lines, and capacitors. It is concluded that HTS has its greatest effect on the weight associated with transmission lines, where the weight penalty could be reduced by as much as 130 kg/kW/km of cable. Transformers, because 28 percent of their mass is in the conductor, are reduced in weight by the same factor. Capacitors are helped the least with only negligible savings possible. Finally, because HTS can relax the requirement to use alternating current in order

to reduce conductor mass, it will be possible to generate significant savings by eliminating most transformers and capacitors. J.P.B.

N88-24254# New Mexico Univ., Albuquerque. Dept. of Chemical and Nuclear Engineering.
TRANSACTIONS OF THE FOURTH SYMPOSIUM ON SPACE NUCLEAR POWER SYSTEMS
MOHAMED S. EL-GENK, ed. and MARK D. HOOVER, ed. (Lovelace Inhalation Toxicology Research Inst., Albuquerque, N. Mex.) 1987 513 p Symposium held in Albuquerque, N. Mex., 12-16 Jan. 1987; co-sponsored by American Inst. of Chemical Engineers, ASTM, GE Co., LANL, Sandia National Labs., AFSTC, and American Nuclear Society
(DE88-006164; CONF-870102-SUMM) Avail: NTIS HC A22/MF A01

The preceedings of the 4th Symposium on Space Nuclear Power Systems are presented. Research and progress on the SP-100 Space Power Reactor and Multimegawatt Space Nuclear Power Programs are detailed. The transactions are divided into several headings including: Future space station power options; Space nuclear missions and applications; Reactors and shielding; Nuclear electric and nuclear propulsion; Refractory alloys and high temperature materials; Testing; Reactors and Shielding II; Nuclear electric and nuclear propulsion II; Radioisotope power systems; Instrumentation and control; Energy conversion and storage; Radiation, thermal and environmental effects; Energy conversion and storage II; Space nulcear fuels; Thermal management; Energy conversion and storage III; Thermal management II; Multimegawatt system concepts; Simulation and modeling; and Nuclear safety

N88-24256*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
BENEFITS OF 20 KHZ PMAD IN A NUCLEAR SPACE STATION
GALE R. SUNDBERG *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 7-10 1987
Avail: NTIS HC A22/MF A01 CSCL 09C

Compared to existing systems, high frequency ac power provides higher efficiency, lower cost, and improved safety benefits. The 20 kHz power system has exceptional flexibility, is inherently user friendly, and is compatible with all types of energy sources; photovoltaic, solar dynamic, rotating machines and nuclear. A 25 kW, 20 kHz ac power distribution system testbed was recently (1986) developed. The testbed possesses maximum flexibility, versatility, and transparency to user technology while maintaining high efficiency, low mass, and reduced volume. Several aspects of the 20 kHz power management and distribution (PMAD) system that have particular benefits for a nuclear power Space Station are discussed. Author

N88-24257# Air Force Wright-Patterson Aeronautical Labs., Wright-Patterson AFB, OH.
OPERATIONAL CONCERNS INVOLVING A SHADOW-SHIELDED NUCLEAR REACTOR FOR SPACE STATION APPLICATIONS
E. B. KENNEL and J. R. WETCH (Space Power, Inc., San Jose, Calif.) *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 11-14 1987
Avail: NTIS HC A22/MF A01

It is concluded that a shadow shielded reactor can be operated safely for a manned space station application providing it can be shut down during docking attempts and possibly certain EVA activities. A shadow shielded reactor carries an enormous weight advantage compared to a 4-pi shielded device, although the shadow shielded system will certainly introduce new complexities to thermal management during shutdown and restart. Ways in which the weight advantage can be exploited include increasing the power output of the reactor, carrying additional backup power or carrying additional cargo. Author

N88-24292# Cincinnati Univ., OH. Dept. of Physics.
BIFOLD: A DUAL-MODE NUCLEAR SPACE POWER SYSTEM
WARREN FENTON STUBBINS *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 157-160 1987
Avail: NTIS HC A22/MF A01

With Pu-238 as its dominate fuel, the BIFOLD nuclear power source's quiescent base power from radioactive decay is augmented during periods of high demand by operation as a fast reactor. The BIFOLD concept unites reactor technology with radioactive thermal generator technology and provides several distinct advantages. These include demand power capability, freedom from auxiliary power sources and energy storage elements, the possibility of premission operation and testing of all components without the introduction of extraneous power, the inherent prevention of slow neutron criticality, freedom from reactor and component startup uncertainties, and a minimum base power for mission survival. Author

N88-24374# New Mexico Univ., Albuquerque. Dept. of Chemical and Nuclear Engineering.
TRANSACTIONS OF THE FIFTH SYMPOSIUM ON SPACE NUCLEAR POWER SYSTEMS
MOHAMED S. EL-GENK, ed. and MARK D. HOOVER, ed. (Lovelace Inhalation Toxicology Research Inst., Albuquerque, N. Mex.) 1988 611 p Symposium held in Albuquerque, N. Mex., 11-14 Jan. 1988; co-sponsored by American Inst. of Chemical Engineers, American Society of Mechanical Engineers, GE Co., LANL, Sandia National Labs., AFSTC, American Nuclear Society and ASTM
(DE88-006165; CONF-880122-SUMM) Avail: NTIS HC A99/MF A01

The Fifth Symposium on Space Nuclear Power Systems took place in Albuquerque, New Mexico, on January 11 to 14, 1988. It was the fifth in an annual series of symposia sponsored principally by the University of New Mexico and the New Mexico technical community, and included Federal government, industrial, national laboratory, and university participants. The past year had seen continued technical and programmatic successes in the SP-100 Space Power Reactor and Multimegawatt Space Nuclear Power programs. With the Space Shuttle to fly again in 1988, more attention can be devoted to developing the technology needed for future long duration space travel. Safe, reliable space nuclear power systems are essential for the success of these missions. Reports of symposium participants follow.

N88-24402# Sundstrand Corp., Rockford, IL.
STATUS OF THE ORGANIC RANKINE CYCLE FOR SPACE APPLICATIONS
T. J. BLAND, P. D. LACEY, and G. L. SORENSEN *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 135-138 1988
Avail: NTIS HC A99/MF A01

The Organic Rankine Cycle (ORC) has been under continuous development and evaluation since the 1960s for both terrestrial and space power applications. Recent activities (Bland et al, 1987) have focused primarily on the Space Station's solar dynamic power system and Dynamic Isotope Power Systems (DIPS) applications. This paper addresses ORC-DIPS system level trade studies conducted during the past year and a half. Two companion papers (Bland and Pearson) present more detailed data on specific ORC-DIPS technology issues and testing conducted during the same period. Author

N88-24407*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
OPTIMIZATION OF ORGANIC RANKINE CYCLES FOR SPACE STATION APPLICATIONS
DANA L. EUBANKS, FREDERICK R. BEST (Texas A&M Univ., College Station.), and NANETTE FAGET *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 159-162 1988
Avail: NTIS HC A99/MF A01 CSCL 10B

The purpose of the current program is to investigate the tradeoffs between solar dynamic and nuclear powered systems for the space station. This research is based on a typical Rankine

cycle using toluene as the working fluid. The first objective is to produce an adequate thermodynamic cycle model and calculate its efficiency. The next step is to implement a sizing algorithm that calculates the capacity of the various elements of the system, such as the radiator and regenerator, for a given electrical output. Then, the mass of each component must be calculated to give the overall total system mass. Likewise, the space for each component can be determined, giving an estimate of what volume must be available to place the system into orbit. Author

N88-24451# United Technologies Corp., South Windsor, CT. Power Systems Div.
HIGH POWER DENSITY ALKALINE FUEL CELL TECHNOLOGY FOR MMW SPACE BURST POWER
J. LAWRENCE PRESTON, JR., JOHN C. TROCCIOLA, and RONALD J. WERTHEIM (International Fuel Cells Corp., South Windsor, Conn.) *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 375-378 1988
Avail: NTIS HC A99/MF A01

The use of advanced alkaline regenerative fuel cell energy storage systems to provide 10's to 100's of MWe of sprint (burst) power for 100's of seconds per orbit of SDI weapons platform was studied. Recharge power is supplied by a multimegawatt space based nuclear power system. Regenerative fuel cell energy storage systems offer the potential for significant platform mass reduction by reducing the size and mass of the nuclear power source required. This is because the reactor can be sized for the smaller average power level for the energy storage system, rather than the sprint power level. The regenerative fuel cell is a particularly attractive energy storage device because the fuel cell is essentially a static power conversion device, which results in excellent platform stability for weapon pointing and tracking. Based upon the detailed point design and conceptual layout, the alkaline regenerative fuel cell energy storage system is an attractive choice for integration with a nuclear thermionic system for providing multimegawatt burst power and multi orbit capability. Author

N88-25474*# Minnesota Mining and Mfg. Co., Saint Paul.
DESIGN AND DEMONSTRATION OF A SYSTEM FOR THE DEPOSITION OF ATOMIC-OXYGEN DURABLE COATINGS FOR REFLECTIVE SOLAR DYNAMIC POWER SYSTEM CONCENTRATORS Final Contractor Report
DONALD J. MCCLURE Jul. 1988 68 p
(Contract NAS3-25075)
(NASA-CR-4158; E-4150; NAS 1.26:4158) Avail: NTIS HC A04/MF A01 CSCL 22B

A system for the vacuum deposition of atomic-oxygen durable coatings for reflective solar dynamic power systems (SDPS) concentrators was designed and demonstrated. The design issues pertinent to SDPS were developed by the Government Aerospace Systems Division of the Harris Corporation and are described in NASA-CR-179489. Both design and demonstration phases have been completed. At the time of this report the deposition system was ready for coating of facets for SDPS concentrators. The materials issue relevant to the coating work were not entirely resolved. These issues can only be resolved when substrates which are comparable to those which will be used in flight hardware are available. The substrates available during the contract period were deficient in the areas of surface roughness and contamination. These issues are discussed more thoroughly in the body of the report. Author

N88-25475*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMAL DISTORTION ANALYSIS OF THE SPACE STATION SOLAR DYNAMIC CONCENTRATOR
JEFFREY J. TRUDELL, VITHAL DALSANIA, JOSEPH F. BAUMEISTER (Analex Corp., Cleveland, Ohio.), and KENT S. JEFFERIES 1988 25 p Presented at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored by ASME, AIAA, SAE, ANS, IEEE, ASC and AIChE
(NASA-TM-100868; E-4090; NAS 1.15:100868) Avail: NTIS HC A03/MF A01 CSCL 10B

A method was developed to evaluate the thermal distortion of the Space Station Solar Dynamic Concentrator and the effects of thermal distortion on concentrator optical performance. The analytical method includes generating temperature distributions with TRASYS and SINDA models, interfacing the SINDA results with the SINDA-NASTRAN Interface Program (SNIP), calculating thermal distortion with a NASTRAN/PATRAN finite element model, and providing flux distribution maps within the receiver with the ray tracing OFFSET program. Temperature distributions, thermally induced slope errors, and flux distribution maps within the receiver are discussed. Results during a typical orbit indicate that temperatures of the hexagonal panels and triangular facets range between -18 and 99 C (-1 to 210 F), facet rotations are less than 0.2 mrad, and a change in facet radius due to thermal flattening is less than 5 percent. The predicted power loss with thermal distortion effects was less than 0.3 percent. The thermal distortion of the Solar Dynamic concentrator has negligible effect on the flux distribution within the receiver cavity. Author

N88-26402*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
ADVANCED PHOTOVOLTAIC POWER SYSTEM TECHNOLOGY FOR LUNAR BASE APPLICATIONS
DAVID J. BRINKER and DENNIS J. FLOOD 1988 10 p Presented at the Lunar Bases and Space Activities in the 21st Century Symposium, Houston, Tex., 5-7 Apr. 1988; sponsored by NASA, AIAA, Lunar and Planetary Inst., American Geophysical Unions, ANS, ASCE, Space Studies Inst. and National Space Society
(NASA-TM-100965; E-4258; NAS 1.15:100965) Avail: NTIS HC A02/MF A01 CSCL 21H

Advanced photovoltaic/electrochemical (batteries or regenerative fuel cells for storage) power system options for a lunar base are discussed and compared. Estimated system masses are compared with those projected for the SP-100 nuclear system. The results of the comparison are quantified in terms of the mass saved in a scenario which assembles the initial base elements in Low Earth Orbit (LEO) and launches from there to the lunar surface. A brief summary is given of advances in photovoltaic-electrochemical power system technologies currently under development in the NASA/OAST program. A description of the planned focussed technology program for surface power in the new Pathfinder initiative is also provided. Author

N88-28091*# General Dynamics Corp., San Diego, CA. Space Systems Div.
AC POWER SYSTEM BREADBOARD Final Report
LORAN J. WAPPES, R. SUNDBERG, J. MILDICE, D. PETERSON, and S. HUSHING Nov. 1987 92 p
(Contract NAS8-36429)
(NASA-CR-179369; NAS 1.26:179369; GDSS-MBB-87-001)
Avail: NTIS HC A05/MF A01 CSCL 10B

The object of this program was to design, build, test, and deliver a high-frequency (20-kHz) Power System Breadboard which would electrically approximate a pair of dual redundant power channels of an IOC Space Station. This report describes that program, including the technical background, and discusses the results, showing that the major assumptions about the characteristics of this class of hardware (size, mass, efficiency, control, etc.) were substantially correct. This testbed equipment has been completed and delivered to LeRC, where it is operating as a part of the Space Station Power System Test Facility. Author

N88-29375*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EXPERT SYSTEMS FOR MSFC POWER SYSTEMS
DAVID J. WEEKS *In its* Second Conference on Artificial Intelligence for Space Applications p 215-226 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 10B

Future space vehicles and platforms including Space Station

will possess complex power systems. These systems will require a high level of autonomous operation to allow the crew to concentrate on mission activities and to limit the number of ground support personnel to a reasonable number. The Electrical Power Branch at NASA-Marshall is developing advanced automation approaches which will enable the necessary levels of autonomy. These approaches include the utilization of knowledge based or expert systems. Author

N88-29863*# Sundstrand Energy Systems, Rockford, IL.
STUDY OF TOLUENE STABILITY FOR AN ORGANIC RANKINE CYCLE (ORC) SPACE-BASED POWER SYSTEM Final Report
VANCE HAVENS and DANA RAGALLER Jul. 1988 292 p
(Contract NAS3-24663)
(NASA-CR-180884; NAS 1.26:180884) Avail: NTIS HC A13/MF A01 CSCL 21H

The design, fabrication, assembly, and endurance operation of a dynamic test loop, built to evaluate the thermal stability of a proposed Organic Rankine Cycle (ORC) working fluid, is discussed. The test fluid, toluene, was circulated through a heater, simulated turbine, regenerator, condenser and pump to duplicate an actual ORC system. The maximum nominal fluid temperature, 750 F, was at the turbine simulator inlet. Samples of noncondensible gases and liquid toluene were taken periodically during the test. The samples were analyzed to identify the degradation products formed and the quantity of these products. From these data it was possible to determine the degradation rate of the working fluid and the generation rate of noncondensible gases. A further goal of this work was to relate the degradation observed in the dynamic operating loop to degradation obtained in isothermal capsule tests. This relationship was the basis for estimating the power loop degradation in the Space Station Organic Rankine Cycle system. Author

N88-29872*# Sundstrand Energy Systems, Rockford, IL.
STUDY OF TOLUENE ROTARY FLUID MANAGEMENT DEVICE AND SHEAR FLOW CONDENSER PERFORMANCE FOR A SPACE-BASED ORGANIC RANKINE POWER SYSTEM Final Report
VANCE HAVENS and DANA RAGALLER Jul. 1988 103 p
(Contract NAS3-24663)
(NASA-CR-180885; NAS 1.26:180885) Avail: NTIS HC A06/MF A01 CSCL 10B

Management of two-phase fluid and control of the heat transfer process in microgravity is a technical challenge that must be addressed for an orbital Organic Rankine Cycle (ORC) application. A test program was performed in 1-g that satisfactorily demonstrated the two-phase management capability of the rotating fluid management device (RFMD) and shear-flow condenser. Operational tests of the RFMD and shear flow condenser in adverse gravity orientations, confirmed that the centrifugal forces in the RFMD and the shear forces in the condenser were capable of overcoming gravity forces. In a microgravity environment, these same forces would not have to compete against gravity and would therefore be dominant. The specific test program covered the required operating range of the Space Station Solar Dynamic Rankine Cycle power system. Review of the test data verified that: fluid was pumped from the RFMD in all attitudes; subcooled states in the condenser were achieved; condensate was pushed uphill against gravity; and noncondensible gases were swept through the condenser. Author

N88-30181*# Lockheed Missiles and Space Co., Sunnyvale, CA.
ADVANCED PLANAR ARRAY DEVELOPMENT FOR SPACE STATION Final Report, 1 Jun. 1985 - 1 Jun. 1987
Jun. 1987 101 p
(Contract NAS8-36419)
(NASA-CR-179373; NAS 1.26:179373; LMSC-F115808) Avail: NTIS HC A05/MF A01 CSCL 10B

The results of the Advanced Planar Array Development for the Space Station contract are presented. The original objectives of the contract were: (1) to develop a process for manufacturing superstrate assemblies, (2) to demonstrate superstrate technology through fabrication and test, (3) to develop and analyze a preliminary solar array wing design, and (4) to fabricate a wing segment based on wing design. The primary tasks completed were designing test modules, fabricating, and testing them. LMSC performed three tasks which included thermal cycle testing for 2000 thermal cycles, thermal balance testing at the Boeing Environmental Test Lab in Kent, Washington, and acceptance testing a 15 ft x 50 in panel segment for 100 thermal cycles. The surperstrate modules performed well during both thermal cycle testing and thermal balance testing. The successful completion of these tests demonstrate the technical feasibility of a solar array power system utilizing superstrate technology. This final report describes the major elements of this contract including the manufacturing process used to fabricate modules, the tests performed, and the results and conclusions of the tests. Author

N88-30182# AEG-Telefunken, Wedel (Germany, F.R.). Space and New Technologies Subdivision.
ALTERNATIVE MODULE CONFIGURATIONS FOR ADVANCED SOLAR ARRAYS ON LOW ORBIT AND EXTENDED LIFETIME MISSIONS (AMOC 2) Final Report
D. GRINGEL, U. HOFFMANN, J. KOCH, F. REISSMANN, and W. SCHMITZ Paris, France ESA 15 Dec. 1987 116 p
(Contract ESTEC-5508/83-NL-PB(SC))
(ESA-CR(P)-2581; ETN-88-93026) Avail: NTIS HC A06/MF A01

The applicability of the bifacial solar cell for generators operating in the low earth orbit and having extended life time mission was studied. Two candidate module concepts for flexible roll out and/or fold out solar generator systems were defined. One module concept is characterized by a continuous light transparent substrate and uses a transparent adhesive to glue the solar cells onto the substrate. The other module concept uses a nontransparent substrate with cutouts (windows) in the solar cell area of the substrate so that only small rearside areas of the individual solar cells are covered. The design and the bifacial solar cell technology were improved with regard to their applicability for larger assemblies. A thermal vacuum cycling test on a foldable ATOX resistant window type solar panel assembly confirms design feasibility. ESA

N88-30184*# United Technologies Corp., South Windsor, CT. Power Systems Div.
REGENERATIVE FUEL CELL ENERGY STORAGE SYSTEM FOR A LOW EARTH ORBIT SPACE STATION
R. E. MARTIN, J. GAROW, and K. B. MICHAELS 1988 139 p
(Contract NAS3-22234)
(NASA-CR-174802; FCR-6128; NAS 1.26:174802) Avail: NTIS HC A07/MF A01 CSCL 10C

A study was conducted to define characteristics of a Regenerative Fuel Cell System (RFCS) for low earth orbit Space Station missions. The RFCS's were defined and characterized based on both an alkaline electrolyte fuel cell integrated with an alkaline electrolyte water electrolyzer and an alkaline electrolyte fuel cell integrated with an acid solid polymer electrolyte (SPE) water electrolyzer. The study defined the operating characteristics of the systems including system weight, volume, and efficiency. A maintenance philosophy was defined and the implications of system reliability requirements and modularization were determined. Finally, an Engineering Model System was defined and a program to develop and demonstrate the EMS and pacing technology items that should be developed in parallel with the EMS were identified. The specific weight of an optimized RFCS operating at 140 F was defined as a function of system efficiency for a range of module sizes. An EMS operating at a nominal temperature of 180 F and capable of delivery of 10 kW at an overall efficiency of 55.4 percent is described. A program to develop the EMS is described including a technology development effort for pacing technology items. Author

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ELECTRONICS

Includes descriptions of analytical techniques, analyses, systems, and requirements for internal and external communications, electronics, sensors for position and systems monitoring and antennas.

A88-33443*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ADVANCED COMMUNICATIONS, TRACKING, ROBOTIC VISION TECHNOLOGY FOR SPACE APPLICATIONS
KUMAR KRISHEN (NASA, Johnson Space Center, Houston, TX) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 143-154. refs

Recent advancements in the areas of tracking, communications, and robotics vision sensors being pursued within NASA, as applicable to space programs, are presented. Optical and laser-based communications and tracking systems and applications to space programs are discussed. Communication systems for multiple access, broadband, high data rate, and efficient operations are given. Current efforts at 20/30 GHz and millimeter wave bands are summarized. The use of optical data processing in control system applications for rendezvous and docking is presented. Robotics vision, based on television, laser, and microwave sensors for space applications, is discussed. The fusion of these technologies for remote control, station keeping, tracking, inspection, and satellite repair is detailed. Author

A88-33448
KA, C, S FREQUENCY BANDS, MULTI-BEAM DEPLOYABLE ANTENNA SYSTEM FOR LARGE-CAPACITY COMMUNICATION SATELLITE
HIROYUKI KUMAZAWA, ISAO OHTOMO, YOSHIHIDE YAMADA, and TETSUO YASAKA (Nippon Telegraph and Telephone Public Corp., Radio Communications Systems Laboratories, Yokosuka, Japan) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 185-191. refs

The design and characteristics of electrical and structural models of a satellite-borne antenna system comprising large 3.5-m and 2.5-reflectors, feeders, and a tower for stowing the 3.7-m ID-class rocket are described. The reflectors, Ka band cluster horns, frequency-selective surfaces, C and S band horns, and the tower are integrally examined for electrical and mechanical performance. Measurement results with a verification model antenna are found to conform to design values. C.D.

A88-33626
ITC/USA/'87; PROCEEDINGS OF THE INTERNATIONAL TELEMETERING CONFERENCE, SAN DIEGO, CA, OCT. 26-29, 1987
Conference sponsored by the International Foundation for Telemetering. Research Triangle Park, NC, Instrument Society of America (ITC Proceedings. Volume 23), 1987, 882 p. For individual items see A88-33627 to A88-33693.

Various papers on telemetering are presented. The general topics considered include: International Space Station telemetry, new technology, recording equipment and systems, Voyager-Neptune telemetry, adaptive signal processing, spacecraft telemetry, data acquisition, PCM telemetry, airborne telemetry, telemetry systems, ballistic application, test range instrumentation radars, and unique applications. C.D.

A88-33627*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SPECTRUM UTILIZATION FOR THE INTERNATIONAL SPACE STATION COMMUNICATIONS AND TRACKING SYSTEMS
SYDNEY W. NOVOSAD (NASA, Johnson Space Center, Houston, TX) IN: ITC/USA/'87; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 1-10.

The frequency spectrum which will be used over the lifetime of the International Space Station Program is discussed. Primary communications traffic will initially occur in the S-band and Ku-band regions. Tracking will initially consist mostly of L-band satellite links. As the service demand increases, use of millimeter and optical wavelengths will be required. The particular space/ground links, space/space links, and other links that will be used are described. C.D.

A88-33628*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TRENDS IN SPACE STATION TELEMETRY APPLICATIONS
JOHN F. MURATORE (NASA, Johnson Space Center, Houston, TX) IN: ITC/USA/'87; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 11-16.

Spacecraft telemetry systems have evolved from simple hardware devices to complex computer applications performing data acquisition and formatting tasks. This paper reviews the role of spacecraft computers in performing telemetry functions and examines computer-based telemetry systems being considered for use on the NASA Space Station. Author

A88-33629*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TELEMETRY HANDLING ON THE SPACE STATION DATA MANAGEMENT SYSTEM
VIRGINIA A. WHITELAW (NASA, Johnson Space Center, Houston, TX) IN: ITC/USA/'87; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 17-26.

This paper examines the impact of telemetry handling on the design of the onboard networks that are part of the Space Station Data Management System (DMS). An architectural approach to satisfying the DMS requirement for support of the high throughput needed for telemetry transport and for servicing distributed computer systems is discussed. Several of the functionality vs. performance tradeoffs that must be made in developing an optimized mechanism for handling telemetry data in the DMS are considered. C.D.

A88-33630*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TELEMETRY FORMATS FOR THE SPACE STATION RF LINKS
WALTER MARKER (NASA, Johnson Space Center, Houston, TX) IN: ITC/USA/'87; Proceedings of the International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 27-33.

This paper discusses the formats that have been proposed for the manned Space Station space/ground RF link. In addition to discussing the specific RF formats, the paper seeks to discuss the requirements that have caused the proposed format to exist in its current form. The paper begins by briefly discussing the historical basis for telemetry formats within NASA, and then discusses the unique requirements that the Space Station imposes, compared to traditional space probes. The paper next treats the overall requirements that must be satisfied by the Space Station communications system. Finally the paper discusses the details of the RF format and its proposed operational usage. Author

A88-33673
AUTOMATING SATELLITE CONTROL AND TELEMETRY NETWORKS
CONSTANCE J. GOLDEN (Ford Aerospace and Communications Corp., Sunnyvale, CA) IN: ITC/USA/'87; Proceedings of the

International Telemetering Conference, San Diego, CA, Oct. 26-29, 1987. Research Triangle Park, NC, Instrument Society of America, 1987, p. 503-508.

Space Station and satellite control applications will require systems that have generic processing applicable to many different knowledge bases, the ability to learn from experience, the ability to handle situations not encountered before and behave at least as well as an expert would in the same new situation, the ability to respond in real time, and the ability to be formally verified and validated. A knowledge-based system approach that promises to meet all these requirements has been developed, and its applications to several satellite and network control applications are described. C.D.

A88-34190
AVIONIC STANDARD MODULE DEVELOPMENT
STANLEY C. MAKI, EDMOND P. CORMIER, and THOMAS A. PISZKIN (General Dynamics Corp., Space Systems Div., San Diego, CA) IN: NAECON 87; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 18-22, 1987. Volume 4. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 1274-1281.

Avionics standard modules with redundancy offer substantial economic benefits compared to special-purpose processor units for the orbital transfer vehicle and advanced launch vehicle programs. A fiber optic, serial vehicle bus provides high throughput with modest hardware. A bistage, split tapered, star optical coupler uses a token-pass/token-demand protocol. It is reported that a standard module implementation of the above is a feasible, cost-effective approach to avionics design using standard buses and standard packaging. The VHSIC integrated package readily accommodates higher-speed VLSI chips as they become available. I.E.

A88-35112
DEPLOYABLE PRECISION REFLECTORS
BERND ABT (Dornier System GmbH, Friedrichshafen, Federal Republic of Germany) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 989-996.
(AAS PAPER 86-298)

Solid panel-based precision reflectors required to serve as antenna collectors by the larger satellites and orbiting radio telescopes, with diameters of up to 12 m, can be launched with existing or near-term-available launch systems without need for EVA for deployment. Attention is presently given to two state-of-the-art composite panel structure deployable antennas, wich illustrate proprietary German expertise in this field: the Multibeam Deployable Antenna for the 30/20 GHz communications payload of a future German satellite, and the Far Infrared and Submillimeter Space Telescope. O.C.

A88-35118
THE SPACE STATION COMMUNICATIONS AND TRACKING SYSTEM
GERALD KOWALSKI (Harris Corp., Government Aerospace Systems Div., Melbourne, FL) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1059-1072.
(AAS PAPER 86-258)

The Space Station Program is to provide a flexible, growing, and permanent facility in space to accommodate significant advances in science, manufacturing, and exploration. This paper defines the role of the Space Station Communications and Tracking System in supporting data transfer and control services between the on-orbit payloads (both attached and detached) and the user/investigator. Author

A88-35274* Drexel Univ., Philadelphia, PA.
SYSTEM ARCHITECTURE OF MMIC-BASED LARGE APERTURE ARRAYS FOR SPACE APPLICATIONS
P. R. HERCZFELD, M. KAM (Drexel University, Philadelphia, PA), R. R. KUNATH, K. B. BHASIN (NASA, Lewis Research Center, Cleveland, OH), and NICK LA PRADE (RCA, RCA Astro-Electronics Div., Hightstown, NJ) IN: Optical technologies for space communication systems; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 164-172. Research supported by the Commonwealth of Pennsylvania. Previously announced in STAR as N87-20468. refs

The persistent trend to use millimeter-wave frequencies for satellite communications presents the challenge to design large-aperture phased arrays for space applications. These arrays, which comprise 100 to 10,000 elements, are now possible due to the advent of lightwave technology and the availability of monolithic microwave integrated circuits. In this paper, system aspects of optically controlled array design are studied. In particular, two architectures for a 40 GHz array are outlined, and the main system-related issues are examined: power budget, synchronization in frequency and phase, and stochastic effects. Author

A88-35275
KU-BAND (14GHZ) FIBER OPTIC COMMUNICATION LINKS FOR DISTRIBUTED ANTENNAS IN THE SPACE STATION
A. S. DARYOUSH, R. GLATZ, P. R. HERCZFELD (Drexel University, Philadelphia, PA), and M. P. BACCARINI (RCA, Government Communications Systems Div., Camden, NJ) IN: Optical technologies for space communication systems; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 173-182. Research supported by the Commonwealth of Pennsylvania and RCA. refs

Fiber optic networks are considered as a viable alternative to the conventional coaxial distribution systems for the Space Station. The multiple access communication subsystem provides 450-750 MHz data signal on offset quadrature phase shift keying (OQPSK) format to antenna-mounted electronics. For coherent communication 100 MHz frequency reference signal is transmitted to each module to phase lock a dielectric resonator oscillator at 14.15GHz. Experimental results of phase locked oscillator's spectral purity, synchronized via two commercial fiber-optic links at 1.3 and 0.8 microns are reported. These two fiber-optic links were compared in terms of phase noise degradation. Furthermore, experimental results of fiber-optic link linearity, third-order intermodulation distortion, dynamic range and effect of mixing between data and the frequency reference are reported. Author

A88-35516
EXPLICIT APPROXIMATIONS FOR THE STATIC CAPACITANCE OF A MICROSTRIP PATCH OF ARBITRARY SHAPE
EDWARD F. KUESTER (Colorado, University, Boulder) Journal of Electromagnetic Waves and Applications (ISSN 0920-5071), vol. 2, no. 1, 1988, p. 103-135. refs
(Contract N00014-82-K-0264)

Closed-form expressions for the static capacitance of a microstrip patch of arbitrary shape are derived for both large and small patch size relative to the substrate thickness. For these formulas, only the capacitance of the isolated patch in free space, or the area, perimeter, and Neumann self-inductance of the perimeter are required. Comparison with existing data obtained by rather extensive numerical computation shows good agreement in the appropriate ranges of validity. The results of this paper have direct application to microstrip lumped circuit elements and to the evaluation of the quasi-static portion of the input impedance of a microstrip patch antenna. Author

A88-37285#
ANTENNAS FOR DIVERSE REQUIREMENTS
JOACHIM BOUKAMP Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 12-15.

An account is given of a major German aerospace manufacturer's state-of-the-art methods for development, design, construction, testing and certification of a wide variety of civilian

and military communications and radar antennas. Attention is given to reflector antennas for very large aperture/wavelength ratios, slotted waveguide arrays in which the radiating aperture is synthesized by guided structures, and both microstrip arrays and active arrays, for the creation of very large area antennas. Antenna tests and measurements are conducted in an anechoic chamber. O.C.

A88-37398*# General Electric Co., Philadelphia, PA.
POTENTIAL GPS USER ARCHITECTURE FOR THE NASA SPACE STATION BASED ON LANDSAT 4/5 EXPERIENCE
DAVID A. KORENSTEIN (General Electric Co., Astro-Space Div., Philadelphia, PA) IN: Institute of Navigation, Technical Meeting, 1st, Colorado Springs, CO, Sept. 21-25, 1987, Proceedings. Washington, DC, Institute of Navigation, 1987, p. 171-175. refs
(Contract NAS5-25300)

A Landsat 4/5 GPS system is described which uses an inertial reference attitude control system and precision real-time ephemeris generation to achieve precision earth pointing. The system has application to the validation of the use of GPS for the low earth orbit navigation of the Space Station. The present system consists of a receiver/processor assembly (R/PA), an L-band GPS antenna, a precision oscillator, and the Landsat computer. The R/PA is integrated with a GPS receiver which selects, acquires, tracks, times, and decodes navigation signals from GPS satellites in order to derive ephemerides. Ephemeris estimates were found to be accurate to better than 50 meters. R.R.

A88-38098
BEYOND THE DIAMETER-WAVELENGTH-RATIO OF REFLECTOR ANTENNAS - A FILM LENS ANTENNA
YOSHIHIRO CHIKADA (Nobeyama Radio Observatory, Minamimaki, Japan) IN: Radio astronomy from space; Proceedings of the Workshop, Green Bank, WV, Sept. 30-Oct. 2, 1986. Charlottesville, VA, National Radio Astronomy Observatory, 1987, p. 221-224.

The theoretical basis and design concept of a thin-film-lens (TFL) space telescope for mm or sub-mm astronomical observations are discussed. The practical limitations on the size of reflector antennas (currently corresponding to a maximum diameter/wavelength ratio of about 10,000) are pointed out, and the results of Milne (1982) for an 89-cm dipole-array TFL antenna are extended to a much larger scale, stressing that TFLs operate using phase shift rather than delay, have no thickness, and should be relatively easy to fabricate and deploy. The allowable TFL parameters at different wavelengths are indicated in a graph: good observing qualities should be obtainable with a 30-m TFL for space VLBI in X-band, a 400-m TFL for the 2.6-mm band of CO, and a 1.5-km TFL for the 1.3-mm band of CO. T.K.

A88-38672#
RELIABILITY EVALUATION ON ON-BOARD SATELLITE ANTENNA DEPLOYMENT MECHANISM
MASAYOSHI MISAWA, SHOJIRO MIYAKE, and TETSUO YASAKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 36, no. 410, 1988, p. 125-130. In Japanese, with abstract in English. refs

A procedure is proposed to evaluate the reliability of the antenna deployment mechanism for large satellite antennas. Failure mode and effects analysis is conducted to identify all possible failure modes. The bearing performance and friction are found to be critical. Test results show that the deployment and friction torque distributions can be assumed as normal distributions. The deployment reliability of the ADM is calculated based on these distributions. A method for preventing failure derived from the reduction in bearing clearannce is also described. C.D.

A88-39423#
DEPLOYABLE 20/30-GHZ MULTI-BEAM ANTENNA FOR FUTURE COMMUNICATIONS SATELLITES
DIETMAR SCHEULEN Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 60-62.

The West German Multi-Beam Antenna, designated MEA, is a 20/30-MHz device of offset Cassegrain type with an offset paraboloid main reflector with a total of 16 beams. The primary challenge in the design of the reflector used is a surface contour accuracy of 0.2 mm rms, including production and deployment errors as well as thermal deformations in orbit. This high surface accuracy has been obtained by means of the 'replica' technique. The admissible deviations from the given contour were limited to less than 20 microns rms. Attention is given to the mold-forming method. O.C.

A88-43176
FIBER OPTIC SYSTEMS FOR MOBILE PLATFORMS; PROCEEDINGS OF THE MEETING, SAN DIEGO, CA, AUG. 20, 21, 1987
NORRIS LEWIS, ED. and EMERY L. MOORE, ED. (Litton Industries, Beverly Hills, CA) SPIE-sponsored research. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 840), 1987, 181 p. For individual items see A88-43177 to A88-43187.
(SPIE-840)

Various papers on fiber optic systems for mobile platforms are presented, including automotive, shipboard, aircraft, spacecraft, launch, and missile applications. Individual topics addressed include: new plastic optical fiber with polycarbonate core and fluorescence-doped fiber for high-temperature use, lost-cost 1 x 2 fiber optic coupler using plastic fiber, microminiature fiber optic accelerometer, fiber optic circuits for aircraft engine controls, and linear fiber optic data bus for aircraft applications. Also discussed are: comparison of various architectures of microwave fiber optic links - a system-level analysis, rf characteristics of wideband optical link for interconnection of microwave rf subsystems for airborne communications satellite terminals, cable and connector design issues for mobile platform applications, role of fiber optics on commercial aircraft, FO-LAN-based intelligent sensor testbed for propulsion and avionics module, and optical technology for spacecraft antennas. C.D.

A88-43187* Drexel Univ., Philadelphia, PA.
OPTICAL TECHNOLOGY FOR SPACECRAFT ANTENNAS
P. R. HERCZFELD (Drexel University, Philadelphia, PA) IN: Fiber optic systems for mobile platforms; Proceedings of the Meeting, San Diego, CA, Aug. 20, 21, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 169-174. Research supported by General Electric Co., RCA, U. S. Navy, and NASA. refs

The issues involved in the design and implementation of high-speed fiberoptic distribution networks for spacecraft antennas are examined. The phased array antennas and antenna remoting are considered. The system requirements for these two generic system types are summarized, and their architectures are described. Optical beamforming of phased arrays is discussed, including beam control at the T/R module level, optical beam control on the fiber optic distribution network, and optical beamforming in free space. C.D.

A88-44638* Kansas Univ. Center for Research, Inc., Lawrence.
DETERMINATION OF THE VERTICAL PATTERN OF THE SIR-B ANTENNA
RICHARD K. MOORE and MEHRZAD HEMMAT (University of Kansas Center for Research, Inc., Lawrence) International Journal of Remote Sensing (ISSN 0143-1161), vol. 9, May 1988, p. 839-847. refs
(Contract JPL-956902)

Determination of the antenna pattern is important for a spaceborne Synthetic Aperture Radar such as Shuttle Imaging Radar-B (SIR-B). For SIR-B the antenna was so large that apart from one section, no complete pattern could be measured on the ground. Attempts were made to measure the pattern while the shuttle was in space by using ground receivers and active radar calibrators. The method used and described is a supplement to these measurements. The vertical pattern of an antenna can be extracted from radar signals returned from regions whose scattering coefficients versus incidence angle characteristics are suitably flat

and uniform. The method used shows that the main vertical lobe of the SIR-B antenna is slightly wider than previously reported (6.9 deg at 3 dB points versus 6.2 deg used in radiometric corrections). Author

A88-45774
APERTURE EFFICIENCIES OF LARGE AXISYMMETRIC REFLECTOR ANTENNAS FED BY CONICAL HORNS
J. A. MURPHY (Saint Patrick's College, Kildare, Ireland) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. 36, April 1988, p. 570-575. refs

It is shown how the radiation patterns of conical horns can be understood in terms of Laguerre-Gaussian beam modes. This approach provides a simple method for calculating the horn radiation pattern as it propagates through a multielement optical system consisting of lenses or offset mirrors with large focal ratio and/or a small angle of incidence, and can be used in quantitatively determining aperture efficiencies for systems where conical horns are coupled to antennas via tertiary optics. The resulting aperture efficiency results and a practical quasi-optical system fed by a conical horn are discussed. I.E.

A88-50306
FIBER BASED PHASED ARRAY ANTENNAS
JOEL L. GUGGENMOS and RONALD L. JOHNSON (TRW, Inc., Defense Communications Div., Redondo Beach, CA) IN: Optical technology for microwave applications III; Proceedings of the Meeting, Orlando, FL, May 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 70-77. refs

A phased array antenna is a multielement antenna capable of agile electronic beam forming and steering requiring several hundred high frequency, wide bandwidth, interconnections. Conventional distribution methods using waveguide or coax are impractical because they exhibit high attenuation, limited bandwidth, sensitivity to EMI, temperature drifts, and phase instability. Additionally, for large numbers of antenna elements, the size and weight of such systems make them impossible for large scale implementation on communication satellites. RF signal distribution via fiber optic technology is a potential solution to these phased array antenna problems. Author

A88-50431#
DESIGN OF AN ON-BOARD ANTENNA POINTING CONTROL SYSTEM FOR COMMUNICATION SATELLITES
YOICHI KAWAKAMI, HIROSHI HOJO, and MASAZUMI UEBA (Nippon Telegraph and Telephone Public Corp., Radio Communication Systems Laboratories, Kanagawa, Japan) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 689-694.
(AIAA PAPER 88-4306)

This paper describes system design methods of an on-board antenna pointing control system necessary for communication satellites in the 1990s. Four system configurations were studied for a typical antenna system. The system consists of two reflectors of about 3 meters diameter, and is required to maintain a high pointing accuracy requirement. A new system which consists of two control systems, an attitude control system and an antenna drive control system, was selected by the antenna pointing error analysis. New parameters are applied to the control system design in order to estimate interaction between two control systems, and dynamics with a flexible structure was studied for design of both the antenna drive control system and the antenna structures. Author

A88-50441#
CONTROL OF SPACECRAFT WITH MULTI-TARGETED FLEXIBLE ANTENNAS
LEONARD MEIROVITCH and MOON K. KWAK (Virginia Polytechnic Institute and State University, Blacksburg) AIAA and AAS, Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988. 9 p. refs
(Contract F49620-88-C-0044)
(AIAA PAPER 88-4268)

This paper is concerned with the problem of reorienting the line of sight of a given number of flexible antennas in a spacecraft. The maneuver of the antennas is carried out according to a minimum-time policy, which implies bang-bang control. Regarding the maneuver angular motion of the antennas as known, the equations of motion contain time-dependent terms in the form of coefficients and persistent disturbances. The control of the elastic vibration and of the rigid-body motions of the spacecraft caused by the maneuver is implemented by means of a proportional-plus-integral control. The approach is demonstrated by means of a numerical example in which a spacecraft consisting of a rigid platform and two maneuvering flexible antennas is controlled. Author

A88-50546
SURFACE ACCURACY MEASUREMENT OF A DEPLOYABLE MESH REFLECTOR BY PLANAR NEAR-FIELD SCANNING
WATARU CHUJO, TAKEO ITO, YOSHIAKI HORI, and TASUKU TESHIROGI (Ministry of Posts and Communications, Radio Research Laboratories, Koganei, Japan) IEEE Transactions on Antennas and Propagation (ISSN 0018-926X), vol. 36, June 1988, p. 879-883. refs

Using a near-field antenna measurement facility, it is possible to simultaneously evaluate the surface accuracy of a reflector antenna as well as the far-field pattern of the antenna for a short time. The surface errors of a 2-m deployable mesh reflector for satellite use were measured by a planar near-field system. As a result, the influence of periodic structures, due to the antenna ribs, has been clearly observed. Also, the surface accuracy obtained with the near-field scanning technique has coincided well with that obtained by an optical measurement technique. I.E.

A88-54749
FOCAL-PLANE AND APERTURE-PLANE HETERODYNE ARRAY RECEIVERS FOR MILLIMETER-WAVE RADIOASTRONOMY - A COMPARISON
J. ANTHONY MURPHY (Maynooth College, Ireland) and RACHAEL PADMAN (Mullard Radio Astronomy Observatory, Cambridge, England) International Journal of Infrared and Millimeter Waves (ISSN 0195-9271), vol. 9, Aug. 1988, p. 667-704. refs

Maximization of the throughput of a single large antenna is investigated for the cases of focal plane imaging arrays and aperture plane phased arrays. Trade-offs between these two types of arrays are considered with respect to field of view, sampling efficiency, and time to map a source. Limits imposed on the number of feed elements in an imaging array by the deterioration in aperture efficiency off-axis are determined. Advantages of the focal plane array over the aperture plane array include simpler electronics and fewer restrictions on the field of view. R.R.

N88-20529*# Smithsonian Astrophysical Observatory, Cambridge, MA.
THEORETICAL INVESTIGATION OF EM WAVE GENERATION AND RADIATION IN THE ULF, ELF AND VLF BANDS BY THE ELECTRODYNAMIC ORBITING TETHER Semiannual Report, 1 May - 31 Oct. 1987
ROBERT D. ESTES Apr. 1988 62 p
(Contract NAG8-638)
(NASA-CR-182720; NAS 1.26:182720; SAR-1) Avail: NTIS HC A04/MF A01 CSCL 20N

The goal is to extend the previous analysis of electromagnetic wave generation by an electrodynamic tethered satellite system to a more realistic model that includes the effects on wave propagation and reflection to the boundaries between ionosphere, atmosphere, and earth. One of the major activities was searching the scientific literature for publications that might be relevant to the problem. The software developed as SAO to follow the path of waves along field lines through the ionosphere to the atmosphere starting from an arbitary position in the atmosphere is described. Some preliminary results are presented from applying the code to the location of wave reception hot spots on the earth's surface

for satellites operating at 300 and 600 km altitudes. A generalization of the Alfven wing analysis is presented to allow for arbitrary angles between the velocity vector, geomagnetic field, and the veritcal. This will be utilized in the modeling of the problem with boundaries included. B.G.

N88-21193# Teldix Luftfahrt-Ausruestungs G.m.b.H., Heidelberg (Germany, F.R.).
HEMISPHERICAL POINTING MECHANISM DRIVE UNIT
H. H. SCHULTZ *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 11-14 Dec. 1987
Avail: NTIS HC A14/MF A01

A wide angle pointing device for controlling medium sized instrument and antenna payloads in the 10 to 50 kg range for missions requiring angular coverage of at least a hemisphere with a pointing accuracy of the order of 1 arcmin was developed. The drive unit which is the main part of the Hemispherical Pointing Mechanism (HPM) is a lightweight, pancake shaped package. It contains the motor, the reduction gear, the bearing, and the angular encoder. Results of a life test and breadboard model tests are presented. The HPM drive unit demonstrates that it can be used not only in the HPM but also for applications such as antenna pointing, bearing and power transfer, momentum wheel gimballing, control moment gyros, and robotics. ESA

N88-21203# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Space and Strategic Systems Div.
AEROSPATIALE UNFURLABLE REFLECTOR AND ASSOCIATED MECHANISMS
Y. BROUSTET, G. BRAZZINI, and E. JOSEPH-GABRIEL *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 83-89 Dec. 1987
Avail: NTIS HC A14/MF A01

An unfurlable antenna concept, particularly the spring actuated hinge used in truss motorization, is presented. A 9 m reflector consisting of 24 prismatic truss sections with articulated connecting bars and a similar 4 m design are described. Torque characteristics of the hinge are discussed. ESA

N88-21469*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 15-METER DIAMETER HOOP/COLUMN ANTENNA SURFACE CONTROL ACTUATOR SYSTEM
ELVIN L. AHL, JR. and JAMES B. MILLER *In its* The 22nd Aerospace Mechanisms Symposium, p 1-11 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13E

The design, development, and implementation status of the Surface Control Actuator System (SCAS) for the Hoop/Column Antenna are described with the primary focus on the design of the mechanical element. The SCAS is an electromechanical system that will automatically adjust the antenna shape by changing the length of control cords. Achieving and maintaining the proper surface shape and smoothness are critical to optimizing the electromagnetic characteristics of the antenna. Author

N88-21478*# Toshiba Corp., Kawasaki (Japan). Mechanical Engineering Lab.
DEVELOPMENT OF A MAGNETICALLY SUSPENDED, TETRAHEDRON-SHAPED ANTENNA POINTING SYSTEM
KENICHI TAKAHARA, TAMANE OZAWA, HIROSHI TAKAHASHI, SHITTA SHINGU, TOSHIRO OHASHI, and HITOSHI SUGIURA *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 133-147 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13I

A magnetically suspended, tetrahedron-shaped antenna pointing system is proposed for use in a multibeam broadcasting satellite system in the future. The structure of this system is presented, along with its design concept and the functional test results which were obtained in a laser tracking system in the laboratory. According to these results, it has been confirmed that the system has many advantages over conventional systems and excellent performance. Author

N88-23073*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CASE STUDY OF ACTIVE ARRAY FEED COMPENSATION WITH SIDELOBE CONTROL FOR REFLECTOR SURFACE DISTORTION
R. J. ACOSTA, A. J. M. ZAMAN, E. A. BOBINSKY, A. R. CHERRETTE, and S. W. LEE (Illinois Univ., Urbana-Champaign.) 1988 7 p Presented at the 1988 AP-S/URSI International Symposium, Syracuse, N.Y., 6-10 Jun. 1988; sponsored by IEEE (NASA-TM-100287; E-3932; NAS 1.15:100287) Avail: NTIS HC A02/MF A01 CSCL 20N

The feasibility of electromagnetically compensating for reflector surface distortions has been investigated. The performance characteristics (gain, sidelobe levels, etc.) of large communication antenna systems degrade as the reflector surface distorts mainly due to thermal effects from a varying solar flux. The techniques described in this report can be used to maintain the design performance characteristics independently of thermal effects on the reflector surface. With the advent of monolithic microwave integrated circuits (MMIC), a greater flexibility in array-fed reflector system design can be achieved. MMIC arrays provide independent control of amplitude and phase for each of many radiating elements of the feed array. It is assumed that the surface characteristics (x,y,z, its first and second derivatives) under distorted conditions are known. Author

N88-23929*# Houston Univ., TX. Applied Electromagnetics Lab.
AN INVESTIGATION OF CONFORMABLE ANTENNAS FOR THE ASTRONAUT BACKPACK COMMUNICATION SYSTEM Final Report
STUART A. LONG, DAVID R. JACKSON, JEFFERY T. WILLIAMS, and DONALD R. WILTON 1 Jun. 1988 190 p
(Contract NAG9-219)
(NASA-CR-182908; NAS 1.26:182908; TR-88-18) Avail: NTIS HC A09/MF A01 CSCL 17B

During periods of extravehicular activity it is obviously important that communication and telemetry systems continue to function independently of the astronaut. A system of antennas must therefore be designed that will provide the necessary isotropic coverage using circular polarization over both the transmit and receive frequency bands. To avoid the inherent physical limitations to motion that would be incurred with any sort of protruding antenna, it is necessary that the radiator be essentially flush-mounted or conformable to the structure on which it is attached. Several individual antenna elements are needed for the desired coverage. Both the particular elements chosen and their location determine the ultimate radiation pattern of the overall system. For these reasons a two-fold research plan was undertaken. First, individual elements were investigated and designed. Then various mounting locations were considered and the radiation patterns were predicted taking into account the effects of the astronaut's backpack. Author

N88-24958* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RANGE AND RANGE RATE SYSTEM Patent
OLIN L. GRAHAM, inventor (to NASA), JIM K. RUSSELL, inventor (to NASA), and WALTER L. EPPERLY, inventor (to NASA) (Westinghouse Electric Corp., Baltimore, Md.) 5 Apr. 1988 8 p Filed 4 May 1987 Supersedes N87-25570 (25 - 19, p 2614)
(NASA-CASE-MSC-20867-1; US-PATENT-4,736,247; US-PATENT-APPL-SN-045984; US-PATENT-CLASS-358-107; US-PATENT-CLASS-356-1; US-PATENT-CLASS-356-4; US-PATENT-CLASS-356-376; US-PATENT-CLASS-364-561)
Avail: US Patent and Trademark Office CSCL 20E

A video controlled solid state range finding system which requires no radar, high power laser, or sophisticated laser target is disclosed. The effective range of the system is from 1 to about 200 ft. The system includes an opto-electric camera such as a lens CCD array device. A helium neon laser produces a source beam of coherent light which is applied to a beam splitter. The beam splitter applies a reference beam to the camera and produces

an outgoing beam applied to a first angularly variable reflector which directs the outgoing beam to the distant object. An incoming beam is reflected from the object to a second angularly variable reflector which reflects the incoming beam to the opto-electric camera via the beam splitter. The first reflector and the second reflector are configured so that the distance travelled by the outgoing beam from the beam splitter and the first reflector is the same as the distance travelled by the incoming beam from the second reflector to the beam splitter. The reference beam produces a reference signal in the geometric center of the camera. The incoming beam produces an object signal at the camera.
Official Gazette of the U.S. Patent and Trademark Office

N88-25745*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
LARGE ANTENNA EXPERIMENTS ABOARD THE SPACE SHUTTLE: APPLICATION OF NONUNIFORM SAMPLING TECHNIQUES
Y. RAHMATSAMII *In its* Proceedings of the Mobile Satellite Conference p 459-464 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

Future satellite communication and scientific spacecraft will utilize antennas with dimensions as large as 20 meters. In order to commercially use these large, low sidelobe and multiple beam antennas, a high level of confidence must be established as to their performance in the 0-g and space environment. Furthermore, it will be desirable to demonstrate the applicability of surface compensation techniques for slowly varying surface distortions which could result from thermal effects. An overview of recent advances in performing RF measurements on large antennas is presented with emphasis given to the application of a space based far-field range utilizing the Space Shuttle and the concept of a newly developed nonuniform sampling technique. Author

N88-25746*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 15-METER ANTENNA PERFORMANCE OPTIMIZATION USING AN INTERDISCIPLINARY APPROACH
WILLIAM L. GRANTHAM, LYLE C. SCHROEDER, MARION C. BAILEY, and THOMAS G. CAMPBELL *In* Jet Propulsion Lab., Proceedings of the Mobile Satellite Conference p 465-470 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

A 15-meter diameter deployable antenna has been built and is being used as an experimental test system with which to develop interdisciplinary controls, structures, and electromagnetics technology for large space antennas. The program objective is to study interdisciplinary issues important in optimizing large space antenna performance for a variety of potential users. The 15-meter antenna utilizes a hoop column structural concept with a gold-plated molybdenum mesh reflector. One feature of the design is the use of adjustable control cables to improve the paraboloid reflector shape. Manual adjustment of the cords after initial deployment improved surface smoothness relative to the build accuracy from 0.140 in. RMS to 0.070 in. Preliminary structural dynamics tests and near-field electromagnetic tests were made. The antenna is now being modified for further testing. Modifications include addition of a precise motorized control cord adjustment system to make the reflector surface smoother and an adaptive feed for electronic compensation of reflector surface distortions. Although the previous test results show good agreement between calculated and measured values, additional work is needed to study modelling limits for each discipline, evaluate the potential of adaptive feed compensation, and study closed-loop control performance in a dynamic environment. Author

N88-25748*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TECHNOLOGIES FOR ANTENNA SHAPE AND VIBRATION CONTROL
EDWARD METTLER, ROBERT SCHEID, and DANIEL ELDRED *In its* Proceedings of the Mobile Satellite Conference p 477-482 May 1988
Avail: NTIS HC A23/MF A01 CSCL 17B

This paper describes the application of advanced control methods and techniques to the second- and third-generation mobile satellite (MSAT) configurations having wrap-rib offset feed construction. The technologies are generically applicable to other designs such as hoop-column and other elastically deformable non-rigid structures. The focus of the discussion is on reflector shape determination and control, dynamics identification, and pointing jitter suppression. Author

09

PROPULSION/FLUID MANAGEMENT

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

A88-28084
THE GALACTIC CENTER
REINHARD GENZEL (Max-Planck-Institut fuer Physik und Astrophysik, Garching, Federal Republic of Germany) IN: The galaxy; Proceedings of the NATO Advanced Study Institute, Cambridge, England, Aug. 4-15, 1986. Dordrecht, D. Reidel Publishing Co., 1987, p. 51-79. refs

Recent observations of the central 10 pc of the Galaxy are reviewed. An overview is given of phenomena occurring in the center, and the energetics and luminosity of the center are discussed. The distribution and excitation of the neutral interstellar matter in Sgr A are considered, current knowledge on the mass distribution is addressed, and the evidence for and against a massive black hole at the center is examined. The nature of the central 0.1 pc of the Galaxy is discussed. C.D.

A88-33441*# General Dynamics Corp., San Diego, CA.
LONG TERM ORBITAL STORAGE OF CRYOGENIC PROPELLANTS FOR ADVANCED SPACE TRANSPORTATION MISSIONS
JOHN R. SCHUSTER (General Dynamics Corp., Space Systems Div., San Diego, CA) and NORMAN S. BROWN (NASA, Marshall Space Flight Center, Huntsville, AL) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 127-133.

A comprehensive study has developed the major features of a large capacity orbital propellant depot for the space-based, cryogenic OTV. The study has treated both the Dual-Keel Space Station and co-orbiting platforms as the accommodations base for the propellant storage facilities, and trades have examined both tethered and hard-docked options. Five tank set concepts were developed for storing the propellants, and along with layout options for the station and platform, were evaluated from the standpoints of servicing, propellant delivery, boiloff, micrometeoroid/debris shielding, development requirements, and cost. These trades led to the recommendation that an all-passive storage concept be considered for the platform and an actively refrigerated concept providing for reliquefaction of all boiloff be considered for the Space Station. The tank sets are modular, each storing up to 45,400 kg of LO2/LH2, and employ many advanced features to provide for microgravity fluid management and to limit boiloff. The features include such technologies as zero-gravity mass gauging, total communication capillary liquid acquisition devices, autogenous pressurization, thermodynamic vent systems, thick multilayer insulation, vapor-cooled shields, solar-selective coatings, advanced micrometeoroid/debris protection systems, and long-lived cryogenic refrigeration systems. Author

A88-33792#
TESTING OF PROPELLANT MANAGEMENT DEVICE FOR 3-AXIS GEOSYNCHRONOUS SPACECRAFT
TSO-PING YEH and DONALD L. BOND (Ford Aerospace and Communications Corp., Palo Alto, CA) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 137-141.

Testing on scale models, components, and subassemblies and on the integrated tank is being used to qualify a propellant tank for Ford Aerospace's new class of geosynchronous satellites. Experimental methods used to simulate fluid behavior, including drop tower and zero-g KC-135 aircraft flights, are discussed and correlated to analytical models. The testing planned during the PMD assembly, tank qualification, and acceptance testing while in the normal one-g environment is discussed. Author

A88-35093
AEROSPACE CENTURY XXI: SPACE FLIGHT TECHNOLOGIES; PROCEEDINGS OF THE THIRTY-THIRD ANNUAL AAS INTERNATIONAL CONFERENCE, BOULDER, CO, OCT. 26-29, 1986
GEORGE W. MORGENTHALER, ED. and W. KENT TOBISKA, ED. (Colorado, University, Boulder) Conference sponsored by AAS. San Diego, CA, Univelt, Inc., 1987, 606 p. For individual items see A88-35094 to A88-35122.

Among the topics discussed are advanced electric propulsion for interplanetary missions, NASA Space Station propulsion, nuclear reactor-based space power systems, electrodynamic tethers for space power and thrust generation, exotic 21st-century spacecraft propulsion, control systems for autonomous operation of the Magellan spacecraft, spacecraft thermal management systems, aerobraking maneuver-related problems, and advanced heavy lift launch vehicles. Also discussed are a space telerobot concept, space-based robotic assembly and maintenance, advanced Al alloys and Al/polymer laminates for aerospace structures, lubrication for space environments, distributed and concurrent computation methods for space structures, and 32-GHz deep space communications. O.C.

A88-35094
SPACE STATION PROPULSION (UTILIZATION OF EFFLUENTS FOR OPTIMIZED FLIGHT PROFILES AND STS LOGISTICS CAPABILITIES)
S. M. BRENNAN (Boeing Aerospace Co., Huntsville, AL) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 627-640. Research supported by the Boeing Aerospace Co.
(AAS PAPER 86-260)

Logistics-related features are the major contributors to operation costs in the NASA Space Station as a whole and in its propulsion system specifically; attention has accordingly been given to the reduction of the number and weights of such factors, while improving the effectiveness of each Space Shuttle logistic flight to the Space Station in orbit. An economically attractive course involves the use of excess and waste fluids generated aboard both the Shuttle and the Station in a combined O2/H2 water electrolysis and resistojet propulsion system. These fluids can be used to fly an optimized, variable-altitude profile that increases Space Shuttle payload-to-orbit capabilities. O.C.

A88-35100
EXOTIC PROPULSION IN THE 21ST CENTURY
ROBERT L. FORWARD (Hughes Research Laboratories, Malibu, CA) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 717-744. refs
(Contract F04611-86-C-0039)
(AAS PAPER 86-409)

Possible forms of interplanetary spacecraft propulsion for next-century development and implementation are presented and comparatively evaluated, with a view to the types of technology involved. Both Western and Soviet proposals are discussed. The propulsion system types are (1) laser thermal; (2) 'Skyhook' and 'rotavator' propulsion tethers; (3) proton-antiproton annihilation; (4) solar radiation-pushed light sails; and (5) laser radiation-pushed light sails. Laser-pushed light sails are held to be capable of supporting round-trip interstellar travel. O.C.

A88-35943#
DESIGN OF LIGHT-WEIGHT IMPACT RESISTANT PRESSURE VESSELS FOR SPACE STATION FLUID AND PROPULSION SYSTEMS
K. A. MCCLYMONDS, H. W. BABEL, and D. P. RYAN (McDonnell Douglas Astronautics Co., Huntington Beach, CA) AIAA SDM Issues of the International Space Station, Conference, Williamsburg, VA, Apr. 21, 22, 1988. 7 p. Research supported by McDonnell Douglas Astronautics Co. refs
(AIAA PAPER 88-2466)

The Space Station requires many gas storage tanks to operate the fluid management and distribution systems, and propulsion systems. Composites are attractive candidates for pressure containment based on their high specific tensile strengths. This work addresses the issues for such tanks and focuses on the critical problem of meeting leak-before-burst requirements for hypervelocity particle impacts. Test data is reported for 30 caliber gunfire and hypervelocity impacts on graphite/epoxy overwrapped bottles with aluminum liners. Author

A88-41210
CRYOGENIC THERMAL STRATIFICATION IN LOW-GRAVITY
WILLIAM F. WILDHABER (Ball Corp., Ball Aerospace Systems Div., Boulder, CO) IN: Low-gravity sciences. San Diego, CA, Univelt, Inc., 1987, p. 101-116. refs
(AAS 86-555)

Cryogenic space technology and the associated problems of thermal stratification are considered. Potential thermal stratification control concepts are presented. It is noted that the stratification database for the design of orbital cryogenic sysems is limited to the Apollo program and the Space Transportation System. One advantage of a supercritical system over a subcritical system is that on-orbit testing is not required for verification of fluid acquisition and expulsion. K.K.

A88-41287
LEO TO GEO TRANSPORTATION SYSTEM COMBINING ELECTRIC PROPULSION WITH BEAMED MICROWAVE POWER FROM EARTH
WILLIAM C. BROWN (Microwave Power Transmission Systems, Inc., Weston, MA) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 195-217. refs
(AAS PAPER 87-126)

Transportation of space payloads aboard OTVs from LEO to GEO is presently envisioned with a system combining electric propulsion with beamed microwave power from earth, via a rectenna that both absorbs and rectifies the microwave beam focused on the vehicle by an electronically steerable phased array. The rectenna's mass, at 1 kg/kW, is an order of magnitude lower than other proposed space power sources. The transmitters are located on the equator, and the OTVs are launched into an equatorial-plane orbit, so that the beam can sweep a large angle west-to-east. Microwave OTVs are compared with a nuclear propulsion alternative; these technologies are noted to be complementary for large scale lunar and Martian missions. O.C.

A88-42832#
APPLICABILITY OF THE FLOW-NET PROGRAM TO SOLUTION OF SPACE STATION FLUID DYNAMICS PROBLEMS
J. NAVICKAS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) and W. C. RIVARD (Flow Science, Inc., Los Alamos, NM) IN: International Symposium on Thermal Problems in

Space-Based Systems, Boston, MA, Dec. 13-18, 1987, Proceedings. New York, American Society of Mechanical Engineers, 1987, p. 19-24. refs

The Space Station design encompasses a variety of fluid systems that require extensive flow and combined flow-thermal analyses. The types of problems encountered range from two-phase cryogenic to high-pressure gaseous systems. Design of such systems requires the most advanced analytical tools. Because Space Station applications are a new area for existing two-phase flow programs, typically developed for nuclear safety applications, a careful evaluation of their capabilities to treat generic Space Station flows is appropriate. The results from an assessment of one particular program, FLOW-NET, developed by Flow Science, In., are presented. Three typical problems are analyzed: (1) fill of a hyperbaric module with gaseous nitrogen from a high-pressure supply system, (2) response of a liquid ammonia line to a rapid pressure decrease, and (3) performance of a basic two-phase, thermal control network. The three problems were solved successfully. Comparison of the results with those obtained by analytical methods supports the FLOW-NET calculations. Author

A88-43710#
OPEN-CYCLE CHEMICAL POWER AND THERMAL MANAGEMENT SYSTEM WITH COMBUSTION PRODUCT-FREE EFFLUENT
G. S. HOSFORD, K. WEBER (Sundstrand Corp., Rockford, IL), and R. GIELLIS (Martin Marietta Corp., Denver, CO) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 6 p.
(AIAA PAPER 88-2625)

Open-cycle chemical prime power sources offer a nonnuclear alternative for satisfying the burst electrical power requirements for space-based multimegawatt power concepts. Although hydrogen-oxygen chemical energy sources require long-term cryogenic storage technology, they have less mass than systems that use fuels and oxidizers that can be stored at temperatures found in the low earth orbit environment. Open-cycle chemical concepts typically exhaust undesirable products of combustion into the environment surrounding space platforms. Innovative application of thermophysical principles in a new open-cycle chemical power generation concept prevents these combustion products from entering the exhaust gas stream and provides a means of storing them in a liquid state on the platform. This concept eliminates one of the major disadvantages of the open-cycle chemical systems. Author

A88-43715*# Maine Univ., Orono.
A NEW LINEARIZED THEORY OF LAMINAR FILM CONDENSATION OF TWO PHASE ANNULAR FLOW IN A CAPILLARY PUMPED LOOP
Y. K. HSU (Maine, University, Orono), T. SWANSON, and R. MCINTOSH (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 10 p. refs
(AIAA PAPER 88-2637)

Future large space based facilities, such as Space Station, will require energy management systems capable of transporting tens of kilowatts of heat over a hundred meters or more. This represents better than an order of magnitude improvement over current technology. Two-phase thermal systems are currently being developed to meet this challenge. Condensation heat transfer plays a very important role in this system. The present study attempts an analytic solution to the set of linearized partial differential equations. The axial velocity and temperature functions were found to be Bessel functions which have oscillatory behavior. This result agrees qualitatively with the experimental evidence from tests at both NASA Goddard Space Flight Center and elsewhere. Author

A88-44526*# SDRC, Inc., San Diego, CA.
AN ASSESSMENT OF NOMINAL AND CONTINGENCY ALTITUDE REBOOST SCENARIOS DURING SPACE STATION ASSEMBLY
VINCENT J. BILARDO, JR., JOHN HUDIBURG (NASA, Space Station Program Office, Reston, VA), and LEWIS COLLINS (SDRC, Inc., San Diego, CA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 13 p. refs
(AIAA PAPER 88-3501)

The results of an analysis of several reboost scenarios for nominal and contingency SS operations during the Phase I assembly sequence are presented. Space Station program requirements on assembly and operational altitudes are outlined, and essential features of the SS reaction control system are described. A nominal reboost strategy designed to meet the current program requirements is presented. In addition, reboost strategies are developed for several contingency scenarios, including one missed STS mission, and an extended STS outage. It is shown that the time-averaged propellant 'cost' of maintaining altitude is greatest for equivalent continuous-thrusting altitude maintenance; it decreases with increasing reboost/rendezvous time interval to an asymptotic minimum value. K.K.

A88-44668*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PARAMETRIC STUDIES OF ELECTRIC PROPULSION SYSTEMS FOR ORBIT TRANSFER VEHICLES
R. MANVI and T. FUJITA (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. DOE-DOD-sponsored research. refs
(AIAA PAPER 88-2835)

The present parametric tradeoff study for OTV electric propulsion systems encompasses ammonia and hydrogen arcjets as well as Xe-ion propulsion systems with performance characteristics currently being projected for 1993 operation. In all cases, the power source is a nuclear-electric system with 30 kg/kW(e) specific mass, and the mission involves the movement of payloads from lower orbits to GEO. Attention is given to payload capabilities and associated propellant requirements. Mission trip time is identified as the key parameter for selection; while arcjets are preferable for shorter trip times, ion propulsion is more advantageous for longer trip times due to reduced propellant mass fraction. O.C.

A88-44687*# Martin Marietta Corp., Denver, CO.
CRYOGENIC PROPULSION FOR LUNAR AND MARS MISSIONS
LARRY REDD (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 10 p.
(Contract NAS8-36108; NAS8-3712)
(AIAA PAPER 88-2895)

Future missions to the moon and Mars have been investigated with regard to propulsion system selection. The results of this analysis show that near state-of-the-art LO2/LH2 propulsion technology provides a feasible means of performing lunar missions and trans-Mars injections. In other words, existing cryogenic space engines with certain modifications and product improvements would be suitable for these missions. In addition, present day cryogenic system tankage and structural weights appear to scale reasonably when sizing for large payload and high energy missions such as sending men to Mars. Author

A88-44695*# Martin Marietta Corp., Denver, CO.
ORBITAL SPACECRAFT CONSUMABLES RESUPPLY
SAM M. DOMINICK, RALPH N. EBERHARDT, and THOMAS R. TRACEY (Martin Marietta Corp., Denver, CO) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. Research supported by Martin Marietta Corp. refs
(Contract NAS9-17585)
(AIAA PAPER 88-2922)

The capability to replenish spacecraft, satellites, and laboratories on-orbit with consumable fluids provides significant increases in their cost and operational effectiveness. Tanker systems to perform on-orbit fluid resupply must be flexible enough to operate from the Space Transportation System (STS), Space

Station, or the Orbital Maneuvering Vehicle (OMV), and to accommodate launch from both the Shuttle and Expendable Launch Vehicles (ELV's). Resupply systems for storable monopropellant hydrazine and bipropellants, and water have been developed. These studies have concluded that designing tankers capable of launch on both the Shuttle and ELV's was feasible and desirable. Design modifications and interfaces for an ELV launch of the tanker systems were identified. Additionally, it was determined that modularization of the tanker subsystems was necessary to provide the most versatile tanker and most efficient approach for use at the Space Station. The need to develop an automatic umbilical mating mechanism, capable of performing both docking and coupler mating functions was identified. Preliminary requirements for such a mechanism were defined. The study resulted in a modular tanker capable of resupplying monopropellants, bipropellants, and water with a single design. Author

A88-44698*# National Aeronautics and Space Administration, Washington, DC.
PROPULSION SAFETY ALMOST EQUALS MISSION SAFETY
GILBERT L. ROTH (NASA, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 5 p. refs
(AIAA PAPER 88-2881)

Propulsion system hardware and monitoring/control software constitute a given manned or unmanned aerospace system's primary risk-management issue. The present inquiry into the reasons for this dominance attempts to identify development routes to the reduction of propulsion-related management risk issues. A 'life management plan' for propulsion systems would give attention to service life requirements, criteria for the monitoring and evaluation of useful life, a method for the tracking of service life, criteria for hardware reusability and operations inspection, and hardware preassembly screening practices. O.C.

A88-44741#
THE GAMMA RAY OBSERVATORY (GRO) PROPULSION SUBSYSTEM
J. A. WEATHERLY, R. A. CARLSON, and S. C. HEVERT (TRW, Inc., Space and Technology Group, Redondo Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(AIAA PAPER 88-3051)

The Gamma Ray Observatory (GRO) LEO spacecraft's Propulsion Subsystem (PSS) is a large, hydrazine monopropellant system containing over 4000 lbs of fuel to furnish ascent, drag compensation, three-axis stabilization, and controlled reentry power. The PSS uses four 100-lb thrust engines for orbital adjustment and eight 5-lb thrust engines for attitude control. GRO is the first NASA spacecraft to be designed to take advantage of a standardized refueling coupling for on-orbit refueling. O.C.

A88-44820*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF TEST-CELL PRESSURE ON THE PERFORMANCE OF RESISTOJETS
D. H. MANZELLA (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH), P. F. PENKO (NASA, Lewis Research Center, Cleveland, OH), K. J. DE WITT, and T. G. KEITH, JR. (Toledo, University, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p. NASA-supported research. refs
(AIAA PAPER 88-3286)

The effect of test-cell pressure on the performance of two resistojets was investigated. Tests were conducted in a vacuum facility at pressures ranging from 0.000043 to 0.54 torr for two resistojet configurations: a laboratory model and an engineering model for the Space Station. The tests showed that for each thruster there was a decline in performance when tested in vacuum pressures above 0.001 torr. Measurements were made of surface temperature, thrust, and exit-plane pitot pressure over the range of test-cell pressures. From these measurements, the decline in performance of the laboratory-model resistojet at higher cell pressures was attributed to heat losses due to convection. For the engineering-model resistojet, the decline in performance was found to be a combination of heat loss and an effect of cell pressure on the nozzle flow. Author

A88-44875#
ALL ELECTRONIC PROPULSION - KEY TO FUTURE SPACESHIP DESIGN
WILLIAM C. BROWN (Microwave Power Transmission Systems, Weston, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 20 p. refs
(AIAA PAPER 88-3170)

The all-electronic propulsion system combines the high specific impulse of the ion thruster with beamed microwave power to produce a combined power and propulsion system with a self-acceleration as greater at 0.02 m/sec sq with a specific impulse of 4200. This is more than an order of magnitude greater than that provided by other approaches to electric propulsion in their current state of development, including nuclear and photovoltaic power sources. Associated with this new technology are two requirements for its execution: (1) the space vehicles and earth based transmitters must be based in the equatorial plane; and (2) the vehicles are large in area and have very high thrust levels because of efficiency and cost considerations associated with the microwave beam system. These vehicles, both in size and physical configuration, are different from conventional space vehicles and may have an impact upon future space vehicle design including those using photovoltaic power. Author

A88-45712* Georgia Inst. of Tech., Atlanta.
SINGULAR PERTURBATION ANALYSIS OF THE ATMOSPHERIC ORBITAL PLANE CHANGE PROBLEM
A. J. CALISE (Georgia Institute of Technology, Atlanta) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 36, Jan.-June 1988, p. 35-43. refs
(Contract NAG1-660)

A three-state model is presented for the aeroassisted orbital plane change problem. A further model order reduction to a single state model is examined using singular perturbation theory. The optimal solution for this single state model compares favorably with the exact numerical solution using a four-state model; however, a separate boundary layer solution is required to satisfy the terminal constraint on altitude. This, in general, involves the solution of a two-point boundary value problem, but for a two-state model. An approximation is introduced to obtain an analytical control solution for lift and bank angle. Included are numerical simulation results of a guidance law derived from this analysis, along with comparison to earlier work by other researchers. Author

A88-46220*# Michigan State Univ., East Lansing.
ELECTROTHERMAL PROPULSION OF SPACECRAFT WITH MILLIMETER AND SUBMILLIMETER ELECTROMAGNETIC ENERGY
L. L. FRASCH, R. FRITZ, and J. ASMUSSEN (Michigan State University, East Lansing) Journal of Propulsion and Power (ISSN 0748-4658), vol. 4, July-Aug. 1988, p. 334-340. refs
(Contract NAG3-305)

The concept of millimeter and submillimeter wave electrothermal propulsion is considered. State-of-the-art radiation sources from 30-1000 GHz are examined to determine their applicability to electrothermal propulsion systems. The problem of energy conversion and power conditioning in this frequency range is also addressed. The potential advantage of utilizing power beaming with millimeter and submillimeter systems is examined. Finally, areas of future research and development are indicated. Author

A88-46489*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
ADVANCED PROPULSION FOR THE MARS ROVER SAMPLE RETURN MISSION
BRYAN PALASZEWSKI and ROBERT FRISBEE (California Institute

of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(AIAA PAPER 88-2900)

The present evaluation of highly detailed advanced propulsion system design concepts for the Mars Rover Sample Return Mission proceeded by comparing a baseline chemical propulsion option with both storable and cryogenic advanced chemical propulsion alternatives and solar- and nuclear-based electric propulsion OTVs. Substantial launch mass reductions and commensurate payload mass increases were obtainable with both advanced chemical and electric propulsion cycles. O.C.

A88-47969#
TWO-PHASE ALKALI-METAL EXPERIMENTS IN REDUCED GRAVITY
ZENEN I. ANTONIAK (Battelle Pacific Northwest Laboratory, Richland, WA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 146-155. refs
(Contract DE-AC06-76RL-01830)

Future space missions envision the use of large nuclear reactors using either a single or a two-phase alkali-metal working fluid. The design and analysis of such reactors require state-of-the-art computer codes that can properly treat alkali-metal flow and heat transfer in a reduced-gravity environment. Current single and multiphase computer codes rely on the presence of gravity - in the fluid momentum equations, in defining their flow regimes, in specific two-phase flow models, or indirectly in the form of correlations obtained from tests conducted in a 1-g field. New flow regime maps, models, and correlations are required if the codes are to be successfully applied to reduced-gravity flow and heat transfer. A literature search of relevant experiments in reduced gravity is reported on here and reveals a paucity of data for such correlations. The few ongoing experiments in reduced gravity are noted. General plans are put forth for the reduced-gravity experiments that will have to be performed, at NASA facilities, with benign fluids. Data from the reduced-gravity experiments with innocuous fluids are to be combined with normal gravity data from the two-phase alkali-metal experiments. Calculations and analyses undertaken here give every expectation that the correlations developed from this data base will provide a valid representation of alkali-metal heat transfer and pressure drop in reduced gravity. Author

A88-48042#
SOLAR THERMAL PROPULSION FOR ORBIT TRANSFER
JAMES M. SHOJI and PATRICK E. FRYE (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference and Exhibit, 24th, Boston, MA, July 11-13, 1988. 9 p. refs
(AIAA PAPER 88-3171)

A preliminary analysis of pressure-fed and pump-fed solar thermal propulsion systems revealed that a pressure-fed system using cold helium is a much simpler system; however, the resulting payload is too great. In the case of a LEO-to-GEO mission, an optimum thrust level was obtained for the solar thermal propulsion system. For the two-engine concepts considered, the optimum thrust was in the 30 to 45 lbf thrust range. The engine concept providing the higher specific impulse resulted in a lower optimum thrust level. K.K.

A88-48484#
AN ANALYSIS OF ORBIT MANEUVERING CAPABILITIES USING ARCJET PROPULSION
R. J. CASSADY (Rocket Research Co., Redmond, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 6 p. refs
(AIAA PAPER 88-2832)

The thermal arcjet thruster is a leading candidate for several geocentric orbit transfer and maneuvering missions. The objective of this paper is to catalog those missions and perform an analysis for a representative case of the various mission types which will serve to illustrate the expanded capabilities provided by arcjet propulsion. Recent literature sources mention arcjets in conjunction with three classes of missions: N-S stationkeeping of geosynchronous satellites, orbit maneuvering of intermediate orbit satellites, and orbit transfer from Low Earth Orbit (LEO) to higher orbits. These will be considered as the baseline set of missions to be analyzed. In addition, the use of arcjet propulsion as an upper stage of a chemical/electric Orbit Transfer Vehicle (OTV) will be considered, as well as other variations on the basic mission set. Author

A88-48492*# Martin Marietta Corp., Denver, CO.
INTEGRATION OF SPACE STATION PROPULSION AND FLUID SYSTEMS
B. A. BICKNELL, D. A. FESTER, and S. C. WILSON (Martin Marietta Corp., Denver, CO) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p. refs
(Contract NAS8-36438)
(AIAA PAPER 88-3289)

The benefits which would be gained by providing commonality and integration of propulsion and fluid systems associated with various elements of the Space Station are discussed and the results of the integrated propulsion system assessment are presented. The O2/H2 propulsion system with and without resistojets, the integration of O2/H2 systems across the Space Station elements, and an approach for handling waste fluids available for resistojet venting are evaluated. It is shown that major benefits can be gained through commonality and integration. Several systems are recommended, including a gaseous O2/H2 propulsion system with resistojets, a Bosch CO2 reduction process, and pumping electrolysis units. R.B.

A88-48765*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMODYNAMIC MODELING OF THE NO-VENT FILL METHODOLOGY FOR TRANSFERRING CRYOGENS IN LOW GRAVITY
DAVID J. CHATO (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. Previously announced in STAR as N88-24686. refs
(AIAA PAPER 88-3403)

The filling of tanks with cryogens in the low-gravity environment of space poses many technical challenges. Chief among these is the inability to vent only vapor from the tank as the filling proceeds. As a potential solution to this problem, the NASA Lewis Research Center is researching a technique known as No-Vent Fill. This technology potentially has broad application. The focus is the fueling of space based Orbital Transfer Vehicles. The fundamental thermodynamics of the No-Vent Fill is described. The model is then used to conduct a parametric investigation of the key parameters: initial tank wall temperature, liquid-vapor interface heat transfer rate, liquid inflow rate, and inflowing liquid temperatures. Liquid inflowing temperature and the liquid-vapor interface heat transfer rate seem to be the most significant since they influence the entire fill process. The initial tank wall temperature must be sufficiently low to prevent a rapid pressure rise during the initial liquid flashing state, but then becomes less significant. Author

A88-48957#
SPACE-BASED SYSTEM DISTURBANCES CAUSED BY ON-BOARD FLUID MOTION DURING SYSTEM MANEUVERS
J. NAVICKAS (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: AIAA, ASME, SIAM, and APS, National Fluid Dynamics Congress, 1st, Cincinnati, OH, July 25-28, 1988, Technical Papers. Part 3. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 1558-1562. refs
(AIAA PAPER 88-3633)

Disturbing forces and moments are calculated using the FLOW-3D finite difference code for a space-based oxygen tank under a suddenly applied settling acceleration for a case with a simultaneous liquid outflow and a case with no such outflow. Results show that the two conditions result in very different dynamic disturbances. The code accuracy is evaluated as part of the

calculations and is shown to be adequate. Results also indicate that the storage tank geometry has a significant effect on the resulting disturbances. Author

A88-52362* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ORBITAL MANEUVERING VEHICLE SUPPORT TO THE SPACE STATION
WILLIAM E. GALLOWAY (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 10-1 to 10-7.

This paper describes the Orbital Maneuvering Vehicle (OMV) and its intended role as a key element of the National Space Transportation System. Various types of missions, operating modes, and performance capabilities for the OMV are described as are typical mission scenarios, with the OMV based at the Shuttle and at the Space Station (SS). Particular emphasis is placed on OMV missions in support of the SS. Retrieval of a spacecraft to the SS for servicing, followed by redeployment of the spacecraft to its operational orbit is typical of SS-based projected missions. Author

A88-53101*# Rockwell International Corp., Canoga Park, CA.
25-LBF GO2/GH2 SPACE STATION THRUSTER
L. E. FINDEN, G. L. BRILEY, and R. S. IACABUCCI (Rockwell International Corp., Rocketdyne Div., Canoga Park, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 8 p.
(Contract NAS3-25142; NAS8-36418)
(AIAA PAPER 88-2793)

Multiple 25-lbf oxygen/gaseous hydrogen thruster assemblies for the Space Station propulsion application were designed and fabricated by Rocketdyne and endurance tested at the NASA/Marshall Space Flight Center. The thrusters incorporate a regeneratively cooled thrust chamber with a nozzle area ratio of 30, a 12-element coaxial injector, an ignition system, and close-coupled propellant valves. The various thruster configurations comprised of mating different injectors and thrust chambers. Over 2 million lbf-sec of impulse was demonstrated at mixture ratios from 3 to 8.4 at vacuum conditions. A thruster was subjected to over 10,000 pulses during which minimum impulse bits of less than 0.5 lb/sec were repeatedly and reliably demonstrated. A total operating time of 25.6 hr was accumulated on the thruster assemblies with one 6.1-hr. continuous firing duration. The thrusters operated between a thrust range of 11.2 and 36.6 lbf. The test results indicate that all major technology issues for long-life gaseous oxygen/gaseous hydrogen thrusters for the Space Station application have been resolved. Author

A88-53163#
FUNDAMENTAL LIMITATIONS ON LOW GRAVITY FLUID GAUGING TECHNOLOGIES IMPOSED BY ORBITAL MISSION REQUIREMENTS
R. JOHN HANSMAN, JR. (MIT, Cambridge, MA) and JERE S. MESEROLE (Boeing Aerospace Co., Kent, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 9 p. Research supported by Boeing Aerospace Co. refs
(AIAA PAPER 88-3402)

The limitations on low gravity fluid gauging technologies imposed by fluid behavior resulting from the orbital environment is investigated. While there are numerous potential techniques, they are all expected to suffer some degradation under certain low gravity conditions. Specific current and proposed low gravity fluid gauging technologies are briefly reviewed. The impact on these technologies of low gravity modes of fluid behavior including: ambiguous orientation, bubble entrapment, sensor wetting, sensor blocking and reduced convection are discussed. Potential techniques to improve low gravity fluid gauging are discussed including Bond number enhancement, tank and sensor design considerations. In addition, system design considerations are discussed including sensor integration, dynamic measurement techniques and mission design concepts. Author

A88-53197* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PUMP PERFORMANCE REQUIREMENT FOR THE LIQUID HELIUM ORBITAL RESUPPLY TANKER
J. H. LEE (NASA, Ames Research Center, Moffett Field, CA) and Y. S. NG (Sterling Federal Systems, Inc., Palo Alto, CA) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 525-532. refs

The Liquid Helium Orbital Resupply Tanker (currently renamed to Superfluid Helium Tanker) will greatly enhance the lifetime of the space missions which require superfluid helium. The Superfluid Helium Tanker pump performance requirement is driven by the superfluid helium replenishment needs of the Space Infrared Telescope Facility (SIRTF). SIRTF is one of the space missions which will require on-orbit superfluid helium resupply in the 1990s. The Superfluid Helium Tanker will carry at least 10,000 L of superfluid helium and provide a minimum pump head of 170 torr (0 to 200 L/h) to cool SIRTF from 150 to 2 K. When the SIRTF tank starts to collect liquid, a minimum flow rate of 300 L/h with a pump head of 60 torr is required to fill the 4000-liter tank. Author

A88-53220* Cryolab, Inc., San Luis Obispo, CA.
BAYONET FOR SUPERFLUID HELIUM TRANSFER IN SPACE
G. E. MCINTOSH, D. S. LOMBARD, D. L. MARTINDALE (Cryolab, Inc., San Luis Obispo, CA), and MICHAEL J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 885-891.
(Contract NAS5-29224)

A prototype superfluid helium bayonet for potential space applications has been developed and evaluated with a low heat leak test apparatus. Measured heat leak of the 13 mm (1/2 inch) bayonet pair is 0.21 W at 1.8 K with an uncertainty of +0.09/-0.05 W. Bayonets are fabricated with thin, electron beam (EB) welded tubes which are EB welded to machined nose and flange pieces. Low heat leak structural integrity is provided by a 0.9 mm thickness of filament wound fiberglass-epoxy. Superfluid creep is restricted by KEL-F nose seals which form vacuum-tight extensions to the bayonet cold end pieces. Author

A88-53221* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT) FLIGHT EXPERIMENT
MICHAEL J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) and PETER KITTEL (NASA, Ames Research Center, Moffett Field, CA) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 893-900. refs

The SHOOT flight demonstration is being undertaken to verify component and system level technology necessary to resupply large superfluid helium dewars in space. The baseline configuration uses two identical 210 liter dewars connected by a transfer line which contains a quick disconnect coupling. The helium will be transferred back and forth between the dewars under various conditions of flow rate, parasitic heat load, and temperature. An astronaut Extra-vehicular Activity (EVA) is also planned to manually demate and mate the coupling. A number of components necessary for the flight are being developed. These components are described here. Author

A88-53222* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CRYOGENIC AND THERMAL DESIGN FOR THE SUPERFLUID HELIUM ON-ORBIT TRANSFER (SHOOT) EXPERIMENT
J. H. LEE, S. MAA, W. F. BROOKS (NASA, Ames Research Center,

Moffett Field, CA), and Y. S. NG (Sterling Federal Systems, Inc., Palo Alto, CA) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 901-908. refs

The analysis and trade-offs of the external thermal design of the two 200-liter dewars required in the SHOOT experiment to extend space mission life by superfluid helium replenishment are discussed. Also considered are the support electronics and the optimization and prediction of the performance of the dewar and cryostat assemblies. Particular attention is given to the ground-hold and standby performance of the dewars, along with the temperature of the helium bath during high-flow-rate helium transfers. R.R.

A88-53223* Martin Marietta Corp., Denver, CO.
ACQUISITION SYSTEM TESTING WITH SUPERFLUID HELIUM
JOHN E. ANDERSON, DALE A. FESTER (Martin Marietta Corp., Denver, CO), and MICHAEL J. DIPIRRO (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Advances in cryogenic engineering. Volume 33 - Proceedings of the Cryogenic Engineering Conference, Saint Charles, IL, June 14-18, 1987. New York, Plenum Press, 1988, p. 909-916. refs

Minus one-g outflow tests were conducted with superfluid helium in conjunction with a thermomechanical pump setup in order to study the use of capillary acquisition systems for NASA's Superfluid Helium On-Orbit Transfer (SHOOT) flight experiment. Results show that both fine mesh screen and porous sponge systems are capable of supplying superfluid helium to the thermomechanical pump inlet against a one-g head up to 4 cm, fulfilling the SHOOT requirements. Sponge results were found to be reproducible, while the screen results were not. R.R.

A88-54994#
REDUCING THE COST AND RISK OF ORBIT TRANSFER
JAMES R. WERTZ, THOMAS L. MULLIKIN (Microcosm, Inc., Torrance, CA), and ROBERT F. BRODSKY (TRW, Inc., Redondo Beach, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 75-80. Previously cited in issue 08, p. 1059, Accession no. A87-22460. refs

A88-55390#
FAST GEOSTATIONARY SATELLITE RELOCATION
GIACOMO PORCELLI (INTELSAT, Washington, DC) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 8 p. refs
(IAF PAPER 88-314)

A constrained, minimum-time transfer scheme for relocating a geostationary satellite to a nearby orbital location is described. The scheme is based on orbit tangential and radial thrusting (normally available on geostationary satellites) for the attainment of a direct transfer between the initial and final locations via a continuously powered trajectory. The trajectory determination algorithm is presented first. The algorithm generates the trajectory control requirements, the total relocation time, and the required velocity increments. Curves of relocation time and velocity increment versus the orbital relocation angle, for various acceleration levels, are derived. A comparative discussion of the trade-offs of this approach versus the commonly used impulsive transfer is included. Author

N88-20355# Hughes Research Labs., Malibu, CA.
ADVANCED SPACE PROPULSION STUDY - ANTIPROTON AND BEAMED POWER PROPULSION Final Report, 1 May 1986 - 30 Jun. 1987
ROBERT L. FORWARD Oct. 1987 215 p
(Contract F04611-86-C-0039)
(AD-A189218; AFAL-TR-87-070) Avail: NTIS HC A10/MF A01 CSCL 21C

The contract objective was to monitor the research at the forefront of physics and engineering to discover new spacecraft propulsion concepts. The major topics covered were antiproton annihilation propulsion, laser thermal propulsion, laser-pushed lightsails, tether transportation systems, solar sails, and metallic hydrogen. Five papers were prepared and are included as appendices. They covered: (1) pellet, microwave, and laser beamed power systems for interstellar transport; (2) a design for a near-relativistic laser-pushed lightsail using near-term laser technology; (3) a survey of laser thermal propulsion, tether transportation systems, antiproton annihilation propulsion, exotic applications of solar sails, and laser-pushed interstellar lightsails; (4) the status of antiproton annihilation propulsion as of 1986, and (5) the prospects for obtaining antimatter ions heavier than antiprotons. Two additional appendices contain the first seven issues of the Mirror Matter Newsletter concerning the science and technology of antimatter, and an annotated bibliography of antiproton science and technology. GRA

N88-20356# Wisconsin Univ., Madison.
SOAR: SPACE ORBITING ADVANCED FUSION POWER REACTOR Final Report, Oct. 1986 - Jan. 1987
G. L. KULCINSKI and J. F. SANTARIUS Sep. 1987 57 p
(Contract F33615-86-C-2705)
(AD-A189234; AFWAL-TR-87-2048) Avail: NTIS HC A04/MF A01 CSCL 22B

The preconceptual design of a Space Orbiting Advanced Fusion Power Reactor (SOAR), which delivers up to 1000 MWe for at least 600 s from an orbited mass of about 500 tons, was accomplished. The power is produced by a magnetically confined D-3He plasma. Approximately 96 percent of the fusion energy is in charged particles, and a direct converter has been designed which converts much of this energy into electricity at high net efficiency (about 80 percent). An advanced shield design allows SOAR to deliver approximately 2 kilowatts of electricity for every kilogram of material orbited. The shield is designed to absorb all rejected heat during operation, and no active radiator is required. The SOAR reactor concept is designed to allow rapid startup and shutdown procedures. The lack of radioactivity on launch and the low radioactive inventory after operation make the SOAR concept attractive from maintenance, safety and environmental perspectives. The plasma physics approach extrapolates from the present plasma physics and fusion technology knowledge base using concepts which can be tested on existing or near-term devices. The symbiosis of burst mode requirements, D-3He tandem mirror fusion reactor characteristics, and the space environment leads to a very high performance design concept. GRA

N88-20569# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
FEASIBILITY DEMONSTRATION OF A SENSOR FOR HIGH-QUALITY TWO-PHASE FLOW
A. A. M. DELIL 9 Jan. 1987 32 p
(Contract NIVR-2502-N)
(NLR-TR-87009-U; B8729599; ETN-88-91724) Avail: NTIS HC A03/MF A01

Systems to control the liquid flow rates into evaporative cold plates in the two-phase flow heat transport systems for the Columbus Space Platform and the Space Station are discussed. Candidate components for such a control system are sensors monitoring the (very high) mixture quality at the cold plate exit lines, control algorithms, and actuators (valves) to adjust the liquid flow rates. The feasibility of a dedicated sensor is theoretically and experimentally demonstrated. Recommendations for the further development of the sensor are presented. ESA

N88-20599*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
CRYOGENIC FLUID MANAGEMENT TECHNOLOGY WORKSHOP. VOLUME 2: ROUNDTABLE DISCUSSION OF TECHNOLOGY REQUIREMENTS
Mar. 1988 84 p Workshop held in Cleveland, Ohio, 28-30 Apr. 1987
(NASA-CP-10009; E-3987; NAS 1.55:10009) Avail: NTIS HC A05/MF A01 CSCL 20D

The Cryogenic Fluid Management Technology Workshop was held April 28 to 30, 1987, at the NASA Lewis Research Center in Cleveland, Ohio. The major objective of the workshop was to

identify future NASA needs for technology concerning the management of subcritical cryogenic fluids in the low-gravity space environment. In addition, workshop participants were asked to identify those technologies which will require in-space experimentation and thus are candidates for inclusion in the flight experiment being defined at Lewis. The principal application for advanced fluid management technology is the Space-Based Orbit Transfer Vehicle (SBOTV) and its servicing facility, the On-Orbit Cryogenic Fuel Depot (OOCFD). Other potential applications include the replenishment of cryogenic coolants (with the exception of superfluid helium), reactants, and propellants on board a variety of spacecraft including the space station and space-based weapon systems. The last day was devoted to a roundtable discussion of cryogenic fluid management technology requirements by 30 representatives from NASA, industry, and academia. This volume contains a transcript of the discussion of the eight major technology categories. Author

N88-21254*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

POWER SYSTEMS FOR PRODUCTION, CONSTRUCTION, LIFE SUPPORT AND OPERATIONS IN SPACE

RONALD J. SOVIE 1988 16 p Proposed for presentation at Space '88, Albuquerque, N. Mex., 29-31 Aug. 1988; sponsored by the American Society of Civil Engineers

(NASA-TM-100838; E-4026; NAS 1.15:100838) Avail: NTIS HC A03/MF A01 CSCL 22B

As one looks to man's future in space it becomes obvious that unprecedented amounts of power are required for the exploration, colonization, and exploitation of space. Activities envisioned include interplanetary travel and LEO to GEO transport using electric propulsion, Earth and lunar observatories, advance space station, free-flying manufacturing platforms, communications platforms, and eventually evolutionary lunar and Mars bases. These latter bases would start as camps with modest power requirements (kWes) and evolve to large bases as manufacturing, food production, and life support materials are developed from lunar raw materials. These latter activities require very robust power supplies (MWes). The advanced power system technologies being pursued by NASA to fulfill these future needs are described. Technologies discussed will include nuclear, photovoltaic, and solar dynamic space power systems, including energy storage, power conditioning, power transmission, and thermal management. The state-of-the-art and gains to be made by technology advancements will be discussed. Mission requirements for a variety of applications (LEO, GEO, lunar, and Martian) will be treated, and data for power systems ranging from a few kilowatts to megawatt power systems will be represented. In addition the space power technologies being initiated under NASA's new Civilian Space Technology Initiative (CSTI) and Space Leadership Planning Group Activities will be discussed. Author

N88-21493*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.

DEVELOPMENT OF A ROTARY FLUID TRANSFER COUPLING AND SUPPORT MECHANISM FOR SPACE STATION

O. H. BRADLEY, JR., J. A. COSTULIS, and A. H. PORTER (PRC Kentron, Inc., Hampton, Va.) *In its* The 22nd Aerospace Mechanisms Symposium p 355-371 May 1988

Avail: NTIS HC A18/MF A01 CSCL 13K

A design was developed for a rotary fluid coupling to transfer coolant fluids (primarily anhydrous ammonia) across rotating joints of the space station. Development testing using three conceptual designs yielded data which were used to establish the design of a multipass fluid coupling capable of handling three fluid circuits. In addition, a mechanism to support the fluid coupling and allow an astronaut to replace the coupling quickly and easily was designed. Author

N88-24258*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.

SPECULATIONS ON FUTURE OPPORTUNITIES TO EVOLVE BRAYTON POWERPLANTS ABOARD THE SPACE STATION

ROBERT E. ENGLISH *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 15-18 1987 Previously announced as N87-23674

Avail: NTIS HC A22/MF A01 CSCL 10B

The Space Station provides a unique, low risk environment in which to evolve new capabilities. In this way, the Space Station will grow in capacity, in its range of capabilities, and its economy of operation as a laboratory and as a center for space operations. The Brayton cycle using a mixture of He and Xe as its working fluid is examined herein. Using a Brayton powerplant to supply the station's increasing demands for both electric power and heat has the potential to gradually evolve higher and higher performance by exploiting already evolved materials (Ta alloy and molten-Li heat storage), its peak cycle temperature rising ultimately to 1500 K. Adapting the station to exploit long tethers (200 to 300 km) could yield increases in payloads to LEO, to GEO, and to distant destinations in the solar system. Such tethering of the Space Station would not only require additional power for electric propulsion but also would so increase nuclear safety that nuclear powerplants might provide this power. From an 8000 kWt SP-100 reactor, thermoelectric power generation could produce 300 kWe, or adapted solar-Brayton cycle, 2400 to 2800 kWe. Author

N88-24261*# General Electric Co., Philadelphia, PA. Spacecraft Operation.

NUCLEAR ELECTRIC POWER FOR MULTIMEGAWATT ORBIT TRANSFER VEHICLES

R. D. CASAGRANDE *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 27-30 1987 Sponsored by NASA, Lewis Research Center, Cleveland, Ohio, AFOSR, Bolling AFB, Washington, D.C. and AFRPL, Edwards AFB, Calif.

(Contract F29601-86-C-0238)

Avail: NTIS HC A22/MF A01 CSCL 09C

Multimegawatt nuclear propulsion is an attractive option for orbit transfer vehicles. The masses of these platforms are expected to exceed the capability of a single launch from Earth necessitating assembly in space in a parking orbit. The OTV would transfer the platform from the parking orbit to the operational orbit and then return for the next mission. Electric propulsion is advantageous because of the high specific impulse achieved by the technology, 1000 to 5000 s and beyond, to reduce the propellant required. Nuclear power is attractive as the power system because of the weight savings over solar systems in the multimegawatt regime, and multimegawatts of power are required. A conceptual diagram is shown of an OTV with a command control module using electric thrusters powered from an SP-100 class nuclear reactor power system. Author

N88-24272# Brookhaven National Lab., Upton, NY. Dept. of Nuclear Energy.

NUCLEAR PROPULSION SYSTEMS FOR ORBIT TRANSFER BASED ON THE PARTICLE BED REACTOR

J. R. POWELL, H. LUDEWIG, F. L. HORN, K. ARAJ, R. BENENATI, O. LAZARETH, G. SLOVIK, M. SOLON, W. TAPPE, J. BELISLE (Grumman Aerospace Corp., Bethpage, N.Y.) et al. *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 73-76 1987 Previously announced as N87-28405 Sponsored by AFRPL, Edwards AFB, Calif.

Avail: NTIS HC A22/MF A01

The technology of nuclear direct propulsion orbit transfer systems based on the Particle Bed Reactor (PBR) is described. A 200 megawatt illustrative design is presented for LEO to GEO and other high V missions. The PBR-OTV can be used in a one-way mode with the shuttle or an expandable launch vehicle, e.g., the Titan 34D7, or as a two-way reusable space tug. In the one-way mode, payload capacity is almost three times greater than that of chemical OTV's. PBR technology statis is described and development needs outlined. E.R.

N88-24289# Missouri Univ., Columbia. Dept. of Nuclear Engineering.
SPACE BASED NUCLEAR-PUMPED LASER/REACTOR CONCEPTS
GUO-XIANG GU, MARK A. PRELAS, and JAY F. KUNZE *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 143-147 1987
(Contract NSF CBT-83-52345)
Avail: NTIS HC A22/MF A01

Nuclear pumped lasers, which use charged particles from nuclear fission to pump a laser medium, is a concept for the direct use of nuclear fission energy. It is a process for driving lasers without generated electricity so that the efficiency is increased and the system simplified. The design of the nuclear reactor driver system and the laser is considered. Reactor computer codes, such as DISNL, XSDRN, PARET or IREKIN, and AMPX are used for calculations. The possibility and feasibility of surface, volume and aerosol ion sources for high power/energy nuclear pumped laser/reactor concepts are discussed from a neutronics perspective. Author

N88-24321# General Electric Co., Philadelphia, PA. Space Systems Div.
TURBOMACHINERY IN SPACE
T. S. CHAN, W. S. CHIU, R. E. TROEGER, and M. SHAH *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 285-288 1987
(Contract F33615-85-C-2544)
Avail: NTIS HC A22/MF A01

The need to supply high levels of electrical power in the multimegawatt (MMW) range for short durations, such as the Strategic Defense Initiative (SDI) missions, is anticipated in future space applications. A potential power subsystem candidate based upon near-term technology is the turbogenerator consisting of a power turbine driving a generator or alternator. Numerous studies have shown that turbogenerators using either nuclear or chemical heat source can provide the burst MMW power at lowest system mass. However, no full consideration has yet been given to other essential issues associated with operating the power subsystem, such as dynamic interactions with the spacecraft, thermal management, fuel storage and control, and effluent management. The status of a 3 year study to assess the feasibility of turbomachinery for space application is presented. The hardware studied includes: the turbine and its components; the electrical generator and power conditioning elements; and the space platform design. The effects, interactions, and performance of all subsystems are analyzed. Author

N88-24379# Idaho National Engineering Lab., Idaho Falls.
COMPARISON OF A DIRECT THRUST NUCLEAR ENGINE, NUCLEAR ELECTRIC ENGINE AND A CHEMICAL ENGINE FOR FUTURE SPACE MISSIONS
JACK H. RAMSTHALER and TAL K. SULMEISTERS (Martin Marietta Corp., Englewood, Colo.) *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 19-22 1988
(Contract DE-AC07-76ID-01570)
Avail: NTIS HC A99/MF A01

The need for an advanced direct thrust nuclear rocket propulsion engine was identified in Project Forecast 2, Air Force Systems Command report on its future needs. The AF Astronomical Lab (AFAL) has the responsibility to develop the nuclear engine. The Idaho National Engineering Lab (INEL) will collaborate with Martin Marietta to stage design and mission analyses. Science Applications International (SAIC) will do flight safety analysis. Westinghouse will design the nuclear subsystem, and Rocketdyne the engine. INEL is overall manager for program and test facility design, construction and operation. INEL has produced plans for both engine system and ground test facility. AFAL has funded INEL to perform mission analyses and to evaluate cost, performance and operational advantages for a direct thrust nuclear rocket stage in performing AF Space missions. The Advanced Nuclear Rocket Engine (ANRE), a scaled down NERVA derivative, was used as a baseline for comparison with chemical engines and nuclear electric engines for completion of orbital transfer and maneuver missions. Life cycle costs of the three systems are estimated, based on delivery of a 6350 kg payload from LEO to geosynchronous orbit and back to LEO. Author

N88-24392# Los Alamos National Lab., NM.
INDIVIDUAL SATELLITE POWER REQUIREMENTS CALCULATED FROM SPECIFIED CONSTELLATION PERFORMANCE
DUANE R. MARR, RUSSELL B. KIDMAN, and W. GREG LACEY *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 85-88 1988 Sponsored by DOE, Washington, D.C. and DOD, Washington, D.C.
Avail: NTIS HC A99/MF A01

The development of individual station power requirements in a space-based SDI system needs to be made in the context of the defensive effectiveness of the system as a whole, and not on the maximum effectiveness of the individual platform. It is possible, for instance, that a few platforms with high effectiveness might be a less cost effective way to achieve a given level of performance than a larger number of platforms, each with a lesser effectiveness. In order to make a tradeoff study, one needs to calculate the performance of the defensive system as a whole. Further, total system power is important because it is a major determinant of the launch resources required. An evaluation of the resource requirements for such a system thus requires a knowledge not only of the individual station power but also of the number of platforms. These are just two of the problems that the computer program DEFENSE can help solve. DEFENSE is a computer simulation of the engagement of a space-based SDI defense against an offensive threat containing hundreds of thousands of objects. Given the characteristics of a defensive platform and the number of such platforms, DEFENSE calculates the performance of the system as a whole. It can thus be used to determine the size of (numbers in) the constellation required for a given level of performance. It can also help optimize the system through the use of tradeoff studies. Author

N88-24444# Air Force Astronautics Lab., Edwards AFB, CA.
NONCRYOGENIC PROPELLANTS FOR A NUCLEAR ORBIT TRANSFER VEHICLE
RYAN K. HAALAND and ANDREW MARTIN *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 341-344 1988
Avail: NTIS HC A99/MF A01

Recently imposed limitations regarding venting propellants in the STS payload bay may severely limit the capability to place heavier payloads in geosynchronous orbit by not allowing the use of current cryogenic propulsion systems. The two propulsion systems considered represent a wide range of nuclear reactor technology. The Small Nuclear Rocket Engine (SNRE) is derived from the Rover/NERVA program. The particle bed propulsion system represents a yet unproven reactor design offering a significant reduction in mass. Both systems are assumed to have the same operating conditions, approximately 250 Mwt, a chamber temperature of 2770 K, and a chamber pressure of 10.1 MPa. It is concluded that nuclear propulsion systems using various noncryogenic propellants offer a viable option for increasing the payload to GEO capability of the STS. The use of propellants that do not require venting, that is noncryogenic, coupled with a nuclear fission reactor should allow the development of high performance nuclear propulsion systems that meet STS payload safety requirements. A major concern is the effect of the noncryogenic propellants on the reactor concepts. Author

N88-24445# Air Force Astronautics Lab., Edwards AFB, CA. Liquid Rocket Div.
SOLAR THERMAL PROPULSION FOR ORBIT TRANSFER VEHICLES
CHARLES R. FORD *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 345-348

1988
Avail: NTIS HC A99/MF A01

The low thrust of the solar rocket will increase trip time over state-of-the-art chemical propulsion. However, for payloads that are not time critical, the high specific impulse of the solar rocket will cut in half the propellant costs associated with chemical propulsion. Over a 10 year period, this cost savings would be substantial. For instance, a recent NASA study indicated that projected costs of delivering payloads from Earth to GEO in the next few years will be on the order of $20,000 to $50,000/lb of payload. A large percentage of this is associated with the LEO to GEO costs. Reducing these astronomical costs is a major concern of spacecraft designers. Solar thermal propulsion is one concept capable of performing orbit transfers very efficiently and economically. Author

N88-24452# Los Alamos National Lab., NM.
POLYMER FUEL CELL AS AN ENERGY STORAGE COMPONENT FOR SPACE POWER APPLICATIONS
CARMELO A. SPIRIO and NICHOLAS E. VANDERBORGH *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 381-383 1988 Sponsored by DOE, Washington, D.C.
Avail: NTIS HC A99/MF A01

Fuel cells have already been proposed as energy storage candidates for space applications in the multimegawatt regime in a number of studies and the projected performance seems to satisfy the severe requirement of high power density. These chemical energy based systems are particularly important when the mission duration is in the 1000 second domain. Recent measured performance of experimental polymer membranes operating on pure gases has brought this technology into the candidate arena because of its potential near term availability as space traceable hardware. An energy storage system is described which furnishes the mission power for a number of applications, including its candidacy for the SDI. Contemporary fuel cell systems are a factor of nearly 50 below the power density needed for the platform requirements. Author

N88-24464*# Michigan Univ., Ann Arbor. Dept. of Mechanical Engineering and Applied Mechanics.
NUCLEATE POOL BOILING: HIGH GRAVITY TO REDUCED GRAVITY; LIQUID METALS TO CRYOGENS
HERMAN MERTE, JR. *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 437-442 1988
(Contract NAS8-20228; NAG3-633; NAG3-589)
Avail: NTIS HC A99/MF A01 CSCL 22A

Requirements for the proper functioning of equipment and personnel in reduced gravity associated with space platforms and future space station modules introduce unique problems in temperature control; power generation; energy dissipation; the storage, transfer, control and conditioning of fluids; and liquid-vapor separation. The phase change of boiling is significant in all of these. Although both pool and flow boiling would be involved, research results to date include only pool boiling because buoyancy effects are maximized for this case. The effective application of forced convection boiling heat transfer in the microgravity of space will require a well grounded and cogent understanding of the mechanisms involved. Experimental results are presented for pool boiling from a single geometrical configuration, a flat surface, covering a wide range of body forces from a/g = 20 to 1 to a/g = 0 to -1 for a cryogenic liquid, and from a/g = 20 to 1 for water and a liquid metal. Similarities in behavior are noted for these three fluids at the higher gravity levels, and may reasonably be expected to continue at reduced gravity levels. Author

N88-24471# Westinghouse Electric Corp., Pittsburgh, PA. Advanced Energy Systems Div.
A NUCLEAR POWERED SPACE BASED MULTIMEGAWATT MHD DISC POWER SYSTEM
ROBERT R. HOLMAN, JOSEPH R. LANCE, LAWRENCE E. VANBIBBER, and JEAN F. LOUIS (Massachusetts Inst. of Tech., Cambridge.) *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 469-472 1988
(Contract DE-AC22-87PC-79665)
Avail: NTIS HC A99/MF A01

A very compact space based magnetohydrodynamic (MHD) power system capable of meeting space platform burst power needs is examined. An open cycle MHD disc generator concept has been incorporated in a nuclear power system arrangement. Thermal energy for the system is provided by a NERVA derivative nuclear reactor and the MHD disc generator is used for thermal to electric energy conversion. Study results show to date that the NERVA derivative reactor coupled with the MHD disc generator provides a low total system launch mass and a very high energy extraction of greater than 20 MJ/kg in power operation. This energy extraction is much higher than the less than 2.5 MJ/kg values of linear MHD generator systems studied previously. Author

N88-24681# Edgerton, Germeshausen and Grier, Inc., Idaho Falls, ID.
ADVANCED NUCLEAR ROCKET ENGINE MISSION ANALYSIS
J. RAMSTHALER, G. FARBMAN, T. SULMEISTERS, D. BUDEN, and P. HARRIS (Rockwell International Corp., Canoga Park, Calif.) Dec. 1987 11 p Presented at the JANNAF Propulsion Conference, San Diego, Calif., 15 Dec. 1987
(Contract DE-AC07-76ID-01570)
(DE88-006797; EGG-M-41087; CONF-871274-1) Avail: NTIS HC A03

The use of a derivative of the NERVA engine developed from 1955 to 1973 was evluated for potential application to Air Force orbital transfer and maneuvering missions in the time period 1995 to 2020. The NERVA stge was found to have lower Life Cycle Costs (LCC) than an advanced chemical stage for performing Low Earth Orbit (LEO) to geosynchronous orbit (GEO) missions at any level of activity greater than three missions per year. It had lower life cycle costs than a high performance nuclear electric engine at any level of LEO to GEO mission activity. An examination of all unmanned orbital transfer and maneuvering missions from the Space Transportation Architecture Study (STAS 111-3) indicated a LCC advantage for the NERVA stage over the advanced chemical stage of fifteen million dollars. The cost advance accured from both the orbital transfer and maneuvering missions. Parametric analyses showed that the specific impulse of the NERVA stage and the cost of delivering material to low earth orbit were the most significant factors in the LCC advantage over the chemical stage. Lower development costs and a higher thrust gave the NERVA engine an LCC advantage over the nuclear electric stage. DOE

N88-24683# Technische Univ., Berlin (Germany, F.R.). Inst. fuer Luft- und Raumfahrt.
POSSIBILITIES AND LIMITS FOR USE OF LASER PROPULSION SYSTEMS IN INTERORBITAL SPACE FLIGHT [MOEGLICHKEITEN UND GRENZEN DES EINSATZES VON LASER-ANTRIEBEN BEI INTERORBITALEN RAUMFAEHREN]
ANDREAS LINDENTHAL 20 Aug. 1987 109 p In GERMAN
(ILR-MITT-185; ETN-88-91933) Avail: NTIS HC A06/MF A01

State of the art of laser propulsion and developments for the year 2000 are presented. Market simulation gives a guideline for identification and quantification of geostationary space power systems. System analysis concerning space flights and laser space stations in association with operating and economic factors is used for the evaluation of propulsion alternatives. Sensitivity analysis performed for the whole system shows the effects of construction modifications on the state of development of the laser. ESA

N88-24686*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
THERMODYNAMIC MODELING OF THE NO-VENT FILL METHODOLOGY FOR TRANSFERRING CRYOGENS IN LOW GRAVITY
DAVID J. CHATO 1988 10 p Prepared for presentation at the 24th Joint Propulsion Conference, Boston, Mass., 11-13 Jul.

1988; sponsored in part by AIAA, ASME, SAE, and ASEE
(NASA-TM-100932; E-4206; NAS 1.15:100932; AIAA-88-3403)
Avail: NTIS HC A02/MF A01 CSCL 21H

The filling of tanks with cryogens in the low-gravity environment of space poses many technical challenges. Chief among these is the inability to vent only vapor from the tank as the filling proceeds. As a potential solution to this problem, the NASA Lewis Research Center is researching a technique known as No-Vent Fill. This technology potentially has broad application. The focus is the fueling of space based Orbital Transfer Vehicles. The fundamental thermodynamics of the No-Vent Fill process to develop an analytical model of No-Vent Fill is described. The model is then used to conduct a parametric investigation of the key parameters: initial tank wall temperature, liquid-vapor interface heat transfer rate, liquid inflow rate, and inflowing liquid temperatures. Liquid inflowing temperature and the liquid-vapor interface heat transfer rate seem to be the most significant since they influence the entire fill process. The initial tank wall temperature must be sufficiently low to prevent a rapid pressure rise during the initial liquid flashing stage, but then becomes less significant. Author

N88-29870# R and D Associates, Alexandria, VA. Research Lab.
UNIFIED STUDY OF PLASMA/SURFACE INTERACTIONS FOR SPACE POWER AND PROPULSION Final Report, 15 Jul. 1987 - 29 Feb. 1988
29 Feb. 1988 66 p
(Contract F49620-86-C-0069)
(AD-A195971; AFOSR-88-0600TR) Avail: NTIS HC A04/MF A01 CSCL 20I

High specific impulse, high specific power devices, such as magnetoplasmadynamic arcjets, laser or microwave propulsion channels, and MHD generators, involve the flow of modest temperature (0.5 to 5 eV) partially ionized gases at speeds of 5 to 20 km per sec. The interactions of such flows with solid surfaces containing, channeling or penetrating the flow provides a principal source of concern for the efficiency and lifetime of high specific power systems. The present report describes a basic research effort that examines the plasma/surface interaction experimentally in an arrangement providing diagnostic access usually unavailable in mission-oriented, device-development projects. GRA

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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.

A88-20352* Utah State Univ., Logan.
A THEORETICAL STUDY OF THE LIFETIME AND TRANSPORT OF LARGE IONOSPHERIC DENSITY STRUCTURES
R. W. SCHUNK and J. J. SOJKA (Utah State University, Logan) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12343-12351. refs
(Contract F49620-86-C-0109; NAGW-77; NSF ATM-84-17880)

A three-dimensional time-dependent ionospheric model was used to study the spatial and temporal evolution and transport of large-scale high-density ionospheric structures for a range of solar cycle, seasonal, and IMF conditions. Both density depletions and enhancements were considered. It was found that, depending on the IMF, horizontal plasma convection can cause an initial structure to break up into multiple structures of various sizes, to become stretched into elongated segments, or to remain as a single distorted structure. The lifetime of an F-region density structure depends on several factors, including its magnitude, the initial location where it was formed, the season, the solar cycle, and the convection pattern. For example, in summer, the effects of a large density structure can disappear in a few hours or last as long as nine hours, while in winter the effects can persist for 24 hours. The passage of perturbed plasma flux tubes through sunlit and auroral regions can significantly increase the lifetime of plasma enhancements. I.S.

A88-23827
THE X-RAY SPECTRAL PROPERTIES OF ACCRETION DISCS IN X-RAY BINARIES
N. E. WHITE, L. STELLA, and A. N. PARMAR (EXOSAT Observatory, Noordwijk, Netherlands) Astrophysical Journal, Part 1 (ISSN 0004-637X), vol. 324, Jan. 1, 1988, p. 363-378. refs

Exosat observations are used to compare the spectral properties of the persistent emission from a number of X-ray burst sources, high-luminosity low-mass X-ray binaries (LMXRB) and galactic black hole candidates with various models for X-ray emission from an accretion disk surrounding a compact object in a binary system. It is shown that only a Comptonization model provides a good fit to all of the spectra considered. The fits to the spectra of the high-luminosity LMXRB systems necessitate an additional blackbody component with a luminosity 16 to 34 percent that from the Comptonized component. K.K.

A88-24671
SPECIMEN DEFORMATION KINETICS UNDER COMBINED THERMAL AND MECHANICAL LOADING. I - A KINETIC DEFORMATION CRITERION FOR COMBINED THERMAL AND MECHANICAL LOADING [KINETIKA DEFORMIROVANIIA OBRAZTSOV PRI KOMBINIROVANNOM TERMOSILOVOM NAGRUZHENII. I - DEFORMATSIONNO-KINETICHESKII KRITERII PRI KOMBINIROVANNOM TERMOSILOVOM NAGRUZHENII]
L. A. ZASLOTSKAIA and V. V. IVAKHNENKO (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), Dec. 1987, p. 33-37. In Russian. refs

The deformation kinetics of metal specimens is examined with a view to developing an approach to the prediction of the life of materials under combined thermal and mechanical loading using a deformation fracture criterion. Cyclic deformation curves are plotted for VT9, an alpha+beta titanium alloy. An algorithmic expression is obtained for describing deformation curves under conditions of a symmetric cycle at room temperature. V.L.

A88-29377* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
A UNIDIMENSIONAL MODEL OF COMET IONOSPHERE STRUCTURE
AHARON EVIATAR and BRUCE E. GOLDSTEIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, March 1, 1988, p. 1759-1765. Research supported by the U.S. National Academy of Sciences and U.S. National Research Council. refs

The one-dimensional continuity and momentum equations for the plasma formed in the expanding coma of a comet near the sun are studied. An analytic expression for the magnetic field configuration in the presence of outflow, photoionization, dissociative recombination, plasma fluid pressure, and friction between the ions and neutrals is obtained. It is suggested that for a Halley-type comet there will be a region sunward of the nucleus from which the magnetic field is excluded, consistent with Giotto observations. Calculations have been performed for Halley and Giacobini-Zinner type comets, and in the field-free regions it is shown that the dominant terms in the momentum equation balancing the magnetic pressure gradient are the ion neutral friction and the net mass loading momentum gain. R.R.

A88-29378* Hulburt (E. O.) Center for Space Research, Washington, DC.
ANALYSIS OF PIONEER VENUS ORBITER ULTRAVIOLET SPECTROMETER LYMAN ALPHA DATA FROM NEAR THE SUBSOLAR REGION
L. J. PAXTON, D. E. ANDERSON, JR. (U.S. Navy, E. O. Hulburt

Center for Space Research, Washington, D. C.), and A. I. F. STEWART (Colorado, University, Boulder) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, March 1, 1988, p. 1766-1772. NASA-supported research. refs

Pioneer Venus Orbiter ultraviolet spectrometer data from 20 orbits which span 3 years have been analyzed to determine the atomic hydrogen number density and vertical flux at the exobase as a function of solar zenith angle, F(10.7) index, and spacecraft latitude. From 1979 through 1981, the exobase number density n(c) and flux phi(c) are remarkably constant at n(c) = 6.0 + or - 1.5 x 10 to the 4th/cu cm and phi(e) = 7.5 + or - 1.5 x 10 to the 7th/sq cm per s in the subsolar region. The integrated vertical column density above 110 km is 3.6 + or - 1 x 10 to the 13th/sq cm. An empirical relationship is determined between the line center solar flux at H Lyman alpha, piF(0), and the F(10.7) index.

Author

A88-29411
STATISTICAL METHODS FOR EVALUATING THE CONDITION OF AIRCRAFT EQUIPMENT [STATISTICHESKIE METODY OTSENKI SOSTOIANIIA AVIATSIONNOI TEKHNIKI]
EVGENII IUR'EVICH BARZILOVICH and MAKSIM VASIL'EVICH SAVENKOV Moscow, Izdatel'stvo Transport, 1987, 240 p. In Russian. refs

The use of the methods of reliability theory and mathematical statistics in the analysis of data on the operation of aircraft equipment is discussed. In particular, a method is presented for the statistical verification of the aging hypothesis from data collected during aircraft operation. Statistical tests are presented for estimating the aging of aircraft system elements from the results of operational performance monitoring or failure data. The methods of the statistical analysis of the condition of aircraft systems proposed here are oriented toward computer processing of large amounts of data. V.L.

A88-35111
CONCEPTS AND ISSUES FOR A SPACE TELEROBOT
JIM CHAPEL (Martin Marietta Corp., Denver, CO) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 971-984. refs
(AAS PAPER 86-302)

The requirement for a dexterous space teleoperator for Space Station activities are presently addressed by a dextrerous space telerobotic servicer concept which will be equivalent in capabilities to an astronaut on EVA duties. The potential benefits derivable from the incorporation of force feedback, compliant teleoperation, predictive displays, computer vision, and supervisory control are discussed. Attention is drawn to the substantial amount of off-the-shelf hardware that is directly applicable to the present telerobotic servicer concept. O.C.

A88-35144
AI FOR SPACE MISSIONS
ROBERT W. HOBBS and RICHARD DESJARDINS (Computer Technology Associates, Inc., Lanham, MD) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1453-1466. refs
(AAS PAPER 86-390)

The advantages and possible applications of AI for highly complex, multiple use, high data rate space environments of the 21st century are discussed. Advantages of AI include their ease of duplication and documentation, cost effectiveness, aggregation of the knowledge of several experts, and facilitation of robotics. A major difficulty in their use is the inability to validate systems employing AI techniques. Applications considered include systems design, spacecraft command and control, the control of on-board systems, and the operation of ground data systems. R.R.

A88-35453* Grumman Aerospace Corp., Bethpage, NY.
TELEROBOTIC CONTROL OF A DEXTROUS MANIPULATOR USING MASTER AND SIX-DOF HAND-CONTROLLERS FOR SPACE ASSEMBLY AND SERVICING TASKS
JOHN M. O'HARA (Grumman Corp., Grumman Space Systems Div., Bethpage, New York) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 791-795. refs
(Contract NAS9-17229)

Two studies were conducted evaluating methods of controlling a telerobot; bilateral force reflecting master controllers and proportional rate six degrees of freedom (DOF) hand controllers. The first study compared the controllers on performance of single manipulator arm tasks, a peg-in-the-hole task, and simulated satellite orbital replacement unit changeout. The second study, a Space Station truss assembly task, required simultaneous operation of both manipulator arms (all 12 DOFs) and complex multiaxis slave arm movements. Task times were significantly longer and fewer errors were committed with the hand controllers. The hand controllers were also rated significantly higher in cognitive and manual control workload on the two-arm task. The master controllers were rated significantly higher in physical workload. There were no significant differences in ratings of manipulator control quality. Author

A88-35457* Lockheed Engineering and Management Services Co., Inc., Houston, TX.
HUMAN-TELEROBOT INTERACTIONS - INFORMATION, CONTROL, AND MENTAL MODELS
RANDY L. SMITH and DOUGLAS J. GILLAN (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 806-810. refs
(Contract NAS9-17900)

A part of the NASA's Space Station will be a teleoperated robot (telerobot) with arms for grasping and manipulation, feet for holding onto objects, and television cameras for visual feedback. The objective of the work described in this paper is to develop the requirements and specifications for the user-telerobot interface and to determine through research and testing that the interface results in efficient system operation. The focus of the development of the user-telerobot interface is on the information required by the user, the user inputs, and the design of the control workstation. Closely related to both the information required by the user and the user's control of the telerobot is the user's mental model of the relationship between the control inputs and the telerobot's actions. Author

A88-42328
ROBOT PATH PLANNING IN SPACE
A. F. BRINDLE, W. KOHN, G. M. LOBDELL, and J. H. ALBERT (Boeing Co., Seattle, WA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 26-34. refs

This project is investigating autonomous path planning for vehicles such as satelllite services operating on orbit. In the spacecraft domain, the problem of planning for obstacle avoidance is compounded by several interesting features, most notably the need to avoid plume impingement. The plume from the thrusters of a robotic vehicle may impose particle contamination or orbit altering forces upon other bodies as the vehicle navigates. The system under development is a hierarchical planner with modules for: (1) waypoint generation based on simple constraint models and heuristics, (2) waypoint realignment or smoothing, (3) generation of a pipe representing feasible trajectories from the robot to the next waypoint, and (4) trajectory planning. The planner is placed within a system which simulates the sensing and control for a vehicle similar to NASA's Manned Maneuvering Unit. This

paper discusses the architecture of the planner and the coinstraints which the modules must address. Author

A88-42339* Hercules Aerospace Co., Magna, UT.
PROCESSES FOR FABRICATING AND LOAD TESTING NASA SCATTEROMETER ANTENNA ASSEMBLIES
JAMES R. BARTH (Hercules Aerospace Co., Magna, UT) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 229-239. NASA-sponsored research.

The purpose of this paper is to present the processes used to fabricate and load test the NASA Scatterometer Antenna Assemblies. The fabrication processes include layup, curing and machining of antenna components, and the bonding and assembly of the components into the final antenna configuration. The design of each antenna consists of an aluminum waveguide bonded to a sandwich structure of Nomex honeycomb core with graphite/epoxy skins. A titanium end fitting with fiberglass/epoxy transitions is bonded into one end of each antenna. Several antenna components are fabricated using a process where aluminum foil is co-cured to a composite surface. The antenna assemblies are radiographically inspected, thermally cycled, and load tested prior to shipment. Author

A88-42641*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
AI APPLICATIONS FOR THE SPACE STATION
MARLON BOARNET, CHRIS CULBERT, and ROBERT T. SAVELY (NASA, Johnson Space Center, Houston, TX) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 131-136. refs

NASA is currently developing a space station for long-term usage of space. This space station presents NASA with numerous problems which may be best handled by effective use of expert systems. The authors outline some of the benefits expert systems will provide, some of the issues involved in choosing appropriate applications, and the impact expert systems will have on the design of the space station. I.E.

A88-42642* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
ROBOTIC VISION/SENSING FOR SPACE APPLICATIONS
KUMAR KRISHEN, OLIN GRAHAM (NASA, Johnson Space Center, Houston, TX), and RUI J. P. DE FIGUEIREDO (Rice University, Houston, TX) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 138-150. refs
(Contract NAS9-17145; N00014-85-K-0152; NSF DCR-83-18514)

A review is presented of efforts currently in progress at the NASA/Johnson Space Center and Rice University, the accomplishments to date, and some of the anticipated future developments. Both systems and algorithms are discussed. The evolution of future vision/sensing is projected to included the fusion of multisensors ranging from microwave to optical with multimode capability to include position, attitude, recognition, and motion parameters. The algorithms for information extraction are expected to incorporate aspects of intelligence and knowledge for the interpolation and extrapolation of the needed data. The key features of the overall system design will be small size and weight, fast signal processing, robust algorithms, and accurate parameter determination. These aspects of vision/sensing are also discussed. I.E.

A88-42657* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SENSING AND PERCEPTION RESEARCH FOR SPACE TELEROBOTICS AT JPL
DONALD B. GENNERY, TODD LITWIN, BRIAN WILCOX, and BRUCE BON (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 311-317. refs

PIFLEX is a pipelined-image processor that can perform elaborate computations whose exact nature is not fixed in the hardware, and that can handle multiple images. A wire-wrapped prototype PIFEX module has been produced and debugged, using a version of the convolver composed of three custom VLSI chips (plus the line buffers). A printed circuit layout is being designed for use with a single-chip convolver, leading to production of a PIFEX with about 120 modules. A high-level language for programming PIFEX has been designed, and a compiler will be written for it. The camera calibration software has been completed and tested. Two more terms in the camera model, for lens distortion, probably will be added later. The acquisition and tracking system has been designed and most of it has been coded in Pascal for the MicroVAX-II. The feature tracker, motion stereo module and stereo matcher have executed successfully. The model matcher is still under development, and coding has begun on the tracking initializer. The object tracker was running on a different computer from the VAX, and preliminary runs on real images have been performed there. Once all modules are working, optimization and integration will begin. Finally, when a sufficiently large PIFEX is available, appropriate parts of acquisition and tracking, including much of the feature tracker, will be programmed into PIFEX, thus increasing the speed and robustness of the system. I.E.

A88-42667
THE SPACE AND TELEROBOTIC CONCEPTS OF DFVLR ROTEX
G. HIRZINGER (DFVLR, Institut fuer Dynamik der Flugsysteme, Wessling, Federal Republic of Germany) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 443-449. refs

Concepts are outlined for a robot technology experiment ROTEX the author has proposed to fly with the next Germany spacelab, mission D2 (originally planned for 1988, but delayed for at least two years). It provides a small, six-axis robot inside a space-lab rack, equipped with a multisensory gripper (force/torque, an array of range finders, stereo optical fibers). The robot is supposed to handle a biological experiment, to perform several assembly and servicing tasks, and to grasp floating objects. The authors focus on the man-machine and supervisory control concepts for teleoperation from the spacecraft and from ground and especially explains the predictive estimation schemes for an extensive use of delay-compensating three-dimensional computer graphics. I.E.

A88-42668*# Oak Ridge National Lab., TN.
TRACTION-DRIVE TELEROBOT FOR SPACE MANIPULATION
J. N. HERNDON, W. R. HAMEL, and D. P. KUBAN (Oak Ridge National Laboratory, TN) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 450-455. NASA-supported research. Previously announced in STAR as N87-22233. refs
(Contract DE-AC05-84OR-21400)

The National Aeronautics and Space Administration (NASA) Space Station Program marks the begining of a new era in space utilization and habitation. Extensive use of remote manipulation and robotics to reduce astronaut extra-vehicular activity is expected. Emphasis on teleoperator technology in early Space Station phases, followed by growth of autonomous robotics capabilities, is planned. A new telerobot concept has been developed at Oak Ridge National Laboratory (ORNL) under NASA Langley Research Center sponsorship, to address the technical needs of both teleoperations and telerobotics for these future NASA programs. The concept is based on traction drives, redundant kinematics, modular construction, and a state-of-the-art distributed, hierarchical control system. Author

A88-42677* Massachusetts Inst. of Tech., Cambridge.
ON THE DYNAMICS OF MANIPULATORS IN SPACE USING THE VIRTUAL MANIPULATOR APPROACH
Z. VAFA and S. DUBOWSKY (MIT, Cambridge, MA) IN: 1987 IEEE International Conference on Robotics and Automation, Raleigh, NC, Mar. 31-Apr. 3, 1987, Proceedings. Volume 1. Washington, DC, IEEE Computer Society Press, 1987, p. 579-585. refs
(Contract NAG1-489)

A virtual manipulator (VM) concept has been developed recently for the modeling of manipulators working in space. The authors show that the VM facilitates planning and control of the motions of manipulators mounted on spacecraft, minimizing the degrading consequences of manipulator/vehicle dynamic interactions. I.E.

A88-46982
SIMULATION OF SPACE MANIPULATOR OPERATIONS (EUROSIM)
C. N. A. PRONK (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), A. ELFVING (ESA, Noordwijk, Netherlands), E. ERSUE (ISRA Systemtechnik GmbH, Darmstadt, Federal Republic of Germany), and A. L. LIPPAY (CAE Electronics, Ltd., Montreal, Canada) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 845-850. refs
(Contract ESA-6482/85)

The requirements for the simulation software of a European robotics operations simulator (Eurosim) are outlined and discussed. Eurosim has to cover a wide range of applications including general research and development; design; development; testing, verification, and qualification; training of human operators; and operations planning support. In an early stage of definition of Eurosim, four main functional subsystems were identified: the simulation subsystem, the image generation subsystem, the real-word operations subsystem, and the supervision subsystem. It is suggested that standards in software development be used, such as modularity, calling standards, and high-level languages to minimize maintenance costs. K.K.

A88-46986
ORBITER SERVICER RENDEZVOUS SIMULATION (ORSIM)
AMIEL AMATO and MICKIE D. HOFFMAN (Advanced Technology, Inc., Reston, VA) IN: 1987 Annual Summer Computer Simulation Conference, 19th, Montreal, Canada, July 27-30, 1987, Proceedings. San Diego, CA, Society for Computer Simulation, 1987, p. 964-969. SDIO-sponsored research.

Orbiter Servicer Rendezvous Simulation (ORSIM) is an automated tool that simulates sequential transfer maneuvers of an orbital maneuvering vehicle (OMV) transporting orbital replaceable units from a space-based depot, or logistics platform, to higher altitude SDI sdatellites. ORSIM calculates OMV energy expenditures (velocity changes) and event histories for various combinations of user-selected orbital transfer maneuvers. Additionally, ORSIM determines the optimal configuration/quantities of logistics platforms and OMVs which conform to the dynamics of differential nodal precession, given user-prescribed values of the scheduled maintenance cycle and required servicing times. ORSIM is coded in FORTRAN-77 and is resident on an IBM PC/AT. Author

A88-50199#
REDUNDANCY CONTROL OF A FREE-FLYING TELEROBOT
DAVID AKIN (MIT, Cambridge, MA) and JOHN SPOFFORD IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 347-357. refs
(AIAA PAPER 88-4094)

The 'coordinated control' algorithm allows the simultaneous reduced-order control of a vehicle and its attached manipulator. An entire telerobot system is thereby controlled by commanding the end-effector inertially with respect to the task, through a unified dynamic system treatment which considers the free-flying teleoperator as a redundant manipulator. The coordinated trajectory algorithm is a blend of two modes: (1) gradient pseudoinverse trajectory control, which uses both vehicle thrust and manipulator motion, and (2) reaction-compensation trajectory control, which allows the base to react freely to manipulator interaction torques. O.C.

A88-50201#
ATTITUDED TUMBLING DUE TO FLEXIBILITY IN SATELLITE MOUNTED ROBOTS
RICHARD W. LONGMAN (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 365-373.
(AIAA PAPER 88-4096)

Future satellite mounted robots will often be required to manipulate load masses that are not insignificant compared to the satellite mass. These robots will also exhibit structural flexibility because of their size and the need for a light weight design. Here it is shown by simple example, that the structural vibrations induced by robot manipulations will generally try to tumble the spacecraft. The satellite attitude control system will have to compensate for this attitude disturbance. A general formalism is developed to determine the attitude control torque which must be generated to counteract the flexibility effects and the robot motion. The results are useful for analysis and evaluation of attitude control, and with proper instrumentation might serve as the control law in a feedforward control signal. Author

A88-50202#
THE KINETICS AND WORKSPACE OF A ROBOT MOUNTED ON A SATELLITE THAT IS FREE TO ROTATE AND TRANSLATE
RICHARD W. LONGMAN (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 1. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 374-381. refs
(AIAA PAPER 88-4097)

Satellite mounted robots are considered that manipulate loads whose mass is not negligible compared to the satellite mass. By contrast to previous works on this subject, the satellite is considered free to not only translate, but to rotate as well, in reaction to robot motions. Three basic topics in robotics, the forward kinematics, the inverse kinematics, and the robot workspace, are generalized here for the problem at hand. The generalized versions of the kinematics problems are found to have become dynamics problems instead - their solutions are functions of the whole history of robot motion rather than the final joint angles alone. It is demonstrated that any desired satellite orientation can be obtained for any final robot joint angles. The robot workspace is generated, and found to be a perfect sphere whose radius is a function of the load mass. The workspace is compared to that of a robot on an attitude fixed satellite, and an inertially mounted robot, and found to be larger in many cases. Author

A88-50398#
A FORMULATION FOR STUDYING DYNAMICS AND CONTROL OF THE SPACE STATION BASED MRMS AND ITS APPLICATION
Y. MORITA and V. J. MODI (British Columbia, University, Vancouver, Canada) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 401-409. refs
(Contract NSERC-0032682)
(AIAA PAPER 88-4269)

A relatively general formulation for studying dynamics of a flexible Mobile Remote Manipulator System (MRMS), supported by an orbiting flexible platform, is developed using the Lagrangian approach with generalized forces accounting for the environmental

effects, damping and control. The flexible members are treated as continua and their flexural deformations are represented by a series of admissible functions. The computational algorithm is so structured as to isolate the effects of various system parameters thus helping in assessment of their relative importance. Appplication of the general formulation, illustrated through several typical MRMS configurations of practical importance, reveals complex interactions between vibrational and librational degrees of freedom, in the presence of MRMS maneuver, over a range of system parameters and initial conditions. Effectiveness of the formulation is also demonstrated through another illustrative example of the SCOLE configuration representing the Shuttle based flexible beam supporting a rigid reflector plate at its end. The information is fundamental to the design of the manipulator and the associated controls system. Author

A88-52238*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
KNOWLEDGE BASED SYSTEM VERIFICATION AND VALIDATION AS RELATED TO AUTOMATION OF SPACE STATION SUBSYSTEMS - RATIONALE FOR A KNOWLEDGE BASED SYSTEM LIFECYCLE
KEITH RICHARDSON and CARLA WONG (NASA, Ames Research Center, Moffett Field, CA) IN: AAAIC '87 - Aerospace Applications of Artificial Intelligence; Proceedings of the Third Annual Conference, Dayton, OH, Oct. 5-9, 1987. Dayton, OH, AAAIC Conference Secretariat, 1988, p. 306-311. Previously announced in STAR as N88-24192.

The role of verification and validation (V and V) in software has been to support and strengthen the software lifecycle and to ensure that the resultant code meets the standards of the requirements documents. Knowledge-based system (KBS) V and V should serve the same role, but the KBS lifecycle is ill-defined. The rationale of a simple form of the KBS lifecycle is presented, including accommodation to certain critical KBS differences from software development. Author

A88-52323
TELEROBOTIC SPACE STATION APPLICATIONS
SCOTT A. HOFACKER (United Technologies Corp., Huntsville, AL), BERNARD J. SCHROER, and ARTHUR HERKERT (Alabama, University, Huntsville) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-9 to 3-14. refs

Issues related to space telerobotics and research concerning the Space Station applications of telerobotics are reviewed. The number of camera views needed for a telerobotic task, black and white vs. color view, the camera position for telerobotic tasks, lighting intensity and position, feedback delays, predictive displays, the types of end effectors needed for space tasks, the number of robot arms necessary, reach considerations, and design for space automation are discussed. The development and use of a space telerobotics laboratory are examined. Also, telerobotics space requirements and applications are listed. R.B.

A88-52326
AUTOMATION AND ROBOTICS FOR EXPERIMENT OPERATIONS IN AN ENHANCED MAN TENDED FREE FLYER (EMTFF)
EIKE SCHMIDT (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-38 to 3-46.

As a baseline for investigations into automation and robotics for microgravity experiment operations an enhanced version of the Columbus Man Tended Free Flyer (MTFF) is used. Four relevant experiments are selected as a basis for detailed analysis to derive typical classes of experiment tasks which have crucial importance for the identification of automation and robotics concepts. The description of the Enhanced MTFF (EMTFF), a definition of a reference payload, and the derivation of a preliminary concept for EMTFF automation is presented in this paper as results of an appropriate study funded by ESA/ESTEC. Author

A88-52329* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
AUTOMATION AND ROBOTICS FOR THE SPACE STATION - THE INFLUENCE OF THE ADVANCED TECHNOLOGY ADVISORY COMMITTEE
ROBERT R. NUNAMAKER and KELLI F. WILLSHIRE (NASA, Langley Research Center, Hampton, VA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-76 to 3-79.

The reports of a committee established by Congress to identify specific systems of the Space Station which would advance automation and robotics technologies are reviewed. The history of the committee, its relation to NASA, and the reports which it has released are discussed. The committee's reports recommend the widespread use of automation and robotics for the Space Station, a program for technology development and transfer between industries and research and development communities, and the planned use of robots to service and repair satellites and their payloads which are accessible from the Space Station. R.B.

A88-53666*# Stanford Univ., CA.
TELESCIENCE TESTBED PILOT PROJECT - EVALUATION ENVIRONMENT FOR SPACE STATION OPERATIONS
MICHAEL J. WISKERCHEN (Stanford University, CA) and BARRY M. LEINER (NASA, Ames Research Center, Moffett Field, CA) IN: AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 319-324.
(AIAA PAPER 88-4629)

The objectives of the Telescience Testbed Pilot Program (TTPP) are discussed. The purpose of the TTPP, which involves 15 universities in cooperation with various NASA centers, is to demonstrate the utility of a user-oriented rapid prototyping testbed approach to developing and refining science requirements and validation concepts and approaches for the information systems of the Space Station era and beyond. It is maintained that the TTPP provides an excellent environment, with low programmatic schedule and budget risk, for testing and evaluating new operations concepts and technologies. K.K.

A88-54773#
TELESCIENCE - PREPARING FOR THE INTERACTIVE OPERATION OF COLUMBUS PAYLOADS
A. BALOGH (Imperial College of Science and Technology, London, England), J. C. DEGAVRE, P. BUIA (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands), and G. NAJA (ESA, Columbus Promotion and Utilisation Dept., Paris, France) ESA Bulletin (ISSN 0376-4265), no. 55, Aug. 1988, p. 68-73.

The Telescience Preparatory Program to define the way in which research will be conducted in the Columbus/Space Station laboratories. The characteristics and requirements of telescience, or research on the Space Station, are discussed. The Telescience Preparatory Program will develop a test bed and technological support for future research, conduct system studies and end-to-end simulation, and analyze operational requirements. The Telescience Test Bed will derive ground-based pilot experiments to determine the way in which research will be conducted on the Space Station. The pilot investigation which have been proposed include studies dealing with human physiology, fluid and material sciences, botanical sciences, and medical diagnosis. R.B.

A88-55320#
TELEPRESENCE FOR SPACE APPLICATIONS
G. M. MCKINNON and M. L. KING (CAE Electronics, Ltd., Montreal, Canada) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 5 p. refs
(IAF PAPER 88-018)

In future space applications, the remote operation of manipulators for maintenance and assembly tasks will take on much greater importance. This paper reviews some of the principal

concerns in the field of teleoperation, with particular reference to applications in space. A generalized approach to the control of telemanipulators, and other remote devices is presented. In particular, the remote control of manipulators and the requirements for associated displays are discussed. Author

A88-55322*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
TECHNOLOGY FORECAST AND APPLICATIONS FOR AUTONOMOUS, INTELLIGENT SYSTEMS
HENRY LUM, JR. (NASA, Ames Research Center, Moffett Field, CA) and EWALD HEER (Heer Associates, Inc., LaCanada, CA) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. refs
(IAF PAPER 88-025)

Significant research products which have emerged from the core program of NASA's Office of Aeronautics and Space Technology (OAST) are discussed. The Space Station Thermal Control System, the Space Shuttle Integrated Communications Officer Station, the Launch Processing System, the Expert Scheduling System for Pioneer Venus Spacecraft, a Bayesian classification system, and a spaceborne multiprocessor system are included. The technology trends which led to these results are discussed and future developments in technology are forecasted. R.B.

A88-55335#
ADVANCED MAN-MACHINE INTERFACES TECHNIQUES FOR EXTRA-VEHICULAR ACTIVITY
S. GALIMBERTI, R. PERSICO, and R. CORTINOVIS (Laben - Industrie per lo Spazio e le Comunicazioni S.p.A., Vimodrone, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 9 p. ESA-supported research. refs
(IAF PAPER 88-077)

Man-machine interfaces (MMI) technologies which could be used to improve the efficiency and effectiveness of EVA are discussed. The servicing of the Man-Tended Free Flyer (MTFF) is given as a reference for determining performance requirements for baseline EVA. Environmental and human related EVA limitations are analyzed. MMI components which could be applied to EVA include the upper torso terminal (or display and control module), a forearm mounted terminal, head-up and helmet mounted displays, direct voice input and output and command input devices. Guidelines for optimum visual displays, command inputs, and auditory displays are given and a breadboard for MMI evaluation is presented. It is concluded that, for the servicing of the MTFF, the MMI facilities should be restricted to a helmet mounted display with a forearm mounted terminal as a back-up or support device. R.B.

N88-20646*# Massachusetts Inst. of Tech., Cambridge. Dept. of Mechanical Engineering.
THE DYNAMIC CONTROL OF ROBOTIC MANIPULATORS IN SPACE Semiannual Report, 31 Jul. 1987 - 31 Jan. 1988
S. DUBOWSKY 29 Apr. 1988 30 p
(Contract NAG1-801)
(NASA-CR-182710; NAS 1.26:182710; SAR-1) Avail: NTIS HC A03/MF A01 CSCL 13I

Described briefly is the work done during the first half year of a three-year study on dynamic control of robotic manipulators in space. The research focused on issues for advanced control of space manipulators including practical issues and new applications for the Virtual Manipulator. In addition, the development of simulations and graphics software for space manipulators, begun during the first NASA proposal in the area, has continued. The fabrication of the Vehicle Emulator System (VES) is completed and control algorithms are in process of development. Author

N88-21192# Ball Aerospace Systems Div., Boulder, CO.
CRRES CHEMICAL RELEASE MECHANISMS
C. HOFFMAN *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 5-9 Dec. 1987
Avail: NTIS HC A14/MF A01

The Combined Release and Radiation Effects Satellite (CRRES) is described. The CRRES will use plasma tracing to study the Earth's magnetic field. The chemical payload subsystem to produce the plasmas consists of 2 sizes of canisters (48 total), their individual eject mechanisms, and their carrier modules. Satellite system level requirements are met with a lightweight, simple, and reliable module which allows off-line processing of the chemical payload. It is shown how the ejection velocities were estimated and verified for the spring ejected canisters shooting from a spinning spacecraft. Lubricant data, collected during a search for a vacuum stable, electrically conductive lubricant is presented. The complications involved in predicting the effects of allowing rattle space between the canisters and their guide tubes, and how tests were used to isolate these effects, are outlined. ESA

N88-21198# Max-Planck-Inst. fuer Physik und Astrophysik, Garching (Germany, F.R.). Inst. fuer Extraterrestrische.
DEPLOYABLE BOOMS AND ANTENNAS ON AMPTE-IRM
J. E. STOECKER and P. PARIGGER *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 47-50 Dec. 1987
Avail: NTIS HC A14/MF A01

Two instruments of the AMPTE ion release module satellite were deployed radially by rigid booms with two and one articulated sections respectively, which had to be balanced in the stowed and deployed configuration. Made from carbon and glass fiber, they deflected after deployment and protected the instruments against the locking shock. All boom mechanisms were made from nonmagnetic material. Tests were performed to qualify the booms. Two S-band radiators on top of 1.4 m solid booms were pivoted to the satellite skirt. Both could be oriented either parallel to the spin axis or, after deployment, perpendicular to it. A third S-band radiator was extended axially from the satellite aft end. The extension system was a modified commercial automobile antenna drive. The release mechanism of the 16 canisters which were ejected from the satellite to produce barium and lithium-plasma clouds is described. ESA

N88-21204# Spar Aerospace Ltd., Weston (Ontario). Canadian Space Station Program.
SYSTEM AND CONCEPT DESIGN OF THE SSRMS LATCHING END EFFECTOR
E. QUITTNER, R. VANDERSLUIS, J. RAKHSHA, and I. FARMER *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 93-103 Dec. 1987
Avail: NTIS HC A14/MF A01

The latching end effector of the relocatable Space Station Remote Manipulator System (SSRMS) for the Mobile Servicing Center contribution to the Space Station is presented. The latching end effector, when installed on the two ends (shoulder and wrist) of the symmetrical manipulator arm provides the capability to interchange wrist and shoulder of the arm thus enabling manipulator relocatability. The latching end effector combines the snare and rigidize features of the existing Shuttle RMS end effector, with latching and umbilical electrical power and signal transfer features. Modified, existing, and new components are combined in an assembly of modular, orbit replaceable units. The existing components are enhanced by adding redundancy and orbit-maintainability provisions. Associated with the above is the power and data grapple fixture. The functions associated with the existing snare/rigidize and the new latching and umbilical elements can be executed independently. The SRMS based end effector and the SSRMS based functions can, therefore, be performed with the existing and the modified grapple fixtures as an interface. ESA

N88-21205# Sener S.A., Madrid (Spain).
LATCHING MECHANISMS FOR IOC
F. DELCAMPO *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 105-112 Dec. 1987
Avail: NTIS HC A14/MF A01

Two different latch mechanisms were designed for the IOC experiment in EURECA, to help the antenna pointing mechanism

(APM) withstand the flight loads and to increase its first natural eigenfrequency. In both cases, the main objective is to obtain a high stiffness, paying special attention to the structural discontinuities (clamp, hinges, etc.), in order to eliminate the backlash. This is obtained mainly by preloading these discontinuities and by selecting adequate materials to avoid problems of differential CTE that could change the preload in critical areas. The first latching system consists of two overcenter latches driven by a stepper motor through a worm gear reducer. Each of them locks one of the two degrees of freedom of the APM during launch and reentry. The second system has three pyrotechnically released mechanisms which fix the APM during launch. ESA

N88-21212# RCA Aerospace and Defense, Princeton, NJ. Astro-Space Div.
DEVELOPMENT OF AN INTERMODULE CONNECTOR FOR SERVICEABLE SPACECRAFT
A. P. MATTHEWS, S. W. JACKSON, D. W. GROSS, and O. L. REGALADO *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 169-176 Dec. 1987
Avail: NTIS HC A14/MF A01

An Intermodular Connector (IMC) that can be applied universally to all types of spacecraft modules to optimize the remote mating of platform modules was developed. The operating principle is based on gross alignment to put the screw in contact with the floating nut. Once the face plates are together, the screw continues to rotate, drawing the connector plate down. The IMC uses an acme threaded screw mechanism for closure, rigidization, and connector-mating functions. This mechanism, centrally located on a triangular plate, was manufactured in three parts: the motor and gears, the acme threaded screw, and the floating nut. Mechanical models for proof of concept testing were built. ESA

N88-21216# Milan Univ. (Italy).
MECHANICAL DESIGN OF A ULTRAHIGH GRAVITY UHV FACILITY TO LAUNCH AND RECOVER A LOW-SPEED PROJECTILE TESTED ON BOARD KC 135
G. POLETTI and D. CAMBIAGHI (Centrotecnica, Milan, Italy) *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 197-203 Dec. 1987 Sponsored by Piano Spaziale Nazionale-CNR
Avail: NTIS HC A14/MF A01

To perform an experiment on surface forces in metals a facility was designed, manufactured and tested on the ground and in microgravity in preparation for a EURECA experiment, on surface forces and adhesion in contacting solids. The facility must launch a small projectile against a plane target at very low velocity. After rebounding the projectile must be recovered and launched again several times at different velocities. The motion of the projectile is a pure translation and the experiment is performed under ultrahigh vacuum. The mechanical design of the facility is discussed together with the results of the tests performed in the laboratory and on board a KC135 in microgravity conditions. The facility meets requirements. ESA

N88-21232# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
A JOINT ACTUATOR DESIGN FOR A ROBOTIC MANIPULATOR
K. PRIESETT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 311-316 Dec. 1987
Avail: NTIS HC A14/MF A01

A rotary actuator design for space robotic manipulator applications was established. Major characteristics are high torque capability, high stiffness, very low backlash, backdriveability, and high resolution position measurement. The unit is very compact and includes a cyclo drive as the major gear system. However, due to the modular concept, a different gear system could be implemented with only minor changes in the gearbox module. The results of the main trade-offs performed on the gear system are summarized. ESA

N88-21233# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
DOCKING/BERTHING SUBSYSTEM: DESIGN AND BREADBOARD TEST
N. CABLE and J. HARTMANN (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) *In its* Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 317-326 Dec. 1987
Avail: NTIS HC A14/MF A01

Based on a low impact docking concept and a latching mechanism concept, a docking/berthing subsystem and its operations were defined. A set of four breadboard models of the latch were manufactured and locking tests were performed on a four degree of freedom air bearing table. The tests demonstrate feasibility of the low impact docking concept under the test facility conditions. ESA

N88-21468*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THE 22ND AEROSPACE MECHANISMS SYMPOSIUM
May 1988 416 p Symposium held in Hampton, Va.; sponsored by NASA, Washington, California Inst. of Tech., Pasadena, and LMSC, Sunnyvale, Calif.
(NASA-CP-2506; L-16433; NAS 1.55:2506) Avail: NTIS HC A18/MF A01 CSCL 20K

The proceedings of the symposium, which was held at the NASA Langley Research Center, on May 4 to 6, 1988, are reported. Technological areas covered include space lubrication, bearings, aerodynamic devices, spacecraft latches, deployment, positioning, and pointing. Devices for space station docking and manipulator and teleoperator mechanisms are also described.

N88-21488*# Astro Aerospace Corp., Carpinteria, CA.
SPACE STATION MOBILE TRANSPORTER
JAMES RENSHALL, GEOFF W. MARKS, and GRANT L. YOUNG *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 271-286 May 1988
Avail: NTIS HC A18/MF A01 CSCL 22B

The first quarter of the next century will see an operational space station that will provide a permanently manned base for satellite servicing, multiple strategic scientific and commercial payload deployment, and Orbital Maneuvering Vehicle/Orbital Transfer Vehicle (OMV/OTV) retrieval replenishment and deployment. The space station, as conceived, is constructed in orbit and will be maintained in orbit. The construction, servicing, maintenance and deployment tasks, when coupled with the size of the station, dictate that some form of transportation and manipulation device be conceived. The Transporter described will work in conjunction with the Orbiter and an Assembly Work Platform (AWP) to construct the Work Station. The Transporter will also work in conjunction with the Mobile Remote Servicer to service and install payloads, retrieve, service and deploy satellites, and service and maintain the station itself. The Transporter involved in station construction when mounted on the AWP and later supporting a maintenance or inspection task with the Mobile Remote Servicer and the Flight Telerobotic Servicer is shown.
Author

N88-21489*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
OPERATIONAL EXPERIENCE AND DESIGN RECOMMENDATIONS FOR TELEOPERATED FLIGHT HARDWARE
T. W. BURGESS, D. P. KUBAN (Oak Ridge National Lab., Tenn.), W. W. HANKINS, and R. W. MIXON *In its* The 22nd Aerospace Mechanisms Symposium p 287-305 May 1988
(Contract DE-AC05-84OR-21400)
Avail: NTIS HC A18/MF A01 CSCL 13I

Teleoperation (remote manipulation) will someday supplement/minimize astronaut extravehicular activity in space to perform such tasks as satellite servicing and repair, and space station construction and servicing. This technology is being

investigated by NASA with teleoperation of two space-related tasks having been demonstrated at the Oak Ridge National Lab. The teleoperator experiments are discussed and the results of these experiments are summarized. The related equipment design recommendations are also presented. In addition, a general discussion of equipment design for teleoperation is also presented. Author

N88-21491*# McDonnell-Douglas Astronautics Co., Huntington Beach, CA.
SPACE STATION FULL-SCALE DOCKING/BERTHING MECHANISMS DEVELOPMENT
GENE C. BURNS, HAROLD A. PRICE, and DAVID B. BUCHANAN *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 325-340 May 1988
Avail: NTIS HC A18/MF A01 CSCL 22B

One of the most critical operational functions for the space station is the orbital docking between the station and the STS orbiter. The program to design, fabricate, and test docking/berthing mechanisms for the space station is described. The design reflects space station overall requirements and consists of two mating docking mechanism halves. One half is designed for use on the shuttle orbiter and incorporates capture and energy attenuation systems using computer controlled electromechanical actuators and/or attenuators. The mating half incorporates a flexible feature to allow two degrees of freedom at the module-to-module interface of the space station pressurized habitat volumes. The design concepts developed for the prototype units may be used for the first space station flight hardware. Author

N88-23237*# Army Aviation Systems Command, Cleveland, OH. Structural Dynamics Branch.
MICROGRAVITY MECHANISMS AND ROBOTICS PROGRAM
DOUGLAS A. ROHN *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 143-155 May 1988
Avail: NTIS HC A20/MF A01 CSCL 13I

The primary goal of this program is to produce the motion control tools necessary to enhance and enable a particular NASA mission - space laboratory-based microgravity experiments. To that end, a spectrum of technology is being developed in the disciplines of precision mechanisms and robotics. Author

N88-23238*# Carnegie-Mellon Univ., Pittsburgh, PA. Dept. of Mechanical Engineering.
BASE REACTION OPTIMIZATION OF MANIPULATORS WITH REDUNDANT KINEMATICS
C. L. CHUNG and S. DESA *In* NASA, Lewis Research Center, Lewis Structures Technology, 1988. Volume 1: Structural Dynamics p 157-173 May 1988
(Contract NAG3-811)
Avail: NTIS HC A20/MF A01 CSCL 13I

A trajectory generation method for space manipulators is introduced. The approach developed employs a manipulator with redundant kinematics. The method is implemented in two steps. First, the end-effector trajectory is developed to satisfy motion requirements. Next, the joint trajectories are developed to minimize base reactions. The analytical development of this method is described and an example illustrating the method is presented. Author

N88-23828* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE SPIDER CRANE Patent
IAN O. MACCONOCHIE, inventor (to NASA), MARTIN M. MIKULAS, JR., inventor (to NASA), JACK E. PENNINGTON, inventor (to NASA), REBECCA L. KINKEAD, inventor (to NASA), and CHARLES F. BRYAN, JR., inventor (to NASA) 19 Apr. 1988 13 p Filed 30 Sep. 1986 Supersedes N87-15259 (25 - 07, p 874)
(NASA-CASE-LAR-13411-1-SB; US-PATENT-4,738,583; US-PATENT-APPL-SN-913432; US-PATENT-CLASS-414-735; US-PATENT-CLASS-414-750; US-PATENT-CLASS-901-1; US-PATENT-CLASS-901-33; US-PATENT-CLASS-180-8.6) Avail: US Patent and Trademark Office CSCL 22B

A space spider crane for the movement, placement, and or assembly of various components on or in the vicinity of a space structure is described. As permanent space structures are utilized by the space program, a means will be required to transport cargo and perform various repair tasks. A space spider crane comprising a small central body with attached manipulators and legs fulfills this requirement. The manipulators may be equipped with constant pressure gripping end effectors or tools to accomplish various repair tasks. The legs are also equipped with constant pressure gripping end effectors to grip the space structure. Control of the space spider crane may be achieved either by computer software or a remotely situated human operator, who maintains visual contact via television cameras mounted on the space spider crane. One possible walking program consists of a parallel motion walking program whereby the small central body alternatively leans forward and backward relative to end effectors.
Official Gazette of the U.S. Patent and Trademark Office

N88-23940*# Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Electrical Engineering.
THE LDCM ACTUATOR FOR VIBRATION SUPPRESSION
ERIC N. IDE and DOUGLAS K. LINDNER 1988 4 p
(Contract NAG1-719)
(NASA-CR-182898; NAS 1.26:182898) Avail: NTIS HC A02/MF A01 CSCL 09C

A linear dc motor (LDCM) has been proposed as an actuator for the COFS I mast and the COFS program ground test Mini-Mast. The basic principles of operation of the LDCM as an actuator for vibration suppression in large flexible structures are reviewed. Because of force and stroke limitations, control loops are required to stabilize the actuator, which results in a non-standard actuator-plant configuration. A simulation model that includes LDCM actuator control loops and a finite element model of the Mast is described, with simulation results showing the excitation capability of the actuator. Author

N88-23979* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
BI-STEM GRIPPING APPARATUS Patent
FRED G. SANDERS, inventor (to NASA) 9 Feb. 1988 7 p Filed 3 Jun. 1987 Supersedes N87-25586 (25 - 19, p 2616)
(NASA-CASE-MFS-28185-1; US-PATENT-4,723,800; US-PATENT-APPL-SN-056930; US-PATENT-CLASS-294-16; US-PATENT-CLASS-294-106; US-PATENT-CLASS-294-113; US-PATENT-CLASS-294-119.2) Avail: US Patent and Trademark Office CSCL 13I

This invention relates to devices which grip cylindrical structures and more particularly to a device which has three arcuate gripping members having frictional surfaces for gripping and compressing a bi-stem. The bi-stem gripping apparatus is constructed having a pair of side gripping members, and an intermediate gripping member disposed between them. Sheets of a gum stock silicone rubber with frictional gripping surfaces are bonded to the inner region of the gripping members and provide frictional engagement between the bi-stem and the apparatus. A latch secures the gripping apparatus to a bi-stem, and removable handles are attached, allowing an astronaut to pull the bi-stem from its cassette. A tethering ring on the outside of the gripping apparatus provides a convenient point to which a lanyard may be attached.
Official Gazette of the U.S. Patent and Trademark Office

N88-24188*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THIRD CONFERENCE ON ARTIFICIAL INTELLIGENCE FOR SPACE APPLICATIONS, PART 2
JUDITH S. DENTON, comp., MICHAEL S. FREEMAN, comp., and MARY VEREEN, comp. Jun. 1988 66 p Conference held in Huntsville, Ala., 2-3 Nov. 1987; sponsored by NASA, Marshall Space Flight Center, Huntsville, Ala. and Alabama Univ., Huntsville Sponsored by NASA, Washington

(NASA-CP-2492-PT-2; M-576-PT-2; NAS 1.55:2492-PT-2) Avail: NTIS HC A04/MF A01 CSCL 09B

Topics relative to the application of artificial intelligence to space operations are discussed. New technologies for space station automation, design data capture, computer vision, neural nets, automatic programming, and real time applications are discussed.

N88-24189*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
MTK: AN AI TOOL FOR MODEL-BASED REASONING
WILLIAM K. ERICKSON and MARY R. RUDOKAS *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 1-5 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

A 1988 goal for the Systems Autonomy Demonstration Project Office of the NASA Ames Research Office is to apply model-based representation and reasoning techniques in a knowledge-based system that will provide monitoring, fault diagnosis, control, and trend analysis of the Space Station Thermal Control System (TCS). A number of issues raised during the development of the first prototype system inspired the design and construction of a model-based reasoning tool called MTK, which was used in the building of the second prototype. These issues are outlined here with examples from the thermal system to highlight the motivating factors behind them, followed by an overview of the capabilities of MTK, which was developed to address these issues in a generic fashion. Author

N88-24190*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
INTEGRATION OF SYMBOLIC AND ALGORITHMIC HARDWARE AND SOFTWARE FOR THE AUTOMATION OF SPACE STATION SUBSYSTEMS
HUGH GREGG, KATHLEEN HEALEY, EDMUND HACK (Lockheed Engineering and Management Services Co., Inc., Houston, Tex.), and CARLA WONG *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 7-14 Jun. 1988 Previously announced as N88-15497 (Contract W-7405-ENG-48)
Avail: NTIS HC A04/MF A01 CSCL 09B

Expert systems that require access to data bases, complex simulations and real time instrumentation have both symbolic and algorithmic needs. Both of these needs could be met using a general purpose workstation running both symbolic and algorithmic codes, or separate, specialized computers networked together. The later approach was chosen to implement TEXSYS, the thermal expert system, developed by the NASA Ames Research Center in conjunction with the Johnson Space Center to demonstrate the ability of an expert system to autonomously monitor the thermal control system of the space station. TEXSYS has been implemented on a Symbolics workstation, and will be linked to a microVAX computer that will control a thermal test bed. The integration options and several possible solutions are presented. Author

N88-24191*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
CONNECTING REMOTE SYSTEMS FOR DEMONSTRATION OF AUTOMATION TECHNOLOGIES
R. M. BROWN and R. YEE *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 15-23 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

An initial estimate of the communications requirements of the Systems Autonomy Demonstration Project (SADP) development and demonstration environments is presented. A proposed network paradigm is developed, and options for network topologies are explored. Author

N88-24194*# Environmental Research Inst. of Michigan, Ann Arbor.
ORBITAL NAVIGATION, DOCKING AND OBSTACLE AVOIDANCE AS A FORM OF THREE DIMENSIONAL MODEL-BASED IMAGE UNDERSTANDING
J. BEYER, C. JACOBUS, and B. MITCHELL *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 37-46 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

Range imagery from a laser scanner can be used to provide sufficient information for docking and obstacle avoidance procedures to be performed automatically. Three dimensional model-based computer vision algorithms in development can perform these tasks even with targets which may not be cooperative (that is, objects without special targets or markers to provide unambiguous points). Role, pitch, and yaw of a vehicle can be taken into account as image scanning takes place, so that these can be correlated when the image is converted from egocentric to world coordinated. Other attributes of the sensor, such as the registered reflectance and texture channels, provide additional data sources for algorithm robustness. Author

N88-24195*# Alabama Univ., Huntsville. Center for Applied Optics.
GENETIC ALGORITHMS FOR ADAPTIVE REAL-TIME CONTROL IN SPACE SYSTEMS
J. VANDERZIJP and A. CHOUDRY *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 47-51 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

Genetic Algorithms that are used for learning as one way to control the combinational explosion associated with the generation of new rules are discussed. The Genetic Algorithm approach tends to work best when it can be applied to a domain independent knowledge representation. Applications to real time control in space systems are discussed. Author

N88-24197*# Hamilton Standard, Windsor Locks, CT.
TES: A MODULAR SYSTEMS APPROACH TO EXPERT SYSTEM DEVELOPMENT FOR REAL-TIME SPACE APPLICATIONS
RALPH CACACE and BRENDA ENGLAND *In* NASA, Marshall Space Flight Center, Third Conference on Artificial Intelligence for Space Applications, Part 2 p 59-63 Jun. 1988
Avail: NTIS HC A04/MF A01 CSCL 09B

A major goal of the Space Station era is to reduce reliance on support from ground based experts. The development of software programs using expert systems technology is one means of reaching this goal without requiring crew members to become intimately familiar with the many complex spacecraft subsystems. Development of an expert systems program requires a validation of the software with actual flight hardware. By combining accurate hardware and software modelling techniques with a modular systems approach to expert systems development, the validation of these software programs can be successfully completed with minimum risk and effort. The TIMES Expert System (TES) is an application that monitors and evaluates real time data to perform fault detection and fault isolation tasks as they would otherwise be carried out by a knowledgeable designer. The development process and primary features of TES, a modular systems approach, and the lessons learned are discussed. Author

N88-25206*# Catholic Univ. of America, Washington, DC. Dept. of Electrical Engineering.
ANALYSIS OF A CLOSED-KINEMATIC CHAIN ROBOT MANIPULATOR Semiannual Report
CHARLES C. NGUYEN and FARHAD J. POORAN Jul. 1988 20 p
(Contract NAG5-780)
(NASA-CR-183031; NAS 1.26:183031) Avail: NTIS HC A03/MF A01 CSCL 09B

Presented are the research results from the research grant entitled: Active Control of Robot Manipulators, sponsored by the

Goddard Space Flight Center (NASA) under grant number NAG-780. This report considers a class of robot manipulators based on the closed-kinematic chain mechanism (CKCM). This type of robot manipulators mainly consists of two platforms, one is stationary and the other moving, and they are coupled together through a number of in-parallel actuators. Using spatial geometry and homogeneous transformation, a closed-form solution is derived for the inverse kinematic problem of the six-degree-of-freedom manipulator, built to study robotic assembly in space. Iterative Newton Raphson method is employed to solve the forward kinematic problem. Finally, the equations of motion of the above manipulators are obtained by employing the Lagrangian method. Study of the manipulator dynamics is performed using computer simulation whose results show that the robot actuating forces are strongly dependent on the mass and centroid locations of the robot links. Author

N88-25472*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
DESIGN GUIDELINES FOR ROBOTICALLY SERVICEABLE HARDWARE
SCOTT A. GORDON Apr. 1988 23 p
(NASA-TM-100700; NAS 1.15:100700) Avail: NTIS HC A03/MF A01 CSCL 13I

Research being conducted at the Goddard Space Flight Center into the development of guidelines for the design of robotically serviceable spaceflight hardware is described. A mock-up was built based on an existing spaceflight system demonstrating how these guidelines can be applied to actual hardware. The report examines the basic servicing philosophy being studied and how this philosophy is reflected in the formulation of design guidelines for robotic servicing. A description of the mock-up is presented with emphasis on the design features that make it robot friendly. Three robotic servicing schemes fulfilling the design guidelines were developed for the mock-up. These servicing schemes are examined as to how their implementation was affected by the constraints of the spacecraft system on which the mock-up is based. Author

N88-26044# Centre National d'Etudes Spatiales, Toulouse (France).
TASKS FORESEEN FOR SPACE ROBOTS AND AN EXAMPLE OF AN ASSOCIATED ORBITAL INFRASTRUCTURE [TACHES ENVISAGEES POUR LES ROBOTS SPATIAUX ET EXEMPLE D'INFRASTRUCTURE ORBITAL ASSOCIEE]
PIERRE DUTTO *In* ESA, Proceedings of the Colloquium on Space and Sea p 199-208 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Robot activities on manned space stations are discussed and permanent installation of robots on automatic space platforms is considered. Robot interventions in dangerous areas such as spaceborne nuclear reactors and platforms subjected to high doses of radiation are treated. Robots on deep space probes are assessed. The actual and envisaged orbital infrastructures of the NASA, USSR, and European space programs are reviewed.
ESA

N88-26398* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MOBILE REMOTE MANIPULATOR SYSTEM FOR A TETRAHEDRAL TRUSS Patent
CLARENCE J. WESSELSKI, inventor (to NASA) and WILLIAM C. SCHNEIDER, inventor (to NASA) 19 Jul. 1988 15 p Filed 5 Sep. 1986 Supersedes N87-15260 (25 - 07, p 0875) Sponsored by NASA
(NASA-CASE-MSC-20985-1; US-PATENT-4,757,767;
US-PATENT-APPL-SN-904134; US-PATENT-CLASS-104-49;
US-PATENT-CLASS-104-35; US-PATENT-CLASS-104-172.1;
US-PATENT-CLASS-244-159) Avail: US Patent and Trademark Office CSCL 05H

The mobile remote manipulator system (MRMS) was initially developed for transit about the trusses of the delta space station; however, it can be utilized just as easily for transit about the trusses of the dual keel station. The MRMS is comprised of a mobile platform having a rail system formed of transversely disposed T-shaped tracks, which engage with guide pins located at the nodes of the trusses. The guide pins form a grid and the tracks are so designed as to permit travel in either of two orthogonal directions. The present invention provides a near-uniform traversing velocity with minimal dynamic loading on the system. Pivoting changers move the platform from one face to another.
Official Gazette of the U.S. Patent and Trademark Office

N88-27760*# TRW Defense and Space Systems Group, Redondo Beach, CA.
BLOCK ORIENTED SIMULATION SYSTEM (BOSS)
JAIMIE RATCLIFFE 1988 45 p Submitted for publication (Contract NAS9-17677)
(NASA-CR-182947; NAS 1.26:182947) Avail: NTIS HC A03/MF A01 CSCL 09B

Computer simulation is assuming greater importance as a flexible and expedient approach to modeling system and subsystem behavior. Simulation has played a key role in the growth of complex, multiple access space communications such as those used by the space shuttle and the TRW-built Tracking and Data Relay Satellites (TDRS). A powerful new simulator for use in designing and modeling the communication system of NASA's planned Space Station is being developed. Progress to date on the Block (Diagram) Oriented Simulation System (BOSS) is described. B.G.

N88-29180* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
COLLET LOCK JOINT FOR SPACE STATION TRUSS Patent
CLARENCE J. WESSELSKI, inventor (to NASA) 16 Aug. 1988 13 p Filed 1 Apr. 1987 Supersedes N87-25576 (25 - 19, p 2615)
(NASA-CASE-MSC-21207-1; US-PATENT-4,763,459;
US-PATENT-APPL-SN-032818; US-PATENT-CLASS-52-646;
US-PATENT-CLASS-52-648; US-PATENT-CLASS-403-217;
US-PATENT-CLASS-403-171) Avail: US Patent and Trademark Office CSCL 13I

A lock joint for a Space Station has a series of struts joined together in a predetermined configuration by node point fittings. The fittings have removeable inserts. The lock joint has an elongated housing connected at one end to a strut. A split-fingered collet is mounted within the housing to insure reciprocal movement. A handle on the housing is connected to the collet for moving the collet into the insert where the fingers of the collet expand to lock the joint to the fitting.
Official Gazette of the U.S. Patent and Trademark Office

N88-29352*# National Aeronautics and Space Administration, Washington, DC.
SPACE STATION AS A VITAL FOCUS FOR ADVANCING THE TECHNOLOGIES OF AUTOMATION AND ROBOTICS
GIULIO VARSI (Jet Propulsion Lab., California Inst. of Tech., Pasadena.) and DANIEL H. HERMAN *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 1-6 Aug. 1988
(IAF-86-62) Avail: NTIS HC A99/MF E03 CSCL 22B

A major guideline for the design of the U.S. Space Station is that the Space Station address a wide variety of functions. These functions include the servicing of unmanned assets in space, the support of commercial labs in space and the efficient management of the Space Station itself; the largest space asset. The technologies of Automation and Robotics have the promise to help in reducing Space Station operating costs and to achieve a highly efficient use of the human in space. The use of advanced automation and artificial intelligence techniques, such as expert systems, in Space Station subsystems for activity planning and failure mode management will enable us to reduce dependency on a mission control center and could ultimately result in breaking the umbilical link from Earth to the Space Station. The application of robotic technologies with advanced perception capability and hierarchical intelligent control to servicing system will enable the servicing of assets either in space or in situ with a high degree of

human efficiency. The results of studies leading toward the formulation of an automation and robotics plan for Space Station development are presented. Author

N88-29387*# Georgia Inst. of Tech., Atlanta.
CONCEPTS FOR ROBOT MOTION PRIMITIVES REQUIRED FOR SPACE STATION TELEOPERATIONS
JEFFREY L. GROVER and STEVEN A. E. SUCHTING (Boeing Aerospace Co., Huntsville, Ala.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 337-346 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

Ground controlled teleoperations are expected to be used to augment Space Station manned extravehicular activities (EVA) and Intravehicular activities (IVA). However, ground controlled teleoperations will encounter communications time delays of from 3 to 8 secs. Time delays greater than 1 sec have been shown to be detrimental to safe and efficient teleoperations. Therefore, concepts must be developed to overcome the hazards and limitations of time delays when performing teleoperations using robots. The concept for robot motion primitives incorporate force/torque and tactile sensor feedback to implement the degree of autonomy required for interactive, ground controlled telerobotics. Several primitives are studied that augment human initiated actions by providing rapid response interaction with the physical environment of a telerobot. These primitives are detailed. They constitute a level of intelligent sensing and reaction required to augment human actions through autonomous interaction with the physical environment. Author

N88-29388*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
THE USE OF COMPUTER GRAPHIC SIMULATION IN THE DEVELOPMENT OF ROBOTIC SYSTEMS
KEN FERNANDEZ *In its* Second Conference on Artificial Intelligence for Space Applications p 347-354 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The use of computer graphic simulation techniques to resolve critical design and operational issues for robotic systems is described. Use of this technology will result in greatly improved systems and reduced development costs. The major design issues in developing effective robotic systems are discussed and the use of ROBOSIM, a NASA developed simulation tool, to address these issues is presented. Three representative simulation case studies are reviewed: off-line programming of the robotic welding development cell for the Space Shuttle Main Engine; the integration of a sensor to control the robot used for removing the Thermal Protection System from the Solid Rocket Booster; and the development of a teleoperator/robot mechanism for the Orbital Maneuvering Vehicle. Author

N88-29394*# Martin Marietta Aerospace, Denver, CO. Space Station Program.
KNOWLEDGE ACQUISITION AND RAPID PROTYPING OF AN EXPERT SYSTEM: DEALING WITH REAL WORLD PROBLEMS
PATRICK A. BAILEY and BRETT B. DOEHR *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 395-402 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

The knowledge engineering and rapid prototyping phases of an expert system that does fault handling for a Solid Amine, Water Desorbed CO2 removal assembly for the Environmental Control and Life Support System for space based platforms are addressed. The knowledge acquisition phase for this project was interesting because it could not follow the textbook examples. As a result of this, a variety of methods were used during the knowledge acquisition task. The use of rapid prototyping and the need for a flexible prototype suggested certain types of knowledge representation. By combining various techniques, a representative subset of faults and a method for handling those faults was achieved. The experiences should prove useful for developing future fault handling expert systems under similar constraints. Author

N88-29405*# Martin Marietta Aerospace, Denver, CO. Space Station Program.
INTELLIGENT INTERFACE DESIGN AND EVALUATION
FRANK L. GREITZER *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 489-496 Aug. 1988 Sponsored in part by Martin Marietta Denver Aerospace Independent Research and Development
Avail: NTIS HC A99/MF E03 CSCL 09B

Intelligent interface concepts and systematic approaches to assessing their functionality are discussed. Four general features of intelligent interfaces are described: interaction efficiency, subtask automation, context sensitivity, and use of an appropriate design metaphor. Three evaluation methods are discussed: Functional Analysis, Part-Task Evaluation, and Operational Testing. Design and evaluation concepts are illustrated with examples from a prototype expert system interface for environmental control and life support systems for manned space platforms. Author

N88-29407*# Boeing Aerospace Co., Huntsville, AL. Space Station.
A ROBOTIC SYSTEM FOR AUTOMATION OF LOGISTICS FUNCTIONS ON THE SPACE STATION
J. C. MARTIN, R. B. PURVES, R. N. HOSIER, and B. A. KREIN (Westinghouse Mfg. Systems and Technology Center, Columbia, Md.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 503-511 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

Spacecraft inventory management is currently performed by the crew and as systems become more complex, increased crew time will be required to perform routine logistics activities. If future spacecraft are to function effectively as research labs and production facilities, the efficient use of crew time as a limited resource for performing mission functions must be employed. The use of automation and robotics technology, such as automated warehouse and materials handling functions, can free the crew from many logistics tasks and provide more efficient use of crew time. Design criteria for a Space Station Automated Logistics Inventory Management System is focused on through the design and demonstration of a mobile two armed terrestrial robot. The system functionally represents a 0 gravity automated inventory management system and the problems associated with operating in such an environment. Features of the system include automated storage and retrieval, item recognition, two armed robotic manipulation, and software control of all inventory item transitions and queries. Author

N88-29408*# Alabama Univ., Huntsville.
PERSONNEL OCCUPIED WOVEN ENVELOPE ROBOT
FRANCIS WESSLING, WILLIAM TEOH, and M. CARL ZIEMKE *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 513-521 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

The Personnel Occupied Woven Envelope Robot (POWER) provides an alternative to extravehicular activity (EVA) of space suited astronauts and/or use of long slender manipulator arms such as are used in the Shuttle Remote Manipulator System. POWER provides the capability for a shirt sleeved astronaut to perform such work by entering a control pod through air locks at both ends of an inflated flexible bellows (access tunnel). The exoskeleton of the tunnel is a series of six degrees of freedom (Six-DOF) articulated links compressible to 1/6 of their fully extended length. The operator can maneuver the control pod to almost any location within about 50 m of the base attachment to the space station. POWER can be envisioned as a series of hollow Six-DOF manipulator segments or arms wherein each arm grasps the shoulder of the next arm. Inside the hollow arms ia a bellow-type access tunnel. The control pod is the fist of the series of linked hollow arms. The fingers of the fist are conventional manipulator arms under direct visual control of the nearby operator in the pod. The applications and progress to date of the POWER system is given. Author

N88-29409*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.
REMOTE SERVICING OF SPACE SYSTEMS
S. L. COLLINS and R. B. PURVES *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 523-535 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

Space systems are difficult to maintain on orbit. The difficulty arises from the limited ability and availability of the astronaut work force in the hazardous space environment. Remote robotic manipulation can free the astronaut from the hazardous working environment while also increasing the work force. However, remote robotic servicing is not without its own set of problems and limitations, such as communication time delay and unstructured worksites. Tests and test equipment are described which are designed to increase the understanding of the remote servicing problems and to allow development of potential solutions. A half scale satellite mockup was developed for evaluating and improving upon the design of replaceable subsystems, such as batteries and electronic boxes. A servicer system, that includes a six degree of freedom PUMA 560 robot and interchangeable end effectors (tools), was developed to aid in driving out servicer design requirements. The results include the time delay impact on servicing timelines and requirements for the servicer system. Author

N88-29410*# Boeing Aerospace Co., Huntsville, AL. Space Station Program.
A TELEOPERATED ROBOTIC MANIPULATOR SYSTEM FOR MATERIALS PROCESSING EXPERIMENT SERVICING
STEVEN SUCHTING, R. BYRON PURVES, JEFFREY L. GROVER, and ROY SCRUGGS (Georgia Inst. of Tech., Atlanta.) *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 537-542 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

In 1984 Congress authorized NASA to begin the Space Station Program, and requested that 10 percent of program funds be spent in implementing automation and robotics (A and R) on the Space Station. In response to that request, Boeing established several Independent Research and Development (IR and D) projects to explore possible uses for A and R on the Space Station. One of those projects, and automated materials processing experiment, is discussed. The project uses a teleoperated robot to demonstrate telescience applied to a Chemical Vapor Transport materials processing experiment. Author

N88-29412*# Rockwell International Corp., Canoga Park, CA. Rocketdyne Div.
UTILIZATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES FOR THE SPACE STATION POWER SYSTEM
THOMAS C. EVATT and EDWARD W. GHOLDSTON *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 555-562 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 09B

Due to the complexity of the Space Station Electrical Power System (EPS) as currently envisioned, artificial intelligence/expert system techniques are being investigated to automate operations, maintenance, and diagnostic functions. A study was conducted to investigate this technology as it applies to failure detection, isolation, and reconfiguration (FDIR) and health monitoring of power system components and of the total system. Control system utilization of expert systems for load scheduling and shedding operations was also researched. A discussion of the utilization of artificial intelligence/expert systems for Initial Operating Capability (IOC) for the Space Station effort is presented along with future plans at Rocketdyne for the utilization of this technology for enhanced Space Station power capability. Author

N88-29839# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany, F.R.).
STUDY OF ROBOTICS SPACECRAFT SERVICING AND ASSEMBLY IN SPACE. VOLUME 1: EXECUTIVE SUMMARY
Final Report
Paris, France ESA Feb. 1988 94 p Prepared in cooperation with Sener S.A., Madrid, Spain; Aeritalia S.p.A., Turin, Italy; Fraunhofer Inst. fuer Productionstechnik und Konstruktionstechnik, Berlin, Fed. Republic of Germany and Spar Aerospace Ltd., Ste-Anne-de-Bellevue, Quebec
(Contract ESA-6837/86-NL-PP(SC))
(ESA-CR(P)-2612-VOL-1; ETN-88-93147) Avail: NTIS HC A05/MF A01

The robotics, servicing, and assembly requirements of a microgravity mission and an orbital assembly mission were defined. The microgravity mission is based on the Man-Tended Free Flyer (MTFF) enhanced by additional elements, like an airlock, a multiberthing node, and an unpressurized payload area. The in-orbit assembly mission deals with the buildup of this enhanced version of the MTFF towards a European autonomous Space Station. For the micro-g mission the central transportation robot and a rack-dedicated manipulator are outlined as elements of an overall automation concept for the MTFF operation, while the in-orbit assembly mission identifies a moveable assembly manipulator for handling of modules and large structures. ESA

N88-29842# Air Command and Staff Coll., Maxwell AFB, AL.
SENSOR AND ACTUATOR SELECTION FOR LARGE SPACE STRUCTURE CONTROL
MICHAEL L. DELORENZO Apr. 1988 41 p
(AD-A194912; ACSC-88-0725) Avail: NTIS HC A03/MF A01 CSCL 22B

This paper presents an algorithm which aids the controls engineer in specifying a sensor and actuator configuration for regulation of large scale, linear, stochastic systems such as a Large Space Structure (LSS). The algorithm uses a Linear Quadratic Gaussian (LQG) controller, an efficient weight selection technique based upon successive approximation, and a measure of sensor and actuator effectiveness to provide a final sensor and actuator configuration. This configuration enables the closed-loop system to meet output specifications with minimal input power. The algorithm involves no complex gradient calculations and has proven numerically tractable for large linear models. Additionally, the algorithm provides the controls engineer information on the important design issues of actuator sizing, reliability, redundancy, and optimal number. GRA

N88-30330*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
THE 1988 GODDARD CONFERENCE ON SPACE APPLICATIONS OF ARTIFICIAL INTELLIGENCE
JAMES RASH, ed. and PETER HUGHES, ed. Aug. 1988 437 p Conference held in Greenbelt, Md., 24 May 1988 Sponsored by NASA, Washington, D.C.
(NASA-CP-3009; REPT-88B0212; NAS 1.55:3009) Avail: NTIS HC A19/MF A01 CSCL 09B

This publication comprises the papers presented at the 1988 Goddard Conference on Space Applications of Artificial Intelligence held at the NASA/Goddard Space Flight Center, Greenbelt, Maryland on May 24, 1988. The purpose of this annual conference is to provide a forum in which current research and development directed at space applications of artificial intelligence can be presented and discussed. The papers in these proceedings fall into the following areas: mission operations support, planning and scheduling; fault isolation/diagnosis; image processing and machine vision; data management; modeling and simulation; and development tools/methodologies.

N88-30333*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
A SHARED-WORLD CONCEPTUAL MODEL FOR INTEGRATING SPACE STATION LIFE SCIENCES TELESCIENCE OPERATIONS
VICKI JOHNSON and JOHN BOSLEY (Bionetics Corp., Moffett Field, Calif.) *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 33-44 Aug. 1988
Avail: NTIS HC A19/MF A01 CSCL 09B

Mental models of the Space Station and its ancillary facilities

will be employed by users of the Space Station as they draw upon past experiences, perform tasks, and collectively plan for future activities. The operational environment of the Space Station will incorporate telescience, a new set of operational modes. To investigate properties of the operational environment, distributed users, and the mental models they employ to manipulate resources while conducting telescience, an integrating shared-world conceptual model of Space Station telescience is proposed. The model comprises distributed users and resources (active elements); agents who mediate interactions among these elements on the basis of intelligent processing of shared information; and telescience protocols which structure the interactions of agents as they engage in cooperative, responsive interactions on behalf of users and resources distributed in space and time. Examples from the life sciences are used to instantiate and refine the model's principles. Implications for transaction management and autonomy are discussed. Experiments employing the model are described which the authors intend to conduct using the Space Station Life Sciences Telescience Testbed currently under development at Ames Research Center. Author

N88-30350*# George Mason Univ., Fairfax, VA. Dept. of Computer Science.
PARALLEL AND DISTRIBUTED COMPUTATION FOR FAULT-TOLERANT OBJECT RECOGNITION
HARRY WECHSLER *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 275-293 Aug. 1988
Avail: NTIS HC A19/MF A01 CSCL 09B

The distributed associative memory (DAM) model is suggested for distributed and fault-tolerant computation as it relates to object recognition tasks. The fault-tolerance is with respect to geometrical distortions (scale and rotation), noisy inputs, occulsion/overlap, and memory faults. An experimental system was developed for fault-tolerant structure recognition which shows the feasibility of such an approach. The approach is futher extended to the problem of multisensory data integration and applied successfully to the recognition of colored polyhedral objects. Author

N88-30353*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SPACELAB DATA PROCESSING FACILITY (SLDPF) QUALITY ASSURANCE (QA)/DATA ACCOUNTING (DA) EXPERT SYSTEMS: TRANSITION FROM PROTOTYPES TO OPERATIONAL SYSTEMS
LISA BASILE *In its* The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 329-341 Aug. 1988
Avail: NTIS HC A19/MF A01 CSCL 05B

The SLDPF is responsible for the capture, quality monitoring processing, accounting, and shipment of Spacelab and/or Attached Shuttle Payloads (ASP) telemetry data to various user facilities. Expert systems will aid in the performance of the quality assurance and data accounting functions of the two SLDPF functional elements: the Spacelab Input Processing System (SIPS) and the Spacelab Output Processing System (SOPS). Prototypes were developed for each as independent efforts. The SIPS Knowledge System Prototype (KSP) used the commercial shell OPS5+ on an IBM PC/AT; the SOPS Expert System Prototype used the expert system shell CLIPS implemented on a Macintosh personal computer. Both prototypes emulate the duties of the respective QA/DA analysts based upon analyst input and predetermined mission criteria parameters, and recommended instructions and decisions governing the reprocessing, release, or holding for further analysis of data. These prototypes demonstrated feasibility and high potential for operational systems. Increase in productivity, decrease of tedium, consistency, concise historial records, and a training tool for new analyses were the principal advantages. An operational configuration, taking advantage of the SLDPF network capabilities, is under development with the expert systems being installed on SUN workstations. This new configuration in conjunction with the potential of the expert systems will enhance the efficiency, in both time and quality, of the SLDPF's release of Spacelab/AST data products. Author

11

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.

A88-24817
HIGH TEMPERATURE COATINGS; PROCEEDINGS OF THE SYMPOSIUM, ORLANDO, FL, OCT. 7-9, 1986
M. KHOBAIB, ED. (Dayton, University, OH) and R. C. KRUTENAT, ED. (Avco Specialty Materials Textron, Lowell, MA) Symposium sponsored by the Metallurgical Society. Warrendale, PA, Metallurgical Society, Inc., 1987, 220 p. No individual items are abstracted in this volume.

This book covers a broad spectrum of topics related to high-temperature coatings. Most of the papers deal with coatings for turbine engine applications, while others address methods for applying coatings and the performance and mechanical behavior of a variety of coatings. The application and performance of thermal barrier coatings is addressed. Coating/substrate interactions and the interfacial stability are also extensively discussed in terms of interdiffusion, microstructural stability, formation of various phases, etc. A novel idea for inspection of the integrity of a coating bond is considered, and the use of chromized coatings for protection against stress corrosion cracking in Space Shuttle applications is examined. C.D.

A88-35565* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TRIBOLOGICAL PROPERTIES OF POLYMER FILMS AND SOLID BODIES IN A VACUUM ENVIRONMENT
ROBERT L. FUSARO (NASA, Lewis Research Center, Cleveland, OH) STLE Tribology Transactions (ISSN 0569-8197), vol. 31, April 1988, p. 174-180; Discussion, p. 181. Previously announced in STAR as N87-17906. refs

The tribological properties of ten different polymer based materials were evaluated in a vacuum environment to determine their suitability for possible lubrication applications in a space environment, such as might be encountered on the proposed Space Station. A pin-on-disk tribometer was used and the polymer materials were evaluated either as solid body disks or as films applied to 440C HT stainless steel disks. A 440C HT stainless steel hemispherically tipped pin was slid against the polymer materials. For comparison, similar tests were conducted in a controlled air atmosphere of 50 percent relative humidity air. In most instances, the polymer materials lubricated much better under vacuum conditions than in air. Thus, several of the materials show promise as lubricants for vacuum applications. Friction coefficients of 0.05 or less and polymer material wear rates of up to 2 orders of magnitude less than in air were obtained. One material showed considerable promise as a traction drive material. Relative high friction coefficients (0.36 to 0.52) and reasonably low wear rates were obtained in vacuum. Author

A88-36762*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
DEGRADATION OF GRAPHITE-EPOXY DUE TO ELECTRON RADIATION
C. T. HERAKOVICH, D. J. FOX (Virginia Polytechnic Institute and State University, Blacksburg), and G. F. SYKES (NASA, Langley Research Center, Hampton, VA) ASME, Transactions, Journal of Engineering Materials and Technology (ISSN 0094-4289), vol. 110, April 1988, p. 146-152. refs
(Contract NAG1-343)

Experimental results are presented showing that electron irradiation has a variable effect on the properties of graphite-epoxy depending upon the test temperature and the property of interest. In general, compression properties are improved at cold

temperature and degraded at elevated temperature. With the exception of some moduli, tensile and shear properties are degraded at both cold and elevated temperatures. Electron irradiation lowers the glass transition temperature of graphite/epoxy significantly. Property degradation of irradiated materials at the elevated temperature is associated with the reduction in Tg. It is shown that a (0) compression-strength test is the most sensitive test for exhibiting the effects of electron irradiation. Results from tests on neat resin also show that the bulk matrix is degraded after irradiation, and that the correlation between resin and composite response is good. Author

A88-41547* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE RADIATION EFFECTS ON POLY(ARYL-ETHER-KETONE) THIN FILMS AND COMPOSITES
JOAN G. FUNK (NASA, Langley Research Center, Hampton, VA) and GEORGE F. SYKES, JR. SAMPE Quarterly (ISSN 0036-0821), vol. 19, April 1988, p. 19-26. refs

The purpose of this study was to assess the space durability of poly(aryl-ether-ketone) (PEEK) in the forms of films and graphite fiber reinforced composites. The influence of the film's crystallinity on electron radiation stability was evaluated using X-ray diffraction, DSC, FTIR, and mechanical property tests. The mechanical properties of the composites material were evaluated after electron radiation and after electron radiation followed by thermal cycling simulating 30 years in geosynchronous orbit. Author

A88-41882
ADVANCED COMPOSITES III: EXPANDING THE TECHNOLOGY; PROCEEDINGS OF THE THIRD ANNUAL CONFERENCE, DETROIT, MI, SEPT. 15-17, 1987
Conference sponsored by ASM International, Engineering Society of Detroit, Society of Plastics Engineers. Metals Park, OH, ASM International, 1987, 408 p. For individual items see A88-41883 to A88-41895.

The present conference discusses topics in the design features and methods, manufacturing processes, secondary fabrication techniques, and materials science aspects of advanced composites. Attention is given to composite structural armor for ground combat vehicles, composite structures for automotive energy management, CAD/CAM of braided preforms for advanced composites, composite automobile bumper beams, preforming for structural applications, the three-dimensional braiding of thermoplastic composite preforms, and recent advancements in tooling technology. Also discussed are instrument-grade MMCs for imaging IR guidance systems, automated tape layup of a vertical stabilizer fin, the mechanical properties of thermoplastic matrix composites, surface chemistry and adhesion of SMCs, fiber-matrix bonding, and hybrid yarns for high performance thermoplastic composites. O.C.

A88-42372
A TECHNIQUE TO EVALUATE COATINGS FOR ATOMIC OXYGEN RESISTANCE
J. B. CROSS (Los Alamos National Laboratory, NM), E. H. LAN, and C. A. SMITH (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 693-702. refs

Space Shuttle flight data has shown that the LEO environment significantly degrades a variety of spacecraft materials. Atomic oxygen, the major constituent of the LEO atmosphere, is primarily responsible for the degradation due to its oxidative ability, high collision energy (approximately 5 eV for a spacecraft traveling at 8 km/sec), and high flux. Atomic oxygen-reactive materials to be used on long-term spacecraft such as Space Station must be coated with an oxygen-resistant coating if they are to survive in LEO for an extended period of time. A technique using oxidation of silver film as an atomic oxygen detector has been developed to evaluate the effectiveness of coatings in protecting substrates which react with atomic oxygen. The paper discusses results from a bare silver and a PTFE Teflon-coated silver sample which show that this technique is viable for detecting atomic oxygen penetration through coatings. A discussion of the advantages and disadvantages of the technique is included. Author

A88-42412* Boeing Aerospace Co., Seattle, WA.
EVALUATION OF CHROMIC ACID ANODIZED ALUMINUM FOIL COATED COMPOSITE TUBES FOR THE SPACE STATION TRUSS STRUCTURE
HARRY W. DURSCH (Boeing Aerospace Co., Seattle, WA) and WAYNE S. SLEMP (NASA, Langley Research Center, Hampton, VA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1342-1354. refs

This paper describes the development and evaluation of chromic acid anodized (CAA) Al foil as a protective and thermal control coating for graphite/epoxy tubes designed for the Space Station truss structure. Special consideration is given to the development of solar-absorptance and thermal-emittance properties required of Al foil, the development of CAA parameters necessary to achieve these optical properties, and the atomic oxygen and UV testing of CAA Al foil. Results showed that 0.003-in CAA Al foil cocured or secondary bonded to graphite/epoxy tubes with thin epoxy film adhesive retains excellent bond strength and provides a superior protective and thermal control coating to the LEO environment. Processes were developed for CAA Al foils long enough to continuously wrap the 23-ft-long diagonal struts of the Space Station truss structure. Specifications are presented for the processes of chromic acid anodizing of Al foil and for the bonding of anodized Al foil to graphite/epoxy tubes. I.S.

A88-42419
GRAPHITE THERMOPLASTIC COMPOSITES FOR SPACECRAFT APPLICATIONS
EDWARD M. SILVERMAN and ROBERT J. JONES (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1418-1432. refs

Spacecraft application evaluations encompassing dynamic mechanical analysis, flexural and transverse tensile strength, outgassing/condensable volatiles, equilibrium water absorption, damping capability, and the effect of 500 -250 to + 250 F thermal cycles on microcracking, have been conducted for both graphite/PEEK- and graphite/PPS-based prepreg tapes and comingled, bidirectional graphite/PEEK fabrics. SEM analysis results indicate that the higher level of mechanical properties of the PEEK composites may be due to better interfacial bonding than that obtainable with PPS. O.C.

A88-42434* National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
THERMAL CYCLING EFFECTS ON THE DIMENSIONAL STABILITY OF P75 AND P75-T300 (FABRIC) HYBRID GRAPHITE/EPOXY LAMINATES
DAVID E. BOWLES (NASA, Langley Research Center, Hampton, VA) and JAMES SHEN (PRC Kentron, Inc., Hampton, VA) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1659-1671. refs

The response of cross-ply P75/934 laminates and hybrid laminates consisting of P75/934 unidirectional tape and T300/934 woven fabric were compared for temperature exposures between + and - 250 F up to a maximum of 250 cycles. The properties monitored included microcrack density, coefficient of thermal expansion (CTE), residual strain, and tensile modulus. Hybrid laminates, with stiffnesses and CTE's comparable to P75/934 cross-ply laminates, demonstrated significantly improved thermal

cycling stability in one direction. The hybrid laminates also had predicted longitudinal properties comparable to low angle, off-axis P75/934 configurations, but had significantly higher predicted transverse strengths. T300 Gr/Ep plain-weave fabric laminates were shown to be much less susceptible to thermal cycling damage than T300 Gr/Ep cross-ply laminates. None of the laminates tested exhibited any significant changes in tensile modulus after thermal cycling. Author

A88-42440* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
QUALIFICATION OF ROOM-TEMPERATURE-CURING EPOXY ADHESIVES FOR SPACECRAFT STRUCTURAL APPLICATIONS
ALAIN CARPENTER and TIM O'DONNELL (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Materials - Pathway to the future; Proceedings of the Thirty-third International SAMPE Symposium and Exhibition, Anaheim, CA, Mar. 7-10, 1988. Covina, CA, Society for the Advancement of Material and Process Engineering, 1988, p. 1761-1772. refs
(Contract NAS7-918)

An adhesive-bonding test program is being conducted in order to develop structural adhesives applicable to JPL spacecraft. A noteworthy application for such an adhesive will be JPL's Galileo mission, whose trajectory will involve the circumnavigation of the planet Venus prior to Jupiter rendezvous, and will accordingly require stringent temperature and radiation environment requirements. The baseline adhesive for the test program is the EA 934 room temperature-cure epoxy, which has been widely used as a 'space-qualified' material. O.C.

A88-42585
PRODUCTION OF GROUND STATE ATOMIC OXYGEN IN A MULTIFACTOR STRESS ENVIRONMENT
W. C. NEELY, T. C. YANG, J. P. WEY, E. J. CLOTHIAUX, and S. D. WORLEY (Auburn University, AL) IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 313-316.

A system for the production of ground state atomic oxygen was designed with attention given to the use of a generation method in which the O-atom flux could be accurately characterized with respect to the exact identity and the absolute flux of the O-atom species produced. Moreover, the system was designed to permit multifactor stress studies of test samples upon exposure to the O-atom flux. Atomic oxygen generation is discussed as well as multifactor stress capability. K.K.

A88-45201
ALUMINUM-LITHIUM ALLOYS: DESIGN, DEVELOPMENT AND APPLICATION UPDATE; PROCEEDINGS OF THE SYMPOSIUM, LOS ANGELES, CA, MAR. 25, 26, 1987
RAMESH J. KAR, ED., SUPHAL P. AGRAWAL, ED. (Northrop Corp., Aircraft Div., Hawthorne, CA), and WILLIAM E. QUIST, ED. (Boeing Commercial Airplane Co., Seattle, WA) Symposium organized and sponsored by ASM International. Metals Park, OH, ASM International, 1988, 470 p. For individual items see A88-45202 to A88-45205.

The present conference on the development status of aluminum-lithium alloys for aerospace applications discussed topics in the availability of these alloys, their fatigue, fracture, and corrosion characteristics, their design criteria, and manufacturing techniques developed for them to date. Attention is given to developments in rapidly-solidified Al-Li alloys, the mechanisms of fatigue crack propagation in commercial Al-Li alloys, the effects of processing on Al-Li microstructures and fracture behavior, and Al-Li exfoliation and stress corrosion cracking behavior. Also discussed are design considerations for novel aerospace vehicle materials, critical Al-Li alloy design factors, the application of Al-Li alloys in naval aircraft, and the superplastic forming characteristics of Al-Li sheet alloys. O.C.

A88-45205
SUPERPLASTIC FORMING CHARACTERISTICS AND PROPERTIES OF ALUMINUM-LITHIUM SHEET ALLOYS
MICHAEL J. REYNOLDS (Superform USA, Inc., Riverside, CA), CONSTANCE A. HENSHALL, and JEFFREY WADSWORTH (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) IN: Aluminum-lithium alloys: Design, development and application update; Proceedings of the Symposium, Los Angeles, CA, Mar. 25, 26, 1987. Metals Park, OH, ASM International, 1988, p. 357, 359-365, 367-399. Research supported by the Lockheed Missiles and Space Co., Inc.

A process has been developed for ingots of the Al-Li alloy 2090 which imparts the requisite microstructure for superplastic forming. Attention is presently given to representative applications of the alloy and the results of aging studies aimed at determining the T6 condition of 2090 alloy components. No apparent correlation is found between the degree of thinning and the strength developed after aging; the aged alloy exhibits an ultimate tensile strength of 61.8 ksi, with 10.2 percent elongation. Microstructure appeared uniform in both the as-formed and aged conditions, and cavitation was minimal. O.C.

A88-46305
MATERIALS SCIENCE IN SPACE: THEORY-EXPERIMENTS-TECHNOLOGY
LIA L. REGEL (Akademiia Nauk SSSR, Institut Kosmicheskikh Issledovanii, Moscow, USSR) (Itogi Nauki i Tekhniki, Seriia Issledovanie Kosmicheskogo Prostranstva, vol. 21, 1984) New York, Halsted Press, 1987, 253 p. Translation. Previously cited in issue 03, p. 270, Accession no. A85-13500. refs

A88-47449
RECENT ADVANCES IN AEROSPACE REFRACTORY METAL ALLOYS
J. WADSWORTH, T. G. NIEH, and J. J. STEPHENS (Lockheed Missiles and Space Co., Inc., Research and Development Div., Palo Alto, CA) International Materials Reviews (ISSN 0950-6608), vol. 33, no. 3, 1988, p. 131-150. Research supported by the Lockheed Independent Research and Development Program. refs

The development of refractory metal alloys for aerospace applications is discussed. While refractory metals are prime candidates for many high-temperature aerospace components due to their high melting points and inherent creep resistance, their use is often limited by poor room temperature properties, inadequate oxidation resistance at elevated temperatures, or difficulties associated with joining or welding. Current research on the development of creep resistant niobium and tantalum alloys that are inherently oxidation resistant is described. Examples of novel solid state joining developments in tungsten and molybdenum alloys below and above their recrystallization temperatures are provided. K.K.

A88-47971*# Communications Research Centre, Ottawa (Ontario).
RESULTS OF APPARENT ATOMIC OXYGEN REACTIONS WITH SPACECRAFT MATERIALS DURING SHUTTLE FLIGHT STS-41G
D. G. ZIMCIK (CDC, Communications Research Centre, Ottawa, Canada) and C. R. MAAG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA) (Shuttle Environment and Operations II Conference, Houston, TX, Nov. 13-15, 1985, Technical Papers, p. 181-189) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 162-168. Previously cited in issue 03, p. 268, Accession no. A86-14403. refs

A88-49260
RADIATION INSPECTION METHODS FOR COMPOSITES
T. S. JONES, D. POLANSKY, and H. BERGER (Industrial Quality, Inc., Gaithersburg, MD) NDT International (ISSN 0308-9126), vol. 21, Aug. 1988, p. 277-282. refs

Radiography and ultrasonics are the generally selected methods for nondestructive inspection of fiber-reinforced polymer

composites used in high-performance applications such as aircraft and space structures. As a result of their application and adaptation in this field, both methods have taken on a number of new aspects. Some of the advances in radiographic inspection techniques are reviewed here, together with the various criteria affecting their use in a particular situation. Examples of composites radiography by several different methods are presented. Author

A88-54990*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
VELOCITY DISTRIBUTIONS OF OXYGEN ATOMS INCIDENT ON SPACECRAFT SURFACES
P. N. PETERS, R. C. SISK (NASA, Marshall Space Flight Center, AL), and J. C. GREGORY (Alabama, University, Huntsville) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 53-58. refs
(Contract NAGW-823; NAS8-36645)

The angular distributions of oxygen atoms incident on surfaces in low earth orbit have been calculated for a number of ambient gas temperatures. Atom fluxes to surfaces were modeled by integrals over all permitted angles of incidence. Angles of incidence are limited by masking structures, and a number of types of mask were considered. Combustible surfaces exposed to the orbital atmosphere are heavily etched, creating profiles in mask shadows that are sensitive to ambient temperatures. The influence of the angular distributions on the characteristics of etched surfaces is discussed. Profiles measured for a September, 1983 flight were fitted to this model profile with a temperature of 750 + or - 50 K, which agrees with estimates based on solar activity at that time. Applications to sensing ambient temperatures and oxygen atom densities are discussed. Author

N88-27341# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France). Div. Systemes Strategiques et Spatiaux.
REINFORCED PLASTICS: WINDING AND WEAVING TECHNOLOGIES FOR SPACE PRODUCTS
J. BOUVARD 1988 12 p In FRENCH
(REPT-881-430-103; ETN-88-92851) Avail: NTIS HC A03/MF A01

Multidirectional weaving and filament winding techniques are described and application examples to space structures are presented, including the Ariane 5 booster model, sandwich structures for several spacecraft, solar panel structures, helium containers, pipes, and inserts. It is shown that the space applications of these techniques are growing very fast due to definite weight saving advantages. ESA

N88-28754# Dynamics Technology, Inc., Torrance, CA.
LABORATORY FEASIBILITY STUDY OF A COMPOSITE EMBEDDED FIBER OPTIC SENSOR FOR MEASUREMENT OF STRUCTURAL VIBRATIONS Report, Oct. 1987 - Feb. 1988
C. M. DUBE, TOM D. WANG, ROBERT G. MELTON, DAVID W. JENSON, and MIKE KOHARCHIK (Pennsylvania State Univ., University Park.) Feb. 1988 47 p
(AD-A194270; DT-8723-01) Avail: NTIS HC A03/MF A01
CSCL 11D

The feasibility is assessed of using fiber optic strain sensors embedded in a composite material to measure the magnitude and frequency of structural vibrations for control of flexible elements. This study demonstrates the ability to embed fiber optic strain sensors in a composite material, determines the performance of these sensors, identifies active control system architectures that are matched to the fiber optic system measurands to damp vibrations of large space structures, and estimates the stability achievable by these methods. A detailed laboratory study was performed using a wide band closed-loop-fiber Mach-Zehnder interferometer to conduct transverse vibration measurements on sub-scale composite elements with embedded fiber sensors. The interferometer detects vibrations by measuring the strain transferred by the composite to the embedded optical fiber. The strain sensor demonstrated the ability to track the vibrations of a cantilever beam over a frequency bandwidth ranging from approximately 5 Hz to almost 1000 Hz. The sensor was unable to detect dc strains because of thermal drift and laser power fluctuations. These factors produced a drift in the dc signal level, which was indistinguishable from static strain measurements. Beyond 1000 Hz, the composite element was unable to follow the drive mechanism. The noise equivalent strain was epsilon is approximately 10 to the minus 10th power. GRA

N88-28977# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
CONTRIBUTION TO THE STUDY OF MATERIALS BEHAVIOR IN SPACE ENVIRONMENT
P. PLOTARD and F. ALBUGUES 1988 9 p
(SNIAS-881-430-104; ETN-88-92852) Avail: NTIS HC A02/MF A01

Facilities to study dimensional stability and for nondestructive in situ analysis of spacecraft materials and components are described. The simulation takes into account solar UV, vacuum, temperature, thermal cycle, and particle effects, with computed dose evaluation corresponding to selected orbits. Results for kevlar and carbon with epoxy resin matrix composites are presented. ESA

N88-28978# Societe Nationale Industrielle Aerospatiale, Saint-Medard-en-Jalles (France).
VERY HIGH TEMPERATURE MATERIALS FOR MECHANICAL APPLICATION
V. L. MAGRET and A. HORBONNEAU 1988 5 p
(SNIAS-881-430-106; ETN-88-92854) Avail: NTIS HC A02/MF A01

Ceramic composite materials which demonstrate temperature resistance up to 1400 C, and oxidation resistant carbon-carbon with coating adapted to service temperature were developed for space use. Base on experience in weaving and densification, demonstration parts were manufactured. ESA

N88-29190# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials and Processes Div.
MATERIAL AND PROCESS SELECTION AND QUALITY CONTROL FOR ESA SPACE SYSTEMS AND ASSOCIATED EQUIPMENT
Oct. 1987 26 p
(ESA-PSS-01-70-ISSUE-3; ISSN-0379-4059; ETN-88-92913)
Avail: NTIS HC A03/MF A01

The requirements for a material and process selection and control program for space systems and associated equipment in which the use of controlled materials and processes is mandatory are established. ESA

N88-30012# Universidad Autonoma de Madrid, Cantoblanco (Spain). Dept. of Applied Physics.
STUDY OF SECONDARY EMISSION PROPERTIES OF MATERIALS USED FOR HIGH POWER RF COMPONENTS IN SPACE Final Report
L. GALAN, C. MORANTI, F. RUEDA, and J. M. SANZ Paris, France ESA 1988 86 p
(Contract ESTEC-6577/85-NL-PB)
(ESA-CR(P)-2587; ETN-88-93031) Avail: NTIS HC A05/MF A01

Secondary electron emission (SEE) properties of materials used for high power waveguide components in space, particularly on surfaces for space hardware were studied, including Alodine surfaces before and after power conditioning. Surface treatments to aid multipactor suppression for these materials, including methods for surface protection and handling, were examined. If only true SEE is considered, Alodine coatings have better characteristics than TiN, TiC, Cr2O3, and C. The rugosity of Alodine may explain its good properties. No clear correlation between SEE characteristic values and multipactor threshold power is found; smaller SEE is not determinant for obtaining higher multipactor threshold power. ESA

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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.

A88-29402
NONLINEAR WAVES: STRUCTURES AND BIFURCATIONS [NELINEINYE VOLNY: STRUKTURY I BIFURKATSII]
A. V. GAPONOV-GREKHOV, ED. and M. I. RABINOVICH, ED. Moscow, Izdatel'stvo Nauka, 1987, 400 p. In Russian. For individual items see A88-29403 to A88-29409.

The papers contained in this volume focus on the problems of self-organization, dynamic chaos, and turbulence in relation to various physical applications. Papers are presented on the dynamics of structures in shear flows, two-dimensional vortices in an ideal liquid, interaction of systems with stochastic behavior, and spiral waves in distributed active media. Other topics discussed include solitons and chaos during resonance wave interaction, sound generation by turbulence, three-dimensional structures and nonlinear energy dissipation in strong plasma turbulence, and bifurcations and autowaves. V.L.

A88-34568
GRADUAL IMPLEMENTATION OF MICROGRAVITY TELESCIENCE - CONCEPT AND OPERATIONS
R. MONTI (Napoli, Universita, Naples, Italy) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 185-189.

The potential advantages of telescience (remote control of a space experiment by the principal investigator on the ground) are reviewed, and its implementation in the context of the ESA Columbus program is considered. It is pointed out that telescience applies the scientist's expertise with a particular experiment, permits quasi-real-time data processing using ground-based computer facilities, and saves valuable astronaut time for the most delicate operations. A gradual program of technology-evaluation studies, modifications of already flown experiments, ground tests on experimental test beds (including simulation of space communication links), and flight trials is described in detail and illustrated with diagrams. T.K.

A88-35143
DATA MANAGEMENT FOR COLUMBUS SPACE STATION
SILVIO BOESSO and RODOLFO GAMBERALE (Selenia Spazio S.p.A., Rome, Italy) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1433-1452. refs
(AAS PAPER 86-300)

The data management system of the pressurized module (PM-DMS) of ESA Columbus is discussed, with emphasis on the interconnection system and its constituent parts. Hardware and software features are discussed, in addition to fault tolerance and technological aspects. Intraelement communications between the PM-DMS functional blocks are performed by two low-rate networks, the subsystem local area network (LAN) and the payload LAN, and a medium-rate data collection network. Interconnection between the networks is nonhierarchical. Choices for the network physical medium, topology, and access protocols are also considered. R.R.

A88-36311* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
REAL-TIME MODEL-BASED VISION SYSTEM FOR OBJECT ACQUISITION AND TRACKING
BRIAN WILCOX, DONALD B. GENNERY, BRUCE BON, and TODD LITWIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Optical and digital pattern recognition; Proceedings of the Meeting, Los Angeles, CA, Jan. 13-15, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 276-281. refs

A machine vision system is described which is designed to acquire and track polyhedral objects moving and rotating in space by means of two or more cameras, programmable image-processing hardware, and a general-purpose computer for high-level functions. The image-processing hardware is capable of performing a large variety of operations on images and on image-like arrays of data. Acquisition utilizes image locations and velocities of the features extracted by the image-processing hardware to determine the three-dimensional position, orientation, velocity, and angular velocity of the object. Tracking correlates edges detected in the current image with edge locations predicted from an internal model of the object and its motion, continually updating velocity information to predict where edges should appear in future frames. With some 10 frames processed per second, real-time tracking is possible. V.L.

A88-45034
DATA MANAGEMENT FOR LARGE SPACE SYSTEMS
C. J. SHELFORD (British Aerospace, PLC, Space and Communications Div., Stevenage, England) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 41, July 1988, p. 307-309.

This paper examines the major tasks and features of an on-board data management system (DMS) being currently designed for large space systems. The special features of this DMS will include high damage tolerance, ability to provide communications between a large number of dissimilar data sources and to transfer data at high speed, high flexibility in terms of system operation and growth, and easy maintenance and servicing. A major element of the DMS is the data network which will be implemented as a 'local area network' and which will transport data between users at rates compatible with users' requirements. The network interfaces will be made simple, reliable, and effective and of a complexity consistent with the mission objectives. I.S.

A88-54853*# National Aeronautics and Space Administration, Washington, DC.
CONNECTIVITY IS THE KEY
DANA L. HALL (NASA, Space Station Program Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, Sept. 1988, p. 24-27.

Connectivity that would allow users at home to interact with an experiment in space and with facilities and services worldwide is a primary goal of the international Space Station program. The systems supporting such connectivity, including the Space Station Information System, the Technical and Management Information System, and the Software Support Environment, are discussed here. The primary purposes of each system and their operational data are addressed. C.D.

N88-23812*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
ENVIRONET: AN INTERACTIVE SPACE-ENVIRONMENT INFORMATION RESOURCE
ALFRED L. VAMPOLA, WILLIAM N. HALL (Air Force Geophysics Lab., Hanscom AFB, Mass.), and MICHAEL LAURIENTE 24 May 1988 13 p Prepared for Air Force Space Div., Los Angeles, Calif.
(Contract F04701-85-C-0086-P00019)
(NASA-TM-101137; TR-0088(3671-01)-1; NAS 1.15:101137; SD-TR-88-60; AD-A197556) Avail: NTIS HC A03/MF A01 CSCL 22A

EnviroNET is an interactive menu-driven system set up as an information resource for experimenters, program managers, and design and test engineers involved in space missions. Its basic use is as a fundamental single source of data for the environment encountered by Shuttle and Space Station payloads, but it also has wider applicability in that it includes information on

environments encountered by other satellites in both low altitude and high altitude (including geosynchronous) orbits. It incorporates both a text-retrieval mode and an interactive modeling code mode. The system is maintained on the ENVET MicroVAX computer at NASA/Goddard Space Flight Center. Its services are available at no cost to any user who has access to a terminal and modem. It is a tail-node on SPAN, and so it is accessible either directly or through BITNET, ARPANET, and GTE/TELENET via NPSS.
Author

N88-23931*# Ohio State Univ., Columbus. ElectroScience Lab.
MANUAL FOR OBSCURATION CODE WITH SPACE STATION APPLICATIONS
R. J. MARHEFKA and L. TAKACS May 1986 237 p
(Contract NSG-1498)
(NASA-CR-178099; NAS 1.26:178099; REPT-716199-7) Avail: NTIS HC A11/MF A01 CSCL 20N

The Obscuration Code, referred to as SHADOW, is a user-oriented computer code to determine the case shadow of an antenna in a complex environment onto the far zone sphere. The surrounding structure can be composed of multiple composite cone frustums and multiply sided flat plates. These structural pieces are ideal for modeling space station configurations. The means of describing the geometry input is compatible with the NEC-BASIC Scattering Code. In addition, an interactive mode of operation has been provided for DEC VAX computers. The first part of this document is a user's manual designed to give a description of the method used to obtain the shadow map, to provide an overall view of the operation of the computer code, to instruct a user in how to model structures, and to give examples of inputs and outputs. The second part is a code manual that details how to set up the interactive and non-interactive modes of the code and provides a listing and brief description of each of the subroutines.
Author

N88-24632*# Taylor and Associates, Inc., Wrightwood, CA.
SPACE STATION ARCHITECTURAL ELEMENTS MODEL STUDY
T. C. TAYLOR, J. S. SPENCER, C. J. ROCHA, E. KAHN, E. CLIFFTON, and C. CARR Washington NASA Jan. 1987 155 p
(NASA-CR-4027; NAS 1.26:4027) Avail: NTIS HC A08/MF A01 CSCL 01C

The worksphere, a user controlled computer workstation enclosure, was expanded in scope to an engineering workstation suitable for use on the Space Station as a crewmember desk in orbit. The concept was also explored as a module control station capable of enclosing enough equipment to control the station from each module. The concept has commercial potential for the Space Station and surface workstation applications. The central triangular beam interior configuration was expanded and refined to seven different beam configurations. These included triangular on center, triangular off center, square, hexagonal small, hexagonal medium, hexagonal large and the H beam. Each was explored with some considerations as to the utilities and a suggested evaluation factor methodology was presented. Scale models of each concept were made. The models were helpful in researching the seven beam configurations and determining the negative residual (unused) volume of each configuration. A flexible hardware evaluation factor concept is proposed which could be helpful in evaluating interior space volumes from a human factors point of view. A magnetic version with all the graphics is available from the author or the technical monitor.
Author

N88-29383*# Martin Marietta Aerospace, Denver, CO.
A SCHEDULING AND RESOURCE MANAGEMENT SYSTEM FOR SPACE APPLICATIONS
DANIEL L. BRITT, AMY L. GEOFFROY, and JOHN R. GOHRING *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 303-310 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05A

Every spacecraft, whether in orbit around the earth or an a deep space flight, has at its disposal limited amounts of the resources for it to accomplish its mission. Activity scheduling is currently a costly, human intensive task which requires a great deal of expertise. It belongs to a class of problems whose complexity increases exponentially with the number of operations. NASA has in the past accomplished this task by using a great deal of manpower, a large number of negotiating sessions, interminable bouts of phone tag, and mountains of paperwork. Lately the situation has improved with the introduction of automated scheduling techniques, but these to date still require expert involvement and fall short in some important ways. A prototype activity scheduler, MAESTRO, is introduced which is capable of meeting the needs of many NASA missions, eventually to include the Space Station. The approach to resource constrained scheduling is first discussed, then the intended domain for MAESTRO is described along with its design and current capabilities. A description of planned enhancements and revisions to the systems is also presented.
Author

N88-29384*# General Dynamics Corp., San Diego, CA. Space Systems Div.
AN EXPERT SYSTEMS APPLICATION TO SPACE BASE DATA PROCESSING
STEPHEN M. BABB *In* NASA, Marshall Space Flight Center, Second Conference on Artificial Intelligence for Space Applications p 311-318 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05A

The advent of space vehicles with their increased data requirements are reflected in the complexity of future telemetry systems. Space based operations with its immense operating costs will shift the burden of data processing and routine analysis from the space station to the Orbital Transfer Vehicle (OTV). A research and development project is described which addresses the real time onboard data processing tasks associated with a space based vehicle, specifically focusing on an implementation of an expert system.
Author

N88-29404*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
EXPERIMENT SCHEDULING FOR SPACELAB MISSIONS
JOHN JAAP and ELIZABETH DAVIS *In its* Second Conference on Artificial Intelligence for Space Applications p 475-488 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05A

The Experiment Scheduling Program (ESP) is the heart of a group of programs developed at NASA-Marshall to schedule the experiment activities of Spacelab and other Shuttle missions. Other programs in the group either prepare input data for ESP or produce derivative information based on the schedule produced by ESP. The task of experiment scheduling can be simply stated as positioning the experiment activities in a mission to that they collect their desired data without interfering with other activities. The program's capabilities as seen by the user are described along with mission constraints the program handles, and how the expert system in the program handles these constraints.
Author

N88-30342*# Ford Aerospace and Communications Corp., College Park, MD.
INTEGRATED RESOURCE SCHEDULING IN A DISTRIBUTED SCHEDULING ENVIRONMENT
DAVID ZOCH and GARDINER HALL *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 155-172 Aug. 1988
Avail: NTIS HC A19/MF A01 CSCL 09B

The Space Station era presents a highly-complex multi-mission planning and scheduling environment exercised over a highly distributed system. In order to automate the scheduling process, customers require a mechanism for communicating their scheduling requirements to NASA. A request language that a remotely-located customer can use to specify his scheduling requirements to a NASA scheduler, thus automating the customer-scheduler interface, is described. This notation, Flexible Envelope-Request Notation (FERN), allows the user to completely specify his scheduling

requirements such as resource usage, temporal constraints, and scheduling preferences and options. The FERN also contains mechanisms for representing schedule and resource availability information, which are used in the inter-scheduler inconsistency resolution process. Additionally, a scheduler is described that can accept these requests, process them, generate schedules, and return schedule and resource availability information to the requester. The Request-Oriented Scheduling Engine (ROSE) was designed to function either as an independent scheduler or as a scheduling element in a network of schedulers. When used in a network of schedulers, each ROSE communicates schedule and resource usage information to other schedulers via the FERN notation, enabling inconsistencies to be resolved between schedulers. Individual ROSE schedules are created by viewing the problem as a constraint satisfaction problem with a heuristically guided search strategy. Author

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ACCOMMODATIONS

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

A88-29856
PHONON GENERATION UNDER CONDITIONS OF THE DAYEM-MARTIN EFFECT [GENERATSIIA FONONOV V USLOVIIAKH EFFEKTA DAIEMA-MARTINA]
V. N. KOSTUR, V. P. SEMINOZHENKO, and S. E. SHAFRANIUK (AN USSR, Institut Metallofiziki, Kiev; Nauchno-Proizvodstvenoe Ob'edinenie Monokristallreaktiv, Kharkov, Ukrainian SSR) Fizika Nizkikh Temperatur (ISSN 0132-6414), vol. 14, Feb. 1988, p. 118-124. In Russian. refs

The paper is concerned with nonequilibrium effects arising in SIS-prime film junctions in a microwave field in the multiphoton regime. It is shown that the absorption of the field energy takes place mainly in electron tunneling processes involving photons along two channels (scattering and recombination), with part of the absorbed energy transformed to the energy of radiated nonequilibrium phonons. Various regimes of phonon radiation by symmetric and nonsymmetric junctions are examined. V.L.

A88-34569
CREW WORK STATION TEST-BED
J. HOWIESON, W. VAN LEEUWEN, and W. J. OCKELS (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 191-194.

The quality of the man machine combination in a manned space system depends on how safely and reliably the astronaut can execute responsibilities and effectively perform the work. The Crew Work Station (CWS) Test-Bed in ESTEC has been established as a reference of state-of-the-art man machine interface technology so that ESA and industry can acquire the expertise necessary for Columbus. It is an experimental laboratory for early validation of concepts and technology, and to provide facilities for the Columbus utilization community to influence Columbus design. An initial program of investigations was carried out during 1987 into a wide range of CWS aspects. Author

A88-35102
GROUND-TEST OF SPACECRAFT CONTROL AND DYNAMICS
SHERMAN M. SELTZER and MICHAEL A. POPE (Control Dynamics Co., Huntsville, AL) IN: Aerospace century XXI: Space flight technologies; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 763-785.
(AAS PAPER 86-267)

The dynamic behavior and closed-loop control of large space structures are being demonstrated and verified at NASA-Marshall in a new facility that consists of a control torque command-furnishing payload-mounting system to which test articles are connected. The mounting system is in turn attached to a base-excitation system that can simulate the disturbances that are most likely to occur with Space Shuttle Orbiter and Department of Defense payloads. A control computer contains the calibration software, reference system, alignment procedures, telemetry software, and control algorithms. The facility can be extensively modified to emulate various spacecraft configurations. O.C.

A88-43372* Boeing Co., Seattle, WA.
SPACE STATION SYNERGETIC RAM-LOGISTICS ANALYSIS
EDMUND T. DEJULIO (Boeing Co., Seattle, WA) and JOEL H. LEET (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Annual Reliability and Maintainability Symposium, Los Angeles, CA, Jan. 26-28, 1988, Proceedings. New York, Institute of Electrical and Electronics Engineers, Inc., 1988, p. 410-415.

NASA's Space Station Maintenance Planning and Analysis (MP&A) Study is a step in the overall Space Station Program to define optimum approaches for on-orbit maintenance planning and logistics support. The approach used in the MP&A study and the analysis process used are presented. Emphasis is on maintenance activities and processes that can be accomplished on orbit within the known design and support constraints of the Space Station. From these analyses, recommendations for maintainability/maintenance requirements are established. The ultimate goal of the study is to reduce on-orbit maintenance requirements to a practical and safe minimum, thereby conserving crew time for productive endeavors. The reliability, availability, and maintainability (RAM) and operations performance evaluation models used were assembled and developed as part of the MP&A study and are described. A representative space station system design is presented to illustrate the analysis process. I.E.

A88-52330* National Aeronautics and Space Administration. John F. Kennedy Space Center, Cocoa Beach, FL.
SYSTEMS INTEGRATION FOR THE KENNEDY SPACE CENTER (KSC) ROBOTICS APPLICATIONS DEVELOPMENT LABORATORY (RADL)
V. LEON DAVIS and ROSS NORDEEN (NASA, Kennedy Space Center, Cocoa Beach, FL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 3-80 to 3-88.

A laboratory for developing robotics technology for hazardous and repetitive Shuttle and payload processing activities is discussed. An overview of the computer hardware and software responsible for integrating the laboratory systems is given. The center's anthropomorphic robot is placed on a track allowing it to be moved to different stations. Various aspects of the laboratory equipment are described, including industrial robot arm control, smart systems integration, the supervisory computer, programmable process controller, real-time tracking controller, image processing hardware, and control display graphics. Topics of research include: automated loading and unloading of hypergolics for space vehicles and payloads; the use of mobile robotics for security, fire fighting, and hazardous spill operations; nondestructive testing for SRB joint and seal verification; Shuttle Orbiter radiator damage inspection; and Orbiter contour measurements. The possibility of expanding the laboratory in the future is examined. R.B.

A88-55333#
EARLY SPACE STATION LABORATORY USER ACTIVITIES
R. W. HAGER and H. J. WILLENBERG (Boeing Aerospace Co., Huntsville, AL) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 5 p.
(IAF PAPER 88-068)

The international Space Station laboratories are being designed to accommodate a variety of scientific and technological disciplines,

including materials processing research and applications, biological and biomedical science, and technology development. Efforts are underway to ensure that valuable scientific value is achieved as early as possible in the Space Station assembly schedule. These efforts include planning for external payloads on the Space Station even before pressurized volume is available, revising the assembly sequence to accelerate the U.S. Laboratory launch schedule, operating experimental payloads in the USL in a man-tended mode of operation with remote control from earth-bound experimenters, and providing a laboratory robot to enhance the USL capabilities to operate in this mode. Resources available to support user operations during the early assembly sequence will also be addressed. Author

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GROWTH

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

A88-26397
DECENTRALIZED ROBUST OUTPUT AND ESTIMATED STATE FEEDBACK CONTROLS FOR LARGE-SCALE UNCERTAIN SYSTEMS
Y. H. CHEN (Syracuse University, NY) International Journal of Control (ISSN 0020-7179), vol. 46, Dec. 1987, p. 1979-1992. refs

This paper considers the design of decentralized robust output controls. The system under consideration is composed of interconnected subsystems with time-varying uncertainties. The decentralized control is based on the information of the local output. No communication is allowed among subsystems. The proposed control strategy is a combination of direct and indirect decentralized controls. The salient feature of the controls is that they require only information about the possible bounds of uncertainties. Author

A88-35051
AEROSPACE CENTURY XXI: SPACE MISSIONS AND POLICY; PROCEEDINGS OF THE THIRTY-THIRD ANNUAL AAS INTERNATIONAL CONFERENCE, BOULDER, CO, OCT. 26-29, 1986
GEORGE W. MORGENTHALER, ED. (Colorado, University, Boulder) and GAYLE L. MAY, ED. Conference sponsored by AAS. San Diego, CA, Univelt, Inc., 1987, 685 p. For individual items see A88-35052 to A88-35092.

The present conference discusses the NASA Space Station's evolution and development status, the Spacehab testbed, Space Station benefits from tether operations, the Columbus resource module for ESA's man-tended free-flier, global climate research with Topex/Poseidon, the Saenger and Hotol reusable launcher concepts, the Tethered Satellite System, mission analysis and phased development of a lunar base, and extraterrestrial infrastructure design projects. Also discussed are the Galileo mission to Jupiter and the Magellan mission to Venus; future international space programs; ESA, German, and Japanese space exploration plans; future applications of space law, and recent developments in U.S. space policy and law; space science and engineering education; and public and professional attitudes to space exploration in the U.S. O.C.

A88-35052* National Aeronautics and Space Administration, Washington, DC.
SPACE STATION DEVELOPMENT
EDWIN E. SPEAKER (NASA, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 3-11.
(AAS PAPER 86-255)

NASA has recently completed an in-depth review of the Space Station Program plan and is considering several changes to the baseline configuration and to the launch and assembly sequence. These configurational changes will facilitate development as well as system operation, although a few more launches are required. However, the new sequence will allow more useful payload activities earlier than previously planned, and will still result in a permanently manned capability by 1994. Author

A88-35053* National Aeronautics and Space Administration, Washington, DC.
SPACE STATION EVOLUTION
DAVID C. BLACK (NASA, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 13-15.
(AAS PAPER 86-262)

The Space Station that will be launched and made operational in the early 1990s should be viewed as a beginning, a facility that will evolve with the passing of time to better meet the needs and requirements of a diverse set of users. Evolution takes several forms, ranging from simple growth through addition of infrastructure elements to upgrading of system capability through inclusion of advanced technologies. Much of the early considerations of Space Station evolution focused on physical growth. However, a series of recent workshops have revealed that the more likely mode of Space Station evolution will not be through growth but rather through a process known as 'branching'. Author

A88-35064* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
RATIONALE FOR AN INTEGRATED MOON/MARS EXPLORATION PROGRAM
MICHAEL B. DUKE (NASA, Johnson Space Center, Houston, TX) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 235-244. refs
(AAS PAPER 86-271)

Although it is possible to design manned missions to Mars that do not involve prior lunar missions, a strategy that includes development of a lunar base before or concurrent with the Mars program offers potential benefits from space infrastructure development, space operations experience, and utilization of lunar materials for propulsion. Common utilization of infrastructure elements (e.g., Orbital Transfer Vehicles, Space Operation Center modules) is emphasized in this approach. Mass flows through a low Earth orbit Space Station change in quantity and in proportion of propellant to hardware as the infrastructure develops. Author

A88-35065* National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
MISSION ANALYSIS AND PHASED DEVELOPMENT OF A LUNAR BASE
BARNEY B. ROBERTS (NASA, Johnson Space Center, Houston, TX) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 245-263. refs
(Contract NAS9-17356; NAS9-17335; NAS9-17317)
(AAS PAPER 86-272)

Planned activities at a manned lunar base can be categorized as supporting one or more of three possible objectives: scientific research, exploitation of lunar resources for use in building a space infrastructure, or attainment of self-sufficiency in the lunar environment as a first step in planetary habitation. Scenarios constructed around each of the three goals have many common elements, particularly in the early phases. In addition, the process of constructing the scenario clearly demonstrated that later phases were critically dependent on technologies, systems, and elements developed during the early phases. The cost and the complexity

of the base, as well as the structure of the Space Transportation System, are functions of the chosen long-term strategy. A real lunar base will manifest some combination of characteristics from these idealized end members. Author

A88-35073* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROSPECTIVE LUNAR, PLANETARY AND DEEP SPACE APPLICATIONS OF TETHERS
PAUL A. PENZO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 419-431. refs
(AAS PAPER 86-367)

Projected flights of an internationally managed Tethered Satellite System from the Space Shuttle in the early 1990s will investigate the behavior, first, of an insulated conducting wire 20 km long as it travels at orbital speeds through the ionosphere and earth magnetic field; subsequently, a nonconducting tether will be used to lower an instrumented 'subsatellite' 100 km downward to investigate upper-atmosphere conditions. Further consideration is presently given to other scientific, electrodynamic, transportational, and artificial gravity-generating applications of the tether concept. O.C.

A88-39420#
FUTURE OPERATIONAL ASPECTS OF THE SPACE STATION
GERHARD LIPPNER Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 49-51.

The tasks of International Space Station operation definition and execution are discussed. A grouping into hierarchical levels of tasks and their planning/update periods would result in the sequence: (1) strategic management; (2) tactical management; (3) mission management; (4) element operation, aimed at execution of the element time line and module control; (5) module operation, with emphasis on task distribution/control for subsystems, crew, payload, and between onboard and ground operators; and (6) subsystem operation, including subsystem control. Attention is given to ground infrastructure and the optimization of operational costs. O.C.

A88-43979#
LUNAR BASE LOGISTICS
DANI EDER (Boeing Aerospace Co., Seattle, WA) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 299-301. refs

Three types of support tasks, or 'logistics', for a lunar base are discussed with an emphasis on using local lunar source materials to reduce support costs for a base. Using a system of two orbiting tethers as momentum transfer devices, and lunar-derived oxygen plus hydrogen from earth for propulsion, cargo can be delivered to the lunar surface with a propellant overhead of 5.6 percent of payload weight. This is 15 times less than a mass driver/OTV/lunar oxygen system and 64 times less than the all-earth-propellant case. Local construction materials can be separated by composition by dense-gas flotation. Glass fibers and cast basalt from lunar sources can be used as construction materials. Supply of photovoltaic power during the lunar night can be accomplished by heating surface material during the day, then using the radiation from the hot regolith at night. Author

A88-43992*# Los Alamos National Lab., NM.
THE ECONOMICS OF MINING THE MARTIAN MOONS
RAYMOND S. LEONARD (Ad Astra, Ltd., Santa Fe, NM), JAMES D. BLACIC, and DAVID T. VANIMAN (Los Alamos National Laboratory, NM) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 380-395. Research supported by Los Alamos National Laboratory, Ad Astra, Ltd., and NASA. refs

The costs for extracting and shipping volatiles such as water, carbon, and nitrogen that might be found on Phobos and Deimos are estimated. The costs are compared to the cost of shipping the same volatiles from earth, assuming the use of nuclear powered mining facilities and freighters. Mineral resources and possible products from the Martian moons, possible markets for these products, and the costs of transporting these resources to LEO or GEO or to transportation nodal points are examined. Most of the technology needed to mine the moons has already been developed. The need for extraterrestrial sources of propellants for ion propulsion systems and ways in which the mining of the moons would reduce the cost of space operations near earth are discussed. It is concluded that it would be commercially viable to mine the Martian moons, making a profit of at least a 10 percent return on capital. R.B.

A88-44150
THE U.S. SPACE STATION - A QUARTER-CENTURY OF EVOLUTION
PHILIP D. HATTIS (Charles Stark Draper Laboratory., Inc., Cambridge, MA) Technology Review (ISSN 0040-1692), vol. 91, July 1988, p. 28-40.

In October, 1986, NASA Langley's Critical Evaluation Task Force recommended that the Space Station be built in two phases. The relatively modest Phase I station would encompass the central horizontal truss of the dual-keel model, together with all pressurized modules; this would entail 19 Space Shuttle flights over three years. Phase II, for which funding approval would be sought only after substantial progress toward launching Phase I, would use six additional Shuttle flights to put the full dual-keel Space Station configuration in operating order. As Phase I is embarked upon, major programmatic questions remain as to the intersection of military and international interests in the Space Station's design and use. O.C.

A88-44670#
AUTONOMOUS FLIGHT CONTROL FOR LOW THRUST ORBITAL TRANSFER VEHICLES
RONALD E. OGLEVIE, THOMAS R. EGAN (Irvine Technology Group, Inc., CA), and JAY P. PENN (Aerospace Corp., El Segundo, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 12 p.
(Contract F04701-87-C-0078)
(AIAA PAPER 88-2838)

USAF's Systems Command is evaluating the use of an electric-propulsion OTV (EOTV) for the reduced-cost replenishment of GPS and geosynchronous spacecraft. The EOTV must be capable of highly autonomous navigation, docking, and fault-management operations; it will be so optimally guided as to minimize transfer time, irrespective of the effects of solar occultation and earth oblateness. GPS navigation, cellestially-aided inertial attitude determination, and scanning lidar for docking, will be incorporated in the EOTV. Software requirements have been determined to lie within the capacity of existing flight-qualified computers. O.C.

A88-44684#
EXTENDED DURATION ORBITER
T. BARRERA (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 24th, Boston, MA, July 11-13, 1988. 5 p.
(AIAA PAPER 88-2864)

This paper describes the existing Space Shuttle Orbiter on-orbit stay time capability and enhancements required to provide additional mission duration. Improvements to the Orbiter Power Generation System, Environmental Control and Life Support System and crew accommodations are discussed. In addition, Extended Duration Orbiter Program benefits and Program Implementation Plans are discussed. Author

A88-52338
SPACE STATION RAPID SAMPLE RETURN REVISITED
CARL M. CASE and BENJAMIN J. HARMAN (Boeing Aerospace Co., Huntsville, AL) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-77 to 5-80. refs

The future users of the Space Station's U.S. Laboratory module, which will contain life science and materials science experiments, expressed a desire for a user-directed rapid sample return (RSR) capability for providing rapid feedback to the spaceborne experiments. This paper estimates the projected annual frequency of material samples requiring ground characterization, examines the capability of an RSR system, and explores the requirements and cost drivers for such a system. It is shown that significant productivity benefits can be derived from a Space Station RSR system which is relatively low cost and capable of returning experimental samples to earth between regularly scheduled Shuttle visits. I.S.

A88-52373
SHUTTLE-C - A SHUTTLE DERIVED LAUNCH VEHICLE
TERRY R. MITCHELL IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 12-1 to 12-12.

The cargo version of the NASA Space Shuttle, designated 'Shuttle-C', uses the main engines, solid rocket boosters, external tanks, and launch facilities of the standard vehicle, replacing the manned Orbiter with an unmanned cargo carrier capable of placing payloads weighing 100,000-150,000 lbs into LEO; this compares with a 65,000-lb capability for the standard Shuttle. Shuttle-C will be used to launch and assemble such structures as those of the Space Station, as well as for the launching of large planetary probe payloads requiring heavy upper stages. Initial operation is projected to lie in the 1994 time-frame. O.C.

N88-21188*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
SPACE STATION HEAVY LIFT LAUNCH VEHICLE UTILIZATION Technical Memorandum, Jan. - Dec. 1987
L. J. DERYDER Apr. 1988 177 p
(NASA-TM-100604; NAS 1.15:100604) Avail: NTIS HC A09/MF A01 CSCL 22B

The use of Heavy Lift Launch Vehicles (HLLVs) for Space Station assembly, logistics. and resupply is explored. Potential HLLVs, including those based on the Titan, and Shuttle-derived vehicles (SDV), are discussed. The baseline Critical Evaluation Task Force (CETF) Space Station assembly sequence is described and compared with assembly options made possible through the use of HLLVs. The issues of cost, dual compatibility with the Space Shuttle Space Transportation System (STS), co-manifesting of payloads with other science missions cargo return, and ground handling and launch facilities are also considered. The main advantage achieved by using HLLVs are simplification of assembly procedures, added resupply capability, and increased assured access to space. The major disadvantages are increased orbital flight operations complexity, higher logistics costs, and additional ground handling/launch facility requirements. Also, there will not be any improvement in return cargo capacity, nor any addition to crew transport capabilities. Finally, the dual STS/HLLV compatibility should be maintained to minimize program risk. HLLV and Orbital Maneuvering Vehicle design must parallel that of the Space Station. Author

N88-23711*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
MANNED MARS MISSION ACCOMMODATION: SPRINT MISSION
WILLIAM M. CIRILLO, MARTIN J. KASZUBOWSKI, J. KIRK AYERS, CHARLES P. LLEWELLYN (PRC Systems Services Co., Hampton, Va.), DEENE J. WEIDMAN, and BARRY D. MEREDITH Apr. 1988 157 p
(NASA-TM-100598; NAS 1.15:100598) Avail: NTIS HC A08/MF A01 CSCL 03B

The results of a study conducted at the NASA-LaRC to assess the impacts on the Phase 2 Space Station of Accommodating a Manned Mission to Mars are documented. In addition, several candidate transportation node configurations are presented to accommodate the assembly and verification of the Mars Mission vehicles. This study includes an identification of a life science research program that would need to be completed, on-orbit, prior to mission departure and an assessment of the necessary orbital technology development and demonstration program needed to accomplish the mission. Also included is an analysis of the configuration mass properties and a preliminary analysis of the Space Station control system sizing that would be required to control the station. Results of the study indicate the Phase 2 Space Station can support a manned mission to Mars with the addition of a supporting infrastructure that includes a propellant depot, assembly hanger, and a heavy lift launch vehicle to support the large launch requirements. Author

N88-25414*# Eagle Engineering, Inc., Webster, TX.
MARS ROVER/SAMPLE RETURN MISSION REQUIREMENTS AFFECTING SPACE STATION
31 Mar. 1988 117 p
(Contract NAS9-17878)
(NASA-CR-172048; NAS 1.26:172048; EEI-88-183) Avail: NTIS HC A06/MF A01 CSCL 03B

The possible interfaces between the Space Station and the Mars Rover/Sample Return (MRSR) mission are defined. In order to constrain the scope of the report a series of seven design reference missions divided into three major types were assumed. These missions were defined to span the probable range of Space Station-MRSR interactions. The options were reduced, the MRSR sample handling requirements and baseline assumptions about the MRSR hardware and the key design features and requirements of the Space Station are summarized. Only the aspects of the design reference missions necessary to define the interfaces, hooks and scars, and other provisions on the Space Station are considered. An analysis of each of the three major design reference missions, is reported, presenting conceptual designs of key hardware to be mounted on the Space Station, a definition of weights, interfaces, and required hooks and scars. Author

N88-28944*# Eagle Engineering, Inc., Houston, TX.
SPACE TRANSPORTATION NODES ASSUMPTIONS AND REQUIREMENTS: LUNAR BASE SYSTEMS STUDY TASK 2.1
TAHER ALI KAHN, CHARLES H. SIMONDS, and WILLIAM R. STUMP 18 Apr. 1988 86 p
(Contract NAS9-17878; TO-87-57)
(NASA-CR-172052; NAS 1.26:172052; EEI-87-174) Avail: NTIS HC A05/MF A01 CSCL 22B

The Space Transportation Nodes Assumptions and Requirements task was performed as part of the Advanced Space Transportation Support Contract, a NASA Johnson Space Center (JSC) study intended to provide planning for a Lunar Base near the year 2000. The original task statement has been revised to satisfy the following queries: (1) What vehicles are to be processed at the transportation node; (2) What is the flow of activities involved in a vehicle passing through the node; and (3) What node support resources are necessary to support a lunar scenario traffic model composed of a mix of vehicles in an active flight schedule. The Lunar Base Systems Study is concentrating on the initial years of the Phase 2 Lunar Base Scenario. The study will develop the first five years of that phase in order to define the transportation and surface systems (including mass, volumes, power requirements, and designs). F.M.R.

N88-29845*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
TECHNOLOGY REQUIREMENTS FOR AN ORBITING FUEL DEPOT: A NECESSARY ELEMENT OF A SPACE INFRASTRUCTURE
R. M. STUBBS, R. R. CORBAN, and A. J. WILLOUGHBY (Analex Corp., Cleveland, Ohio.) 1988 10 p Presented at the 39th Annual Astronautical Congress of the International Astronautical

Federation, Bangalore, India, 8-15 Oct. 1988
(NASA-TM-101370; E-4414; NAS 1.15:101370) Avail: NTIS HC A02/MF A01 CSCL 22B

Advanced planning within NASA has identified several bold space exploration initiatives. The successful implementation of these missions will require a supporting space infrastructure which would include a fuel depot, an orbiting facility to store, transfer and process large quantities of cryogenic fluids. In order to adequately plan the technology development programs required to enable the construction and operation of a fuel depot, a multidisciplinary workshop was convened to assess critical technologies and their state of maturity. Since technology requirements depend strongly on the depot design assumptions, several depot concepts are presented with their effect on criticality ratings. Over 70 depot-related technology areas are addressed.
Author

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MISSIONS, TETHERS, AND PLATFORMS

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

A88-22921 Washington Univ., Saint Louis, MO.
EVIDENCE FOR INTERSTELLAR SIC IN THE MURRAY CARBONACEOUS METEORITE
THOMAS BERNATOWICZ, BRIGITTE WOPENKA (Washington University, Saint Louis, MO), GAIL FRAUNDORF (Monsanto Research Center, Saint Louis, MO), TANG MING, EDWARD ANDERS (Chicago, University, IL) et al. Nature (ISSN 0028-0836), vol. 330, Dec. 24, 1987, p. 728-730. NSF-NASA-supported research. refs

Silicon carbide has been identified in two separates from the Murray carbonaceous chondrite that are enriched 20,000-fold in isotopically anomalous neon and xenon. The SiC is present in the form of crystalline grains 0.1-1 micron in size. Cubic and 111-plane-twinned cubic are the most common ordered polytypes observed so far. The anomalous isotopic composition of its carbon, nitrogen, and silicon indicates a presolar origin, probably in the atmospheres of red giants. An additional silicon- and oxygen-rich phase shows large isotropic anomalies in nitrogen and silicon, also associated with a presolar origin. C.D.

A88-28949#
MODELING MECHANICAL SUBSYSTEMS BY BOUNDARY IMPEDANCE IN THE FINITE ELEMENT METHOD
F. CHABAS and C. SOIZE (ONERA, Chatillon-sous-Bagneux, France) La Recherche Aerospatiale (English Edition) (ISSN 0379-380X), no. 5, 1987, p. 59-75. refs

The linear vibrations in the medium frequency range of a mechanical system consisting of two coupled subsystems (one modeled by the FEM and one modeled by a given boundary impedance determined experimentally or numerically) are investigated. An approximate method is used which consists of establishing a system of second-order linear differential equations that govern vibrations of the coupled system in the temporal domain. By introducing hidden variables, this method allows a fast algorithm to be used, resulting in computational savings. Results are presented for the cases of two simple linear oscillators, a straight beam, and a smooth cylindrical shell. R.R.

A88-32955#
EARTH OBSERVATIONS OPPORTUNITIES FROM SPACE STATION
W. LINWOOD JONES (Harris Corp., Government Aerospace Systems Div., Melbourne, FL), ALAN ROSEN (TRW, Inc., Space and Technology Group, Redondo Beach, CA), and JAY CAREY (Rockwell International Corp., Space Station Systems Div., Downey, CA) IN: Thematic Conference on Remote Sensing for Exploration Geology, 5th, Reno, NV, Sept. 29-Oct. 2, 1986, Proceedings. Volume 2. Ann Arbor, MI, Environmental Research Institute of Michigan, 1987, p. 785-797.

The use of the Space Station polar platform for scientific and operational earth observations is discussed. The technical issues associated with the accomodation of user requirements for the 1990s are addressed. It is believed that the success of the polar platform will depend on the cooperation and mutual support of the NASA/NOAA/DOD funding agencies and the international user communities of scientists, governmental, and commercial users.
K.K.

A88-33131*# National Aeronautics and Space Administration, Washington, DC.
RESEARCH AT THE EARTH'S EDGE
JOHN L. ANDERSON (NASA, Washington, DC), GEORGE M. WOOD, JR., and PAUL M. SIEMERS (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 26, April 1988, p. 30-32.

The Space Shuttle Orbiter-deployed Tethered Satellite System (TSS) could allow an Orbiter at a 200 km orbital altitude to reach down to atmospheric altitudes of 90 km, in order to study weather phenomena, pollutant transport, 'nuclear winter' smoke transport, atmospheric physics and dynamics, sun-earth interactions, ecosystem interactions, and radio communications. The TSS satellite, a 1.5-m diameter sphere, would carry scientific instrumentation which could initially be dedicated to the investigation of energy and momentum transfer between a tethered system and the upper atmosphere. O.C.

A88-34536
REFLECTIVE OPTICS; PROCEEDINGS OF THE MEETING, LOS ANGELES, CA, JAN. 15, 16, 1987
DIETRICH KORSCH, ED. (Korsch Optics, Inc., Huntsville, AL) Meeting sponsored by SPIE. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers (SPIE Proceedings. Volume 751), 1987, 157 p. For individual items see A88-34537 to A88-34549.
(SPIE-751)

The present conference discusses prospects for astrophysical space observatories in the next 25 years, a two-mirror three-surface telescope, the structural and thermal feasibility of a 10-m primary mirror space telescope, precision machining implications for optical systems with large off-axis elements, optical wavelength aperture-synthesis interferometry, Space Station lidar measurements with 1.5-m reflective optics, and the performance of phased-array and thinned-aperture optical telescopes. Also discussed are the R-theta diamond-turning system for optical surfaces, diamond-turned Cu mirrors at grazing incidence, the use of visible and IR interferometry in optical testing of large single-point diamond-turned mirrors, the performance of a fast diamond-turned two-mirror colimator, and all-reflecting afocal telescopes. O.C.

A88-34537* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
ASTROPHYSICS SPACE OBSERVATORIES - THE NEXT 25 YEARS
S. H. MORGAN, M. E. NEIN, J. HOWELL (NASA, Marshall Space Flight Center, Huntsville, AL), and D. KOCH (Smithsonian Astrophysical Observatory, Cambridge, MA) IN: Reflective optics; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 2-23. refs

The design characteristics and performance capabilities of orbiting astrophysical observatory optics are projected from the state-of-the-art to the next 25 years. Attention is given to the possible features of large optical/UV observatories as well as to an advanced gamma-ray observatory that could employ the Space Shuttle's External Tank as its structural basis. It is noted that telescope performance has reached fundamental technological

barriers to further progress which demand radical innovations in optical configurations' design. O.C.

A88-34539* Space Telescope Science Inst., Baltimore, MD.
SPACE TEN-METER TELESCOPE (STMT) - STRUCTURAL AND THERMAL FEASIBILITY STUDY OF THE PRIMARY MIRROR
PIERRE Y. BELY (Space Telescope Science Institute, Baltimore, MD), JOHN F. BOLTON, STEVEN P. NEECK (NASA, Goddard Space Flight Center, Greenbelt, MD), and PHILIP J. TULKOFF (Swales and Associates, Inc., Beltsville, MD) IN: Reflective optics; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 29-36. refs

The structural and thermal behavior of a ten-meter primary mirror for a space optical/near-IR telescope in geosynchronous orbit is studied. The glass-type lightweighted mirror is monolithic, of the double arch type, and is supported at only three points. The computer programs SSPTA (thermal), NASTRAN (finite element), and ACCOS V (optical) are used in sequence to determine the temperature, deformation, and optical performance of the mirror. A mirror temperature of 130 K or less appears to be obtainable by purely passive means. With a fused silica or standard Zerodur blank, thermally-induced deformation is unacceptable and cannot be fully corrected by an active secondary mirror over the desired field. Either active thermal control or a blank of lower thermal expansion coefficient would be required. Author

A88-34552
POLAR PLATFORM CONFIGURATION AND SERVICING
P. J. CONCHIE and E. P. L. WINDSOR (British Aerospace, PLC, Space and Communications Div., Bristol, England) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 37-44.

The design concept and operation of the ESA Columbus Polar Platform, a spacecraft intended for ELV (Ariane 5 or Titan 4) launch to an 850-km sun-synchronous orbit and subsequent servicing by the NASA STS, are discussed. The factors influencing the design process are outlined; the system requirements are defined; and the present platform configuration is presented in drawings and described in detail, with reference to power supply (4.0 kW in daylight and 3.0 kW in eclipse), data rates (500 Mb/s via EDRS or 300 Mb/s via NASA TDRSS, plus 300 Mb/s via a direct X-band link), data recording capacity (30 Gb), pointing accuracy (0.03 deg), servicing needs (3 times in 10 yrs), and lifetime (30 yrs). The payload section provides 27 sq m of attachment area for 2500 kg (net) of earth observation, solar terrestrial physics, life science, and communication experiments. T.K.

A88-34556
EUROPEAN EARTH OBSERVATION FROM THE SPACE STATION POLAR PLATFORMS
DAVID L. CROOM (SERC, Rutherford Appleton Laboratory, Didcot, England) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 97-101. refs

The planning and coordination of terrrestrial remote sensing from the polar platforms (PPs) of the International Space Station are discussed, summarizing the results of recent conferences and committee and working-group meetings. The scope of the planned earth observations is indicated; the major organizations working on PP planning are listed; the components of the overall PP system are briefly characterized (ESA PP1 and PP2, NASA PP1 and PP2, and Japan PP1); and particular attention is given to the core instrumentation for ESA PP1 and opportunities for additional experiments. T.K.

A88-34557
CRITICAL ASPECTS FOR THE MATERIALS RESEARCH UNDER MICROGRAVITY
E. KALDIS (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 103, 104.

Plans for space materials research and crystal-growth experiments in the ESA Columbus program are examined critically from a science perspective. Attention is focused on the lack of ESA or national funding for microgravity experiments in the period before the International Space Station becomes operational (about 1996), preliminary plans for a Columbus crystallization laboratory based mainly on Spacelab technology, the need for facilities which permit continuous in situ monitoring of crystal-growth parameters, and techniques for preventing contamination of the Space Station atmosphere by toxic vapors (e.g., III-V and II-VI compounds) from experiments on the growth of semiconductor crystals. T.K.

A88-35054
SPACE STATION BENEFITS FROM TETHER OPERATIONS
WILLIAM R. WOOD and JOHN M. VANPELT (Martin Marietta Corp., Denver, CO) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 47-65. refs
(AAS PAPER 86-368)

Significant cost benefits are projected from the use of momentum transfer from various bodies leaving the NASA Space Station via a space tether, due to reductions in the use of Space Shuttle Orbit Maneuvering System deorbit propellant and Space Station orbit-stationkeeping propellant. It is required that a momentum balance be established to insure that downward deployments causing an increase in Space Station altitude are counteracted; attention is given to methods for achieving this balance. Selecting an optimum variable altitude for the 1994-1998 time period will save the equivalent of four to seven Space Shuttle flights. Hardware design concepts and operational scenarios are identified. O.C.

A88-35061
TETHERED ELEVATOR - A USEFUL FACILITY FOR MICROGRAVITY AND TRANSPORTATION APPLICATIONS
FRANCO BEVILACQUA, PIETRO MERLINA (Aeritalia S.p.A., Turin, Italy), and MARCO GALANTINO (CNR, Rome, Italy) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 187-205.
(AAS PAPER 86-365)

An account is given of a joint NASA/Italian plan for the development of a tethered elevator facility that is to be deployed from the Space Station. The tethered elevator's applicability to such roles as microgravity laboratory isolation, transportation to and from the Space Station, instrumented earth atmosphere research, waste materials' ejection, and Space Station center-of-gravity management, are discussed in light of a tether dynamics analysis, as well as configurational and mechanical considerations. Technology demonstration criteria are also evaluated. O.C.

A88-35062* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
TETHERED SATELLITE SYSTEM
JAY H. LAUE (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 207-221. refs
(AAS PAPER 86-374)

The Tethered Satellite System (TSS) will operate from the Space Shuttle as an earth-orbiting facility that will permit tethered deployment of numerous types of payloads to altitudes both above and below that of the Shuttle. The TSS has evolved from initial studies, beginning in the sixties, to a cooperative development program that is currently being carried out by NASA and the National Space Plan of Italy's CNR. This cooperative agreement

between NASA and CNR includes system development and science instrumentation for the first mission, and planning for two additional missions. This paper will (1) discuss predevelopment activities, (2) review the development approach and management relationships between NASA and CNR, (3) describe the current hardware/software configuration and functional interfaces, (4) discuss the mission profile and flight operations planning, and (5) overview science experiment status/plans for the first TSS mission. Author

A88-35131
TRANSITIONING FROM SPACELAB TO SPACE STATION SCIENCE
BYRON K. LICHTENBERG (Payload Systems, Inc., Wellesley, MA) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1279-1286.
(AAS PAPER 86-284)

Space science operations issues are discussed with respect to both the current capabilities of the Spacelab portion of the National Space Transportation System and future requirements for operation of the Space Station. The capabilities and weaknesses of Spacelab are illustrated with examples from the first four flights. Projected operations scenarios for the Space Station are considered, emphasizing the need for system flexibility. Suggestions for the Space Station development include the use of 'telescience' to maximize the efficient use of the crew and the ground investigator team, and the continuation of ground-based experiments and data analysis on archived data. R.R.

A88-35162
POTENTIAL FOR EARTH OBSERVATIONS FROM THE MANNED SPACE STATION
JAMES V. TARANIK (Nevada, University, Reno) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1725-1729.
(AAS PAPER 86-426)

This paper outlines a few potential uses of the Manned Space Station for earth observations and sensor development in support of earth observations. The way the Space Station can assist in earth-based observations is briefly considered. The advantages of the Space Station for instrument development and for calibrating free-flying instruments are addressed. C.D.

A88-35165* Battelle Memorial Inst., Columbus, OH.
MATERIALS PROCESSING IN SPACE
RAJIV KOHLI and LOUIS A. RANCITELLI (Battelle Memorial Institute, Columbus, OH) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1753-1759. refs
(Contract NAGW-811)
(AAS PAPER 86-442)

Prospects for materials processing in space are addressed. The types of materials that are of the most commercial interest in this regard are examined, and the relevant microgravity facilities and technologies are discussed. The characteristics of the Space Shuttle and the Free Flyer with regard to materials processing in space are briefly considered. The principal manufacturers and consumers of space-processed products are described. The potential impact of these products is assessed. C.D.

A88-36706*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PRELIMINARY PERFORMANCE ANALYSIS OF AN INTERPLANETARY NAVIGATION SYSTEM USING ASTEROID BASED BEACONS
J. RODNEY JEE, AHMAD R. KHATIB, RONALD J. MUELLERSCHOEN, BOBBY G. WILLIAMS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), and MARK A. VINCENT (Colorado, University, Boulder) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Mar.-Apr. 1988, p. 103-109. refs
(AIAA PAPER 86-2217)

A futuristic interplanetary navigation system using transmitters placed on selected asteroids is introduced. This network of space beacons is seen as a needed alternative to the overly burdened Deep Space Network. Covariance analyses on the potential performance of these space beacons located on a candidate constellation of eight real asteroids are initiated. Simplified analytic calculations are performed to determine limiting accuracies attainable with the network for geometric positioning. More sophisticated computer simulations are also performed to determine potential accuracies using long arcs of range and Doppler data from the beacons. The results from these computations show promise for this navigation system. Author

A88-37150
REMOTE SENSING IN THE SPACE STATION AND COLUMBUS PROGRAMMES
D. D. HARDY (British National Space Centre, London, England) IN: Remote sensing applications in meteorology and climatology; Proceedings of the NATO Advanced Study Institute, Dundee, Scotland, Aug. 17-Sept. 6, 1986. Dordrecht, D. Reidel Publishing Co., 1987, p. 441-450.

Plans for terrestrial remote sensing from the International Space Station are reviewed, with an emphasis on ESA activities (the Columbus program). The advantages of large, long-duration (servicable) multiple-instrument platforms for remote sensing are indicated; the history of the Space Station and Columbus is briefly traced; and relevant results from the UK Space Station Utilization Study (1986) are summarized in tables. It is concluded that the two unmanned polar platforms planned for the Space Station will meet most, but not all, of the remote-sensing objectives identified in the study. It is pointed out, however, that two such platforms will overload the data-relay capacity of TDRSS and the proposed ESA DRS systems. T.K.

A88-38077
RADIO ASTRONOMY FROM SPACE; PROCEEDINGS OF THE WORKSHOP, GREEN BANK, WV, SEPT. 30-OCT. 2, 1986
KURT W. WEILER, ED. (U.S. Navy, Naval Research Laboratory, Washington, DC) Workshop sponsored by the National Radio Astronomy Observatory. Charlottesville, VA, National Radio Astronomy Observatory (NRAO Workshop, No. 18), 1987, 341 p. For individual items see A88-38078 to A88-38109.

The scientific aims and technological implementation of planned and proposed space radio observatories are examined in reviews and reports. Observations at mm and submm, cm, dkm, and hm wavelengths are considered, and particular attention is given to astrophysical problems requiring space-based observations; radio astronomy from the moon; coordination of ground, airborne, balloon-borne, and space-based mm and submm astronomy; microwave-background observations at 15-90 GHz, the Large Deployable Reflector, the Space Station mm-wave facility, the use of TDRSS as an orbiting VLBI observatory, and interstellar scattering and resolution limitations. Also discussed are Quasat, Astro-Array, VLBA, solar-system radio astronomy at low frequencies, radio emission from coronal and interplanetary shocks, and Tasmanian LF Galactic background surveys. T.K.

A88-38097
SELF-CORRECTION OF TELESCOPE SURFACE ERRORS USING A CORRELATING FOCAL PLANE ARRAY
T. J. CORNWELL and P. J. NAPIER (National Radio Astronomy Observatory, Socorro NM) IN: Radio astronomy from space; Proceedings of the Workshop, Green Bank, WV, Sept. 30-Oct. 2, 1986. Charlottesville, VA, National Radio Astronomy Observatory, 1987, p. 215-219. refs

The effects on the performance of a large radio telescope of aberrations such as reflector surface errors, defocussing, coma and pointing errors can be removed if the telesocpe is equipped

with an array feed in its focal plane. If the cross correlations between all possible pairs of array elements are measured, then aberration-free images of radio sources can be obtained. Because of the great cost of building very precise large structures in space, in the future this concept may offer the possibility of a more economical design for a large, high frequency, spaceborn radio telescope. Author

A88-38320* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SPACE TETHERS
RODICA IONASECU and PAUL A. PENZO (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) Spaceflight (ISSN 0038-6340), vol. 30, May 1988, p. 200-208. refs

The principles involved in various applications of space tethers are discussed, with emphasis placed on tethers approved for flight on the US Shuttle. Special consideration is given to the NASA-Italy Tethered Satellite System (TSS) experiment, which will consist of three missions. The purposes of these missions and the types of experiments planned for the TSS are described. Other scientific applications of thether use in the fields of aeronomy and aerodynamics, geodynamics and remote sensing, electrodynamics, physics, astronomy, and life sciences are discussed together with particulars inolved in the measurements. I.S.

A88-38687*# Department of the Air Force, Washington, DC.
CONCEPTUAL ANALYSIS OF A LUNAR BASE TRANSPORTATION SYSTEM
TREVOR D. HOY, LLOYD B. JOHNSON (USAF, Washington, DC), MARK B. PERSONS (George Washington University; Joint Institute for Advancement of Flight Sciences, Hampton, VA), and ROBERT L. WRIGHT (NASA, Langley Research Center, Hampton, VA) NASA, AIAA, Lunar and Planetary Institute et al., Symposium on Lunar Bases and Space Activities in the 21st Century, Houston, TX, Apr. 5-7, 1988, Paper. 12 p. refs

A systems analysis and assessment has been conducted on the transportation requirements to support a Phase II lunar base mission. It is noted that the development of such a base will require 3-4 million lbm. total weight in LEO over the course of some 20-30 launches of a 150,00 lbm leavy-lift launch vehicle. The results indicate that the optimum transportation system would be a one-stage, aerobraked, reusable vehicle with the highest engine efficiency attainable. Furthermore, the use of lunar oxygen is advised. R.R.

A88-39489
BOTANICAL PAYLOADS FOR PLATFORMS AND SPACE STATIONS [BOTANISCHE NUTZLASTEN FUER PLATTFORMEN UND RAUMSTATIONEN]
H. R. LOESER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, Mar.-Apr. 1988, p. 116-121. In German.

The scientific aims and technological implementation of botany experiment packages for Eureca and the Columbus platforms of the International Space Station are reviewed. Both basic research in seed germination and plant development, tropisms, circumnutation, and chronobiology under space conditions and practical studies of the role of growing plants in long-term space missions are considered. The Botany Facility for Eureca is described in detail and illustrated with drawings, diagrams, flow charts, and photographs, and the initial design concept for the Columbus Gravitational Biology Facility is briefly discussed. Particular attention is given to technological challenges regarding centrifuge design, the minimization of the air and water consumption of the life-support system, and the recycling of water and CO2 extracted from the crew air supply. T.K.

A88-39557
MOTION OF THE TETHER DURING THE DEPLOYMENT AND RETRIEVAL OF A TETHERED SYSTEM IN ORBIT [O DVIZHENII TROSA PRI RAZVERTYVANII I SVETYVANII TROSOVOI SISTEMY NA ORBITE]
E. M. LEVIN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, Mar.-Apr. 1988, p. 199-208. In Russian. refs

The motion of a system of two bodies connected with a tether of variable length in elliptical orbit is considered. The excitation of transverse oscillations of the tether during its deployment or retreival are analyzed in the framework of a model of two material points connected by an inextensible flexible filament. Generative pendulum-like rigid-body motions of the system are identified. It is shown that the tether undergoes quasi-steady bending when it is deployed uniformly; the retrieval process is characterized by an increase in the transverse oscillations of the tether. B.J.

A88-43969#
A CONCEPT FOR MANNED VARIABLE GRAVITY FACILITIES
J. ALEX GIMARC IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 175-187. refs

This paper will discuss the needs for and the configurations of an early space platform that will provide artificial gravity. The platform will be a tethered dumbbell capable of rotation to provide artificial gravity levels up to 1-G earth normal with reasonable rotation rates. The facility should be able to provide life support and living quarters for a number of inhabitants, and should allow the study of the long term effects of various 'G' levels on the human body, plants and animals. It also may be able to minimize those problems by providing a 1-G habitat or crewmembers who might 'commute' to and from the workplace. This type of facility should be affordable, manned and operational in a minimum number of flights. It should also be capable of expansion to provide living quarters for those involved in large scale space manufacturing and construction projects. Author

A88-45464
MOTION OF A SATELLITE CARRYING AN END-LOADED VISCOELASTIC ROD IN CIRCULAR ORBIT [O DVIZHENII SPUTNIKA, NESUSHCHEGO VIAZKOUPRUGUIU SHTANGU S GRUZOM NA KONTSE, NA KRUGOVOI ORBITE]
V. G. DEMIN, IU. G. MARKOV, and I. S. MINIAEV Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, May-June 1988, p. 366-373. In Russian.

The paper examines the rotation about the mass center of a system consisting of a symmetric rigid satellite carrying a viscoelastic rod with a point load at its end. It is assumed that the mass center of the system moves in circular orbit in a central Newtonian force field. The rotational motion of the system evolves as a result of bending deformations of the rod accompanied by energy dissipation. Approximate equations describing this evolution are obtained by the method of the separation of motions and averaging. B.J.

A88-46575#
REUSABLE SPACE PLATFORMS AND THEIR APPLICATIONS
D. E. KOELLE (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany) and J. K. VON DER LIPPE (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) International Academy of Astronautics and AIAA, Symposium on Commercial Opportunities in Space: Roles of Developing Countries, Taipei, Republic of China, Apr. 19-24, 1987, Paper. 10 p.
(MBB-UR-973/87-PUB)

The different applications of reusable space platforms are discussed, showing that they provide an ideal means for space activities of developing countries. The basic characteristics of small experimental platforms, dedicated platforms, and large operational platforms are summarized. The reusable space platforms SPAS-01, Eureca, and Astro-Spas are described. C.D.

A88-46711#
OPTIMAL PAYLOAD LOFTING WITH TETHERS
WILLIAM E. WIESEL (USAF, Institute of Technology,

Wright-Patterson AFB, OH) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 352-356. refs

The problem of optimal use of a tether to increase the final energy of a payload is posed. The optimal solution must consist of zero tension arcs, full tension arcs, and possibly singular arcs. For a massless tether, the state solution can be obtained for both full tension and free arcs, reducing the system to a parameter optimization problem. Optimal trajectories begin with a coasting arc to obtain separation between the payload and the orbiter, and then the payload is accelerated toward the orbiter with positive cable tension. Optimal lofting trajectories thus require reel-in deployment systems. Example solutions are given for several values of the cable tension. The maximum reel-in speed at the winch device is always a substantial fraction of the payload release speed. Author

A88-46712#
SOME APPROXIMATIONS FOR THE DYNAMICS OF SPACECRAFT TETHERS
A. H. VON FLOTOW (MIT, Cambridge, MA) (Structures, Structural Dynamics and Materials Conference, 28th, Monterey, CA, Apr. 6-8, 1987 and AIAA Dynamics Specialists Conference, Monterey, CA, Apr. 9, 10, 1987, Technical Papers. Part 2A, p. 314-321) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 357-364. USAF-sponsored research. Previously cited in issue 14, p. 2116, Accession no. A87-33687. refs

A88-46717# Beijing Inst. of Control Engineering (China).
DYNAMICS AND CONTROL OF A SPACE PLATFORM WITH A TETHERED SUBSATELLITE
RUYING FAN (Beijing Institute of Control Engineering, People's Republic of China) and PETER M. BAINUM (Howard University, Washington, DC) (NASA, AIAA, and PSN, International Conference on Tethers in Space, Arlington, VA, Sept. 17-19, 1986) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, July-Aug. 1988, p. 377-381. Abridged. Research supported by the Ministry of Astronautics of the People's Republic of China, Howard University, and NASA. Previously cited in issue 03, p. 309, Accession no. A87-14074.

A88-46804
RESULTS FROM A TETHERED ROCKET EXPERIMENT (CHARGE-2)
N. KAWASHIMA, S. SASAKI, K. I. OYAMA, K. HIRAO, T. OBAYASHI (Tokyo, University, Japan) et al. (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 197-201. refs

A tethered payload experiment (Charge-2) was carried out as an international program between Japan and the USA using a NASA sounding rocket at White Sands Missile Range. The objective of the experiment was to perform a new type of active experiment in space by injecting an electron beam from a mother-daughter rocket system connected with a long tether wire. The electron beam with voltage and current up to 1 kV and 80 mA (nominal) was injected from the mother payload. An insulated conductive wire of 426 m length connected the two payloads, the longest tether system flown so far. The electron gun system and diagnostic instruments (plasma, optical, particle and wave) functioned correctly throughout the flight. The potential rise of the mother payload during the electron beam emission was measured with respect to the daughter payload. The beam trajectory was detected by a camera onboard the mother rocket. Wave generation and current induction in the wire during the beam emission were also studied. Author

A88-46805
THEORY OF THE ELECTRODYNAMIC TETHER
C. E. RASMUSSEN (Utah State University, Logan) and P. M. BANKS (Stanford University, CA) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 203-211. refs

The motion of the long conducting wire of a tethered satellite across the geomagnetic field creates an emf of about 0.1-0.2 V/m along the length of the tether. This emf can be utilized to excite wave modes in the ionosphere ranging in frequency from the magnetohydrodynamic regime to the upper hybrid frequency. The emitted spectrum depends principally upon the size (in the direction perpendicular to the magnetic field) of the moving source. The amplitude of radiated waves having a frequency less than the ion cyclotron frequency has been calculated. The shear Alfven wave is always excited and forms an 'Alfven-wing' structure whose amplitude diminishes as the length of the tether increases. In the near-field zone, the emitted waves propagate along magnetic field lines as packets but disperse into individual Fourier components as the far field is reached. However, as the distance to the far-field zone is at least 10 to the 6th kilometers for typical tether configurations, the shear Alfven wave will be reflected by the earth's ionosphere with accompanying coupling to the compressional Alfven mode before the far field is reached. Author

A88-46806
LABORATORY MODEL OF A TETHERED SATELLITE - CURRENT COLLECTION UPON AND SHEATH FORMATION AROUND A CHARGED BODY IN A DRIFTING MAGNETOPLASMA
J.-P. LEBRETON (ESA, Space Science Dept., Noordwijk, Netherlands), C. BONIFAZI, M. SMARGIASSI (CNR, Istituto di Fisica dello Spazio Interplanetario, Frascati, Italy), and R. DEBRIE (CNRS, Laboratoire de Physique et de Chimie de l'Environnement, Orleans, France) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 213-217, 219, 220. refs

The I-V characteristic and the sheath of a Tethered Satellite laboratory model are investigated in a simulated ionospheric plasma environment with particular emphasis on magnetic field effects. The current collection in the ion regime can be described by a power law: I varies as V exp 0.85 and no magnetic field effect is observed. Strong magnetic field effects are observed in the electron current collection regime which cannot be described by a single power law. In the presence of a magnetic field transverse to the plasma flow, the wake of a highly positively charged body is found sideways the body rather than downstream. Author

A88-46807* Colorado State Univ., Fort Collins.
PLASMA CONTACTOR DESIGN FOR ELECTRODYNAMIC TETHER APPLICATIONS
PAUL J. WILBUR and THOMAS G. LAUPA (Colorado State University, Fort Collins) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 221-224. refs
(Contract NGR-06-002-112; NAG9-120)

The plasma contacting process is described and experiments are discussed that suggest the key role that cold ions play in establishing a low impedance plasma bridge that can conduct current in either direction between a contactor electrode and a dilute plasma. A ring cusp contactor is shown to provide from 1000-mA of electron emission to 500-mA of electron collection as its bias relative to a simulated space plasma is varied through an 80-v range. Author

A88-46810* National Aeronautics and Space Administration, Washington, DC.
OPPORTUNITIES FOR SPACE STATION WAVE EXPERIMENTS
STANLEY D. SHAWHAN (NASA, Office of Space Science and Applications, Washington, DC) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space

Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 243-252. refs

The solar terrestrial observatory (STO) concept is discussed as well as Space Station accommodations for STO. Instruments for the initial STO which can be used to excite and detect waves include the electrodynamic tether, waves in space plasmas, space experiments with particle accelerators, vehicle charge and potential experiments, recoverable plasma diagnostics package, magnetospheric multiprobes, and theoretical and experimental beam plasma physics. An example is given of a typical campaign mode of operation which is appropriate for active experiments. K.K.

A88-47907
ASTRODYNAMICS PROBLEMS OF THE SPACE STATION
J.-P. MAREC, P. BAINUM, J. V. BREAKWELL, C. MARCHAL, V. J. MODI (IAF, Paris, France) et al. Acta Astronautica (ISSN 0094-5765), vol. 17, May 1988, p. 491-494.

The preliminary views of the IAF Astrodynamics Committee on the astrodynamics problems related to the Space Station concept are presented. A brief description of the Space Station system and of its original features is given. Some astrodynamics problems are considered in more detail, concerning attitude motion (modeling, attitude determination and control, and tether applications) and orbital motion (transfer, docking, navigation/positioning/guidance, collision hazards, and data links). Author

A88-48457
SATELLITES ON A STRING
TIM FURNISS Flight International (ISSN 0015-3710), vol. 134, July 16, 1988, p. 34-37.

The Space Shuttle Discovery mission scheduled for January 1991 will carry and deploy upwards to higher orbit the Tethered Satellite System, designated TSS 1, that will remain attached to the Orbiter by a 20 km-long electrically-conductive tether. The mission will study the feasibility of generating electricity as the tether cuts through the earth's magnetic field and interacts with the ionospheric plasma. Plasma electrodynamics, magnetic fields, vehicle charging, potential plasma coupling, and dynamic noise will also be investigated. Two years later, TSS 2 will be deployed downwards into the upper atmosphere. More than a dozen other missions have been identified for TSS satellites. A TSS using an electromagnetic tether could be the basis of an orbiting long antenna for ULF/ELF/VLF wave generation for global communications. O.C.

A88-50262#
TWO NON-LINEAR CONTROL APPROACHES FOR RETRIEVAL OF A THRUSTING TETHERED SUB-SATELLITE
D. J. PINES, A. H. VON FLOTOW (MIT, Cambridge, MA), and D. C. REDDING (Charles Stark Draper Laboratory, Inc., Cambridge, MA) IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 975-983. refs
(AIAA PAPER 88-4171)

This paper presents an analysis of the dynamics and control of the pitch and roll motion during retrieval of a Tethered Satellite System, consisting of the Space Shuttle Orbiter and the tethered satellite. Two nonlinear control designs are investigated and compared. The first approach uses visual observation of the line of sight angle and phase plane switch logic to generate simple pilotage rules for orbiter pilots. The second uses a controller designed using computational sliding mode techniques. It assumes more precise sensing of system state and would be implemented using the Orbiter and sub-satellite jets. Author

A88-50407#
TRANSIENT DYNAMICS OF THE TETHER ELEVATOR/CRAWLER SYSTEM
M. COSMO, E. C. LORENZINI (Harvard-Smithsonian Center for Astrophysics, Cambridge, MA), S. VETRELLA, and A. MOCCIA (Napoli, Universita, Naples, Italy) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 480-489. refs
(AIAA PAPER 88-4280)

This paper describes the dynamics and control of a 4-mass tethered system, attached to the Space Station, for conducting micro-g and variable-g experiments. After deriving the two-dimensional equations of motion by means of the Lagrangian function, the eigenfrequencies and eigenvectors of the system have been computed. Control algorithms have been devised to damp out the fundamental oscillations of the system, namely in-plane libration, lateral deflections, and tethers' longitudinal oscillations. Numerical results show that the control strategies adopted can effectively damp the oscillations excited during transient phases of the system dynamics such as the end of the deployment phase. Author

A88-50409#
OUT OF PLANE MANEUVERING WITH TETHERED SATELLITES
M. D. HAYNES and D. G. BODEN (U.S. Air Force Academy, Colorado Springs, CO) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 498-502.
(AIAA PAPER 88-4282)

This paper consists of an investigation into the use of a tethered satellite system to maneuver a parent satellite out of the orbital plane, and return the satellite to its initial orbit. This study is directed at obtaining a more efficient method of enabling the satellite to avoid an inplane intercept. The use of a tethered satellite system instead of a conventional delta v maneuver will result in an overall weight savings, greater simplicity in deployment, and a reusable maneuver capability. Author

A88-50410#
THE FIGURE-OF-8 LIBRATIONS OF THE GRAVITY GRADIENT PENDULUM AND MODES OF AN ORBITING TETHER. II - GEODETIC, MASS DISTRIBUTION, AND ECCENTRICITY EFFECTS
PETER J. MELVIN (U.S. Navy, Naval Research Laboratory, Washington, DC) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 503-513. refs
(AIAA PAPER 88-4283)

As a continuation of previous work on figure-of-eight librations, the gravity gradient tensor for a nonspherical earth has been derived in Orlov's coordinates in order to assess geodetic effects, and a nonlinear tether model has been developed for Keplerian orbits. The equations are linearized for circular orbits, with a second order finite difference equation governing the forces of constraint for a tether of constant length. The numerical integrations show a region of instability in small amplitude out-of-plane motions for large amplitude in-plane librations of a gravity gradient pendulum on a circular orbit. It is noted that in the same region the tether sometimes inverts for a slightly elliptical orbit. R.R.

A88-50411#
TETHERED SATELLITES - THE ORBIT DETERMINATION PROBLEM AND MISSILE EARLY WARNING SYSTEMS
T. A. ASHER, D. G. BODEN, and R. J. TEGTMEYER (U.S. Air Force Academy, Colorado Springs, CO) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 514-518.
(AIAA PAPER 88-4284)

The following is a discussion of the results of research done on the topic of tethered satellite effects on missile early warning systems. This research was accomplished as part of a senior astronautics project at the U.S. Air Force Academy during the fall of 1987 and spring of 1988. A brief background on the subject is given: the problem and the research done are outlined; and some

possible solutions, based on this research and on computer simulations are identified. The conclusions reached are discussed, and recommendations concerning future work are given. Author

A88-50979* Texas Univ., Arlington.
PRECISION POINTING OF SCIENTIFIC INSTRUMENTS ON SPACE STATION: THE LFGGREC PERSPECTIVE
C. C. BLACKWELL (Texas, University, Arlington), S. W. SIRLIN, and R. A. LASKIN (California Insitute of Technology, Jet Propulsion Laboratory, Pasadena) IN: NAECON 88; Proceedings of the IEEE National Aerospace and Electronics Conference, Dayton, OH, May 23-27, 1988. Volume 2. New York, Institute of Electrical and Electronics Engineers, 1988, p. 566-573. refs

An application of Lyapunov function-gradient-generated robustness-enhancing control (LFGGREC) is explored. The attention is directed to a reduced-complexity representation of the pointing problem presented by the system composed of the Space Infrared Telescope Facility gimbaled to a space station configuration. Uncertainties include disturbance forces applied in the crew compartment area and control moments applied to adjacent scientific payloads (modeled as disturbance moments). Also included are uncertainties in gimbal friction and in the structural component of the system, as reflected in the inertia matrix, the damping matrix, and the stiffness matrix, and the effect of the ignored vibrational dynamics of the structure. The emphasis is on the adaptation of LFGGREC to this particular configuration and on the robustness analysis. I.E.

A88-51135
A MOON WITH A VIEW
HELEN CAVAGHAN New Scientist (ISSN 0028-6664), vol. 119, July 28, 1988, p. 49-52.

The possibility of building a lunar base is examined. It is suggested that exploration, operational, space suit, and transport technologies must be further developed before the building of a lunar base may begin. The problems of seismic events on the moon, overcoming the temperature range of 117 C to -173 C, and resource allocation are discussed. The role of a space station in constructing a lunar base, and the use of a base in the search for extraterrestrial intelligence are also considered. R.B.

A88-52335
MODELLING OF THE MICROGRAVITY ENVIRONMENT OF THE MAN TENDED FREE FLYER (MTFF)
W. WOEHLKE (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-42 to 5-52. ESA-supported research. refs

One of the major purposes of the International Space Station (ISS) and MTFF is the performance of experiments and processes in a very low gravity environment. Considering the user's demands upon the microgravity quality, it appears more and more difficult to meet the corresponding requirements under worst case constraints. In this situation, the availability of an overall model as a tool for the assessment of the microgravity quality is of utmost importance. Based upon a critical review of the microgravity requirement in the time and frequency domain the present paper describes the development of an overall microgravity model to analyze both the low frequency microgravity distrubance sources such as air drag, gravity gradient and S/C dynamic and the high frequency microgravity disturbance sources such as reaction wheels, fluid loops, gyros, etc. The computerization of the comprehensive model exhibits the benefits of a computer aided design and engineering of future orbital systems, such as design optimization on system, subsystem, and assembly level with a quick access to various representations of microgravity performance such as vector fields, amplitude spectra, time profiles and envelopes. Author

A88-52336* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION GAS-GRAIN SIMULATION FACILITY - MICROGRAVITY PARTICLE RESEARCH
GLENN C. CARLE, GUY FOGLEMAN, and JUDITH L. HUNTINGTON (NASA, Ames Research Center, Moffett Field, CA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-53 to 5-62. refs

The proposed Space Station gas-grain simulation facility (GGSF) and the possibilities for research in the facility are discussed. The physics of particles in microgravity is reviewed. The proposed design of the GGSF is illustrated and examined. Examples of experiments which have been suggested for the GGSF are presented, including the formation of organic haze particles in Titan's atmosphere, organic compound synthesis on surfaces of growing particles, fractal particles, planetary ring particle dynamics, aggregation of fine geological particulates in planetary atmospheres, and dipolar grain coagulation and orientation. R.B.

A88-54471* Honeywell, Inc., Clearwater, FL.
OBSTACLES TO HIGH FIDELITY MULTIBODY DYNAMICS SIMULATION
K. W. LIPS (Honeywell, Inc., Space and Strategic Avionics Div., Clearwater, FL) and R. P. SINGH (DYNACS Engineering Co., Inc., Clearwater, FL) IN: 1988 American Control Conference, 7th, Atlanta, GA, June 15-17, 1988, Proceedings. Volume 1. New York, Institute of Electrical and Electronics Engineers, 1988, p. 587-594. refs
(Contract NAS8-34588)

The authors take a wide ranging look at issues involved in the dynamic modeling of complex, multibodied orbiting space systems. The nature of the multibody problem is reviewed and capabilities and limitations of two major codes (DISCOS, TREETOPS) are assessed. Problem areas that limit accuracy or contribute to uncertainty in the modeling, simulation process are identified. As a specific case, the significance of including, or of not including, second-degree geometric nonlinearity in the elastic displacement field (foreshortening) is evaluated. Conclusions and recommendations are made concerning the direction future development should take to achieve higher-fidelity and more computationally efficient multibody software solutions. I.E.

A88-54766#
QUASAT - A 50,000 KM-DIAMETER QUASAR PROBE
U. FRISK, A. HAWKYARD, and J. W. CORNELISSE (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 55, Aug. 1988, p. 18-23.

Quasat, an earth-orbiting radio antenna used in conjunction with ground-based VLBI networks to produce radio images at frequencies of 22, 5, 1.6, and 0.3 GHZ, is discussed. The Quasat mission would observe the compact, bright, high temperature objects in the nuclei of galaxies and quasars, in molecular masers, and on the surfaces of active stars in the Galaxy. The operational mission for Quasat is examined and the spacecraft configuration is described, including the radio-astronomy antenna, the spacecraft bus, and the booms which allow for viewing past the radio-astronomy antenna. The operational orbit of Quasat would have an apogee of about 37,000 km, with the space-borne antenna providing interferometer baselines ranging up to about 50,000 km. R.B.

A88-55062#
ADVANTAGES OF TETHER RELEASE OF SATELLITES FROM ELLIPTIC ORBITS
GEORGE A. KYROUDIS (TRW, Inc., TRW Space and Technology Group, Redondo Beach, CA) and BRUCE A. CONWAY (Illinois, University, Urbana) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Sept.-Oct. 1988, p. 441-448. Previously cited in issue 23, p. 3421, Accession no. A86-47944. refs

A88-55067#
TETHERED SUBSATELLITE SWINGING FROM ATMOSPHERIC GRADIENTS
JUNJIRO ONODA and NAOYUKI WATANABE (Tokyo, University, Japan) Journal of Guidance, Control, and Dynamics (ISSN 0731-5090), vol. 11, Sept.-Oct. 1988, p. 477-479.

The mechanism responsible for the instability described by Yuhara et al. (1986) in the in-plane motion of a tethered satellite in LEO is investigated analytically. The equations of motion are derived with a series of simplifying assumptions and linearized; a stability analysis is performed; and numerical results for a 500-kg satellite with drag coefficient 2.2 and projected drag area 10 sq m (including the tether) deployed at altitude 115 km are presented in tables. The instability is shown to result from the action of atmospheric density gradients, with the unstable region depending on the longitudinal rigidity of the tether and the atmospheric drag. T.K.

N88-21197# I.A.M. Rinaldo Piaggio, Finale Ligure (Italy).
DEPLOYABLE/RETRIEVABLE BOOM: ONE APPLICATION TO TETHERED SATELLITE
P. BECCHI and D. MIRANDA *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 37-46 Dec. 1987
Avail: NTIS HC A14/MF A01

The development, design, and qualification of a telescopic tubular deployable/retrievable boom rated to shuttle requirements for the tethered satellite mission are reviewed. The mechanism includes jettisoning provision and deployable harness for the supported payloads connection. Applications to other payloads and comparisons with other designs are discussed. ESA

N88-22080*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
RAY TRACING OPTICAL ANALYSIS OF OFFSET SOLAR COLLECTOR FOR SPACE STATION SOLAR DYNAMIC SYSTEM
KENT S. JEFFERIES 1988 20 p Prepared for presentation at the 23rd Intersociety Energy Conversion Engineering Conference, Denver, Colo., 31 Jul. - 5 Aug. 1988; sponsored in part by ASME, AIAA, ANS, SAE, IEEE, ACS, and AIChE
(NASA-TM-100853; E-4056; NAS 1.15:100853) Avail: NTIS HC A03/MF A01 CSCL 10A

OFFSET, a detailed ray tracing computer code, was developed at NASA Lewis Research Center to model the offset solar collector for the Space Station solar dynamic electric power system. This model traces rays from 50 points on the face of the Sun to 10 points on each of the 456 collector facets. The triangular facets are modeled with spherical, parabolic, or toroidal reflective surface contour and surface slope errors. The rays are then traced through the receiver aperture to the walls of the receiver. Images of the collector and of the Sun within the receiver produced by this code provide insight into the collector receiver interface. Flux distribution on the receiver walls, plotted by this code, is improved by a combination of changes to aperture location and receiver tilt angle. Power loss by spillage at the receiver aperture is computed and is considerably reduced by using toroidal facets. Author

N88-23903*# Princeton Univ., NJ. Dept. of Mechanical and Aerospace Engineering.
REQUIREMENTS FOR TEMPERATURE AND SPECIES CONCENTRATION MEASUREMENTS IN MICROGRAVITY COMBUSTION EXPERIMENTS
PAUL D. RONNEY *In* NASA, Washington, D.C. Noncontact Temperature Measurement p 129-138 Mar. 1988
Avail: NTIS HC A19/MF A01 CSCL 22A

The requirements for a nonintrusive optical diagnostic facility for Space Station are assessed by examining the needs of current and future combustion experiments to be flown aboard the Space Station. Requirements for test section geometry and size, spatial and temporal resolution, species type and concentration range, and temperature range are reviewed. The feasibility of the development of this system is also addressed. The suitability of this facility to non-combustion experiments in gases and liquids is also considered. Author

N88-24653# British Aerospace Public Ltd. Co., Bristol (England). Configuration Control Dept.
P-PLUS: POLAR PLATFORM UTILIZATION STUDY, EXECUTIVE SUMMARY
C. P. LEE Paris, France ESA Jul. 1987 49 p Prepared in cooperation with Dornier Werke GmbH, Friedrichshafen, Fed. Republic of Germany; Matra Espace, Toulouse, France; Telespazio S.p.A., Rome, Italy; Logica Ltd., London, England; and Laben Space Instrumentation and Systems, Milan, Italy
(Contract ESA-6608/85)
(BAE-TP-8391; ESA-CR(P)-2507; ETN-88-92552) Avail: NTIS HC A03/MF A01

Space Station Polar Platform users and their requirements were identified. Earth observations and solar terrestrial physics are the main users. The STS system provides a more flexible servicing capability than Hermes. The ground segment, particularly data systems, is the main cost and utilization aspect for users. Data management must be studied closely. ESA

N88-24811*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, OH.
PREPARATION FOR MICROGRAVITY: THE ROLE OF THE MICROGRAVITY MATERIALS SCIENCE LABORATORY
J. CHRISTOPHER JOHNSTON, BRUCE N. ROSENTHAL, MARYJO B. MEYER, and THOMAS K. GLASGOW 1988 11 p Presented at the Space Programs and Technologies Conference, Houston, Tex., 21-24 Jun. 1988; sponsored by the AIAA
(NASA-TM-100906; E-4157; NAS 1.15:100906; AIAA-88-2645)
Avail: NTIS HC A03/MF A01 CSCL 22A

A laboratory dedicated to ground based materials processing in preparation for space flight was established at the NASA Lewis Research Center. Experiments are performed to delineate the effects of gravity on processes of both scientific and commercial interest. Processes are modeled physically and mathematically. Transport model systems are used where possible to visually track convection, settling, crystal growth, phase separation, agglomeration, vapor transport, diffusive flow, and polymers reactions. The laboratory contains apparatus which functionally duplicates apparatus available for flight experiments and other pieces instrumented specifically to allow process characterization. Materials addressed include metals, alloys, salts, glasses, ceramics, and polymers. The Microgravity Materials Science Laboratory is staffed by engineers and technicians from a variety of disciplines and is open to users from industry and academia as well as the government. Examples will be given of the laboratory apparatus typical experiments and results. Author

N88-25471*# General Research Corp., McLean, VA. Aerospace Systems Group.
TECHNOLOGIES APPLICABLE TO SPACE TETHERS
WILLIAM A. BARACAT 1987 6 p
(Contract NASW-4138)
(NASA-CR-183055; NAS 1.26:183055) Avail: NTIS HC A02/MF A01 CSCL 22B

An investigation is presented of technologies which have been accumulated over the years, both on Earth and in space, dealing with tethers, ropes and cables. Many of these technologies can be applied, with modification, to both on-going and future space tether research and demonstration missions. The major areas of tether research and technology developments presented include multimegawatt power transmission, materials and structures, dynamics and control, environmental interactions, and in-space operations. These major topical areas are presented within the context of their associated research program or study. Author

N88-25902# Oak Ridge National Lab., TN.
EVALUATION OF THE ION TRAP MASS SPECTROMETER FOR POTENTIAL APPLICATION IN THE SPACE STATION

G. L. GLISH and S. A. MCLUCKEY Apr. 1988 166 p
(Contract DE-AC05-84OR-21400)
(DE88-008940; ORNL/TM-10751) Avail: NTIS HC A08/MF A01

This report describes preliminary experiments with an ion trap mass spectrometer, which were done to evaluate its potential for use in the environmental monitoring system of the proposed space station. The first section of the report describes various modes of operation of the instrument, discusses some of the present limitations, and discusses some of the potential solutions to these limitations. The next section discusses the experimental results obtained on sixteen compounds with particular emphasis on comparing these data to that expected from a standard mass spectrometer. The last section consists of a conclusion and comments on suggested future work. DOE

N88-28948# Los Alamos National Lab., NM.
DEFENSIVE PLATFORM SIZE AND SURVIVABILITY
GREGORY H. CANAVAN Jun. 1988 40 p
(Contract W-7405-ENG-36)
(DE88-011634; LA-11244-MS) Avail: NTIS HC A03/MF A01

This report discusses the survivability of space platforms, concentrating on space based kinetic energy interceptors. It evaluates the efficacy of hardening, maneuver, self-defense, and deception in extending the survivability of platforms of varying sizes to expected threats, concluding that they should be adequate in the near and mid terms. DOE

N88-28949*# TRW Defense and Space Systems Group, Houston, TX.
STUDY OF PLASMA MOTOR GENERATOR (PMG) TETHER SYSTEM FOR ORBIT REBOOST Final Report
Jun. 1988 103 p
(Contract NAS9-17751)
(NASA-CR-172074; NAS 1.26:172074) Avail: NTIS HC A06/MF A01 CSCL 22B

A progress report is given on a system study by TRW begun in January 1987 of a 2 kW Plasma Motor Generator Tether to be used for orbit reboost. Following the completion of the initial phase in September 1987, additional tasks were agreed on and work on them begun in March 1988. These tasks fell into three categories: tests on the prototype tether fabricated during the first phase, simulations of the spacecraft and tether system after deployment using GTOSS, and a brief investigation of the impact and feasibility of increasing the system to 20 kW and hosting it on the Orbital Maneuvering Vehicle. The subcontractor, Energy Sciences Laboratory, was assigned the responsibility of performing the simulations and some mechanical tests on the prototype tether to supplement those done at TRW. A summary of the significant findings and issues from each task follows. Recommendations for future work constitutes the third section. A copy of the final briefing is in Appendix A, plus additional reports for each task and additional analysis. Author

N88-28950*# Smithsonian Astrophysical Observatory, Cambridge, MA.
ANALYTICAL INVESTIGATION OF THE DYNAMICS OF TETHERED CONSTELLATIONS IN EARTH ORBIT Quarterly Report No. 13, 1 Apr. - 30 Jun. 1988
ENRICO C. LORENZINI, GORDON E. GULLAHORN, and ROBERT D. ESTES Jul. 1988 124 p
(Contract NAS8-36606)
(NASA-CR-179371; NAS 1.26:179371) Avail: NTIS HC A06/MF A01 CSCL 22B

This Quarterly Report on Tethering in Earth Orbit deals with three topics: (1) Investigation of the propagation of longitudinal and transverse waves along the upper tether. Specifically, the upper tether is modeled as three massive platforms connected by two perfectly elastic continua (tether segments). The tether attachment point to the station is assumed to vibrate both longitudinally and transversely at a given frequency. Longitudinal and transverse waves propagate along the tethers affecting the acceleration levels at the elevator and at the upper platform. The displacement and acceleration frequency-response functions at the elevator and at the upper platform are computed for both longitudinal and transverse waves. An analysis to optimize the damping time of the longitudinal dampers is also carried out in order to select optimal parameters. The analytical evaluation of the performance of tuned vs. detuned longitudinal dampers is also part of this analysis. (2) The use of the Shuttle primary Reaction Control System (RCS) thrusters for blowing away a recoiling broken tether is discussed. A microcomputer system was set up to support this operation. (3) Most of the effort in the tether plasma physics study was devoted to software development. A particle simulation code has been integrated into the Macintosh II computer system and will be utilized for studying the physics of hollow cathodes. Author

N88-29848*# Alabama Univ., Huntsville. Dept. of Mechanical Engineering.
COORDINATED STUDY OF SOLAR-TERRESTRIAL OBSERVATORY (STO) PAYLOADS ON SPACE STATION Report, 10 Jul. 1984 - 15 Jul. 1988
S. T. WU Jul. 1988 65 p
(Contract NAG8-488)
(NASA-CR-183142; NAS 1.26:183142) Avail: NTIS HC A04/MF A01 CSCL 22B

Since the publication of the final report of the science study group in October 1984 on the Solar Terrestrial Observatory (STO), its science goals and objectives have been clearly defined and a conceptual design and analysis was carried out by MSFC/NASA. Plans for the possible placing of the STO aboard the Space Station were made. A series of meetings for the STO science study group were held to review the instruments to be placed on the initial STO at Space Station IOC, and the placement of these instruments on the manned space station, polar platform, and the co-orbiting platform. A summary of these initial STO instruments is presented in Section 2. A brief description of the initial plan for the placement of STO instruments is included in Section 3. Finally, in Section 4, the scenario for the operation of the STO is discussed. These results were obtained from the report of the Solar Terrestrial Observatory mini-workshop held at MSFC on 6 June 1985. F.M.R.

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OPERATIONS SUPPORT

Includes descriptions of models, analyses and trade studies of maneuvers, performance, Logistics support, and EVA and/or IVA servicing requirements of systems such as the OMV and OTV, and experiments.

A88-21212
DAMAGE TOLERANT COMPOSITES
Aerospace Engineering (ISSN 0736-2536), vol. 7, Dec. 1987, p. 8-11.

The emerging requirement for materials with toughness and damage tolerance capabilities superior to those of state-of-the-art epoxy-matrix composites has led to a systematic search for composite systems possessing not only improved mechanical performance in a wide range of environmental moisture and exposure conditions, but also 'melt-processible' characteristics that will reduce fabrication costs and expand the flexibility of composite structures design. The result of this development effort is Avimid K-III, a high-temperature, damage-tolerant polyimide composition of pyromellitic diamhydride and aromatic diamine, whose diamine portion lowers glass transition temperature and retards crystallization. Fracture toughness is an order of magnitude higher than for conventional epoxy. O.C.

A88-24154* Joint Inst. for Lab. Astrophysics, Boulder, CO.
AN INVESTIGATION OF STELLAR CORONAE WITH AXAF
JEFFREY L. LINSKY (Joint Institute for Laboratory Astrophysics,

Boulder, CO) Astrophysical Letters and Communications (ISSN 0888-6512), vol. 26, no. 1-2, 1987, p. 21-34.
(Contract NASA ORDER H-80531-B)

Questions concerning the phenomenon of stellar coronae are discussed together with the physical parameters essential to model stellar coronae and the different AXAF instruments assigned for measurements of these parameters. As an illustration of what AXAF will be able to accomplish, three specific examples of studies by AXAF are described. These include coronal modeling for a bright X-ray source such as HR 1099, using spectra obtained by AXAF; time-resolved spectroscopy of AR Lacertae and YY Geminormum during their eclipses, to use the spectra for the identification and modeling of individual geometrical physical structures on these stars; and time-resolved spectroscopy during stellar flares to obtain high-resolution spectra which will make it possible to infer the changes in the flaring plasma temperatures as a function of time. I.S.

A88-33440
ON-ORBIT ASSEMBLY, INTEGRATION, AND TEST OF LARGE SPACECRAFT - A NEW TECHNIQUE
WALTON CLARK (TRW, Inc., Redondo Beach, CA) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 121-126. refs

A new and unique on-orbit assembly, interaction, and test technique designed to decrease the cost of any space-vehicle program without increasing the risk of failure on-orbit is presented. In the new approach, the vehicle is completely assembled on-orbit prior to the activation of any subsystems. Services essential during buildup are provided by a separate autonomous support vehicle. The new technique eliminates the need for multiple configurations of each subsystem and simplifies the on-orbit deployment activity. C.D.

A88-33776
AEROSPACE TESTING SEMINAR, 10TH, LOS ANGELES, CA, MAR. 10-12, 1987, PROCEEDINGS
Seminar sponsored by the Institute of Environmental Sciences and Aerospace Corp. Mount Prospect, IL, Institute of Environmental Sciences, 1987, 270 p. For individual items see A88-33777 to A88-33800.

The conference presents papers on on-orbit experience, aerospace testing effectiveness, test technology issues, requirements, techniques, and facilities. Topics include an analysis of orbital satellite storage, flight problem evaluation for the Space Shuttle Orbiter, on-orbit man/machine interface verification with simulator testing, managing test program risks, refining test effectiveness through cost of quality analysis, single event upset testing at JPL, and testing of satellites after ground storage. Consideration is also given to the thermal testing of space vehicle electronic components, shower water characterization tests, a weightlessness simulation test in the MDAC underwater test facility, and corner acoustic horns in large reverberation chambers. K.K.

A88-33777#
ANALYSIS OF ORBITAL SATELLITE STORAGE
T. FERGUSON and T. DAVEY (Aerospace Corp., Los Angeles, CA) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 1-14. refs

This study addresses whether service of sufficient duration can be expected from a satellite that has been stored on orbit for significant periods of time. From the thousands of boxes residing in the 165 satellites sampled, it is found that primary boxes (having identical redundant back-ups) rarely fail (N=93). Only 10 redundant boxes failed. One failed at activation; the remaining boxes provided service of varying durations. Unknown factors accounted for most of the variation in the operation time of the failed redundant boxes. The causes may be idiosyncratic, or that a failed redundant box may have a similar predisposition as its primary box to fail. It was concluded that length of dormancy may not be a significant contributor to electronic box failure. Any degrading effects which can be attributed to the dormancy experience will be mild. The relatively successful orbital operation of dormant redundant boxes suggests that satisfactory operation may be expected of electronic boxes in satellites stored on orbit. Author

A88-33780#
ON-ORBIT, MAN/MACHINE INTERFACE VERIFICATION WITH SIMULATOR TESTING
J. D. HYLTON and R. PULLIAM (Martin Marietta Aerospace Corp., Space Operations Simulator Laboratory, Denver, CO) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 27-33.

The Space Operations Simulator Laboratory at Martin Marietta Denver Aerospace is described in detail. Included in the principal test facilities are the motion base carriage, the large-screen video display, the manipulator development laboratory, the Space Shuttle aft flight deck simulator, target gimbals, and the neutral bouyancy facility. Operational development is discussed with attention given to payload handling, flexible body dynamics, the interactive dynamics of multiple bodies in space, and telesimulation operations. K.K.

A88-35455
CREW-INDUCED LOAD MEASUREMENT FOR SPACE OPERATIONS
RUTHAN LEWIS (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 800-802.

A method has been developed to simulate and measure crew-induced and reactive loads for a variety of intravehicular and extravehicular tasks. The method employs the use of a dynamometer attached to an adjustable support, and a three-axis force/torque platform. Translational and rotational hand/arm forces and torques, and foot reaction forces and torques may be measured simultaneously. The apparatus has been designed for on-orbit and ground-based usage. Beyond explanation of the instrumentation, the presentation will address data on forces effected by crew members, and the applications, implications, and integration of the information with regards to planning space operations and design of crew-interfaced items. Author

A88-35462
A METHOD FOR MEASURING THE EFFECT OF GRIP SURFACE ON TORQUE PRODUCTION DURING HAND/ARM ROTATION
RUTHAN LEWIS (Lockheed Engineering and Management Services Co., Inc., Houston, TX) IN: Human Factors Society, Annual Meeting, 31st, New York, NY, Oct. 19-23, 1987, Proceedings. Volume 2. Santa Monica, CA, Human Factors Society, 1987, p. 898-900.

During EVA operations, where time is extremely limited, a grip interface that would cause regripping of a surface or repositioning of the hand to assume a more effective or more comfortable grip must be avoided. This paper presents a method for measuring the effect of grip surface on torque production during rotation by the space-gloved hand during a simulated on-orbit construction operation. An isokinetic dynamometer was used as the measuring device to distinguish human interface differences between various connector surface types; the device was used to test single-joint-effected motions, registering torque and the position of the torque within the range of motion at the joint as a function of applied load. It is shown that this method can be used to simulate the complex resultant of mutiple-joint motion. Controls can be instituted according to the application, so that comparisons of static and dynamic measures can be made between specified conditions. I.S.

A88-36144
OPTIMAL RENDEZVOUS IN A GRAVITATIONAL FIELD WITH LIMITED OBSERVATIONS [OB OPTIMAL'NOI PARITETNOI VSTRECHE V GRAVITATSIONNOM POLE PRI OGRANICHENNYKH NABLIUDENIIAKH]
V. S. NOVOSELOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Jan. 1988, p. 67-71. In Russian.

A solution is presented to the model problem of optimizing the rendezvous of space stations moving in coplanar circular orbits. The solution allows for initial position errors and for errors in impulse processing. The stations have equal characteristic velocities, which are minimized together with the duration of angular position observations. V.L.

A88-36556
COSM: A SPACE STATION EVAS TEST CHALLENGE
FRANK A. PULLO and ANTHONY C. BEARDSLEY (Grumman Corp., Aircraft Div., Bethpage, NY) IN: AUTOTESTCON '87; Proceedings of the International Automatic Testing Conference, San Francisco, CA, Nov. 3-5, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 221-226.

The authors present the requirements that must be addressed to develop equipment that will perform the checkout, servicing, and maintenance (COSM) of the extravehicular activity system (EVAS) for manned space on the proposed US Space Station. An overview is presented of COSM operational requirements, and their relationship to an automatic COSM system. The Space Station environment, routine EVA sorties, and singular mission objectives and tasks are examined with respect to system design. The COSM system architecture and the technical approach taken are also examined. I.E.

A88-42903*# Booz-Allen and Hamilton, Inc., Bethesda, MD.
OPTIMAL USE OF HUMAN AND MACHINE RESOURCES FOR SPACE STATION ASSEMBLY OPERATIONS
JOSEPH C. PARRISH (Booz-Allen and Hamilton, Inc., Bethesda, MD) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 12 p. refs
(Contract NASW-4300)
(AIAA PAPER 88-3498)

This paper investigates the issues involved in determining the best mix of human and machine resources for assembly of the Space Station. It presents the current Station assembly sequence, along with descriptions of the available assembly resources. A number of methodologies for optimizing the human/machine tradeoff problem have been developed, but the Space Station assembly offers some unique issues that have not yet been addressed. These include a strong constraint on available EVA time for early flights and a phased deployment of assembly resources over time. A methodology for incorporating the previously developed decision methods to the special case of the Space Station is presented. This methodology emphasizes an application of multiple qualitative and quantitative techniques, including simulation and decision analysis, for producing an objective, robust solution to the tradeoff problem. Author

A88-42905*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SPACE STATION USER SERVICING SYSTEM ARCHITECTURE AND OPERATIONAL ASPECTS
HELMUT P. CLINE and THOMAS A. LAVIGNA (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 9 p.
(AIAA PAPER 88-3504)

The structure of the Space Station Servicing System architecture, operational aspects of the system, and the potential evolution of the servicing capabilities to accomodate a variety of missions are disscussed. Services to be performed include replacement or repair of failed modules, subsystems or parts, replacement or upgrading of spacecraft or instrument subsystems, replacement of limited lifetime subsystems or components, replenishment of consumables, and assembly of attached payloads and instruments. Elements of the system discussed include intravehicular servicing, the flight telerobotic servicer, and the mobile servicing center. Ground, preservicing, extravehicular and intravehicular servicing, and postservicing operations are examined. Also, a typical mission scenario for mature servicing operations is given. R.B.

A88-42912*# Flight Mechanics and Control, Inc., Hampton, VA.
ADVANCED SATELLITE SERVICING FACILITY STUDIES
GARRY D. QUALLS (Flight Mechanics and Control, Inc., Hampton, VA) and MELVIN J. FEREBEE, JR. (NASA, Langley Research Center, Hampton, VA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 12 p. refs
(AIAA PAPER 88-4200)

A NASA-sponsored systems analysis designed to identify and recommend advanced subsystems and technologies specifically for a manned Sun-synchronous platform for satellite management is discussed. An overview of system design, manned and unmanned servicing facilities, and representative mission scenarios are given. Mission areas discussed include facility based satellite assembly, checkout, deployment, refueling, repair, and systems upgrade. The ferrying of materials and consumables to and from manufacturing platforms, deorbit, removal, repositioning, or salvage of satellites and debris, and crew rescue of any other manned vehicles are also examined. Impacted subsytems discussed include guidance navigation and control, propulsion, data management, power, thermal control, structures, life support, and radiation management. In addition, technology issues which would have significant impacts on the system design are discussed. R.B.

A88-44004#
WELDING IN SPACE - AN OVERVIEW
R. M. RIVETT (Edison Welding Institute, Columbus, OH) IN: Advanced topics in manufacturing technology: Product design, bioengineering; Proceedings of the Symposium, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 73-77. refs

The fabrication and repair of structures in space will be an important part of any long-term plans to commercialize space. In this paper the alternative joining techniques for use in a space environment are reviewed and their limitations discussed. To date the bulk of the work has been conducted on electron beam welding, arc welding and brazing. However, with the exception of the Soviet program to develop a hand-held electron beam gun, this work has been limited in nature and has mainly studied the influence of micro-gravity and vacuum on the process and the properties of the weld pool. From a review of the published literature it would appear that joining technology has not progressed to the point that a large structure could be fabricated or repaired in space using welding techniques. Author

A88-46516
TASKS OF THE SIMULATION INSTALLATIONS FOR SPACE FLIGHT OPERATIONS IN THE OPERATIONS CENTER FOR MANNED SPACE LABORATORIES [AUFGABEN DER SIMULATIONSANLAGEN FUER DEN RAUMFLUGBETRIEB IM BETRIEBSZENTRUM FUER BEMANNTE WELTRAUMLABORS]
KONRAD REINEL, GERHARD HEIMBOLD, THOMAS LANGE, and BERND SCHAEFER (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), June 1988, p. 5-10. In German.

Test installations being built for orbital applications in the DFVLR operational center for manned space operations are described. The activities, equipment, and personnel of the installations for rendezvous and docking, for servicing, and for large space structures are addressed. The building in which these installations are housed is briefly discussed. C.D.

A88-50427#
FUEL AND TIME CONSIDERATIONS FOR SATELLITE SERVICING
FREDERICK H. LUTZE (Virginia Polytechnic Institute and State

University, Blacksburg) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 652-659. Research supported by Advanced Technology, Inc.
(AIAA PAPER 88-4302)

The requirement for timely preventative maintenance on satellites used for manufacturing or military use leads to consideration of a time-fuel budget necessary to perform this service. The scenario discussed involves several orbit planes at given inclination and distributed uniformly about the earth's equator. In each orbit plane satellites are distributed uniformly in true anomaly in a circular orbit. The logistics platform operates in a circular orbit below that of the satellites to be serviced. The orbital maneuvering vehicle must alternately visit a satellite for resupply purposes and then return to the logistic supply platform before proceeding to the next satellite. Fuel and time trade-offs for performing this servicing scenario are discussed. Included is the effect of differential nodal regression which eliminates the requirement of fuel burns to move from one orbit plane to the next, but increases the fuel consumption per plane due to the out-of-plane drift. Author

A88-52334
WELDING THE SPACE STATION COMMON MODULE PROTOTYPE
T. J. BOSWORTH, C. M. MILLER, and C. C. GRIFFEE (Boeing Aerospace Co., Seattle, WA) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-34 to 5-41. refs

The construction of a prototype of the Space Station common module is examined. The prototype is 13.67 feet in diameter and 43.6 feet in length and consists of five basic components: skins, ring frames, gore sections, docking port, and window frame. The design and materials of construction for these components are designed. The variable polarity plasma arc welding process which was used in constructing the prototype is described. The weld requirements and the assembly sequence for building the prototype are considered. R.B.

A88-52337
A RESUPPLY SCENARIO FOR THE COLUMBUS MANTENDED FREEFLYER (MTFF)
H. J. C. KOOPMANN (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 5-63 to 5-76.

The processes involved in the resupply system for the Columbus Man-tended Free Flyer (MTFF) are discussed. The design characteristics of the MTFF pressurized laboratory module and the resource module are examined. Aspects of the MTFF operations concept are described, including launch and initial activation, mission orbit profile, routine operations, servicing, and rendezvous and proximity operations. MTFF in-orbit servicing tasks and requirements are presented. Upload assessments for Hermes and the Space Station and the processes involved in resupply scenarios are presented. R.B.

A88-52374#
OPERATIONAL CAPABILITIES OF GENERIC ADVANCED LAUNCH SYSTEM CONCEPTS
B. P. LEONARD and W. A. KISKO (L Systems, Inc., El Segundo, CA) Canaveral Council of Technical Societies, Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Paper. 48 p.

The present study of generic Advanced Launch Systems (ALS) concepts under consideration in the U.S. defines these concepts, and projects the values of their operational parameters on the basis of the launch histories of the Titan and Delta launcher families. Monte Carlo simulations are then conducted to predict their operational characteristics and capabilities; the operational criteria subsequently defined are applied to assess the generic ALS concepts' comparative advantages. It is concluded that an expendable system should have better operational capabilities than a recoverable one. O.C.

A88-53664#
SPACE OPERATIONS AND SPACE STATION REAL-TIME SIMULATION
D. HERNANDEZ, A. A. MOLINEROS, and W. C. WAGNER (Rockwell International Corp., Space Transportation Systems Div., Downey, CA) IN: AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 304-312. refs
(AIAA PAPER 88-4627)

This paper describes the Space Operations and Space Station Simulator, a man-in-the-loop, real-time test bed designed to support the analysis, design, and evaluation of future space systems. The state-of-the-art, distributed, hybrid simulator was developed and built by the Space Transportation Systems Division of Rockwell International. A high-fidelity facility with prototype Space Shuttle on-board computers and realistic Shuttle and Space Station controls and displays, the simulator is capable of real-time hardware- and human-in-the-loop simulation using embeddded and nonhomogeneous processors, cockpit controls and displays, and out-the-window graphic displays. Presented is an overview of the simulation configuration and capabilities, the hybrid computers and mathematical models, and the hardware and software implementation features. Author

A88-53665*# Massachusetts Inst. of Tech., Cambridge.
A DESIGN METHODOLOGY FOR NEUTRAL BUOYANCY SIMULATION OF SPACE OPERATIONS
DAVID L. AKIN (MIT, Cambridge, MA) IN: AIAA, Flight Simulation Technologies Conference, Atlanta, GA, Sept. 7-9, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 313-318. refs
(Contract NAGW-21)
(AIAA PAPER 88-4628)

Neutral buoyancy has often been used in the past for EVA development activities, but little has been done to provide an analytical understanding of the environment and its correlation with space. This paper covers a set of related research topics at the MIT Space Systems Laboratory, dealing with the modeling of the space and underwater environments, validation of the models through testing in neutral buoyancy, parabolic flight, and space flight experiments, and applications of the models to gain a better design methodology for creating meaningful neutral buoyancy simulations. Examples covered include simulation validation criteria for human body dynamics, and for applied torques in a beam rotation task, which is the pacing crew operation for EVA structural assembly. Extensions of the dynamics models are presented for powered vehicles in the underwater environment, and examples given from the MIT Space Telerobotics Research Program, including the Beam Assembly Teleoperator and the Multimode Proximity Operations Device. Future expansions of the modeling theory are also presented, leading to remote vehicles which behave in neutral buoyancy exactly as the modeled system would in space. Author

A88-54852*# National Aeronautics and Space Administration, Washington, DC.
HOW THE STATION WILL OPERATE
JOHN T. COX (NASA, Space Station Program Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, Sept. 1988, p. 20-22, 27.

Aspects of the upcoming operational phase of the Space Station (SS) are examined. What the crew members will do with their time in their specialized roles is addressed. SS maintenance and servicing and the interaction of the SS Control Center with Johnson Space Center is discussed. The planning of payload operations and strategic planning for the SS are examined. C.D.

N88-20339*# Martin Marietta Corp., Denver, CO. Astronautics Group.
ORBITAL TRANSFER VEHICLE CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY. VOLUME 2: OTV CONCEPT DEFINITION AND EVALUATION. BOOK 1: MISSION AND SYSTEM REQUIREMENTS Final Report, Jul. 1984 - Oct. 1985
ALLEN E. KOFAL Jul. 1987 70 p Revised
(Contract NAS8-36108)
(NASA-CR-179321; NAS 1.26:179321; MCR-86-2601-VOL-2-BK-1)
Avail: NTIS HC A04/MF A01 CSCL 22B

The mission and system requirements for the concept definition and system analysis of the Orbital Transfer Vehicle (OTV) are established. The requirements set forth constitute the single authority for the selection, evaluation, and optimization of the technical performance and design of the OTV. This requirements document forms the basis for the Ground and Space Based OTV concept definition analyses and establishes the physical, functional, performance and design relationships to STS, Space Station, Orbital Maneuvering Vehicle (OMV), and payloads. Author

N88-20340*# General Dynamics Corp., Huntsville, AL. Advanced Space Programs.
TURNAROUND OPERATIONS ANALYSIS FOR OTV. VOLUME 1: EXECUTIVE SUMMARY Final Report
Feb. 1988 88 p
(Contract NAS8-36924)
(NASA-CR-179316; NAS 1.26:179316; GDSS-SP-87-018-VOL-1)
Avail: NTIS HC A05/MF A01 CSCL 22B

Anaylses performed for ground processing, both expendable and reusable ground-based Orbital Transfer Vehicles (OTVs) launched on the Space Transportation System (STS), a reusable space-based OTV (SBOTV) launched on the STS, and a reusable ground-based OTV (GBOTV) launched on an unmanned cargo vehicle and recovered by the Orbiter are summarized. Also summarized are the analyses performed for space processing the reusable SBOTV at the Space Station in low Earth orbit (LEO) as well as the maintenance and servicing of the SBOTV accommodations at the Space Station. In addition, the candidate OTV concepts, design and interface requirements, and the Space Station design, support, and interface requirements are summarized. A development schedule and associated costs for the required SBOTV accommodations at the Space Station are presented. Finallly, the technology development plan to develop the capability to process both GBOTVs and SBOTVs are summarized. Author

N88-20341*# General Dynamics Corp., Huntsville, AL. Advanced Space Programs.
TURNAROUND OPERATIONS ANALYSIS FOR OTV. VOLUME 2: DETAILED TECHNICAL REPORT Final Report
Feb. 1988 263 p
(Contract NAS8-36924)
(NASA-CR-179317; NAS 1.26:179317; GDSS-SP-87-018-VOL-2)
Avail: NTIS HC A12/MF A01 CSCL 22B

The objectives and accomplishments were to adapt and apply the newly created database of Shuttle/Centaur ground operations. Previously defined turnaround operations analyses were to be updated for ground-based OTVs (GBOTVs) and space-based OTVs (SBOTVs), design requirements identified for both OTV and Space Station accommodations hardware, turnaround operations costs estimated, and a technology development plan generated to develop the required capabilities. Technical and programmatic data were provided for NASA pertinent to OTV round and space operations requirements, turnaround operations, task descriptions, timelines and manpower requirements, OTV modular design and booster and Space Station interface requirements. SBOTV accommodations development schedule, cost and turnaround operations requirements, and a technology development plan for ground and space operations and space-based accommodations facilities and support equipment. Significant conclusion are discussed. Author

N88-20342*# General Dynamics Corp., Huntsville, AL. Advanced Space Programs.
TURNAROUND OPERATIONS ANALYSIS FOR OTV. VOLUME 3: TECHNOLOGY DEVELOPMENT PLAN Final Report
Feb. 1988 118 p
(Contract NAS8-36924)
(NASA-CR-179318; NAS 1.26:179318; GDSS-SP-87-018-VOL-3)
Avail: NTIS HC A06/MF A01 CSCL 22B

An integrated technology development plan for the technologies required to process both GBOTVs and SBOTVs are described. The plan includes definition of the tests and experiments to be accomplished on the ground, in a Space Shuttle Sortie Mission, on an Expendable Launch Vehicle, or at the Space Station as a Technology Development Mission (TDM). The plan reflects and accommodates current and projected research and technology programs where appropriate. Author

N88-20343*# General Dynamics Corp., Huntsville, AL. Advanced Space Programs.
TURNAROUND OPERATIONS ANALYSIS FOR OTV. VOLUME 4: WBS AND DICTIONARY AND COST METHODOLOGY Final Report
Feb. 1988 65 p
(Contract NAS8-36924)
(NASA-CR-179319; NAS 1.26:179319; GDSS-SP-87-018-VOL-4)
Avail: NTIS HC A04/MF A01 CSCL 22B

The Work Breakdown Structure (WBS) and WBS Dictionary and a discussion of the cost methodology and ground rules employed for the cost analysis conducted, are documented. Author

N88-21181# Air Force Inst. of Tech., Wright-Patterson AFB, OH. School of Engineering.
AN EVALUATION OF THE METHODS FOR RESCUING EVA (EXTRAVEHICULAR ACTIVITIES) CREWMEMBERS AND RECOVERING EQUIPMENT DETACHED AND ADRIFT FROM THE SPACE STATION M.S. Thesis
THOMAS SELINKA Dec. 1987 130 p
(AD-A189683; AFIT/GSO/AA/87D-4) Avail: NTIS HC A07/MF A01 CSCL 22A

This thesis is an analysis of the methods for extravehicular activity (EVA) crew rescue and recovery of equipment detached and adrift from the space station. This top level analysis is aimed at identifying the proper direction to be taken in finding the solution system to the rescue/recovery problems. Results of the analysis indicate that for short range rescue/recovery operations, both an EVA self rescue device and a space station supported device are the preferred solution systems. For medium range rescue/recovery operations, an unmanned free-flyer is the ideal solution system. Finally, for long range operations, the Orbital Maneuvering Vehicle (OMV) is the preferred solution. The analysis also showed that the combination of all these preferred solutions is needed to completely solve the problems. To this end, the analysis provides an example of a comprehensive rescue/recovery system. Finally, the analysis identifies issues and recommends areas which require further analysis in order to fully understand and solve the problems of EVA crew rescue and recovery of equipment detached and adrift from the space station. GRA

N88-21471*# Rexnord Aerospace Mechanisms, Torrance, CA.
STRUCTURAL LATCHES FOR MODULAR ASSEMBLY OF SPACECRAFT AND SPACE MECHANISMS
WILLIAM MCCOWN and NEAL BENNETT *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium p 29-44 May 1988
Avail: NTIS HC A18/MF A01 CSCL 13E

Latching techniques are changing from early approaches due to the advent of berthing technology. Latch selection for a given interface may be conducted by evaluating candidate capabilities which meet functional interface requirements. A judgment criteria system is presented along with an example of its use in choosing the Rollerscrew Structural Latch (RSL) for the NASA Flat Plate

Interface Prototype (FPIP). Details are given on Rollerscrew operation, design, and development difficulties. A test plan is also outlined for the RSL and FPIP. Author

N88-24147*# McDonnell-Douglas Astronautics Co., Houston, TX.
ADVANCED EVA SYSTEM DESIGN REQUIREMENTS STUDY
T. G. WOODS *In* NASA, Ames Research Center, Space Station Human Factors Research Review. Volume 1: EVA Research and Development p 85-130 Apr. 1988
Avail: NTIS HC A07/MF A01 CSCL 05H

The results are presented of a study to identify specific criteria regarding space station extravehicular activity system (EVAS) hardware requirements. Key EVA design issues include maintainability, technology readiness, LSS volume vs. EVA time available, suit pressure/cabin pressure relationship and productivity effects, crew autonomy, integration of EVA as a program resource, and standardization of task interfaces. A variety of DOD EVA systems issues were taken into consideration. Recommendations include: (1) crew limitations, not hardware limitations; (2) capability to perform all of 15 generic missions; (3) 90 days on-orbit maintainability with 50 percent duty cycle as minimum; and (4) use by payload sponsors of JSC document 10615A plus a Generic Tool Kit and Specialized Tool Kit description. EVA baseline design requirements and criteria, including requirements of various subsystems, are outlined. Space station/EVA system interface requirements and EVA accommodations are discussed in the areas of atmosphere composition and pressure, communications, data management, logistics, safe haven, SS exterior and interior requirements, and SS airlock. J.P.B.

N88-25473*# General Dynamics/Astronautics, San Diego, CA. Space Systems Div.
CENTAUR OPERATIONS AT THE SPACE STATION Final Report, Sep. 1986 - Feb. 1987
J. PORTER, W. THOMPSON, F. BENNETT, and J. HOLDRIDGE 15 Feb. 1987 155 p
(Contract NAS3-24900)
(NASA-CR-179593; NAS 1.26:179593; GDSS-SP-87-003) Avail: NTIS HC A08/MF A01 CSCL 22B

A study was conducted on the feasibility of using a Centaur vehicle as a testbed to demonstrate critical OTV technologies at the Space Station. Two Technology Demonstration Missions (TDMs) were identified: (1) Accommodations, and (2) Operations. The Accommodations TDM contained: (1) berthing, (2) checkout, maintenance and safing, and (3) payload integration missions. The Operations TDM contained: (1) a cryogenic propellant resupply mission, and (2) Centaur deployment activities. A modified Space Station Co-Orbiting Platform (COP) was selected as the optimum refueling and launch node due to safety and operational considerations. After completion of the TDMs, the fueled Centaur would carry out a mission to actually test deployment and help offset TDM costs. From the Station, the Centaur could carry a single payload in excess of 20,000 pounds to geosynchronous orbit or multiple payloads. Author

N88-26023# Centre d'Essais en Vol, Bretigny-Air (France). Lab. de Medecine Aerospatiale.
SPACE CABIN ATMOSPHERE AND EXTRACURRICULAR SORTIE [ATMOSPHERE D'UNE CABINE SPATIALE ET SORTIE EXTRA-VEHICULAIRE]
HENRI MAROTTE and MARC WEIBEL (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) *In* ESA, Proceedings of the Colloquium on Space and Sea p 69-76 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Conditions which provoke aeroembolism were studied to help design space suits which reduce risks entailed in passing from the terrestrial like conditions of a spacecraft cabin atmosphere to the medium and low pressures of space suits. Design constraints on the suite and its pressurizing system were evaluated, especially for the working conditions of space stations, which require frequent extravehicular activity. Given the limits imposed by denitrogenation, a high pressure (at least 650 hPa) is suggested for the American space station program, whereas for ESA, use of Hermes is compatible with a 450 hPa suit. For intravehicular emergency suits, pressure should be as high as compatible with mobility requirements (bearing in mind the reduced level of physical activity). ESA

N88-26041# Norwegian Marine Technology Research Inst., Trondheim.
MARINTEK'S OCEAN BASIN, A TRAINING FACILITY FOR EXTRAVEHICULAR ACTIVITY?
TOR EINER BERG *In* ESA, Proceedings of the Colloquium on Space and Sea p 177-182 Mar. 1988
Avail: NTIS HC A15/MF A01

Equipment and functional requirements for a neutral buoyancy facility for weightlessness simulation are discussed. Time schedule and costs related to modification and upgrading of an ocean basin to become an extravehicular activity training facility for ESA are estimated. ESA

N88-28634*# Life Systems, Inc., Cleveland, OH.
VAPOR COMPRESSION DISTILLATION SUBSYSTEM (VCDS) COMPONENT ENHANCEMENT, TESTING AND EXPERT FAULT DIAGNOSTICS DEVELOPMENT, VOLUME 1 Final Report
L. S. KOVACH and E. M. ZDANKIEWICZ Dec. 1987 90 p
(Contract NAS9-16374)
(NASA-CR-172072; NAS 1.26:172072; LSI-TR-471-26-VOL-1)
Avail: NTIS HC A05/MF A01 CSCL 06K

Vapor compression distillation technology for phase change recovery of potable water from wastewater has evolved as a technically mature approach for use aboard the Space Station. A program to parametrically test an advanced preprototype Vapor Compression Distillation Subsystem (VCDS) was completed during 1985 and 1986. In parallel with parametric testing, a hardware improvement program was initiated to test the feasibility of incorporating several key improvements into the advanced preprototype VCDS following initial parametric tests. Specific areas of improvement included long-life, self-lubricated bearings, a lightweight, highly-efficient compressor, and a long-life magnetic drive. With the exception of the self-lubricated bearings, these improvements are incorporated. The advanced preprototype VCDS was designed to reclaim 95 percent of the available wastewater at a nominal water recovery rate of 1.36 kg/h achieved at a solids concentration of 2.3 percent and 308 K condenser temperature. While this performance was maintained for the initial testing, a 300 percent improvement in water production rate with a corresponding lower specific energy was achieved following incorporation of the improvements. Testing involved the characterization of key VCDS performance factors as a function of recycle loop solids concentration, distillation unit temperature and fluids pump speed. The objective of this effort was to expand the VCDS data base to enable defining optimum performance characteristics for flight hardware development. Author

N88-29367*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
MACHINE VISION FOR REAL TIME ORBITAL OPERATIONS
FRANK L. VINZ *In its* Second Conference on Artificial Intelligence for Space Applications p 141-155 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 05H

Machine vision for automation and robotic operation of Space Station era systems has the potential for increasing the efficiency of orbital servicing, repair, assembly and docking tasks. A machine vision research project is described in which a TV camera is used for inputing visual data to a computer so that image processing may be achieved for real time control of these orbital operations. A technique has resulted from this research which reduces computer memory requirements and greatly increases typical computational speed such that it has the potential for development into a real time orbital machine vision system. This technique is called AI BOSS (Analysis of Images by Box Scan and Syntax). Author

N88-29835*# General Dynamics Corp., San Diego, CA.
CENTAUR OPERATIONS AT THE SPACE STATION: COST AND TRANSPORTATION ANALYSIS Final Report
10 Aug. 1988 241 p
(Contract NAS3-24900)
(NASA-CR-182128; NAS 1.26:182128; GDSS-SP-88-006) Avail: NTIS HC A11/MF A01 CSCL 22B

A study was conducted to expand on the results of an initial study entitled Centaur Operations at the Space Station. The previous study developed technology demonstration missions (TDMs) that utilized the Centaur G-prime upper stage to advance OTV technologies required for accomodations and operations at the Space Station. An initial evaluation was performed of the cost to NASA for TDM implementation. Due to the potential for commercial communication satellite operation utilizing the TDM hardware, an evaluation of the Centaur's transportation potential was also performed. Author

N88-29837*# Eagle Engineering, Inc., Houston, TX.
MAINTENANCE AND SUPPLY OPTIONS
May 1988 59 p
(Contract NAS9-17878)
(NASA-CR-172062; NAS 1.26:172062; EEI-87-173) Avail: NTIS HC A04/MF A01 CSCL 22B

The object of the Maintenance and Supply Option was to develop a high level operational philosophy related to maintenance and supply operations and incorporate these concepts into the Lunar Base Study. Specific products to be generated during this task were three trade studies and a conceptual design of the Logistic Supply Module. The crew size study was performed to evaluate crew sizes from the baseline size of four to a crew size of eight and determine the preferred crew size. The second trade study was to determine the impact of extending surface stay times and recommend a preferred duration of stay time as a function of crew, consumables, and equipment support capabilities. The third trade study was an evaluation of packaging and storage methods to determine the preferred logistics approach to support the lunar base. A modified scenario was developed and served as the basis of the individual trade studies. Assumptions and guidelines were also developed from experience with Apollo programs, Space Shuttle operations, and Space Station studies. With this information, the trade studies were performed and a conceptual design for the Logistic Supply Module was developed. Author

N88-30301*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION PROXIMITY OPERATIONS WINDOWS: HUMAN FACTORS DESIGN GUIDELINES
RICHARD F. HAINES Mar. 1987 109 p
(NASA-TM-88233; A-86185; NAS 1.15:88233) Avail: NTIS HC A06/MF A01 CSCL 06K

Proximity operations refers to all activities outside the Space Station which take place within a 1-km radius. Since there will be a large number of different operations involving manned and unmanned vehicles, single- and multiperson crews, automated and manually controlled flight, a wide variety of cargo, and construction/repair activities, accurate and continuous human monitoring of these operations from a specially designed control station on Space Station will be required. Total situational awareness will be required. This paper presents numerous human factors design guidelines and related background information for control windows which will support proximity operations. Separate sections deal with natural and artificial illumination geometry; all basic rendezvous vector approaches; window field-of-view requirements; window size; shape and placement criteria; window optical characteristics as they relate to human perception; maintenance and protection issues; and a comprehensive review of windows installed on U.S. and U.S.S.R. manned vehicles. Author

N88-30357*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
THE SPACE STATION ASSEMBLY PHASE: SYSTEM DESIGN TRADE-OFFS FOR THE FLIGHT TELEROBOTIC SERVICER
JEFFREY H. SMITH, MAX GYAMFI, KENT VOLKMER, and WAYNE ZIMMERMAN *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 381-396 Aug. 1988
(Contract NAS7-918)
Avail: NTIS HC A19/MF A01 CSCL 05H

The effects of a recent study aimed at identifying key issues and trade-offs associated with using a Flight Telerobotic Servicer (FTS) to aid in Space Station assembly-phase tasks is described. The use of automation and robotic (A and R) technologies for large space systems often involves a substitution of automation capabilities for human EVA or IVA activities. A methodology is presented that incorporates assessment of candidate assembly-phase tasks, telerobotic performance capabilities, development costs, and effects of operational constaints. Changes in the region of cost-effectiveness are examined under a variety of system design assumptions. A discussion of issues is presented with focus on three roles the FTS might serve: as a research-oriented test bed to learn more about space usage of telerobotics; as a research based test bed having an experimental demonstration orientation with limited assembly and servicing applications; or as an operational system to augment EVA and to aid construction of the Space Station and to reduce the program (schedule) risk by increasing the flexibility of mission operations. Author

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SPACE ENVIRONMENT

Includes description of the space environment and effects on Space Station subsystems. Includes requirements for Space Station to accommodate this environment.

A88-20351
HF RADAR OBSERVATIONS OF E REGION PLASMA IRREGULARITIES PRODUCED BY OBLIQUE ELECTRON STREAMING
J. P. VILLAIN, R. A. GREENWALD, K. B. BAKER, and J. M. RUOHONIEMI (Johns Hopkins University, Laurel, MD) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12327-12342. USAF-DNA-supported research. refs
(Contract NSF ATM-85-06851; N00039-87-C-5301)

Data obtained with an HF radar located in Goose Bay, Labrador, were used to study four selected events which occurred in September and October of 1985 and September 1986 in the postmidnight sector at E region altitudes and which exhibited unusual but similar characteristics. The radar data indicated that arclike regions of irregularities were moving approximately along L contours, with a drift velocity of the order of 200 m/s or less. For periods of a few minutes or less, localized regions of irregularities exhibiting high Doppler velocities appeared within the radar arcs. Two distinct types of high Doppler-velocity signals were identified: one type, distributed between 320 and 550 m/s, interpreted as ion acoustic velocity; and the other, distributed between 320 and 550 m/s, interpreted as electrostatic ion cyclotron waves produced by NO(+) ions. I.S.

A88-25391* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
RECENT TRENDS IN PARTS SEU SUSCEPTIBILITY FROM HEAVY IONS
D. K. NICHOLS, L. S. SMITH, W. E. PRICE (California Institute of Technology, Jet Propulsion Laboratory, Pasadena), R. KOGA, and W. A. KOLASINSKI (Aerospace Corp., El Segundo, CA) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and

Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1332-1337.

The authors collected a set of heavy-ion single event upset (SEU) test data since their last publication in December, 1985. Trends in SEU susceptibility for state-of-the-art parts are presented. I.E.

A88-25392
ADVANTAGE OF ADVANCED CMOS OVER ADVANCED TTL IN A COSMIC RAY ENVIRONMENT
JEFFREY H. SOKOL, MANNIX WONG, ROBERT V. SUHRKE (Teledyne Systems Co., Northridge, CA), WOJCIECH A. KOLASINSKI, and ROKUTANO KOGA (Aerospace Corp., Los Angeles, CA) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1338-1340. refs

Samples of the 54F109, 54AS109, 54ALS109, and the 54AHCT109 advanced TTL devices, as well as the 54F374, 54AS374, 54ALS374, and the 54AHCT374 CMOS devices were tested for single-event upset (SEU) sensitivity at the Berkeley Cyclotron. The results indicate that the 54AHCT109 possesses a LET (linear energy transfer) threshold an order of magnitude greater and a SEU cross section that is 20 times less than its advanced TTL counterparts. The same trend was shown for the 54AHCT374 where the LET threshold was four times greater than that for the 54F374, while the SEU cross section was slightly less than that of the 54F374. These results indicate substantial improvement in SEU rejection by the 54AHCT family over advanced TTL. I.E.

A88-25393
A COMPARISON OF POSITIVE CHARGE GENERATION IN HIGH FIELD STRESSING AND IONIZING RADIATION ON MOS STRUCTURES
W. L. WARREN and P. M. LENAHAN (Pennsylvania State University, University Park) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1355-1358. Research supported by IBM Corp. and Sandia National Laboratory. refs

The effects of ionizing radiation and high field stressing on metal-oxide-silicon oxides are compared. Using electron spin resonance, the authors compare the point defects responsible for the positive charge generated by ionizing radiation and high field stressing. The two processes have been found to be different in that the positive charge generated by ionizing radiation is almost entirely due to E' centers in the oxide; however, less than half the positive charge generated by high field stressing can be accounted for by E' centers. I.E.

A88-25396
A SIMPLE METHOD TO IDENTIFY RADIATION AND ANNEALING BIASES THAT LEAD TO WORST-CASE CMOS STATIC RAM POSTIRRADIATION RESPONSE
D. M. FLEETWOOD and P. V. DRESSENDORFER (Sandia National Laboratories, Albuquerque, NM) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1408-1413. refs
(Contract DE-AC04-76DP-00789)

A simple method to identify bias conditions that lead to worst-case postirradiation speed and timing response for static random-access memories (SRAMs) is presented. Switching cell states between radiation and anneal leads to maximum speed and timing degradation for many hardened designs and technologies; examples are presented. The greatest SRAM cell imbalance is also established by these radiation and annealing conditions for the hardened and commercial parts. These results provide insight into the behavior of SRAMs during and after irradiation. The results should also be useful in establishing guidelines for integrated-circuit functionality testing, and SEU (single-event upset) and dose-rate upset testing, after total-dose irradiation. I.E.

A88-25397* North Carolina State Univ., Raleigh.
QUANTIFICATION OF THE MEMORY IMPRINT EFFECT FOR A CHARGED PARTICLE ENVIRONMENT
B. L. BHUVA, R. L. JOHNSON, JR., R. S. GYURCSIK, S. E. KERNS (North Carolina State University, Raleigh), and K. W. FERNALD (NASA, Langley Research Center, Hampton, VA) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1414-1418. refs
(Contract N00014-85-2231)

The effects of total accumulated dose on the single-event vulnerability of NMOS resistive-load SRAMs are investigated. The bias-dependent shifts in device parameters can imprint the memory state present during exposure or erase the imprinted state. Analysis of these effects is presented along with an analytic model developed for the quantification of these effects. The results indicate that the imprint effect is dominated by the difference in the threshold voltage of the n-channel devices. I.E.

A88-25398
PREDICTING TRANSIENT UPSET IN GATE ARRAYS
RICHARD L. WOODRUFF, DONALD A. NELSON, and STEVEN SCHERR (United Technologies Microelectronics Center, Colorado Springs, CO) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1426-1430. refs

A simulation program for predicting dose rate upset has been adapted from the Power Analysis for Integrated Circuits Program (PANIC). The program provides analysis on the Vcc-Vss difference at any location within the array as well as the amount of photocurrent being collected, as a function of design. The simulation has been compared to experiment for a specific design and was found to correlate to within 20 percent at 5 V. I.E.

A88-25399
RADIATION-INDUCED RESPONSE OF OPERATIONAL AMPLIFIERS IN LOW LEVEL TRANSIENT RADIATION ENVIRONMENTS
JOHN J. PAULOS, RICHARD J. BISHOP (North Carolina State University, Raleigh), and THOMAS L. TURFLINGER (U.S. Navy, Naval Weapons Support Center, Crane, IN) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1442-1447. Research supported by USASDC and Texas Instruments, Inc. refs

Computer simulations have been performed on CMOS and bipolar operational amplifiers in an attempt to obtain a better understanding of low-level transient radiation response mechanisms. The simulation methodology has been confirmed using flash X-ray data for the amplifiers studied. Variations in circuit response to loading and feeding configuration have been explored. Several generalizations can be made which may provide a basis for a specification methodology. I.E.

A88-25400
TOTAL-DOSE FAILURE MECHANISMS OF INTEGRATED CIRCUITS IN LABORATORY AND SPACE ENVIRONMENTS
P. S. WINOKUR, F. W. SEXTON, G. L. HASH, and D. C. TURPIN (Sandia National Laboratories, Albuquerque, NM) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1448-1454. DNA-supported research. refs
(Contract DE-AC04-76DP-00789)

Total-dose failure mechanisms are identified over a wide range of dose rate for 2K and 16K static random-access memories (SRAMs) from hardened and commercial CMOS technologies. Failure was defined parametrically, such that an IC fails if one of its parameters, e.g., static power supply current or timing, exceeds a preset specification following irradiation. These studies demonstrate that the dominant failure mechanisms of SRAMs in space radiation environments are often different from those observed at considerably higher laboratory dose rates specified by U.S. Department of Defense test guidelines, i.e., 100 to 300 rad(Si)/s. The total-dose hardness of SRAMs varied significantly between laboratory and space dose rates. Several approaches are discussed for predicting total-dose hardness of ICs in space from laboratory measurements. Results are presented for transistors irradiated over the same range of dose rate, 200 to 0.02 rad(Si)/s, and at all biases, i.e., n-ON/OFF and p-ON/OFF. These transistor measurements are used to characterize the physical mechanisms that govern the radiation response of the more complex SRAMs. A dose-rate dependence for the buildup of radiation-induced interface states was observed. At dose rates from 200 to 0.02 rad(Si)/s, the number of interface states at a given total dose increased as the dose rate decreased. I.E.

A88-25402
RADIATION TOLERANT MEMORY SELECTION FOR THE MARS OBSERVER CAMERA
DAVID K. MYERS (Myers and Associates, Morgan Hill, CA), ALAN S. DANZIGER (APh Technological Consulting, Pasadena, CA), and THOMAS A. SOULANILLE (Altadena Instruments, Pasadena, CA) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1467-1469.

Survey testing, using Co-60 gamma rays, of high-capacity RAM for a spacecraft image buffer has identified a candidate 1 Mb CMOS dynamic RAM device, the M411024xP from AT&T, which showed no functional degradation at 30 krad(Si), and usable performance at 100 krad(Si). I.E.

A88-25403* Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PROPAGATION DELAY MEASUREMENTS FROM A TIMING SAMPLER INTENDED FOR USE IN SPACE
B. R. BLAES, M. G. BUEHLER, and Y.-S. LIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) (IEEE, DOD, NASA, and DOE, 1987 Annual Conference on Nuclear and Space Radiation Effects, Snowmass Village, CO, July 28-31, 1987) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-34, pt. 1, Dec. 1987, p. 1470-1473. DARPA-NASA-sponsored research. refs

A 3-micron CMOS timing sampler is described which is a test circuit designed into the Jet Propulsion Labs' CRRES chip to be flown on the Combined Release and Radiation Effects Satellite (CRRES). The timing sampler consists of 64 inverter-pair stages with sampling latches and decoder circuitry. The sampler is used to measure inverter-pair propagation delays, which are nominally 2.5 ns, with a resolution of 100 ps. A simple model was developed to explain the radiation-induced inverter-pair delay shifts in terms of radiation-induced MOSFET threshold-voltage shifts and effective modal capacitances. The magnitude of the shift in pair delay with radiation was estimated at the point where the n-MOSFET threshold voltage became zero. For a 0.7-V-threshold shift, the pair delay increased from its preradiation value by 360 ps for a rising step input and decreased by 190 ps for a falling step input. I.E.

A88-26387 Sophia Univ., Tokyo (Japan).
ELASTIC BUCKLING AND FLEXURAL VIBRATION OF VARIABLE-THICKNESS ANNULAR PLATES UNDER NONUNIFORM IN-PLANE FORCES
OSAMU MAJIMA and KUNIO HAYASHI (Sophia University, Tokyo, Japan) JSME International Journal (ISSN 0913-185X), vol. 30, Dec. 1987, p. 1890-1897. refs

This paper deals with elastic buckling and flexural vibration of annular plates whose thicknesses vary linearly in the radial direction. The annular plate is subjected to in-plane forces along its inner and outer edges, which vary in the circumferential direction. These problems are analyzed by the Galerkin method. Eigenfunctions of the natural vibration of a constant-thickness annular plate without in-plane forces are used as admissible functions. Two types of in-plane forces are adopted; one a sinusoidally varying nonuniformity along the outer edge, and the other uniform along parts of the outer edge and zero on the remainder of the edge. The influences of the nonuniformity of the in-plane forces on the buckling load and natural frequencies are investigated. It is found that the increase of the nonuniformity decreases the buckling load and the fundamental natural frequency. This tendency becomes more evident when the thickness of the plate at the inner edge is thinner and the hole larger. Author

A88-26396
COMPUTATION OF ANALYTICAL EXPRESSIONS FOR TRANSFER FUNCTIONS
I. D. MAYERGOYZ and F. P. EMAD (Maryland, University, College Park) International Journal of Control (ISSN 0020-7179), vol. 46, Dec. 1987, p. 1935-1945. Research supported by the GE Foundation, Bechtel Corp., BG&E Co., VEPCO, and PEPCO, Inc. refs
(Contract DE-AS05-84EH-13145)

A new method for computing transfer functions of linear time-invariant multivariable control systems is presented. This method has the following attractive features: (1) it produces analytical expressions for transfer functions; (2) computations are inherently parallel and can be implemented, for instance, on parallel processors with a fine-grain architecture; (3) calculations of transfer functions are reduced to two well-studied computational problems (solution of simultaneous linear equations and the FFT); and (4) state-variable formulations can be avoided. Theoretical conclusions are demonstrated with numerical examples. Author

A88-28959
ON THE ITERATIVE LEARNING CONTROL THEORY FOR ROBOTIC MANIPULATORS
PAOLA BONDI, LUCIA GAMBARDELLA (Napoli, Universita, Naples, Italy), and GIUSEPPE CASALINO (Genova, Universita, Genoa, Italy) IEEE Journal of Robotics and Automation (ISSN 0882-4967), vol. 4, Feb. 1988, p. 14-22. refs

A 'high-gain feedback' point of view is considered within the iterative learning control theory for robotic manipulators. Basic results concerning the uniform boundedness of the trajectory errors are established, and a proof of convergence of the algorithm is given. Author

A88-33104
EFFECT OF SOLAR PRESSURE ON THE MOTION AND STABILITY OF THE SYSTEM OF TWO INTER-CONNECTED SATELLITES IN AN ELLIPTICAL ORBIT
SACHINDRA KUMAR SINHA (Rajendra Agricultural University, Pusa Samastiupur, India) and R. B. SINGH (Bihar University, Muzaffarpur, India) Astrophysics and Space Science (ISSN 0004-640X), vol. 140, no. 1, Jan. 1988, p. 49-54. refs

The effect of solar pressure on the motion and stability of a system of two interconnected satellites (such as a manned-space capsule attached to its booster with a flexible and inextensible string near some equilibrium position) is investigated analytically for the case of elliptical orbit. In this model, which is based on the work of Beletsky (1965, 1969), Singh (1973), and Sinha (1987), the equations of motion obtained are nonlinear and nonautomous; the solution of the system was obtained using Bogoliubov et al. (1961) method. The results indicate that the amplitude of the system remains constant up to the order of e-squared (where e denotes eccentricity). If the value of e is very small, the system will always oscillate about the position of equilibrium with tight string-like dumb-bell satellite with changing phase and constant amplitude. I.S.

A88-33548* National Aeronautics and Space Administration, Washington, DC.
RADIATION DOSE AND SHIELDING FOR THE SPACE STATION
PERCIVAL D. MCCORMACK (NASA, Office of Space Station, Washington, DC) (IAF, International Astronautical Congress, 37th, Innsbruck, Austria, Oct. 4-11, 1986) Acta Astronautica (ISSN 0094-5765), vol. 17, Feb. 1988, p. 231-241. refs
(IAF PAPER 86-380)

Significant differences in dose prediction for Space Station arise depending on whether or not the magnetic field model is extrapolated into the future. The basis for these calculations is examined in detail, and the importance of the residual atmospheric layer at altitudes below 1000 km, with respect to radiation attenuation, is emphasized. Dosimetry results from Shuttle flights are presented and compared with the computed results. It is recommended that, at this stage, no extrapolation of the magnetic field into the future be included in the calculations. A model adjustment, to replace this arbitrary procedure, is presented. Dose predictions indicate that, at altitudes below 500 km and at low inclination, and with nominal module wall thickness (0.125 in. aluminum), orbit stay times of 90 days in Space Station would result in quarterly radiation doses to the crew, which are well within present limits for both males and females. Countermeasures would be required for stay times of a year or more and the measure of increasing shielding is examined. Author

A88-33789*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
TEST PROGRAM TO EVALUATE ESD SUSCEPTIBILITY OF EVA SUIT MATERIAL
PHILIP LEUNG (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings. Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 105-110. refs
(Contract NAS7-918)

This paper presents the details of a test program for the evaluation of the electrostatic discharge susceptibility of extravehicular activity equipment in polar orbits. In this program, laboratory simulation tests were performed to obtain the charging and ESD characteristics of the spacesuit material. The results from the simulation tests were used to generate the parameters for a system level ESD test for the existing EVA equipment. These test parameters were also used as a guide for the selection of the test apparatus. Author

A88-33958
ELECTROTOPOGRAPHIC INVESTIGATION OF THE DEGRADATION DYNAMICS OF DIELECTRIC LAYERS IN SPACE [ELEKTROTOPOGRAFICHESKIE ISSLEDOVANIIA DINAMIKI DEGRADATSII DIELEKTRICHESKIKH SLOEV V OTKRYTOM KOSMOSE]
A. E. KRAVTSOV and M. T. SHPAK (AN USSR, Institut Fiziki, Kiev, Ukrainian SSR) Kosmicheskaia Nauka i Tekhnika (ISSN 0321-4508), no. 1, 1986, p. 69, 70. In Russian. refs

The necessity of collecting data on the degradation of spacecraft structural materials under the effects of space flight factors is substantiated. A technique for the electrotopographic monitoring of defects is described. Results are presented on the degradation dynamics of thin dielectric layers under the effect of space flight factors investigated in the Salyut-7 Electrotopograph experiments. B.J.

A88-34541* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
COHERENT LIDAR WIND MEASUREMENTS FROM THE SPACE STATION BASE USING 1.5 M ALL-REFLECTIVE OPTICS
J. W. BILBRO and R. G. BERANEK (NASA, Marshall Space Flight Center, Huntsville, AL) IN: Reflective optics; Proceedings of the Meeting, Los Angeles, CA, Jan. 15, 16, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 44-49. refs

This paper discusses the space-based measurement of atmospheric winds from the point of view of the requirements of the optical system of a coherent CO2 lidar. A brief description of the measurement technique is given and a discussion of previous study results provided. The telescope requirements for a Space Station based lidar are arrived at through discussions of the desired system sensitivity and the need for lag angle compensation. Author

A88-35758
GEOMAGNETIC RESPONSE TO SUDDEN EXPANSIONS OF THE MAGNETOSPHERE
TOHRU ARAKI (Kyoto University, Japan) and HIROSHI NAGANO (Asahi University, Gifu, Japan) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, May 1, 1988, p. 3983-3988. refs

This paper examines the geomagnetic response to five successive sudden expansions of the magnetosphere (as manifested in negative sharp impulses, SI, observed in the H component magnetic field) that took place during a 3-h period between 1300 and 1600 UT on July 6, 1977, using magnetic data obtained by satellites and on-ground observations. The results of a detailed analysis of the negative SI indicate that the geomagnetic variations of the negative SI observed can be well explained by the model for positive SI by reversing the direction of electric current used in the model. I.S.

A88-35877
THE ENVIRONMENT OF EARTH-ORBITING SYSTEMS
H. HAMACHER (DFVLR, Institut fuer Raumsimulation, Cologne, Federal Republic of Germany), B. FITTON (Leiden, Rijksuniversiteit, Sterrewacht, Netherlands), and J. KINGDON (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IN: Fluid sciences and materials science in space: A European perspective. Berlin and New York, Springer-Verlag, 1987, p. 1-50. refs

The environment encountered by earth-orbiting spacecraft is characterized with particular reference to microgravity experimentation. A number of disturbances resulting in accelerations that prevent from achieving ideal zero-gravity conditions in spacecraft are identified, and the most dominant disturbances are discussed. Particular attention is given to the gravitational enviroment of Spacelab and the planned Space Station. The discussion also covers the effects of radiation, atmospheric conditions, high-energy particles, and electric and magnetic fields. V.L.

A88-36103
RADIATION EFFICIENCY OF A LOW-FREQUENCY FRAME ANTENNA IN THE IONOSPHERIC PLASMA [EFFEKTIVNOST' IZLUCHENIIA RAMOCHNOI ANTENNY NIZKOI CHASTOTY V IONOSFERNOI PLAZME]
V. V. AKINDINOV, A. M. BUKHAROVA, I. V. LISHIN, and R. K. SOROKINA Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 33, March 1988, p. 490-494. In Russian. refs

The radiation efficiency of a low-frequency frame antenna in the magnetoactive ionospheric plasma is analyzed as a function of the angle gamma sub 0 between the frame axis and the direction of the constant magnetic field. It is shown that the efficiency of whistler-range radiation at gamma sub 0 = 90 deg is substantially higher than at gamma sub 0 = 0 deg. B.J.

A88-37291#
BOTANY FACILITY - AN ARTIFICIAL ENVIRONMENT FOR PLANTS IN SPACE
PETER KERN and WOLFRAM LORK Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 36, 37.

Due to the short duration of past botanical experiments in microgravity conditions, the long-term effect of space mision duration on plants remains unclear. The ESA Eureca platform will accordingly address this question and the related one as to whether plants grown under microgravity for several generations maintain their CO2-to-O2 metabolic conversion rate, as required for the biological control of life support systems. Eureca is scheduled for

Space Shuttle launch in 1990 for a six-month mission. Attention is given to the design features of the 30 cuvettes forming the life environments for the plants. O.C.

A88-37343
REFILLING PROCESS IN THE PLASMASPHERE AND ITS RELATION TO MAGNETIC ACTIVITY
XIAO-TING SONG, ROGER GENDRIN, and GERARD CAUDAL (Centre de Recherches en Physique de l'Environnement Terrestre et Planetaire, Issy-les-Moulineaux, France) Journal of Atmospheric and Terrestrial Physics (ISSN 0021-9169), vol. 50, March 1988, p. 185-195. refs

Plasma density data obtained by the GEOS-2 satellite are used to study the refilling process in the plasmasphere and the relationship between the refilling process and magnetic activity (the Dst index). The average refilling rate of about 25/cu cm per day experimentally deduced for small absolute values of Dst is found to agree well with the corresponding refilling rate predicted using the theory of Lamaire (1985). It is suggested that the observed correlation of refilling rate with Dst index results from the modification of the composition of the topside ionosphere occurring after intense storms. R.R.

A88-38115
A TECHNIQUE FOR THE MEASUREMENT OF ENVIRONMENTAL LEVELS OF MICROWAVE RADIATION AROUND SATELLITE EARTH STATIONS
W. S. DAVIES and K. H. JOYNER (Telecom Australia Research Laboratories, Clayton) Journal of Electrical and Electronics Engineering, Australia (ISSN 0725-2986), vol. 7, Dec. 1987, p. 274-277. refs

Upper bounds for the levels of environmental microwave radiation measured in the vicinity of large aperture antennas using directive microwave probe antennas are discussed. In addition, the results of several surveys around satellite earth stations are summarized and presented. From the survey results it can be concluded that the environmental levels of microwave radiation outside the immediate vicinity of the antennas are many orders of magnitude below currently accepted exposure standards for members of the general public. As a point of comparison, it was found that the environmental levels of microwave radiation were generally comparable with the combined power densities of FM and TV transmissions measured in Melbourne suburbs. Author

A88-41328
CONTAMINATION INDUCED DEGRADATION OF OPTICAL SOLAR REFLECTORS IN GEOSYNCHRONOUS ORBIT
DARYL L. MOSSMAN, HOSEA D. BOSTIC, and JESUS R. CARLOS (Aerojet ElectroSystems Co., Azusa, CA) IN: Optical system contamination: Effects, measurement, control; Proceedings of the Meeting, Orlando, FL, May 19-22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 12-19. refs (Contract F04701-84-C-0034)

After 2.5 years of exposure to the GEO solar environment, siloxane-contaminated second-surface mirrors exhibited a solar absorptance a(s) enhancement factor of the order of 3.0. A doubling of the siloxane film thickness from 300 to 600 A produced an a(s) only 40 percent greater, suggesting that most of the solar radiation is absorbed in the external 300-A thick layer. Accelerated laboratory test results are comparable to the GEO data, and verify that this orbital solar environment can be simulated for a given type and thickness of contaminant. O.C.

A88-41339* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
SPACE STATION USERS CONTAMINATION REQUIREMENTS
NANCY J. P. CAROSSO (NASA, Goddard Space Flight Center, Greenbelt, MD) IN: Optical system contamination: Effects, measurement, control; Proceedings of the Meeting, Orlando, FL, May 19-22, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1987, p. 138-145. refs

An account is given of the contamination sensitivities and requirements of various planned NASA Space Station users in all science categories, as well as the methods by which the Space Station will accomodate these requirements in the cases of attached payloads, core station-attached payloads, and platform payloads. Attention is given to the Space Station's external contamination environment, the degree of protection from contamination that the Space Station user must provide, the amount of warning users will receive prior to the initiation of potentially contamination-generating activities in the Space Station, and different contamination probabilities for the various parts of the Space Station. O.C.

A88-43516*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
DECISION TIME ON ORBITAL DEBRIS
JOSEPH P. LOFTUS (NASA, Johnson Space Center, Houston, TX), LEE E. TILTON (NASA, Washington, DC), and L. PARKER TEMPLE, III (USAF, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 16-18.

The problem of orbital debris, especially in LEO is discussed, stressing ways to minimize hazards caused by debris. There are over 7,000 objects making up 2.4 X 10 to the 6th kg of debris in LEO with velocities up to 7 km/sec. The least costly way of minimizing hazards from debris is to make spent rocket stages inert, to preclude failures after their useful life, by insuring that all residual propellants and pressurant gases are vented while the stage is still subject to command. A more costly option is the actively controlled deorbit of spent stages and spacecraft at the end of their useful mission life. The removal of inert stages or spacecraft is too costly to be practical. The least expensive methods of removal are deorbit for altitudes below 25,000 km and placing the object in earth-escape trajectory for objects at higher altitudes. NASA is developing a special radar to measure the existing small-particle debris and its changes over time, and international agreements are expected to set standards of operational practices to minimize debris. R.B.

A88-43517*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
PREDICTING DEBRIS
DONALD J. KESSLER (NASA, Johnson Space Center, Houston, TX) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 22-24.

The probable amount, sizes, and relative velocities of debris are discussed, giving examples of the damage caused by debris, and focusing on the use of mathematical models to forecast the debris environment and solar activity now and in the future. Most debris are within 2,000 km of the earth's surface. The average velocity of spacecraft-debris collisions varies from 9 km/sec at 30 degrees of inclination to 13 km/sec near polar orbits. Mathematical models predict a 5 percent per year increase in the large-fragment population, producing a small-fragment population increase of 10 percent per year until the year 2060, the time of critical density. A 10 percent increase in the large population would cause the critical density to be reached around 2025. R.B.

A88-43518*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
SHIELDING AGAINST DEBRIS
BURTON G. COUR-PALAIS (NASA, Johnson Space Center, Houston, TX) and SHERMAN L. AVANS (NASA, Marshall Space Flight Center, Huntsville, AL) Aerospace America (ISSN 0740-722X), vol. 26, June 1988, p. 24, 25.

The damage to spacecraft caused by debris and design of the Space Station to minimize damage from debris are discussed. Although current estimates of the debris environment show that fragments bigger than 2 cm are not likely to hit the Space Station, orbital debris from about 0.5 mm to 2 cm will pose a hazard, especially on brittle surfaces, such as glass. Spacesuits are being designed to reduce debris caused dangers to astronauts during EVA. About 5 cm of high-strength aluminum are needed to prevent penetration by a 1 cm piece of aluminum with a mass near 1.5 g colliding at 10 km/sec. Because aluminum bumpers have the drawback of metallic debris ejected outward after a hypervelocity

collision, the use of nonmetallic materials for bumpers is being studied. Methods of reducing the weight and volume of the shield for the Space Station are also being researched. A space station habitation module using bumpers has a 99.6 percent chance of avoiding penetration during its lifetime. R.B.

A88-43765*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
PARTICLE ADHESION TO SURFACES UNDER VACUUM
JACK B. BARENGOLTZ (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) AIAA, Thermophysics, Plasmadynamics and Lasers Conference, San Antonio, TX, June 27-29, 1988. 9 p. refs
(AIAA PAPER 88-2725)

The release of glass beads and standard dust from aluminum and glass substrates under centrifugation (simulating atmospheric pressure, low vacuum, and high vacuum conditions) was measured, with application to the estimation of contaminant particle release during spacecraft launch. For particles in the 10-100 micron range, dust was found to adhere more strongly than glass beads in all the cases considered. For most of the cases, dust and glass beads adhered more strongly to glass than to aluminum at all pressures. The adhesion force for dust on glass at 10 torr was shown to be as small as the value for dust on aluminum. R.R.

A88-46569* California Inst. of Tech., Pasadena.
DYNAMIC SUBSTORM INJECTIONS - SIMILAR MAGNETOSPHERIC PHENOMENA AT EARTH AND MERCURY
S. P. CHRISTON (California Institute of Technology, Pasadena), J. FEYNMAN, and J. A. SLAVIN (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Magnetotail physics. Baltimore, MD, Johns Hopkins University Press, 1987, p. 393-400. refs

Correlations between energetic electrons, plasma electrons, and magnetic fields during the Mercury 1 energetic particle events are examined and comparisons are made with several well-documented substorm injections at the earth. The data reveal that the B and B-prime events possess the same characteristics as single-point observations of terrestrial dynamic injections. Several recently discovered correlations between the energetic electrons, plasma electrons, and magnetic fields at Mercury are discussed. K.K.

A88-47909* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
NANO-G ENVIRONMENT ON THE ORBITER OR SPACE STATION
FRIEDRICH O. VON BUN (NASA, Goddard Space Flight Center, Greenbelt, MD), OWEN K. GARRIOTT (Effort, Inc., Houston, TX), and DON J. PEARSON (NASA, Johnson Space Center, Houston, TX) Acta Astronautica (ISSN 0094-5765), vol. 17, May 1988, p. 579-583.

To achieve a nanogravity environment on the Space Shuttle Orbiter or Space Station a floating table is proposed. With precise control of the initial release conditions, float times of many minutes can be expected before touching a wall. The use of small thrusters available on the spacecraft to fly the station around the floating table would allow experiment times of many hours. Author

A88-47966*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, AL.
OPTICAL ENVIRONMENT OF THE SPACELAB 1 MISSION
MARSHA R. TORR, J. K. OWENS (NASA, Marshall Space Flight Center, Huntsville, AL), and D. G. TORR (Alabama, University, Huntsville) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 125-131. refs

The passing of large orbital vehicles through the space environment often generates such emissions as glows on or near the vehicle surface and halos surrounding the vehicle. These induced emissions may affect observations made with the optical instrumentation carried by the vehicles. The glows' causative mechanisms appear to be a complex function of altitude, time in orbit, materials, insolation, and vehicular size and orientation. Attention is presently given to contamination environment data obtained for the instrument suite carried by the Spacelab 1 Space Shuttle mission. O.C.

A88-47970#
ELECTROSTATIC CHARGING AND ARC DISCHARGES ON SATELLITE DIELECTRICS SIMULATED BY ELECTRON BEAM
HARUHISA FUJII, YOSHIKAZU SHIBUYA (Mitsubishi Electric Corp., Amagasaki, Japan), TOSHIO ABE, RITAROH KASAI (Mitsubishi Electric Corp., Kamakura, Japan), and HIRONOBU NISHIMOTO (National Space Development Agency of Japan, Tsukuba) (Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers, p. 156-163) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 156-161. Previously cited in issue 19, p. 2741, Accession no. A86-40597. refs

A88-51139
DEBRIS IN SPACE
TIM FURNISS Flight International (ISSN 0015-3710), vol. 134, July 30, 1988, p. 28-31.

Orbital satellite and debris traffic continues to grow by about 300 items/year in 'permanent' orbits from which satellites cannot directly reenter the earth's atmosphere. There are in addition over 30,000 marble-to-baseball-sized objects, trillions of small paint flakes, and tens of thousands of trillions of still-smaller aluminum oxide dust particles; these are impossible to track, and may in the case of paint flake-sized objects result in the death of an astronaut during EVAs. An evaluation is presently made of the prospects for a debris hazard-exacerbating 'cascade' effect, in which the debris population grows to the point where collisions trigger a chain reaction of fragmentations. O.C.

A88-51341#
SPACECRAFT SURFACE COATING HEAT GENERATION BY CHARGED PARTICULATE OF THE NATURAL SPACE ENVIRONMENT
RICHARD D. JIMENEZ (New Mexico, University; Aerospace Corp., Albuquerque) and MOHAMED S. EL-GENK (New Mexico, University, Albuquerque) ASME, Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. 9 p. Research supported by the Aerospace Corp. refs
(ASME PAPER 87-WA/HT-13)

Characteristics of charged particulate trapped within the earth's geomagnetic fields are discussed and their interactions with absorbing media are highlighted. Fundamental treatments for determining primary particle energy transfer of energetic protons and electrons to absorbing media are presented and applied to various simulations of particle flux levels. In particular, the heating of a .025 cm thick zinc orthotitanate coating and tantalum substrate by charged particulate is treated and resulting predicted temperatures are presented. Degradation data of spacecraft surface coating materials are presented and some discussion of established and potential degradation mechanisms are featured. Author

A88-51391#
REAL-TIME, AUTOMATIC VEHICLE-POTENTIAL DETERMINATION FROM ESA MEASUREMENTS - THE DISTRIBUTION FUNCTION ALGORITHM
STANLEY L. SPIEGEL (Lowell, University, MA) and HERBERT A. COHEN (USAF, Geophysics Laboratory, Hanscom AFB, MA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 234-238. refs
(Contract F49620-79-C-0038; AF-AFOSR-85-0015)

A spacecraft-borne electrostatic analyzer's positive ion count measurements at GEO are presently used by a novel technique to ascertain the plasma distribution function, on the basis of which the spacecraft's potential can be inferred with high accuracy and in real time. The method has been found to be highly successful in the test interval containing natural charging events, irrespective of plasma stability. The computational and storage requirements of the technique are suitable for real-time space vehicle potential determination. O.C.

A88-51392#
SEVERAL SPACECRAFT-CHARGING EVENT ON SCATHA IN SEPTEMBER 1982
H. C. KOONS, P. F. MIZERA, J. L. ROEDER, and J. F. FENNELL (Aerospace Corp., El Segundo, CA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, May-June 1988, p. 239-243. Previously cited in issue 08, p. 1059, Accession no. A87-22659. refs
(Contract F04701-85-C-0086)

A88-53470* California Univ., La Jolla.
A STUDY OF SCATHA ECLIPSE CHARGING
WEI-WEI LI and ELDEN C. WHIPPLE (California, University, La Jolla) Journal of Geophysical Research (ISSN 0148-0227), vol. 93, Sept. 1, 1988, p. 10041-10046. refs
(Contract NGL-05-005-007)

The events of charging of the SCATHA satellite in eclipse were investigated and correlated to the spacecraft surface-averaged and angle-averaged fluxes. It is shown that the large negative vehicle potentials produced in eclipse correlated with the net current due to the high-energy plasma electrons. These potentials also depend on the ion energy, ion current, and the average ion yield. An explanation for this behavior is proposed. I.S.

N88-23649*# Colorado State Univ., Fort Collins. Dept. of Mechanical Engineering.
SPACE PLASMA CONTACTOR RESEARCH, 1987 Annual Report, 1 Jan. 1987 - 1 Jan. 1988
PAUL J. WILBUR Jan. 1988 87 p
(Contract NAG3-776)
(NASA-CR-182148; NAS 1.26:182148) Avail: NTIS HC A05/MF A01 CSCL 20I

A simple model describing the process of electron collection from a low pressure ambient plasma in the absence of magnetic field and contactor velocity effects is presented. Experimental measurments of the plasma surrounding the contactor are used to demonstrate that a double-sheath generally develops and separates the ambient plasma from a higher density, anode plasma located adjacent to the contactor. Agreement between the predictions of the model and experimental measurements obtained at the electron collection current levels ranging to 1 A suggests the surface area at the ambient plasma boundary of the double-sheath is equal to the electron current being collected divided by the ambient plasma random electron current density; the surface area of the higher density anode plasma boundary of the double-sheath is equal to the ion current being emitted across this boundary divided by the ion current density required to sustain a stable sheath; and the voltage drop across the sheath is determined by the requirement that the ion and electron currents counterflowing across the boundaries be at space-charge limited levels. The efficiency of contactor operation is shown to improve when significant ionization and excitation is induced by electrons that stream from the ambient plasma through the double-sheath and collide with neutral atoms being supplied through the hollow cathode. Author

N88-24315*# General Electric Co., Philadelphia, PA. Space Systems Div.
RADIATION HARDENING DESIGN OF NUCLEAR POWERED SPACECRAFT
R. E. SCHMIDT *In* New Mexico Univ., Transactions of the Fourth Symposium on Space Nuclear Power Systems p 261-262 1987
(Contract JPL-956473; DE-AC03-86SF-16006)
Avail: NTIS HC A22/MF A01 CSCL 18K

The design and operation of space systems utilizing nuclear fueled power systems must consider the radiation environment from the earliest stages of their design. A range of nuclear systems are being considered for present and future satellite systems capable of supplying tens of kilowatts to multimegawatt and generating a corresponding range of radiation environments. The effects of these radiations on electronics and materials can be minimized by implementing early design considerations which maximize the design efficiency and minimize the impact on system mass. Space systems design considerations for the radiation environment must include all sources in addition to the self induced gamma ray and neutron radiation. These include the orbital dependent environment from the high energy electron and protons encountered in natural space. The system trades which the designer must consider in the development of space platforms which utilize nuclear reactor power supplies are discussed. Author

N88-25390*# National Aeronautics and Space Administration. Langley Research Center, Hampton, VA.
A STUDY OF SPACE STATION CONTAMINATION EFFECTS
M. R. TORR, ed., J. F. SPANN, ed., and T. W. MOOREHEAD, ed. May 1988 141 p Workshop held in Hilton Head Island, S.C., 29-30 Oct. 1987 Sponsored by NASA, Washington
(NASA-CP-3002; M-586; NAS 1.55:3002) Avail: NTIS HC A07/MF A01 CSCL 22B

A workshop was held with the specific objective of reviewing the state-of-knowledge regarding Space Station contamination, the extent to which the various categories of contamination can be predicted, and the extent to which the predicted levels would interfere with onboard scientific investigations or space station functions. The papers presented at the workshop are compiled and address the following topics: natural environment, plasma electromagnetic environment, optical environment, particulate environment, spacecraft contamination, surface physics processes, laboratory experiments and vented chemicals/contaminants.

N88-25394*# Alabama Univ., Huntsville. Dept. of Electrical and Computer Engineering.
SPACE STATION INDUCED ELECTROMAGNETIC EFFECTS
N. SINGH *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 31-42 May 1988
Avail: NTIS HC A07/MF A01 CSCL 20N

Several mechanisms which can cause electric (E) and magnetic (B) field contaminations of the Space Station environment are identified. The level of E and B fields generated by some of them such as the motion of the vehicle across the ambient magnetic field B(0) and the 20-kHz leakage currents and charges can be controlled by proper design considerations. On the other hand, there are some mechanisms which are inherent to the interaction of large vehicles with the plasma and probably their contributions to E and B fields cannot be controlled; these include plasma waves in the wake and ram directions and the effects of the volume current generated by the ionization of neutrals. The interaction of high-voltage solar arrays with plasma is yet another rich source of E and B fields and it is probably uncontrollable. Wherever possible, quantitative estimates of E and B are given. A set of recommendations is included for further study in areas where indepth knowledge is seriously lacking. Author

N88-25401*# Washington State Univ., Pullman. Dept. of Physics.
SURFACE INTERACTIONS RELEVANT TO SPACE STATION CONTAMINATION PROBLEMS
J. T. DICKINSON *In* NASA, Langley Research Center, A Study of Space Station Contamination Effects p 109-121 May 1988
(Contract NSF DMR-86-01281)
Avail: NTIS HC A07/MF A01 CSCL 22B

The physical and chemical processes at solid surfaces which can contribute to Space Station contamination problems are reviewed. Suggested areas for experimental studies to provide data to improve contamination modeling efforts are presented. Author

N88-30501# Joint Publications Research Service, Arlington, VA.
RELATIONSHIP BETWEEN CHARACTERISTICS OF LOW-ENERGY ELECTRONS AND GEOMAGNETIC DISTURBANCE IN GEOSTATIONARY ORBIT Abstract Only
O. S. GRAFODATSKIY, V. I. DEGTYAREV, A. G. KOZLOV, V. I. LAZAREV, O. I. PLATONOV, G. V. POPOV, and M. V. TELTSOV *In its* JPRS Report: Science and Technology. USSR: Space p

12-13 26 Feb. 1988 Transl. into ENGLISH from Geomagnetizm i Aeronomiya (Moscow, USSR), v. 27, no. 3, May - Jun. 1987 p 494-496
Avail: NTIS HC A04/MF A01

Measurements of low-energy (0.3 to 5.0 keV) electrons made on the Raduga geostationary satellite during a period of low magnetospheric disturbance in April-September 1980 are analyzed. The spectra of particles in the substorm disturbance region differ from Maxwellian and their fluxes are increased as a result of acceleration of plasma sheet particles from the tail of the magnetosphere in the region 6.6 R sub E. The fluxes and spectra of these particles are complexly and strongly dependent on the level of magnetic disturbance and LT. In order to ascertain the relationship between the observed spectra and the physical processes in the magnetosphere it was assumed that a magnetosphereic distrubance develops in a spatially limited nucleus near the midnight meridian and in its expansion forms the charged particles injection front. The results of measurements of electron fluxes were averaged for fixed hourly LT intervals and the diurnal variations of fluxes of electrons of different energies was determined from these averaged values. The effects of local magnetospheric disturbances and the effects of movements of the plasma sheet edge could be separated. In a particularly quiet magnetosphere there were no regions in the neighborhood of the geostationary orbit where electron acceleration could occur; in the quiet magnetosphere small local disturbances can occur; in a slightly disturbed magnetosphere the frequency and intensity of local disturbances increase. 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.

A88-20329* Florida State Univ., Tallahassee.
ELECTROSTATIC CHARGE ON A DUST SIZE DISTRIBUTION IN A PLASMA
HARRY L. F. HOUPIS (Florida State University, Tallahassee) and ELDEN C. WHIPPLE, JR. (California, University, La Jolla) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12057-12068. refs
(Contract DE-FC05-85ER-25000; NGL-05-005-007)

The capacitance of a grain immersed in a steady state plasma containing a size distribution of dust particles is studied. The grain charge is determined by assuming the equilibrium potential has been obtained by a simple balance of electron and ion collection currents. It is shown that the validity of the analytical treatment given here for the linearized Poisson equation is confined to a certain region of space. Within this region and starting at very small plasma Debye length lambda(D), the capacitance at first exhibits a monotonic increase with increasing lambda(D). The capacitance eventually reaches a maximum, followed by a monotonic decrease. The charge density of the dust in the plasma is found to be only a function of the lambda(D); there is no significant dependence on the interparticle spacing. C.D.

A88-20349
QUANTITATIVE ANALYSIS OF THERMAL (ABOUT 1 EV) ION DATA FROM MAGNETOSPHERIC SPACECRAFT
D. T. YOUNG (Los Alamos National Laboratory, NM) and C. J. FARRUGIA (Bern, Universitaet, Switzerland) Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12307-12318. Research supported by the Imperial College of Science and Technology, SNSF, and DOE. refs

A physically plausible theoretical model for the analysis of thermal ion data acquired inside the plasmasphere by the Ion Composition Experiment (ICE) on ESA/GEOS 1 is developed. A relationship giving the ion detector counting rates as a function of the potential applied to retarding grids within the ICE, as well as of the detector Mach angle, is presented. Its domain of applicability is discussed, and how to implement it optimally in data analysis is investigated, using the GEOS 1 data set as an example. The role of the spacecraft potential, the single most prominent source of error in all low-energy plasma measurements, is emphasized. C.D.

A88-22224*# Rutgers Univ., New Brunswick, NJ.
SUPERSONIC TURBULENT FLOW PAST A SWEPT COMPRESSION CORNER AT MACH 3. II
DOYLE D. KNIGHT (Rutgers University, New Brunswick, NJ), C. C. HORSTMAN (NASA, Ames Research Center, Moffett Field, CA), SEYMOUR BOGDONOFF (Princeton University, NJ), DENISE RAUFER, and ANDREW KETCHUM AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 18 p. NSF-supported research. refs
(Contract AF-AFOSR-86-0266; F49620-86-C-0094)
(AIAA PAPER 88-0310)

The three-dimensional Mach 3.0 shock wave-turbulent boundary layer interaction generated by a swept compression corner whose geometry is characterized by the angle of streamwise compression angle alpha and the angle of sweep lambda is presently treated by the Baldwin-Lomax (1978) algebraic turbulent eddy viscosity model. The results obtained, and those previously derived by means of Cebeci and Smith (1974) and Jones and Launder (1972) models, are compared with experimental measurements. The rate of change of the mean kinetic energy along a streamline is investigated, and evidence is obtained that the flowfield structure is rotational and inviscid. O.C.

A88-25470
TAKING FIELD SINGULARITY INTO ACCOUNT WHEN SOLVING DIFFRACTION PROBLEMS BY THE METHOD OF MOMENTS [UCHET SINGULIARNOSTI POLIA PRI RESHENII ZADACH DIFRAKTSII METODOM MOMENTOV]
G. N. PARVATOV, A. A. POPOV, and M. IU. NOVOMEISKII (Tomskii Gosudarstvennyi Universitet, Tomsk, USSR) Radiofizika (ISSN 0021-3462), vol. 30, no. 11, 1987, p. 1365-1370. In Russian.

The paper presents a method for taking into account the singularity index in aperture diffraction problems solved by the method of moments. Parvatov and Popov (1980) used the method of moments to solve the problem of TEM-mode diffraction by the aperture of a plane waveguide and to investigate the field within the integration space. In the present paper, this problem is solved using Jacobi quadratures with a uniform division of the integration interval. This makes it possible to analyze the field in the aperture with allowance for singular points. B.J.

A88-34551
COLUMBUS III; PROCEEDINGS OF THE THIRD SYMPOSIUM, CAPRI, ITALY, JUNE 30-JULY 2, 1987
Symposium organized by ESA, BMFT, Ministero per il Coordinamento della Ricerca Scientifica e Tecnologica, and Universita di Napoli; Supported by CNR and Aeritalia S.p.A. Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, 251 p. For individual items see A88-34552 to A88-34575.

The current status of the ESA Columbus program for participation in the International Space Station is surveyed in reviews and reports. Topics addressed include Columbus program definition, Columbus utilization, payloads operation, and international cooperation. Particular attention is given to technological and political factors influencing Columbus, the Columbus Pressurized Modules, the role of Eureca in the Columbus scenario, European earth-observation projects from the Space Station Polar Platform, Columbus and the life sciences, Man-Tended Free Flyer utilization aspects, commercial payload opportunities on Columbus, crew activities, the Japanese Space Station program, and a Canadian view of Space Station utilization issues. T.K.

A88-34553
EURECA IN THE COLUMBUS SCENARIO
R. D. ANDRESEN and W. NELLESSEN (ESA, Columbus System and Projects Dept., Noordwijk, Netherlands) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 45-57.

The current development status of the European Retrievable Carrier (Eureca) and its potential role in the ESA Columbus program are discussed. Plans call for Eureca to be launched, retrieved, and returned to earth for refurbishing by the NASA Space Shuttle after either half-year microgravity missions in a 525-km operational orbit (Eureca A) or 1-2-yr space-science missions (Eureca B); the experiments being developed for these missions are described in detail. Also considered are efforts to set up a user-friendly Eureca utilization program including full documentation, end-to-end data communication, and the activities of the Microgravity User Support Center at DFVLR Koeln. Extensive diagrams, drawings, flow charts, and tables listing experiments, investigators, and spacecraft specifications are provided. T.K.

A88-34554
COLUMBUS PAYLOAD ACCOMMODATION ASPECTS
K. KNOTT (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 59-63.

This paper gives special attention to the aspects to be taken into account in the accommodation of payloads in the Columbus elements. Compared to previous projects a new challenge is created by the presence of man on board which must be reflected in the accessibility and serviceability of the integrated payload. Author

A88-34555
THE ESA IN-ORBIT INFRASTRUCTURE GROUND FACILITIES CONCEPT
C. HONVAULT (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 65-71.

The ground facilities required to control the ESA Columbus In-Orbit Infrastructure (IOI) are discussed. The present IOI comprises the Attached Pressurized Module, the Man-Tended Free Flyer, the Polar Platform, the Coorbiting Platform, Hermes, and EDRS; IOI control tasks include mission direction, operation of individual elements, communication control, and flight-dynamics support for in-orbit maneuvers. Plans call for a decentralized approach with specialized facilities in the FRG (including the present ESOC), France, the UK, Belgium, and Spain. Particular attention is given to the Columbus Flight Operations System and its configuration for specific mission scenarios; detailed block diagrams and flow charts are provided. T.K.

A88-34558
COLUMBUS AND THE LIFE SCIENCES
MALCOLM B. WILKINS (ESA, Dept. of Botany, Glasgow, Scotland) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 105-109.

Plans for life-science experiments in the ESA Columbus program are briefly reviewed. Topics addressed include the kinds of space medicine and human physiology experiments possible with the Spacelab Anthrorack, Biorack gravitational biology experiments, integration of Anthrorack and Biorack in the Attached Pressurized Module, the advantages (quiet and absence of microgravity fluctuations) and limitations (infrequent human intervention) of the Man-Tended Free Flyer for biological experiments, and the self-contained Botany facility to be carried by Eureca. Diagrams and drawings are provided. T.K.

A88-34559
STATUS AND PERSPECTIVES OF MICROGRAVITY FLUID SCIENCE
L. G. NAPOLITANO (Napoli, Universita, Naples, Italy) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 111-120. refs

The paper first reviews critically the present status of microgravity environment utilization and, in this respect, it represents the natural evolution of what the author has stated in the paper presented at the 2nd Columbus Workshop in Hannover (1986). Then the paper presents a first attempt to a comparative study among the existing fluid science facilities in operational, development, study or proposed status. Finally, the paper elaborates upon a recent new approach in designing facilities for the Space Station as represented by the Fluid Sciences Laboratory. Author

A88-34560
SPACE SCIENCE WITH COLUMBUS. II
H. OLTHOF (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 121-125.

The current status of ESA plans for space science research in the Columbus program is surveyed, summarizing the findings of the revised Horizon 2000 implementation plan, and illustrated with drawings, diagrams, and tables listing experiments and instrument features. Particular attention is given to in situ measurements and remote sensing of solar terrestrial physics parameters from the ESA Polar Platform; the Gamma-Ray Astronomy with Spectroscopy and Positioning (GRASP) experiment on Eureca B; and opportunities for attaching space science sensors such as solar irradiance monitors, cryogenic detectors, and interferometers to the main Space Station structure. T.K.

A88-34561
SYSTEM UTILIZATION - EUROPEAN USERS' REQUIREMENTS ANALYSIS
JENS FROMM, WILFRED LEY (DFVLR, Cologne, Federal Republic of Germany), and FRANCO ROSSITTO (CNR, Rome, Italy) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 127-138.

The potential utilization of the major components of Columbus by scientific and industrial users is examined, summarizing the results of an ESA study based on the model payloads concept. Model payloads for material science, life science, space science, earth observation, space communication and navigation, and technology and operational support are listed in tables and characterized, and consideration is given to the accommodation of the model payloads in reference missions of the Attached Pressurized Module, the Man-Tended Free Flyer, the Polar Platform, Eureca-type coorbiting platforms, the main NASA Space Station structure, or the JEM. Recommendations for future activities are discussed, and the implications for technology development in man-machine interfaces, automated facilities, and long-term utilization are indicated. T.K.

A88-34562
THE UTILIZATION POTENTIAL OF THE EUROPEAN MANNED SPACE INFRASTRUCTURE
GUSTAVO OELKER and ALFIO ALLEGRA (Aeritalia S.p.A., Turin, Italy) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 139-143.

The types of microgravity experiments possible with the Columbus Attached Pressurized Module on the International Space Station are considered, summarizing the results of ESA utilization studies. The importance of the microgravity environment for

advanced research in biotechnology, glasses and ceramics, metals and alloys, electronic materials, fluid transport, and combustion is stressed; the need for a flexible, reconfigurable space laboratory is indicated; and the crew services and ground support facilities required are discussed. Also included is a brief account of ongoing efforts to stimulate user interest despite the relatively long time lag involved. T.K.

A88-34563
COLUMBUS UTILIZATION STUDIES - ATTACHED PAYLOADS
A. BIELZA and A. ALDAMIZ (Sener, S. A., Las Arenas, Spain) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 159-162.

The types of payload components which could be attached to the main structure of the International Space Station in its IOC stage are discussed, summarizing the results of ESA utilization studies. The basic payload set is listed and briefly characterized; the buildup sequence for the Space Station is reviewed; a payload mission baseline is established on the basis of NASA constraints on the availability of attachment points and Payload Attach Equipments for ESA payloads; and economic aspects are considered. The need to negotiate more clearly defined regulations on attached payloads is indicated, with an emphasis on the implications for space commercialization. T.K.

A88-34565
PROPOSED GUIDELINES FOR COLUMBUS PAYLOAD OPERATION
A. SESMA (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 167-173.

The concept for the Columbus flight operations and the associated ground facilities allows and assumes that the payload operations will be planned and executed directly by the user within allocated resources and operations envelopes. The intended high degree of decentralization and user autonomy in the planning for and conduct of the operations, may lead, at least initially, to a non-optimal utilization of the Columbus resources. It is expected that the reduced utilization of resources will be compensated for by the improvements in other areas such as higher replanning flexibility and faster decision taking. The final result should be a higher, more adequate output and therefore a more effective use of the overall resources than for a centralized concept. Guidelines are proposed and questions raised regarding payload operations, which are derived from the Columbus phase B operations studies. Author

A88-34567
INTERACTIVE PAYLOAD OPERATIONS ON COLUMBUS - THE APPLICATION OF TELESCIENCE CONCEPTS
A. BALOGH (Imperial College of Science and Technology, London, England) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 179-184.

The operation in flight of the payload, the ease with which investigations are executed, and, in general, the user-friendliness of the system will be major factors in deciding the success of the utilization of Columbus. In this paper it is argued that effective payload operations will be essentially interactive, with ground-based investigators largely in control of the execution of the experiments, with vital contribution to this task by the astronauts. The nature of interactive operations is explored and defined, partly in contrast with the concept of real-time operations, in the context of microgravity sciences. The work and conclusions of the ESA Telescience Users Team are presented with details of the pilot experiments proposed for the recommended testbed project. Preliminary requirements on the communication link are presented introducing the concept and emphasizing the importance of remote visual access to the investigations. Author

A88-34570
SERVICING SUPPORT FACILITIES
E. H. CLASSEN and R. H. BENTALL (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 195-204.

The paper elaborates on the overall servicing needs required by the Columbus space elements and the associated major ground support facilities. Such facilities will initially be required in Europe to support the development of the means for manned and robotic servicing techniques. Later, during the operational phases of the Columbus/Hermes programs, most of these facilities will be used to support the actual servicingmissions. The facilities are briefly described with preliminary planning for their implementation. Author

A88-34571
COLUMBUS UTILISATION COST
I. HILLER and G. NAJA (ESA, Paris, France) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 205-207.

This paper presents a first attempt to define, allocate and compute Columbus utilization costs, and describes the first step towards a charging policy. The buildup of Columbus represents an important investment, but it is likely that the utilization of this big and expensive hardware will not be negligible in terms of costs. It is therefore essential to have correct estimates of these costs in order (1) to identify the cost factors and provide suggestions for cost reductions, and (2) to establish the costs that will be charged to potential users: it is indeed certain that the 'price' of Columbus utilization will be a major factor in the decision of the users, and should be both fair and yet attractive. Author

A88-34572
INTERNATIONAL COOPERATION FOR UTILIZATION - THE ESA VIEWPOINT
L. EMILIANI (ESA, Paris, France) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 209-211.

The current status of planning for cooperation among the U.S., ESA, Japan, and Canada in the allocation of user accommodations and utilization resources in the International Space Station is reviewed. Topics addressed include the transition from the a priori allocations (already agreed upon among the partners) to actual allocations via a bartering process, the formalized planning procedures and organizational structure, and allocations during the buildup of the IOC. The need for further elaboration and detailed definition of the general principles established is indicated. T.K.

A88-34574
JAPANESE SPACE STATION PROGRAM
K. HIGUCHI and T. YAMAWAKI (National Space Development Agency of Japan, Space Experiment Group, Tokyo, Japan) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 221-227.

Since May 1985, when Japan first began participating in the Space Station program, the NASDA has been studying the JEM concept and related Space Station system issues in cooperation with NASA, ESA, and Canada. In a parallel activity, the Space Activities Commission Ad Hoc Committee on the Space Station has been discussing Japan's policy for future phases. This paper presents Japan's approach for participating in this program, the concept, the development plan, Japan's candidate sensor for Polar

Platform, and the future program for promoting space environment utilization. Author

A88-35056
THE COLUMBUS RESOURCE MODULE FOR THE EUROPEAN MAN-TENDED FREE FLYER
KLAUS FAHLENBOCK (Dornier GmbH, Friedrichshafen, Federal Republic of Germany) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 89-101.
(AAS PAPER 86-465)

In April, 1986, it was decided that the ESA Man-Tended Free Flyer (MTFF) would become a dedicated element of the NASA Space Station, with a permanently coupled Resource Module/ Pressurized Module configuration. Attention is presently given to the Resource Module's design-driving requirements, the MTFF/Resource Module reference configuration, first and second MTFF versions, and the Space Station configuration incorporating the MTFF. O.C.

A88-35078
INTERNATIONAL BUFFET PANEL MEETING - FUTURE INTERNATIONAL SPACE PROGRAMMES
A. C. NICHOLAS (British National Space Centre, London, England) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 463-467.
(AAS PAPER 86-432)

Lessons are drawn from ESA experience in the management of international space technology-development, space exploration and space exploitation efforts, as well as from British participation in such efforts. While ESA allows certain countries' interests to be substantially specialized, much value is recognized in the participation of most countries in most programs at some level. It has been found that while national industrial policies have been helpful in increasing the competitiveness of specific companies, the recognition of diminishing returns and withdrawal of government direction remains a positive development. O.C.

A88-35081
UPDATE ON SOVIET SPACE ACTIVITIES
MARCIA S. SMITH (U.S. Library of Congress, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 479-483.
(AAS PAPER 86-466)

It is noted that the assertion in the 1988 Jane's Spaceflight Directory that the USSR is as much as 10 years ahead of the USA in space technology development may not be generally justified, but is at least arguable in the specific field of manned space operations in earth orbit. Through their space station program, which began in 1971, the Soviets have gained considerable experience in the operation of large platforms and ferry spacecraft, the repair of orbiting spacecraft and their refueling, and the performing of experiments in space conditions. O.C.

A88-35092
POTENTIAL OF SPACE FOR HUMANITY
WTARU WAKAI TANAKA IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 595-603.
(AAS PAPER 86-450)

An evaluation is made of Japanese attitudes on space colonization, as well as of their aptitude for participation in international efforts aimed at such colonization. A trust fund is proposed into which the heaviest users of petroleum-derived fuels pay in order to support space exploration, industrialization and colonization, in the form of such projects as an orbiting solar-power station. Attention is given to the concept of a 'cybernaut', a totally autonomous man-like robot capable of all space exploration tasks. O.C.

A88-35128
SPACE SYSTEM FOR MICROGRAVITY RESEARCH
P. VITS and S. WALTHER (Messerschmitt-Boelkow-Blohm GmbH, Bremen, Federal Republic of Germany) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1233-1243.
(AAS PAPER 86-370)

Existing and planned facilities for material science experiments in microgravity are considered. The Spacelab reusable manned space laboratory flown aboard the Space Shuttle Orbiter is discussed, with emphasis on the D-1 flight. Automated facilities include the Texus sounding rocket program and the MAUS program (in which NASA Get Away Special Containers are used). Free-flying facilities include the reusable shuttle-launched SPAS platform and the Eureca platform. Future applications of the Space Station/Columbus facilities are also discussed. R.R.

A88-35164
SPACE MANUFACTURING IN JAPAN - THE INTERESTS AND ACTIVITIES AMONG JAPANESE INDUSTRIES
KAZUO SEZAKI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tanashi, Japan) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1747-1752. refs
(AAS PAPER 86-441)

The Japanese and American efforts in space manufacturing are compared. The role of Japanese governmental organizations in this effort is briefly surveyed, and the role of NASDA in the Space Station is briefly addressed. The activities of various organizations of Japanese industries that will focus Japanese industrial effort in space are discussed. C.D.

A88-37239
NATIONAL SPACE ENGINEERING SYMPOSIUM, 3RD, CANBERRA, AUSTRALIA, JUNE 30-JULY 2, 1987, PREPRINTS OF PAPERS
Symposium sponsored by the Institution of Engineers of Australia, Australian Space Board, and CSIRO. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co. (National Conference Publication, No. 87/8), 1987, 287 p. For individual items see A88-37240 to A88-37282.

The present conference on space engineering considers Aussat's satellite operations, the HOTOL space transport, Australian thoughts on the new reusable launch vehicles, a land-mobile satellite service for Australia, the Australian ERS-1 program, an Australian geosynchronous satellite radio beacon, Europe's 'Esrange', present and future defense satellite communications between the U.S. and Australia, Aussat in-orbit anomalies' correlation with the GEO radiation environment. the Lyman UV space telescope, and low cost exploration of the Sarsat-COSPAS system. Also discussed are the Australian space industry, an international spaceport for Australia, the Endeavour Program, space applications of muon-catalyzed fusion, the Australian Amateur Radio Satellite, the development status of the Australian Telescope, and Australian availability of oxygen and hydrogen fuel gases. O.C.

A88-37257#
THE FLINDERS PLATFORM - A LOW-COST MULTIMISSION PLATFORM FOR AUSTRALIA
M. L. PFITZNER (AUSPACE, Ltd., Australia) IN: National Space Engineering Symposium, 3rd, Canberra, Australia, June 30-July 2, 1987, Preprints of Papers. Barton, Australia/Brookfield, VT, Institution of Engineers/Brookfield Publishing Co., 1987, p. 111-115.

The 'Flinders' 3-axis stabilized orbiting platform presently discussed is relatively small and derives its modest cost from the incorporation of several previously developed subsystems. Flinders is compatible with several Ariane-4 upper stage configurations, and can be applied to a range of orbits, from LEO to GEO. Its possible missions extend to earth observation, mobile communications, astronomical and magnetospheric research, and domestic telecommunications. O.C.

A88-37295#
TWO-PHASE THERMAL LOOPS FOR USE IN FUTURE SPACECRAFT
HANS GEORG WULZ and RALF SIEPMANN Dornier-Post (English Edition) (ISSN 0012-5563), no. 1, 1988, p. 49-51.

In the two-phase thermal loops being developed by ESA for high heat-load space transport systems, such as the Space Shuttle and Spacelab, the working fluid is evaporated in the heat-absorbing 'cold plate' elements, whence it flows in vapor form to a radiator-like heat sink to be condensed as the heat is radiated into space. Attention is presently given to the design features and performance capabilities thus far experimentally established for mechanically-pumped, capillary-pumped, and hybrid versions of the two-phase loop. The hybrid thermal loops are especially promising for use aboard satellites with severe microgravity requirements. O.C.

A88-38826
'GLAZAR' - AN ORBITAL ULTRAVIOLET TELESCOPE ['GLAZAR' - ORBITAL'NYI UL'TRAFIOLETOVYI TELESKOP]
G. M. TOVMASIAN, IU. M. KHODZHAIANTS, M. N. KRMOIAN, A. L. KASHIN, A. Z. ZAKHARIAN (Biurakanskaia Astrofizicheskaia Observatoriia, Byurakan, Armenian SSR; Geneve, Observatoire, Sauverny, Switzerland) et al. Pis'ma v Astronomicheskii Zhurnal (ISSN 0320-0108), vol. 14, April 1988, p. 291-295. In Russian.

The ultraviolet telescope Glazar situated on the Quant astrophysical module of the Mir space station is described. The parameters of the telescope and its star trackers are presented. The scientific program of this space experiment is outlined. Star images obtained with the telescope's detached tracking system after 50 sec of exposure are given. K.K.

A88-39077
THE INFRARED SPACE OBSERVATORY (ISO) PROJECT
M. F. KESSLER (ESA, Space Science Dept., Noordwijk, Netherlands) IN: Planetary and proto-planetary nebulae: From IRAS to ISO; Proceedings of the Frascati Workshop, Vulcano Island, Italy, Sept. 8-12, 1986. Dordrecht, D. Reidel Publishing Co., 1987, p. 261-268; Discussion, p. 268, 269.

The ISO, an approved and funded project of ESA, is an astronomical satellite which will operate at wavelengths from 3 to 200 microns. Its cryogenically cooled 60-cm telescope will be equipped with four complementary and versatile focal-plane instruments, which will enable imaging and also photometric, spectroscopic, and polarimetric observations. These instruments are being built by international consortia of scientific institutes and will be delivered to ESA for in-orbit operations. The expected launch date is 1993, and the in-orbit lifetime will be at least 18 months. In keeping with ISO's role as an observatory, two-thirds of its observing time will be made available to the general astronomical community. Author

A88-39332
WESTERN EUROPEAN SPACE SCIENCE
IAN AXFORD (Max-Planck-Institut fuer Aeronomie, Katlenburg-Lindau, Federal Republic of Germany) Physics Today (ISSN 0031-9228), vol. 41, May 1988, p. 42-52.

An account is given of the national and ESA-coordinated space science research efforts of the West European countries to date, including the substantial portion of these undertaken in collaboration with NASA, such as the Exosat, COS-B, Geos, and ISEE satellites. Program origins, goals, and achievements are discussed for the cases of SPOT, Giotto, Hipparcos, the IUE, Ulysses, Galileo, Rosat, the IR Space Observatory, and the European Retrievable Carrier. Longer-term plans encompass a Solar-Terrestrial Science Program, a Comet Nucleus Sample Return Mission, the Quasat VLBI worldwide network, and the Cassini Saturn probe. O.C.

A88-39424#
REAL-TIME SYSTEMS FOR SPACE APPLICATIONS
ULRICH SCHWAN and HANS-JUERGEN HERPEL Dornier-Post (English Edition) (ISSN 0012-5563), no. 2, 1988, p. 63-65.

A real-time operating system for spacecraft management, in which parallel operation is achieved through the distribution of different tasks to autonomous computers or the assignment of the processing or memory resource of a given computer to different tasks, is a service program which resolves the problem of simultaneity by acting between hardware and application software. Attention is here given to the iRMX86 real-time operating system's application to CO2-removal control in the Columbus space station life-support system, as well as other C programming language-based real-time spacecraft operations systems. O.C.

A88-39919
COMPARATIVE ANALYSIS OF RESULTS OF PHOTOGRAPHIC OBSERVATIONS OF NATURAL OBJECTS FROM SALYUT-7 [SRAVNITEL'NYI ANALIZ REZUL'TATOV FOTOS'EMKI PRIRODNYKH OB'EKTOV SO STANTSII 'SALIUT-7']
L. A. RONZHIN and IU. L. RESHTOGA Geodeziia i Kartografiia (ISSN 0016-7126), April 1988, p. 45-47. In Russian. refs

Photographs taken from space in spectral bands 10 and 40 nm wide are compared. It is shown that, in the 10-nm case, it is possible to satisfactorily identify a significant number of natural objects, as well as to substantially enhance the contrast of objects on the background. Here, a positive effect is achieved for various natural objects, including soils, rocks, vegetation, and water bodies. B.J.

A88-40523
VOLKOV PREPARES FOR AUTUMN FLIGHT
NEVILLE KIDGER Spaceflight (ISSN 0038-6340), vol. 30, June 1988, p. 226.

An exclusive interview is presented with Soviet cosmonaut Alexander Volkov. Particular attention is given to his involvement in the Mir program, with a flight projected for late November of 1988. B.J.

A88-40571
AN ENERGETICS EXPERIMENT ON A SPACE PLATFORM
KYOICHI KURIKI (Tokyo, University, Sagamihara, Japan) and HIROAKI OBARA (Mitsubishi Electric Corp., Tokyo, Japan) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 75-89. refs

This paper discusses the Space Flyer Unit (SFU) free-flying platform and the on-board advanced-technology experiments planned for this system in relation to the Space Power Satellite (SPS) technology. Attention is given to the design of the SFU and payload integration, the energy-exploitation experiments, and to interactive experiments between SFU and SPS. Special consideration is given to the configuration and characteristics and the experimental objectives of a two-dimensionally deployable array and a high-voltage solar array and to electric propulsion experiment, microwave energy transmission experiment, and space experiment with particle accelerators. Design diagrams of the SFU and the various experiments designed for it are included. I.S.

A88-40572
IMPLICATIONS OF THE SOVIET SPACE INDUSTRIALIZATION PROGRAMME
GERRY WEBB (Commercial Space Technologies, Ltd., London, England) (SEE, Conference on Solar Power Satellites - State of the Art, Paris, France, June 5, 6, 1986) Space Power (ISSN 0951-5089), vol. 7, no. 1, 1988, p. 91-112. refs

Evidence is presented that the Soviet Union is about to introduce a very large general-purpose launching system, indicating that it is capable of carrying out its long-term program of space industrialization in the time scales predicted. Special consideration

is given the likely characteristics (as deduced from publications) of this new launch system, the future missions to be supported by the system, and to the impact this increase in Soviet space technical ability is likely to have on the U.S. and European programs. I.S.

A88-42539* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
PERFORMANCE CONSIDERATIONS FOR THE ASTROMETRIC TELESCOPE FACILITY ON THE PHASE I SPACE STATION
KENJI NISHIOKA, ALFRED C. MASCY, CHARLES K. SOBECK, JOEL SPERANS (NASA, Ames Research Center, Moffett Field, CA), and GEORGE D. GATEWOOD (Pittsburgh, University, PA) IN: Optoelectronic technologies for remote sensing from space; Proceedings of the Meeting, Cannes, France, Nov. 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 88-96. Previously announced in STAR as N88-14898. refs

The Astrometric Telescope Facility (ATF) is an optical telescope facility of extreme astrometric precision whose principal scientific purpose is the detection and study of planetary systems about nearby stars. With the recent change in the space station program to two phases, the suitability of initial operations from the phase 1 station need to be evaluated. This paper presents the results of such an evaluation for the Astrometric Telescope Facility. Author

A88-42546
ROSIS (REFLECTIVE OPTICS SYSTEM IMAGING SPECTROMETER) - A CANDIDATE INSTRUMENT FOR POLAR PLATFORM MISSIONS
B. KUNKEL, F. BLECHINGER, R. LUTZ (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, Federal Republic of Germany), R. DOERFFER (GKSS-Forschungszentrum Geesthacht GmbH, Federal Republic of Germany), H. VAN DER PIEPEN (DFVLR, Institut fuer Optoelektronik, Oberpfaffenhofen, Federal Republic of Germany) et al. IN: Optoelectronic technologies for remote sensing from space; Proceedings of the Meeting, Cannes, France, Nov. 19, 20, 1987. Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 134-141. refs

The Reflective Optics System Imaging Spectrometer (ROSIS) employs all-reflective optics and matrix CCD detector arrays in the task of spaceborne chlorophyll measurements possessing high spectral and radiometric resolution and moderate spatial resolution. ROSIS will cover the 430-960 nm spectral range, in resolution steps of 5 nm/channel; a set of up to 28 spectral channels can be read out simultaneously at full spatial resolution, and the full spectrum at reduced resolution. O.C.

A88-43247
SCIENTIFIC AND ECONOMY-ORIENTED SPACE SYSTEMS /REVISED EDITION/
V. S. AVDUEVSKII and G. R. USPENSKII (Narodnokhoziaistvennye i nauchnye kosmicheskie kompleksy, Moscow, Izdatel'stvo Mashinostroenie, 1985) Moscow, MIR Publishers, 1988, 440 p. Translation. Previously cited in issue 13, p. 1803, Accession no. A86-29843. refs

A88-43985#
A SYSTEMS ARCHITECTURE OF EXTRATERRESTRIAL PRODUCTION
H. H. KOELLE (Berlin, Technische Universitaet, Federal Republic of Germany) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 332-341. refs

The advance of space technology in general and the operation of space laboratories in near earth orbits in particular, have led to successful experiments in material processing under microgravity conditions. It also has become clear that the production of lunar oxygen would greatly improve the cost effectiveness of space transportation systems. Thus, it appears the time has come to define a frame-of-reference, including the functions and elements of extraterrestrial production activities which are expected to take place in future space stations and space factories. This report discusses potential product groups, identifies the functions to be performed and the system elements required. The interrelationships between both are illustrated. An attempt is made to show the expected evolutionary development of extraterrestrial production with the help of contextual diagrams and scenarios. Author

A88-44898
BALLISTIC DESIGN OF SPACE SYSTEMS [BALLISTICHESKOE PROEKTIROVANIE KOSMICHESKIKH SISTEM]
PAVEL ROMANOVICH POPOVICH and BORIS SERGEEVICH SKREBUSHEVSKII Moscow, Izdatel'stvo Mashinostroenie, 1987, 240 p. In Russian. refs

The general principles of the ballistic design of space systems are examined. It is shown that the ballistic characteristics of various types of spacecraft are largely determined by the combination of tasks to be performed, technical constraints, and physical environment of the particular space mission. The stages of the process of orbital parameter selection are examined, and methods are presented for solving problems of the synthesis of dynamically stable space systems. V.L.

A88-45049 Norwegian Defence Research Establishment, Kjeller.
STUDIES OF THE ELECTRICAL CHARGING OF THE TETHERED ELECTRON ACCELERATOR MOTHER-DAUGHTER ROCKET MAIMIK
B. N. MAEHLUM, J. TROIM (Forsvarets Forskningsinstitutt, Kjeller, Norway), N. C. MAYNARD, W. F. DENIG (USAF, Geophysics Laboratory, Hanscom AFB, MA), M. FRIEDRICH (Graz, Technische Universitaet, Austria) et al. Geophysical Research Letters (ISSN 0094-8276), vol. 15, July 1988, p. 725-728. Research supported by the Norges Teknisk-Naturvitenskapelige Forskningsrad, NASA, FFWF, and USAF. refs
(AD-A201771; AFGL-TR-88-0271)

The MAIMIK experiment was designed to study the charging of an electron-beam emitting payload using a tethered mother-daughter payload configuration. The particle accelerator on the daughter emitted short pulses of 8 keV energy electrons with a beam current which was varied in 6 steps from 20 to 800 mA. During the highest beam currents the accelerator payload was charged to potentials more than 50 per cent greater than the beam energy. It is speculated that a combination of a low background plasma density and a small payload may account for the apparently anomalous result. Author

A88-45112
EARTH OBSERVATION PROGRAM IN JAPAN AND ITS INTERNATIONAL COOPERATIVE ACTIVITIES
TAKESHI MASUDA, TASUKU TANAKA, MASAHIRO KOJIMA, and KOHEI CHO (National Space Developement Agency of Japan, Tokyo) Geocarto International (ISSN 1010-6049), vol. 3, June 1988, p. 3-12.

An overview of the Japanese Earth Observation Program including the Marine Observation Satellite (MOS-1), the Earth Resources Satellite (ERS-1), the Advanced Earth Observing Satellite, the Polar Orbiting Platform (POP), and the program's international cooperative activies is presented. The MOS-1 is an experimental satellite to establish technology for observing the earth, primarily the oceans. The system parameters of mission instruments, the function and characteristics of sensors and satellite systems and data usefulness of the MOS-1 are being evaluated in the MOS-1 verification program. The goals of the ERS-1 program are to establish SAR and high resolution optic sensor technology primarily for geological and topographical survey. The ADEOS, to be launched in the 1990s, will carry two core sensors, the Ocean Color and Temperature Scanner and the Advanced Visible and Near Infrared Radiometer. NASDA is working with NASA, NOAA, ESA, and Canada to develop the POP program. R.B.

A88-45467
DETERMINATION OF THE MOTION OF THE SALYUT 6 AND 7 ORBITAL STATIONS WITH RESPECT TO THE MASS CENTER IN THE SLOW SPIN MODE ON THE BASIS OF MEASUREMENT DATA [OPREDELENIE DVIZHENIIA ORBITAL'NYKH STANTSII 'SALIUT-6' I 'SALIUT-7' OTNOSITEL'NO TSENTRA MASS V REZHIME MEDLENNOI ZAKRUTKI PO DANNYM IZMERENII]
V. A. SARYCHEV, M. IU. BELIAEV, S. P. KUZ'MIN, V. V. SAZONOV, and T. N. TIAN Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, May-June 1988, p. 390-405. In Russian. refs

A method is proposed for determining the rotational motion of Salyut 6 and 7 in the slow spin mode (with an angular velocity of not greater than about 0.2 deg/s) according to the readings of onboard sensors which measure the geomagnetic frield strength vector and the sun position vector. Particular attention is given to the motion of Salyut-7 with respect to the mass center over long periods of time. It is shown that, several days after the commencement of uncontrolled motion with a small initial angular velocity, the spacecraft is captured into a uniaxial gravity-gradient regime, in which its longitudinal axis undergoes stable oscillations with respect to the local vertical with an amplitude of about 40 deg. B.J.

A88-46070
SOVIET SPACE ACHIEVEMENTS IN 1985 ACCORDING TO PRESS MATERIALS [OSVOENIE KOSMICHESKOGO PROSTRANSTVA V SSSR, 1985: PO MATERIALAM PECHATI]
R. Z. SAGDEEV, ED. Moscow, Izdatel'stvo Nauka, 1987, 200 p. In Russian. No individual items are abstracted in this volume.

The present work is a compilation of press materials (e.g., TASS reports and newspaper articles) reflecting Soviet achievements in space in 1985. Particular consideration is given to space-flight planning, manned flights, and international cooperation in space. B.J.

A88-46192#
MECHANICAL AND ELECTRICAL CHARACTERISTICS OF TIN WHISKERS WITH SPECIAL REFERENCE TO SPACECRAFT SYSTEMS
B. D. DUNN (ESA, Materials and Processes Div., Noordwijk, Netherlands) ESA Journal (ISSN 0379-2285), vol. 11, no. 4/vol. 12, no. 1, 1987/1988, p. 1-17. refs

Tin-whisker samples have been harvested from the surfaces of tin-plated parts from electronic equipment and subjected to laboratory tests. These whiskers were found to have a low strength (Young's modulus of 8.0-85 GPa and UTS of about 8 MPa). Whiskers with a diameter of 3 microns are capable of carrying a current flow of 32 mA. They remain undisturbed by subjection to either a wide vibration spectrum or to mechanical shocks reaching 200 g. Spark discharges have been shown to emanate from the sides and tips of tin whiskers in vacuum. Unwanted growths can severely jeopardize the reliability of spacecraft subsystems. Author

A88-46423#
POSSIBLE STEPS IN THE FURTHER DEVELOPMENT OF THE COLUMBUS PROJECT TO AN AUTONOMOUS EUROPEAN MANNED SPACE-STATION INFRASTRUCTURE [MOEGLICHE SCHRITTE IN DER WEITERENTWICKLUNG DES COLUMBUS PROJEKTES HIN ZU EINER EUROPAEISCH-AUTONOMEN BEMANNTEN RAUMSTATIONS-INFRASTRUKTUR]
U. RIEDEL (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) Hermann Oberth Gesellschaft, Raumfahrtkongress, 36th, Bremen, Federal Republic of Germany, Sept. 10-13, 1987, Paper. 20 p. In German. refs
(MBB-UR-E-993/87-PUB)

The technical feasibility of building up an autonomous manned European Space Station (ESS) on the basis of the Columbus Man-Tended Free Flyer in the first two decades of the 21st century is explored. Several possible ESS mission scenarios and ESS configurations are presented in diagrams and drawings, and the types of scientific, commercial, and operational missions European users would require are discussed. Particular attention is given to the need for balance between international cooperation and European autonomy in the development of orbital systems; long-term planning for ESS build-up and use; the possible roles of Hermes, Ariane, Hotol, Saenger, Beta II, and other ESA launch vehicles and spacecraft in the ESS concept; the technological breakthroughs required for a viable ESS program; and the estimated development and operational costs of the proposed ESS scenarios. T.K.

A88-46515
OPERATIONAL CENTER FOR MANNED SPACE LABORATORIES [BETRIEBSZENTRUM FUER BEMANNTE WELTRAUMLABORS]
JOACHIM KEHR (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) DFVLR-Nachrichten (ISSN 0011-4901), June 1988, p. 1-5. In German.

The role of the DFVLR German Space Operations Center in the planning and direction of manned space payload operations of the Columbus project is discussed. The relevant Columbus project elements are summarized, and the European ground segment of this project is described. The particular tasks of the Operations Center are reviewed, and the Center is depicted. C.D.

A88-46776
ACTIVE EXPERIMENTS; PROCEEDINGS OF SYMPOSIUM 1 OF THE TWENTY-SIXTH COSPAR PLENARY MEETING, TOULOUSE, FRANCE, JUNE 30-JULY 11, 1986
G. HAERENDEL, ED. (Max-Planck-Institut fuer Physik und Astrophysik, Garching, Federal Republic of Germany) and M. MENDILLO, ED. (Boston University, MA) Symposium and Meeting sponsored by COSPAR, URSI, and IAGA. Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, 301 p. For individual items see A88-46777 to A88-46815.

Recent investigations of the thermosphere, ionosphere, magnetosphere, and solar wind by means of active experiments are examined in reviews and reports. Topics discussed include plasma and neutral-gas injections, electron- and ion-beam injections, vehicle-environment interactions, and active wave experiments. Particular attention is given to the results of the AMPTE experiments, computer simulations of ion-beam propagation, the Charge-2 tethered rocket experiment, opportunities for active wave experiments on the Space Station, and the physical processes involved in ionospheric-heating experiments. T.K.

A88-46799* Alabama Univ., Huntsville.
ELECTRON BEAM EXPERIMENTS AT HIGH ALTITUDES
R. C. OLSEN (Alabama, University, Huntsville) and H. A. COHEN (W. J. Schafer Associates, Inc., Arlington, VA) (COSPAR, URSI, and IAGA, Plenary Meeting, 26th, Symposium on Active Experiments, 1st, Toulouse, France, June 30-July 11, 1986) Advances in Space Research (ISSN 0273-1177), vol. 8, no. 1, 1988, p. 161-164. Previously announced in STAR as N87-26946. refs
(Contract NAG3-620)

Experiments with the electron gun on the SCATHA satellite produced evidence of beam-plasma interactions, and heating of the low energy electrons around the satellite. These experiments were conducted near geosynchronous orbit, in the dusk bulge, and plasma sheet, with one short operation in the lobe regions, providing a range of ambient plasma densities. The electron gun was operated at 50 eV, with beam currents of 1, 10, and 100 micro-A. Data from electrostatic analyzers and the DC electric field experiment show that the satellite charged to near the beam energy in sunlight, if the beam current was sufficient. Higher ambient densities required higher beam currents. The electrostatic analyzers showed distribution functions which had peaks, or plateaus, at energies greater than the satellite potential. These measurements indicate heating of the ambient plasma at several Debye lengths from the satellite, with the heated plasma then accelerated into the satellite. It is likely that the ambient plasma is in fact the photoelectron sheath generated by the satellite. Author

A88-49026
PERSPECTIVES OF SOVIET COSMONAUTICS. I [PERSPEKTIVEN DER SOWJETISCHEN KOSMONAUTIK. I]
RENE LORENZI (Zuerich, Eidgenoessische Technische Hochschule, Zurich, Switzerland) Astronautik (ISSN 0004-6221), vol. 25, Apr.-June 1988, p. 41, 42. In German. refs

Recent Soviet manned space activities are briefly reviewed. The present state of orbital stations is addressed, including the state of the art in their construction. Soviet industrial production in space is examined, and the role of energy supply and transport systems in present Soviet manned space activities is addressed. C.D.

A88-49743
COMPATIBILITY OF MICROGRAVITY EXPERIMENTS WITH SPACECRAFT DISTURBANCES
B. FEUERBACHER, H. HAMACHER, and R. JILG (DFVLR, Institut fuer Raumsimulation, Cologne, Federal Republic of Germany) Zeitschrift fuer Flugwissenschaften und Weltraumforschung (ISSN 0342-068X), vol. 12, May-June 1988, p. 145-151. refs

A simple model which permits analysis of the sensitivity of microgravity experiments to residual accelerations has been developed. The results are compared with the disturbance characteristics of typical spacecraft configurations in order to assess compatibility. Experiment sensitivity is characterized by an increasing disturbance tolerance at higher frequencies and a constant limit at low frequencies. The residual acceleration spectra of space structures show quasi-steady and dynamic contributions which vary with orbit attitude and configuration. The calculations are validated by comparison with measured microgravity disturbances during Spacelab flights and are then extrapolated to Space Station operations. Author

A88-49820#
THE EUROPEAN LONG-TERM SPACE PLAN
K.-E. REUTER (ESA, Coordination and Monitoring Office, Paris, France) ESA Bulletin (ISSN 0376-4265), no. 54, May 1988, p. 14-29.

A recent proposal for a coherent European space program for the 1990s and beyond is outlined. The proposed scientific program includes solar terrestrial science research, missions to asteroids and comets, and a spectroscopic observatory for X-ray sources. The earth observing program will involve the use of polar orbiting systems for studying ice, the ocean, coastal processes, and meteorology. The microgravity research program, including the Man-Tended Free Flyer and Eureca, and the telecommunications program are also considered. Other topics discussed include the Space Station and space platforms programs, the space-transportation program, space infrastructure operations, the future ground infrastructure, and organizational and budgetary considerations. R.R.

A88-49825#
THE USE OF PYROTECHNICS ON SPACECRAFT
N. CABLE (ESA, Structures and Mechanisms Div., Noordwijk, Netherlands) ESA Bulletin (ISSN 0376-4265), no. 54, May 1988, p. 66-71.

Because of their extremely high energy-to-volume densities, explosives are an invaluable tool aboard spacecraft for single-operation functions. Highly reliable and safe actuators have been developed to exploit this useful property for a variety of applications, using only standard spacecraft supplies and controls. Author

A88-49914#
A VARIABLE STRUCTURE CONTROL APPROACH TO FLEXIBLE SPACECRAFTS
WEIBING GAO, MIAN CHENG, and WENLING ZENG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica (ISSN 1000-6893), vol. 9, May 1988, p. A274-A280. In Chinese, with abstract in English. refs

The approach of variable structure control strategy is applied to the control problems of large flexible spacecrafts, taking the nonlinear forces into consideration. As the 'assumed modes method' is employed, the measurement technique for obtaining the mode coordinates is studied. After the analysis of a suggested reaching law, the overall nonlinear feedback control law is established. This reaching law guarantees an exponential reaching velocity and a finite reaching time by diminishing the chattering phenomenon. It is assumed that the torque may be more adequate than the force used as control actions. Author

A88-50248#
DYNAMICS AND CONTROL OF EXPERIMENTAL TENDON CONTROL SYSTEM FOR FLEXIBLE SPACE STRUCTURE
Y. MUROTSU, H. OKUBO, K. SENDA (Osaka Prefecture, University, Sakai, Japan), F. TERUI, and K. SHINODA IN: AIAA Guidance, Navigation and Control Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Part 2. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 852-860. refs
(AIAA PAPER 88-4154)

A mathematical model of dynamics for a composite system of a beam/tendon-actuator is developed here using a finite element method. The model is used to design a low-order modal controller. The relation between the dynamics of the tendon actuator and the control system design is investigated for the cases when the rigidity of the tendons is very high and low. C.D.

A88-50425#
ANALYTICAL MODELS FOR RELATIVE MOTION UNDER CONSTANT THRUST
J. VAN DER HA and R. MUGELLESI (ESA, European Space Operations Centre, Darmstadt, Federal Republic of Germany) IN: AIAA/AAS Astrodynamics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 636-644. refs
(AIAA PAPER 88-4300)

A general formulation for relative motion is presented allowing for arbitrary perturbing or thrust forces on each of the two satellites. Exact as well as approximate perturbation solutions for the relative motion under constant radial or circumferential forces acting on the subsatellite are established. The validity and usefulness of these solutions is assessed for a few realistic applications related to Eureca rendezvous maneuvering with the Shuttle. The results are of general interest for the fast calculation of relative subsatellite motion under thrust forces. Author

A88-50671
POSSIBLE VARIANTS OF MICROWAVE-BEAM STRUCTURE FOR SATELLITE SOLAR POWER PLANTS [O VOZMOZHNYKH VARIANTAKH STRUKTURY SVCH-PUCHKA SOLNECHNYKH KOSMICHESKIKH ENERGOSISTEM]
V. A. VANKE, S. K. LESOTA, and A. V. RACHNIKOV Radiotekhnika i Elektronika (ISSN 0033-8494), vol. 33, July 1988, p. 1531-1536. In Russian. refs

An analysis is made of the maximum efficiency of the microwave-beam transmission channel in a satellite solar power system that can be realized for a discrete 10-step amplitude distribution of the transmitting-antenna field. High-efficiency variants of the channel structure are found which are characterized by a high mean field intensity on the receiving antenna and an increased overall level of transmitted power for fixed values of maximum power density on the transmitting and receiving antennas. B.J.

A88-50769
HIGH-TEMPERATURE SOLAR ENERGY SYSTEMS FOR SPACECRAFT POWER AND PROPULSION UNITS [SOLNECHNYE VYSOKOTEMPERATURNYE KOSMICHESKIE ENERGODVIGATEL'NYE USTANOVKI]
OLEG IVANOVICH KUDRIN Moscow, Izdatel'stvo Mashinostroenie, 1987, 248 p. In Russian. refs

The work covers such topics as solar-energy concentrators, concentrator-receiver systems in solar-energy propulsion units, selective absorption as a way to enhance the efficiency of solar energy conversion and the Stirling engine as a solar enery

converter. The development of high-temperature solar energy systems for spacecraft power and propulsion units is investigated in detail, with particular attention given to results of ground-based testing. K.K.

A88-50837
TRANSIENT TESTS FOR SPACE STRUCTURES QUALIFICATION
L. P. BUGEAT and M. R. RAZAFIMAHAROLAHY (Intespace, Toulouse, France) IN: International Modal Analysis Conference, 5th, London, England, Apr. 6-9, 1987, Proceedings. Volume 1. Bethel, CT, Society for Experimental Mechanics, Inc., 1987, p. 799-803. Research supported by CNES and Societe Nationale Industrielle Aerospatiale.

The basic principles and implementation of the spacecraft load-identification and dynamic-qualification methods developed at CNES and described by Imbert et al. (1982), Morand et al. (1985), and Girard and Michel (1982) are reviewed. An open-loop approach based on an equivalent-force formulation and impedance coupling is applied in electrodynamic-shaker tests, and the test data are then used to estimate the severe LF loads on the spacecraft at the cutoff of the first and second stage engines of the launcher. Data from tests on the Arabsat structural model are presented in extensive graphs, demonstrating the feasibility of the method. T.K.

A88-52339
GROUND BASED OPERATIONS SUPPORT BY ARTIFICIAL INTELLIGENCE
RAINER GRUEN and ALBRECHT KELLNER (MBB-ERNO Raumfahrttechnik GmbH, Bremen, Federal Republic of Germany) IN: Space Congress, 25th, Cocoa Beach, FL, Apr. 26-29, 1988, Proceedings. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, p. 6-1 to 6-10.

The application of AI as support for ground-based space operations is considered, and the question of the management of large distributed AI-systems within a complex communications environment is addressed. The future European ground infrastructure is discussed, with special attention given to the space station Columbus, the Ariane 5 launcher, the Hermes spaceplane, and the European data relay satellite. Applicability of AI to the areas of cognition, analysis and interpretation, and the synthesis of activity sequences and scheduling is reviewed. Also considered are AI technologies, knowledge management, and system integration. R.R.

A88-53242
EURECA TICCE - A NINE-MONTH SURVEY OF COSMIC DUST AND SPACE DEBRIS AT 500 KM ALTITUDE
T. J. STEVENSON (Kent, University, Canterbury, England) British Interplanetary Society, Journal (ISSN 0007-084X), vol. 41, Sept. 1988, p. 429-432.

The Eureca-A timeband capture cell experiment is a modest extension of the time honored single foil capture cell technique for recovery of extraterrestrial material. The spacecraft, ostensibly designed for microgravity experimentation in low earth orbit, is the European retrievable carrier which takes advantage of the specific dimensions and payload launch capabilities of the United States Space Transportation System (the Space Shuttle), to provide a low cost reusable platform for missions, with durations of up to 9 months, not requiring celestial pointing. The experiment, of area 0.2 m, will probably return with about 1300 impact sites, each resolvable into a 2-3 day timeband during the flight. Author

A88-53945
SPATIAL EVOLUTION OF THE RESIDUAL-ACCELERATION VECTOR ON BOARD SPACECRAFT [PROSTRANSTVENNAIA EVOLIUTSIIA VEKTORA OSTATOCHNYKH USKORENII NA BORTU KOSMICHESKIKH APPARATOV]
V. S. AVDUEVSKII, A. I. LIKHODED, V. V. SAVICHEV, V. B. DUBOVSKOI, S. S. OBYDENNIKOV et al. Kosmicheskie Issledovaniia (ISSN 0023-4206), vol. 26, July-Aug. 1988, p. 621-625. In Russian. refs

Levels of small residual accelerations were measured on Salyut 6 and 7, the Progress transport vehicle, and a number of Mir rockets. The results indicate that the conditions necessary for space manufacturing operations on board spacecraft are characterized not only by a reduction in mass forces and accelerations but also by the variable character of these forces and accelerations in time and space. The data obtained were used to assess the possibility of prolonging the service life of Salyut-6. B.J.

A88-53993
SPACE BIOLOGY AND AEROSPACE MEDICINE; ALL-UNION CONFERENCE, 8TH, KALUGA, USSR, JUNE 25-27, 1986, REPORTS [KOSMICHESKAIA BIOLOGIIA I AVIAKOSMICHESKAIA MEDITSINA; VSESOIUZNAIA KONFERENTSIIA, 8TH, KALUGA, USSR, JUNE 25-27, 1986, TEZISY DOKLADOV]
O. G. GAZENKO, ED. Moscow, Izdatel'stvo Nauka, 1986, 392 p. In Russian. No individual items are abstracted in this volume.

This book discusses topics on clinical, physiological, and psychophysiological aspects of aerospace medicine, the problems of spacecraft habitability and hygiene, the biological effects of space flight, the effects of cosmic rays, and the regulation of metabolism in space. Papers are presented on a mathematical analysis of heart rhythm in predicting the functional state during EVA, the effects of weightlessness on the vestibular and vestibulo-oculomotor reactions, hypodynamia as the leading factor in the development of atherosclerosis, the psychophysiological aspects of motivation for activity, and the work efficiency of operators of different age under short-term hypercapnia. Other papers are on the house-fly larva as a user of life-support system wastes, the role of unicellular algae in the life-supporting system for humans, the levels of catecholamines and adrenergic receptors in rats after flights on Cosmos satellites, and the erythrocyte metabolism under conditions of prolonged hypokinesia. I.S.

A88-54005
SPACE BIOLOGY AND MEDICINE [KOSMICHESKAIA BIOLOGIIA I MEDITSINA]
O. G. GAZENKO, ED. Moscow, Izdatel'stvo Nauka, 1987, 320 p. In Russian. No individual items are abstracted in this volume.

This book examines the reactions of the human organism to the adverse conditions of space flight, the functioning of life support systems, and the means of maintaining the health and work capacity of cosmonauts. Topics discussed include the effects on humans of the space-flight dynamics; the mechanism of the weightlessness effect and the protective measures; the psychological reliability of the cosmonaut during a space flight and the psychological preparation and support; the habitability of the spacecraft cabin; the physiological-hygienic and ergonomic aspects of the spacesuit design and the medical and biological results of EVA activity; protection against cosmic rays; and the preparation of a cosmonaut for survival after a nonscheduled landing in such areas as the Arctic, taiga, desert, or jungles, or on the ocean. Special attention is given to the medical support of cosmonauts, the methods used for their selection and preparation, and medical assistance during a spaceflight. Various aspects of biological experimentation in space are discussed, including the selection of animals and microorganisms for experiments, and the maintenance of these organisms in space. Results on biological studies in space are included. I.S.

A88-54007#
MEDICAL INVESTIGATIONS RESULTS OBTAINED IN 125-DAY FLIGHT ON 'SALYUT-7' AND 'MIR' ORBITAL STATIONS
A. EGOROV, O. ANASHKIN, O. ITSEKHOVSKII, I. ALFEROVA, L. GOLUBCHIKOVA (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) et al. (International Union of Physiological Sciences Commission on Gravitational Physiology, Annual Meeting, 9th, Nitra, Czechoslovakia, Sept. 28-Oct. 2, 1987) Physiologist, Supplement (ISSN 0031-9376), vol. 31, Feb. 1988, p. S-1 to S-3.

The results of medical experiments and monitoring performed on a long-term Soviet space mission in 1986 are summarized.

Topics addressed include monitoring during normal operations and EVAs, in-depth medical examinations in the resting state, functional tests, metabolic and regulatory experiments, environmental monitoring, and evaluation of proposed prophylactic measures against the adverse effects of weightlessness. Although the cosmonauts were generally healthy throughout the mission, several significant cardiovascular changes were recorded, including redistribution of fluid and general deconditioning. Numerical data on these changes are presented in tables and briefly characterized. T.K.

A88-55314#
DEMONSTRATION MISSION ON COLUMBUS FOR TECHNOLOGY DEVELOPMENTS
J. PULS (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) and D. KASSING (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-002)

The paper deals with the description of technology demonstration missions identified in the European Columbus utilization program. The candidate payloads represent new technologies needed to upgrade the autonomous operational capabilities of the Columbus/ISS infrastructure. The in-orbit demonstration is justified in order to reduce the development risk before the concept is frozen and by the fact that special technical properties cannot be investigated on ground. A survey on the development status is given with an outlook to future activities coordinated by ESA. Author

A88-55324#
SPACE INSPECTION DEVICE FOR EXTRAVEHICULAR REPAIRS - SPIDER SYSTEM
SIMONETTA DI PIPPO and GIOVANNI SYLOS LABINI (CNR, Rome, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 6 p.
(IAF PAPER 88-029)

The main characteristics of the proposed space inspection device for extravehicular repairs (SPIDER) which is being developed for use in the Space Station environment is discussed. The SPIDER system is an autonomous integrated space robot which uses AI tools and techniques for operational control. The SPIDER is expected to be 150 X 90 cm and weigh about 400 kg. The first phase of the SPIDER program, the development of a teleoperated vehicle for visual inspection is examined in detail. Other phases of the program include autonomous navigation, docking, and repairing. R.B.

A88-55332#
MIR/KVANT HARDWARE AND SOFTWARE DESIGN APPROACHES TO ENABLE SCIENTIFIC RESEARCH
V. V. RIUMIN and M. IU. BELIAEV (Glavkosmos SSSR, Moscow, USSR) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 10 p. refs
(IAF PAPER 88-064)

Software developed to solve planning and support tasks on the Mir-Kvant orbital complex is examined. Experiments performed on the complex are discussed and mathematical models to select the dynamic scheme of the experiment performance and to forecast the operation of the systems which affect the experiments are presented. Relay-satellite communication sessions are used to monitor operations. Also, software packages to control the operation of the power supply system and to perform operation control investigations based on a comprehensive daily plan are discussed. R.B.

A88-55334#
MAIN RESULTS OF MEDICAL INVESTIGATIONS DURING LONG-DURATION SPACE FLIGHTS ONBOARD SALYUT-7 - SOYUZ-T
O. G. GAZENKO, A. I. GRIGOR'EV, and A. D. EGOROV (Institut Mediko-Biologicheskikh Problem, Moscow, USSR) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p. refs
(IAF PAPER 88-074)

Medical investigations conducted during six long-term missions (65 to 237 days) and five short-term missions (8 to 12 days) between 1982 and 1986 on the orbital complex Salyut-7-Soyuz-T are discussed. The flight parameters of Salyut-7 are presented including the environmental parameters, diet, water supply, work and rest arrangements, and exercise habits. Results are presented from experiments concerning cosmonauts' health status, nervous responses, sleep, and work capacity. Decreases in body mass and leg volume, and changes in vestibular function, motor activity, and the cardiovascular system are reported. The fluid-electrolyte metabolism and hormonal status of the cosmonauts are given, including an increase in the production of ADH and aldosterone, activation of the sympathoadrenal, cholinergic and histaminergic systems, and inhibition of the serotoninergic system. Experiments on bones, immunology, and extravehicular activity are also presented. R.B.

A88-55336#
SPACE STATION HABITATION MODULE - PRIVACY AND COLLECTIVE LIFE
DANIELE BEDINI and ROBERTO PINOTTI (Futuro, Florence, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p. refs
(IAF PAPER 88-080)

A design for the Space Station habitation module is proposed and illustrated. Problems in designing the module include creating an adaptable configuration, providing a design that will minimize psychological and sociological stress, allowing for an equilibrium between private and collective life. The need for architectural variety and flexibility of architectural elements is examined. The areas of the module are described, noting the possible uses of each section. R.B.

A88-55337#
THE MANNED SPACE LABORATORIES CONTROL CENTER (MSCC) AT DFVLR - OBERPFAFFENHOFEN, GERMANY
J. KEHR and K. REINEL (DFVLR, Oberpfaffenhofen, Federal Republic of Germany) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 18 p.
(IAF PAPER 88-087)

The development of an operations concept for manned laboratories is discussed. European space programs are outlined, stressing the Columbus program. The European ground based operations centers and the operational management structure for the ESA are examined. The activities of the Manned Space Laboratories Control Center (MSCC) are described, including planning manned flights, systems and payload operations, and ground support. The three test facilities for in-orbit operations within the MSCC are the European Proximity Operation Simulation Facility, a servicing test facility, and a test facility for large flexible spacecraft control. R.B.

A88-55339#
USER ACCOMMODATION CONCEPT FOR JAPANESE EXPERIMENT MODULE ON THE SPACE STATION
KIYOSHI HIGUCHI, KIWAO SHIBUKAWA, AKIO OGISO, TOSHIHIKO YAMAWAKI (National Space Development Agency of Japan, Tokyo), TOORU MATSUSIMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) et al. IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-094)

The guidelines set by the Space Activities Commission's Ad Hoc committee on the Space Station (1986) are used to develop mission requirements and planning procedures for the Japanese Experiment Module (JEM). The utilizations and operations concept for the Space Station and Japan's Space Station utilization plan are presented. Plans for payload accommodation and integration are examined, noting the need for experiments concerning scientific

observation, earth observation, communication, material processing, life sciences, and technology development. R.B.

A88-55340#
COLUMBUS PRESSURIZED MODULES - A VERSATILE USER-FRIENDLY SPACE LABORATORY SYSTEM
E. VALLERANI, L. D'EMILIANO, and D. BOGGIATTO (Aeritalia S.p.A., Turin, Italy) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p.
(IAF PAPER 88-097)

The design and features of the Columbus Pressurized Modules (PMs) are presented. The architecture of the PMs are described and illustrated. Racks to house subsytem equipment and payloads, locations for internal maintenance performance, payload accommodation, and resource availability are examined. Also, the roles of the module control station and the general purpose work bench in systems and payload operations support are discussed. R.B.

A88-55377#
STABILITY OF IMPERFECTION-SENSITIVE NONLINEAR SPACE STRUCTURES UNDER STOCHASTIC LOADING
T. S. SANKAR (Concordia University, Montreal, Canada) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p. refs
(Contract NSERC-A-7104)
(IAF PAPER 88-293)

Nonlinear space structures and components subjected to stochastic loading are analyzed by using a quasi-stationary solution to the governing nonlinear stochastic differential equations in phase space to obtain the probability density of the first instability of the system in a specified time of operation. The random loading is modeled as a delta-correlated excitation with a wideband spectra, and the resulting dynamic response is approximated by a Markov process with known initial conditions corresponding to a stable equilibrium state. An expression for the failure probability is derived, and conditions for its validity are defined. V.L.

A88-55397#
THE SYSTEM OF THE MIR STATION MOTION CONTROL
V. N. BRANETS, V. P. LEGOSTAEV, and B. E. CHERTOK IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 9 p.
(IAF PAPER 88-334)

The motion control and navigation system (MCNS) of the Mir station are examined. The tasks of the MCNS are presented, including orientation, control relative to the center of mass, navigation and stabilization. The structure, composition, and operating modes of the MCNS are discussed. In addition, the sensing elements, digital computer complex, and reliability support of the Mir station are described. R.B.

A88-55417#
MULTIMISSION COMMUNICATION SATELLITES
FRANCOIS PANZANI, JACQUES THUERY, and DENIS ROUFFET (Alcatel Espace, Toulouse, France) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 11 p.
(IAF PAPER 88-426)

The constant availability of new space techniques and technologies has made the design of flexible, multimission satellites possible. This paper discusses the resulting multiplicity of services, and gives user and designer criteria which must be respected in order to make such services viable. Techniques that permit using a single satellite for several different missions by providing the required reconfiguration flexibility are examined. Finally, the French National Telecom 2 satellite, which is an excellent example of a multimission system, is described. C.D.

A88-55436#
EVA SPACE SUITS - SAFETY PROBLEMS
G. I. SEVERIN, I. P. ABRAMOV, and V. I. SVERTSHEK (AN SSSR, Sovet Interkosmos, Moscow, USSR) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-515)

Design features of semirigid space suits and portable life support systems for the Salyut and Mir space stations are reviewed. Ways of providing system reliability in these suits are highlighted. It is shown that the solution to the problem of EVA safety is found in the selection of the proper design concepts and arrangements, adequate operating modes, proven manufacturing techniques, and comprehensive development test programs. C.D.

A88-55454#
LUNAR ORBIT SERVICE STATION
H. HERMANN KOELLE (Berlin, Technische Universitaet, Federal Republic of Germany) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 5 p. refs
(IAF PAPER 88-618)

Facts and arguments supporting an early establishment of a manned lunar orbiting service station are presented. Ten specific functions of such a facility are defined, and the characteristics of a 50 km altitude lunar orbit are summarized. Twelve elements and subsystems comprising such a service station are given, and some of the design options are mentioned. A list of 17 system criteria enabling the designer, planner, and decision maker to compare alternatives in a rational way to arrive at an optimal solution for the development scenario is presented. C.D.

N88-20330# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Div. Systems Strategiques et Spatiaux.
STUDY ON LONG TERM EVOLUTION TOWARDS EUROPEAN AUTONOMOUS MANNED SPACEFLIGHT (STEAMS) Final Report
M. GRIMARD Paris, France ESA 22 Jun. 1987 169 p
(Contract ESTEC-6668/86-NL-PP)
(SNIAS-SE/LS/AP-35-073; ESA-CR(P)-2520; ETN-88-91962)
Avail: NTIS HC A08/MF A01

It is shown that a medium sized European space station (ESS) is achievable before 2010. This ESS should allow a permanent occupation by 2 to 4-men crews with a 3 months crew exchange cycle. Manned missions should focus on life sciences, materials, and bioprocessing. A coorbiting platform is required for processing in high quality microgravity environment. It will be a Columbus Man Tended Free Flyer or EURECA derivative. The polar infrastructure is independent of LEO manned one (only hardware commonality). Crew safety is a prime driver for the manned ESS and an escape means permanently docked at the station is required: a dedicated Escape Vehicle or Hermes if it can stay docked for a long time. The logistics support of ESS requires a combined use of Hermes and Ariane 5 flights. This implies high costs for the operations due to launch costs (2 to 4 Hermes flights per year and 1 Ariane 5 flight every 9 to 12 months). This first generation ESS does not allow efficient and intensive commercial activities because of the high operational costs. The reduction of these requires the introduction of new launching systems and the implementation in parallel of a 2nd generation manned infrastructure which might be foreseen in the post-2010 years. ESA

N88-20348# Groningen Rijksuniversiteit (Netherlands). Systems and Control Group.
SIMSAT: SIMULATION PACKAGE FOR FLEXIBLE SYSTEMS. BEAMS IN SPACE M.S. Thesis
MARTIN H. KLOMPSTRA Apr. 1987 61 p
(TW-278; ETN-88-91868) Avail: NTIS HC A04/MF A01

A simulation package (SIMSAT) for flexible systems was developed to study the effects of flexibility, damping, and stabilizing (robust) compensators on these systems. Three partial differential equation models for flexible systems are simulated: Euler-Bernoulli beam with structural damping; Euler-Bernoulli beam with viscous damping; and two Euler-Bernoulli beams with viscous damping connected through a central disk. Possible simulations include simulate the models with or without damping, or connect a compensator to the models (closed loop systems). The SIMSAT

calculates the state-evolution w(x,t) of the system, and the input, output, energy, and mean square error corresponding to these. All these calculations can either be shown in numbers (numerical results) or in curves. For the state-evolution two extra graphical facilities are present namely a motion picture and a three dimensional curve. If desired these numerical results and curves can be sent to a printer. The package was developed in Turbo-Pascal for a personal computer with MS-DOS. ESA

N88-21195# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (Germany, F.R.).
SOME HIGHLIGHTS ON ROSAT MECHANISMS
P. PAWLOWSKI and H. HEIMERDINGER (Dornier-Werke G.m.b.H., Friedrichshafen, West Germany) *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 21-25 Dec. 1987
Avail: NTIS HC A14/MF A01

The ROSAT antenna boom mechanism (ABM), and telescope door mechanism (TDM) are described. The ABM is a 3.5 m long CFRP tube with 80 mm outer diameter and 4.5 mm wall thickness. It carries an S-band communication antenna at the tip, and a magnetometer for attitude measurements in the middle. It is stowed for launch and released by a kick spring, which causes a 180 deg rotation of the boom. Latching stubs bolted to the hinge bracket fix it in position. The TDM is used to avoid contamination of the gold coated X-ray mirrors before use. In orbit it is opened by a pyrotechnical device/kick spring, by a 90 deg rotation and acts as a sun shade. ESA

N88-21196# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
THE CTM PROGRAM OF MASTS AND THE CTM ENGINEERING MODEL
M. AGUIRRE, R. BUREO, F. DELCAMPO, and M. FUENTES (Sener S.A., Madrid, Spain) *In its* Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 27-35 Dec. 1987
Avail: NTIS HC A14/MF A01

A biconvex tube mast that can be flattened and then rolled up around a drum into a small volume package was developed. A drive system pulls the tube by the edges to deploy it. The mast can be manufactured in metal and composite; in both cases a continuous manufacturing method is used, to provide tubes of unlimited length. An engineering model with composite tubes was built and tested with satisfactory results. A qualification model with metal or composite tubes is proposed. Applications include satellite antenna and solar array deployment. ESA

N88-21200# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
NUMERICAL SOLUTION OF MULTIBODY SYSTEMS IN SPACE APPLICATIONS
B. SPECHT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 59-63 Dec. 1987
Avail: NTIS HC A14/MF A01

A numerical analysis tool for 3D mechanical multibody systems is presented. The method is based on Lagrange's equation with constraints which are enforced by the Lagrange multiplier technique. Kinematic, static, and dynamic analysis modes are available. The in orbit deployment of a large parabolic antenna reflector was simulated. The CPU times for kinematic, quasi-static, and dynamic modes are 7.2, 21, and 32 min respectively on a VAX-750. ESA

N88-21211# Societe Nationale Industrielle Aerospatiale, Cannes (France).
THE SPOT SOLAR ARRAY. BOX OPENING MECHANISMS PHYSICAL VAPOR DEPOSITION (PVD)-MOS2: LUBRICATED SLIDES. FUNCTIONAL EVALUATION
J. F. PATIN, J. L. CECCONI, L. DECRAMER, and E. CONDE (Centre National d'Etudes Spatiales, Toulouse, France) *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 161-166 Dec. 1987
Avail: NTIS HC A14/MF A01

To estimate in-flight safety margins and to delineate the parameters which influence the friction coefficient, the MoS2 lubrication of the opening mechanism for the stowage box of the SPOT solar array, a set of steel slides restrained by aluminum alloy jumpers, was investigated. Effects of moisture, vacuum, and repeated operations on friction were studied. Measurements on the stowage box slides show low initial dispersions of the friction characteristics; mean reduction of friction effects by 60 percent to be considered for box opening in orbit with respect to the friction values measured in ground tests at 70 percent moisture; and 10 openings as the desirable number of prelaunch operations, with the frictional characteristics thus stabilized still preserved after 24 openings at least. ESA

N88-21217# Dornier-Werke G.m.b.H., Friedrichshafen (Germany, F.R.).
DESIGN OF A LINEAR ACTUATOR AND BREADBOARD TEST RESULT
R. G. HOSTENKAMP *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 207-210 Dec. 1987
Avail: NTIS HC A14/MF A01

For the set of 15 mechanisms required to control the end positions of the deployable antenna petals of the Far Infrared and Submillimeter Space Telescope, a linear actuator capable of generating submicron steps was designed. The microsteps of a stepper motor are transferred by a spindle to a lever which deflects a slotted circular spring. The resulting diametral change of the spring represents the output stroke of the actuator. By a thermally stable design utilizing conventional material, the actuator is suited for an operational temperature range from 80 C to cryogenic conditions. The design of the linear actuator is described and test results from a breadboard model are reported. ESA

N88-21226# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
QUALIFICATION OF THE OLYMPUS REACTION WHEEL
G. J. STURTIVANT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Symposium p 267-272 Dec. 1987
Avail: NTIS HC A14/MF A01

Functional (torque) vibration, thermal vacuum, and life tests on the OLYMPUS satellite 10 Nms reaction wheel are summarized. Test equipment and procedures are described. Results are satisfactory. ESA

N88-21227# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
DEVELOPMENT AND QUALIFICATION OF THE OLYMPUS ANTENNA POINTING MECHANISM
P. J. LOVETT *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 273-280 Dec. 1987
Avail: NTIS HC A14/MF A01

The OLYMPUS antenna pointing mechanism (APM), a modular mechanical unit which interfaces between antenna reflectors and the spacecraft structure and which is capable of reorientating the reflectors with respect to the spacecraft, is presented. The APM can support reflectors in the launch phase and in the on-station mode. Reorientation of the reflectors is carried out in open loop mode where the APM is repointed upon command from the ground, and in closed loop mode where the APM is required to respond on a continuous basis to RF error signals. In both modes the APMs are controlled by the APM electronics (APME) which generates the required stepping demands for the APM. On OLYMPUS five such APM are controlled by one electronics unit, the APME. These equipments form the antenna pointing subsystem. Four of the mechanisms operate in open loop mode and the fifth can operate both in on and off boresight of a radio frequency beacon. Test results and design modifications are summarized. ESA

N88-21229# British Aerospace Public Ltd. Co., Stevenage (England). Space and Communications Div.
QUALIFICATION TESTING OF THE EUROSTAR SOLAR ARRAY DRIVE MECHANISM (SADM)
I. D. HENDERSON *In* ESA, Proceedings of the 3rd European Space Mechanisms and Tribology Symposium p 285-294 Dec. 1987
Avail: NTIS HC A14/MF A01

The EUROSTAR satellite communication platform solar array drive power ring unit; baseplate shaft and main bearing assembly; motor and gearbox assembly; signal slip-ring unit; and datum sensors are described. Subassembly; nonoperational; functional; vibration; thermal vacuum; and accelerated life tests are summarized. ESA

N88-22054 Centre National d'Etudes Spatiales, Toulouse (France).
SPACECRAFT TRAJECTORIES [TRAJECTOIRES SPATIALES]
O. ZARROUATI Jan. 1987 523 p In FRENCH Previously announced in IAA as A87-26851
(ISBN-2-85-428166-7; ETN-88-91803) Avail: CEPADUES-Editions, 111 rue Nicolas Vauquelin, 31100 Toulouse, France

The development and theoretical analysis of space trajectory systems for practical applications including the tracking of spacecraft for programs such as HERMES are considered. Orbital parameters and Keplerian motion, and the gravitational and nongravitational mathematical modeling of the effects of perturbations on satellites, are first discussed. Inertial reference systems; instrumentation for the measurement of distances; Doppler effects and angles; and the geometric interpretation and evaluation of micromeasurements are then considered. Finally. a discussion is presented of algorithms including linear filter, least-square, Kalman filter, and inversion methods, and of the analysis of error and covariance, with special attention given to the case of geostationary satellite orbits. ESA

N88-23026# Joint Publications Research Service, Arlington, VA.
JPRS REPORT: SCIENCE AND TECHNOLOGY. JAPAN
12 Nov. 1987 94 p Transl. into ENGLISH from various Japanese articles
(JPRS-JST-87-030) Avail: NTIS HC A05/MF A01

Topics addressed included: nuclear developments; aerospace engineering; automotive industry; feedback lasers; and science and technology policy.

N88-23813# Bundesministerium fuer Forschung und Technologie, Bonn (Germany, F.R.).
ARGUMENTS FOR MANNED OR UNMANNED SPACECRAFT ACTIVITIES [ARGUMENTE FUER BEMANNTE UND UNBEMANNTE WELTRAUMAKTIVITAETEN]
19 Oct. 1987 20 p In GERMAN
(REPT-46/87; ETN-88-91949) Avail: NTIS HC A03/MF A01

Arguments for the critical assessment of technology needs to prepare manned spacecraft activities are presented. Studies in materials structure sciences and biosciences are especially required as for the FSLP and D1 missions. This evaluation suggests the possible substitution of man by automation in space experiments. Developments in this field are reviewed. ESA

N88-23814# European Space Agency, Paris (France).
PREPARING FOR THE NEW PROGRAMS. THE ESA TECHNOLOGICAL RESEARCH AND DEVELOPMENT PROGRAM 1988-1990
NORMAN LONGDON, ed. Dec. 1987 209 p Original contains color illustrations
(ESA-SP-1095; TD(88)1; ETN-88-92557) Avail: NTIS HC A10/MF A01

The European Space Agency's R and D activities in Earth-space telematics; space communications infrastructure; global Earth monitoring; deep space and observatory facilities; microgravity utilization; manned systems and platforms; in-orbit operations and servicing; launcher and reentry technology; and common and genetic technology are outlined. ESA

N88-23820# Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (Germany, F.R.).
COLOMBUS FEASIBILITY STUDIES, EXECUTIVE SUMMARY
1988 96 p Sponsored by the Bundesministerium fuer Forschung und Technologie, Bonn, Fed. Republic of Germany and the PSN/MSRT Prepared in cooperation with Aeritalia S.p.A., Turin, Italy and Dornier Werke GmbH, Friedrichshafen, Fed. Republic of Germany
(ETN-88-92334) Avail: NTIS HC A05/MF A01

The Columbus Space Station elements, operating scenario, payload requirements, system design, and development are summarized. Columbus consists of a resource module, pressurized module, payload carrier, and servicing vehicle for work in material and fluid sciences, life sciences, space sciences, and Earth observation. The implementation of respective infrastructure elements is based on experience gained on the space systems produced (e.g., Spacelab) or defined (e.g., EURECA) in Europe, and is tailored to stepwise build-up from initial to ultimate capabilities offered to ESA for European-wide conduct. Cost and schedule assessments, together with technical and programmatic definitions, confirm that the Columbus program is well within realistic European potentials. ESA

N88-23823# Science Applications International Corp., McLean, VA.
SOVIET SPACECRAFT ENGINEERING RESEARCH
J. F. GARIBOTTI, M. ASWANI, E. F. CRAWLEY, W. C. KESSLER, K. SOOSAAR, J. D. TURNER, and W. P. WITT Oct. 1987 164 p
(FASAC-TAR-3090) Avail: NTIS HC A08/MF A01

The Soviet published literature in spacecraft engineering pertaining to future space systems, including those utilizing large structures is assessed. Topical areas emphasized include advanced structural concepts and associated construction approaches, spacecraft materials, precision pointing and rapid retargeting, geometrically precise structures in the presence of static and dynamic disturbances, and spacecraft vulnerability as it relates to these aspects of spacecraft engineering. The assessment indicates that the Soviets have significant strengths and specialties in spacecraft engineering. The Soviet space station appears to be the principal Soviet large system of the near future, and this will expand and evolve in size and capability. Radio astronomy missions are also genuine drivers for large space structure technology, including space construction capability. In the structural materials area, the Soviets can be expected to develop high quality, structurally efficient fiber-reinforced metal-matrix composites, which will be used to improve the performance and possibly the survivability of future Soviet spacecraft. The technology of control-structure interaction, important in the design of large space-based lasers, is receiving considerably more support, based on the published literature, in the United States than in the Soviet Union. Author

N88-24035# United Nations, New York, NY. Outer Space Affairs Div.
THE USSR SPACE SYSTEMS FOR REMOTE SENSING OF EARTH RESOURCES AND THE ENVIRONMENT (SENSOR SYSTEMS, PROCESSING TECHNIQUES, APPLICATIONS) Abstract Only
ROLF-PETER OESBERG *In* INPE, Latin American Symposium on Remote Sensing. 4th Brazilian Remote Sensing Symposium and 6th SELPER Plenary Meeting, Volume 1 p 317 1986
Avail: NTIS HC A99/MF E03

The two main techniques in present use of sensing multispectral information for different applications are photography or scanning with detector arrays from air- or space-borne platforms. The USSR remote sensing program has included manned missions on Soyuz spacecraft and Salyut orbital stations, and regular missions of Meteor and Meteor-Priroda (Meteor-Nature) operational satellites carrying multispectral sensor systems. Photography from space

was acquired in the early and mid-1970s from the short-duration manned missions on Soyuz spacecraft using single-band and multiband cameras. The MKF-6 multiband camera was first flown on Soyuz-22 in 1976 and was subsequently developed further and flown on many missions, including Salyut-6 and 7. The design and technical parameters of this camera and other sensor systems that were flown on board the USSR spacecraft include the KATE-140 photographic camera on the Salyut-6 and 7 and the scanner systems MSU-M, MSU-S, MSU-SK, Fragment-2 and MSU-E on board the spacecraft Meteor and Meteor-Piroda, basic methodologies of image interpretation and processing techniques and examples of different applications. The technical parameters of these sensor systems are compared with those form other photographic and scanner systems launched or planned. Author

N88-24130# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
BOTANY FACILITY PRE-PHASE C/D. CORE PAYLOAD FOR EURECA, VOLUME 2 Final Report
Paris, France ESA 18 Nov. 1986 393 p In ENGLISH and GERMAN Sponsored in cooperation with Microtecnica, Turino, Italy; Sira Institute Ltd., Chislehurst, United Kingdom; and Bell Telephone Mfg. Co., Antwerp, Belgium
(Contract ESA-6415/85-NL-PR)
(BF-RP-ER-015-VOL-2; ESA-CR(P)-2510-VOL-2; ETN-88-91959)
Avail: NTIS HC A17/MF A01

The Life Support Subsystem (LSS); the impact of control errors on the volume/weight demand of the ventilation and dryer; and the activities performed during the EURECA Botany Facility (BF) predevelopment phase of the LSS are presented. Methods for pollen storage and dispersal were examined. The thermal control (TC) subsystem and the heat transfer at the glass disk as well as the temperature distribution in the fluorescent tube were tested. A suitable configuration for the BF illumination system, magnetic fluid seals for the LSS and TC rotating seals, and a balancing system for the BF centrifuge were investigated. Problems of plant fixation, water supply, plant nutrients, and soil in the BF are treated. The study and distribution of plant nutrients, and the removal of phytotoxins in the BF are outlined.
ESA

N88-24131# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
LIFE SUPPORT SUBSYSTEM (LSS). CONCEPT FOR THE BOTANY FACILITY
H. LOESER *In its* Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 21 p 18 Nov. 1986
(TN-RB524-107/86) Avail: NTIS HC A17/MF A01

The design concept of the LSS for the EURECA Botany Facility is described on a functional basis, with a view to systems design drawings and the required inputs for data handling. The LSS is subdived into 3 modules: the Atmosphere Storage And Composition Control module, the Ventilation And Dryer module, and the Soil, Agar And Seed module. The requirements and concept description of each module are given. ESA

N88-24132# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
IMPACT OF CONTROL ERRORS ON THE VOLUME/WEIGHT DEMAND OF THE VENTILATION AND DRYER (VAD) CONCEPT
H. LOESER and W. P. FOTH *In its* Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 28 p 18 Nov. 1986
(TN-RB524-006/87) Avail: NTIS HC A17/MF A01

The soil volume and the water weight required for the VAD-concept based on water reclamation and the VAD-concept centralized water condensation/collection were computed in order to provide inputs for a preliminary component accommodation. After a comparison of the results, the VAD-module based on centralized water condensation/collection, the soil, agar, and aeed module is proposed as baseline solution as the best compromise between technical maturity and weight and volume penalties.
ESA

N88-24133# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
SUMMARY OF THE ACTIVITIES PERFORMED DURING THE BOTANY FACILITY (BF) PREDEVELOPMENT PHASE FOR THE LIFE SUPPORT S/S (LSS)
H. LOESER *In its* Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 89 p 18 Nov. 1986
(TB-RB524-002/87) Avail: NTIS HC A17/MF A01

The results obtained in the predevelopment phase in the different work packages for the LSS are summarized in order to facilitate for the customer comparison between the tasks. The tasks performed and the results obtained in the following work packages are summarized: solution of design problems related to botanical requirements; subsystem design; laboratory model design; model manufacturing; test and verification; design, manufacturing and test of the Atmosphere Storage And Composition Control module for the model; and experiment concept of model payload.
ESA

N88-24134# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
EXAMINATION OF METHODS FOR POLLEN STORAGE AND DISPERSAL
K. LOETZERICH and H. LOESER *In its* Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 19 p 18 Nov. 1986
(TN-RB524-097/86) Avail: NTIS HC A17/MF A01

Methods to store pollens and to dispose of them when pollination is accomplished were examined. The likely basic requirements which a Pollen Storage And Dispersal Device (PSADD) has to meet were compiled, and features of pollen were identified. The pollination methods are discussed, and two PSADD options are described. The preferred option consists of a storage volume formed by a duct and a cylindrical membrane that is opened electrically when pollination has to be initiated. The air flow of the life support system can carry the pollen away and distribute them in the cuvette. It is recommended to review the proposed concept and to test it in a model cuvette of the laboratory model in order to confirm its feasibility. ESA

N88-24135# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
BOTANY FACILITY. THERMAL CONTROL (TC) SUBSYSTEM TEST REPORT ON EXPERIMENT CONTAINER OF LABORATORY MODEL AND BREADBOARD CENTRIFUGE
W. FISCHER *In its* Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 36 p 18 Nov. 1986
(BF-TN-ER-061/86) Avail: NTIS HC A17/MF A01

The Botany Facility TC (Thermal Control or Thermocouple) subsystem was tested in the environmental laboratory. All data could be generated within the required accuracy and to the required extent. The TC-subsystems of the Laboratory Model and Experiment Container and Centrifuge were successfully tested.
ESA

N88-24136# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
BOTANY FACILITY: TEST REPORT ON BREADBOARD TESTS FOR THE DETERMINATION OF THE HEAT TRANSFER AT THE GLASS DISK AND OF THE TEMPERATURE DISTRIBUTION IN THE FLUORESCENT TUBE [BOTANY FACILITY: TESTBERICHT DER BREADBOARD-TESTS ZUR ERMITTLUNG DES WAERMEUBERGANGES AN DER GLASSCHEIBE UND DER TEMPERATURVERTEILUNG AN DER LEUCHTSTOFFROEHRE]
W. FISCHER *In its* Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 110 p 18 Nov. 1986 In GERMAN
(BF-TN-ER-053) Avail: NTIS HC A17/MF A01

Botany Facility tests were performed in an environmental laboratory in order to determine the heat transfer at the glass disk of the breadboard model and the temperature distribution in the fluorescent tube under different environmental conditions. The test objects, test facility, instrumentation, environmental conditions, and test procedures are described. The tests were successful

since all data needed were obtained with the required accuracy. The extent of the data was substantially increased during the tests, allowing safe predictions. ESA

N88-24137# Sira Inst. Ltd., Chislehurst (England). Research and Development Div.
BOTANY FACILITY: BREADBOARDING RESULTS OF THE ILLUMINATION SYSTEM
M. A. CUTTER *In* MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 15 p 18 Nov. 1986
(SIRA-A/7373/WP110/MAC003) Avail: NTIS HC A17/MF A01

Experiments were undertaken to establish a suitable configuration for the EURECA Botany Facility illumination system. The basic requirements for the illumination system are presented. The relationship between photometric and radiometric measurements is discussed. Experimental data aiming at the establishment of a lamp running-in period are discussed. The lamp-to-lamp light output variation was assessed. The results of experiments aiming at the establishment of a suitable cuvette reflector design are treated, including an assessment of the fluorescent lamp reflector design and the back and sidewall reflectors for the cuvettes. The preferred design was analyzed with respect to absolute illuminance and uniformity at the base of the cuvettes. The temporal variation of the cuvette-cuvette light level was assessed. ESA

N88-24138# Sira Inst. Ltd., Chislehurst (England). Research and Development Div.
BOTANY FACILITY: MAGNETIC FLUID SEAL CONSIDERATIONS FOR THE CENTRIFUGE
M. A. CUTTER *In* MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 6 p 18 Nov. 1986
(SIRA-A/7373/WP110/MAC004) Avail: NTIS HC A17/MF A01

The implementation of magnetic fluid seals, proposed for the Life Support and Thermal Control rotating seals on the EURECA Botany Facility Centrifuge, was studied. The magnet assemblies, required at each of the inner/outer interfaces of the rotating seal to retain the magnetic fluid, the shaft for the rotating seals, and the magnetic fluids are described. The vibration and shock resistance, the assembly procedure, the compatibility of rubbers with magnetic fluids, the biocompatibility, the launch/landing conditions, and the lifetimes are discussed. ESA

N88-24139# Sira Inst. Ltd., Chislehurst (England). Research and Development Div.
BOTANY FACILITY: CONSIDERATIONS AND ANALYSES OF THE BALANCING SYSTEM PHILOSOPHY PROPOSED FOR THE BF CENTRIFUGE
P. J. W. FORD *In* MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 39 p 18 Nov. 1986
(SIRA-A/7373/WP110/PWF001) Avail: NTIS HC A17/MF A01

The analyses undertaken during the design phase of the balancing system, proposed for the centrifuge on the EURECA Botany Facility, are explained. The nature of the out-of-balance condition was examined using computer model simulations in order to understand the influence of forces and couples generated by rotating systems on the microgravity environment of the structure that supports it (in this case the EURECA platform). The interdependence of static and dynamic out-of-balance forces and couples for ground and orbital conditions were examined. Specific areas of the system such as the effects of gain differences in the strain gage amplifiers, and the effect of balance mass transfer on the centrifuge rotational inertia, were analyzed. ESA

N88-24140# Sira Inst. Ltd., Chislehurst (England).
BOTANY FACILITY: THE PROBLEMS OF PLANT FIXATION
In MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 10 p 18 Nov. 1986
(SIRA-A/7373/WP220/RJS/001) Avail: NTIS HC A17/MF A01

The problems of specimen fixation are defined and the problems likely to be encountered in performing this process in space are indicated. The fixation process is required to stop plant growth at a specified time and to preserve grass and microscopic structure until the EURECA Botany Facility returns to Earth after a period of up to 9 months. The parts to be preserved are stem, root, fruits, and seeds. The methods of applying fixation are presented. The chemical problems related to the extreme toxicity of some fixatives are discussed. Physical problems such as the good isolation of the cuvette, and the diffusion rate of the fixation through the plant structure are discussed. ESA

N88-24141# Sira Inst. Ltd., Chislehurst (England).
BOTANY FACILITY: PROBLEMS OF WATER SUPPLY, PLANT NUTRIENTS AND SOIL IN THE BOTANY FACILITY
In MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 6 p 18 Nov. 1986
(SIRA-A/7373/WP220/RJS/003) Avail: NTIS HC A17/MF A01

The major points to be considered in providing the correct environment for plant roots in the EURECA Botany Facility (BF) are treated. The term soil describes the medium in which the roots propagate. In relation with water supply the principle of water recycling the in cuvettes, the automatic centrifuge balancing system, the water storage problem, the water distribution system, and the seed storage conditions are discussed. The main problems associated with substrates for plant growth are outlined. The problem of maintaining supplies of nutrients to the plant throughout its life under BF conditions is discussed. ESA

N88-24142# Sira Inst. Ltd., Chislehurst (England). Research and Development Div.
SUPPLY AND DISTRIBUTION OF PLANT NUTRIENTS IN THE BOTANY FACILITY
R. J. SIMPSON *In* MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 9 p 18 Nov. 1986
(SIRA-A/7373/WP220/RJS/004) Avail: NTIS HC A17/MF A01

The adequate supply of nutrients and trace elements required for plants grown in the EURECA Botany Facility (BF) to reach maturity and to generate new seeds is discussed. The delivery of soluble nutrients to plant roots at the required concentrations is a key factor in BF experiments. It is desirable that similarity between zero and microgravity samples be maintained in this respect. Nutrient delivery by passive and active means is discussed. Active (pumped) delivery and feedback control is probably best, although the most complex option. The use of nonspecific measurements, such as electrical conductivity for control is probably feasible in the context of BF, but the use of specific chemical sensors is probably not a viable option at present. The use of porous materials as plant substrates and for water storage is discussed. ESA

N88-24143# Sira Inst. Ltd., Chislehurst (England).
EURECA BOTANY FACILITY. TECHNICAL NOTE: REMOVAL OF PHYTOTOXINS
In MBB GmbH, Botany Facility Pre-Phase C/D Core Payload for EURECA, Volume 2 2 p 18 Nov. 1986
(SIRA-A/7373/WP220/RJS/005) Avail: NTIS HC A17/MF A01

Two methods for the removal of phytotoxins from the atmosphere of the Botany Facility are considered. The only substance produced by plants that is likely to affect them is ethylene. The chemical removal of ethylene requires a reaction in which neither the reagent nor the products are phytotoxic, and which is capable of removing ethylene down to low levels. The most suitable reaction is found to be that with potassium permanganate suported on silica gel. The chemical is simple, but suffers from the resistance to the air flow introduced, thereby increasing the required for power, and from its finite capacity for ethylene removal. The catalytic removal of ethylene by oxidation to carbon dioxide and water has an infinite removal capacity, but requires power and represents an additional thermal load. The catalytic method is preferred. ESA

N88-24144# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.).
BOTANY FACILITY PRE-PHASE C/D. CORE PAYLOAD FOR EURECA, VOLUME 1 Final Report
Paris, France ESA 29 Apr. 1987 231 p Prepared in cooperation with Microtecnica, Turino, Italy; Sira Institute Ltd.,

Chislehurst, United Kingdom; and Bell Telephone Mfg. Co., Antwerp, Belgium
(Contract ESA-6415/85-NL-PR)
(BF-RP-ER-015-VOL-1; ESA-CR(P)-2510-VOL-1; ETN-88-91958)
Avail: NTIS HC A11/MF A01

The EURECA botany facility design definition and interfaces, and testing of the centrifuge and a laboratory model are described. The facility is a multiuser life sciences facility intended to support specific botanical investigations during the lower orbital missions of EURECA. The experiments proposed for the first mission are concerned with plants, fungi, and insects and these factors drive the design of the facility presented. The major aim of the scientific experimentation is to investigate the behavior of the biological samples under microgravity conditions and to compare it with that shown by similar samples accommodated on the on-board 1 g reference centrifuge. Near terrestial conditions are simulated within the facility with respect to sample atmospheric conditions, pressure, and humidity. The facility also provides samples with near terrestial condition with respect to water and nutrient supplies, and a suitable diurnal illumination. ESA

N88-24670# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
SIMULATIONS OF THE ELECTROSTATIC CHARGING OF ESA COMMUNICATIONS SATELLITES
E. J. DALY and W. R. BURKE Dec. 1987 45 p
(ESA-STM-239; ISSN-0379-4067; ETN-88-92555) Avail: NTIS HC A03/MF A01

The NASA Charging Analyzer Program (NASCAP) was used to investigate the electrostatic charging of three-axis stabilized satellites in geostationary plasma environments. Capabilities and limitations are discussed and the use of NASCAP in anomaly investigations is described. Three-dimensional charging simulations were performed for eclipse and sunlight conditions, with various plasma environments. The importance of three-dimensional effects is demonstrated. Differential charging on the solar arrays during eclipse and immediately following eclipse are predicted to be significant. Charging is strongly dependent on exposed material parameter values, since these determine the magnitudes of the seven basic components of the current to a surface. The effects of changes in the properties of exposed materials on the charging of the satellite were investigated to identify ways of reducing the differential charging. The associated program MATCHG was also used to investigate material response to charging environments (including laboratory electron beams) at a more basic level, without consideration of the geometrical or photoemission effects. It proves a useful tool in aiding the interpretation and reconciliation of material testing results before a full NASCAP run is undertaken. ESA

N88-24733# Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering.
COMBUSTION OF PMMA, PE AND PS IN A RAMJET
C. W. M. VANDERGELD, P. A. O. G. KORTING, and T. WIJCHERS Apr. 1987 73 p Sponsored by the Netherlands Technology Foundation and the Management Office for Energy Research, The Netherlands Prepared in cooperation with Prins Maurits Lab. TNO, Rijswijk, The Netherlands
(VTH-LR-514; PML-1987-C-18; SFCC-42; B8733275;
ETN-88-92458) Avail: NTIS HC A04/MF A01

The combustion behavior of polymethyl methacrylate (PMMA), polyethylene (PE) and polystyrene (PS) was investigated in a connected pipe test facility, to study phenomena that control or emanate from the combustion of a cylindrical solid fuel with a rearward facing step, as in solid fuel ramjets, safe burning of toxic waste, and hot gas generators. Regression rate, efficiency, temperatures, and soot production were examined. At pressures between 0.6 and 1.1 MPa, radiative heat transfer from soot causes an increase of regression rate from PMMA and PE. At pressure below 0.5 MPa hardly any soot is observed during combustion of PMMA and PE; PS is already sooting. Combustion efficiency varies from 70 to 90 percent, and depends on oxygen content, fuel grain length, and fuel composition. The large vortex structure downstream of the sudden expansion at the inlet is shed at a regular rate. This phenomenon is essentially two-dimensional and corresponds to temperature fluctuations of 200 K in the downstream end of the chamber and of 600 K in the upstream end. ESA

N88-24810# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany, F.R.).
OPERATIONAL FACILITIES OF EURECA A1 MISSION [DIE NUTZLAST DER EURECA-A1 MISSION]
K. SOMMER, W. KOEHLER-NAUMANN, and O. POPHANKEN Apr. 1987 56 p In GERMAN
(ETN-88-91939) Avail: NTIS HC A04/MF A01

The EURECA microgravitational facilities are reviewed: automatic mirror furnace, crystal growth solution, protein crystallization, multi-furnace assembly, exobiological radiation assembly, high precision thermostat, and surface forces adhesion experiment. Components described relative to aerospace sciences are: solar spectrum experiment, solar variation experiment, occultation radiometer, wide angle telescope for X-ray and timeband capture cell experiment. Demonstration technologies outlined are: radio frequency ionization thruster assembly, interorbit communication experiment, and advanced solar gallium arsenide array. ESA

N88-26038# Avions Marcel Dassault-Breguet Aviation, Saint-Cloud (France).
SAFETY OF EXTRAVEHICULAR SPACE ACTIVITIES [SECURITE DES ACTIVITES SPATIALES EXTRA-VEHICULAIRES]
JACQUES LALOE *In* ESA, Proceedings of the Colloquium on Space and Sea p 161-168 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Factors which influence safety in space missions requiring extravehicular activity (EVA) are recalled. Research and development in EVA techniques are discussed. Life support systems; movement, mobility, and dexterity; interfaces; and crew procedures are considered. ESA

N88-26040# Institut Francais de Recherche pour l'Exploitation de la Mer, La Seyne sur Mer.
UNDERWATER SIMULATION FOR SPACE TELEOPERATION
J.-L. MICHEL and J.-F. DROGOU *In* ESA, Proceedings of the Colloquium on Space and Sea p 175-176 Mar. 1988
Avail: NTIS HC A15/MF A01

The use of water to simulate on land the conditions of microgravity encountered in space is reviewed. Neutral buoyancy is achieved underwater on submersibles and remotely operated vehicles but space simulation imposes specifically that the neutral buoyancy has also to be realized particularly on movable parts as telemanipulators. The physical properties of water limits the validity of the simulation to movements with very extremely low speed. Two vehicles realized for NASA are used to simulate vehicle mobility in docking phase and assembling teleoperations in water tanks. Knowing limitations and constraints, simulation in water offers the possibility to evaluate the relative efficiency of operations involving man and teleoperation on complex tasks. ESA

N88-26045# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands).
MAN VERSUS MACHINE: THE ROLE OF ASTRONAUTS IN EXTRAVEHICULAR ACTIVITY
E. OLIER *In its* Proceedings of the Colloquium on Space and Sea p 213-218 Mar. 1988
Avail: NTIS HC A15/MF A01

Extravehicular acitivity (EVA) in NASA and USSR space programs is reviewed and European needs, particularly for the Columbus and Hermes programs, are assessed. It is suggested that remote manipulators and EVA are complementary, although EVA offers advantages once the work site is reached. ESA

N88-26090# Joint Publications Research Service, Arlington, VA.
AUTOMATED SPECTROMETRIC UNIT FOR THE STUDY OF RADIATION CHARACTERISTICS OF COSMIC RADIATION ABOARD PROGNOZ-9 SPACE STATIONS
V. M. PETROV, YU. I. LOGACHEV, S. N. KARACHEVSKIY, V. V. BENGIN, I. K. GVOZDEV, G. YA. KOLESOV, M. I. KUDRYAVTSEV, A. I. MARTYNOV, A. N. PODOROLSKIY, and S. A. SUD *In its* JPRS Report: Science and Technology. USSR: Space Biology and Aerospace Medicine, v. 22, no. 1, Jan.-Feb. 1988 p 107-111 23 Jun. 1988 Transl. into ENGLISH from Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina, Moscow (USSR), v. 22, no. 1, Jan.-Feb. 1988 p 75-78
Avail: NTIS HC A08/MF A01

At the present time there is no question that progress in investigation of the aggregate of processes in the active region of the Sun, defined as a solar proton even (SPE) is possible only on the basis of combined analysis of its diverse components. Analysis is usually made to restore the measured spectra of solar cosmic ray to the source and investigate the characteristics of the spectrum of accelerated particles thus determined with consideration of the various possible mechanisms of generation and injection. In order to improve the effectiveness of taking measurements, it becomes necessary to form a special measuring complex that would permit not only obtaining data about the amplitude characteristics of various SPE factors, but time analysis of different factors and time relationship between them. Hence, it is necessary to measure SPE characteristics with high informativeness. A spectrometric unit was developed, which is intended for investigation of SPE in the range of charged particle energy from a few hundreds of MeV/nucleon and hard X-radiation in experiments aboard space stations. The unit is described and discussed. Author

N88-26678# National Aerospace Lab., Amsterdam (Netherlands). Space Div.
SIMULATION OF SPACE MANIPULATOR OPERATIONS (EUROSIM)
C. N. A. PRONK, A. ELFVING, E. ERSUE, and A. L. LIPPAY 13 Mar. 1987 10 p Presented at the Summer Computer Simulation Conference, Montreal, Quebec, 27-30 Jul. 1987
(Contract ESA-6482/85)
(NLR-MP-87017-U; B8805305; ETN-88-92609; PB88-209747; AD-B119669L) Avail: NTIS HC A02/MF A01

Definition and planning of application software for ESA's European Robotic Operations Simulator are reviewed. Simulation definition and test control software; overall system dynamic model; generic models for the in-orbit infrastructure, including spacecraft, environment, and payload; and mathematical models for the space manipulator system are discussed. A survey of existing models and software completed the requirements study. A plan for further development was specified. ESA

N88-28833# European Space Agency. European Space Research and Technology Center, ESTEC, Noordwijk (Netherlands). Materials and Processes Div.
THE TECHNICAL REPORTING AND APPROVAL PROCEDURE FOR MATERIALS AND PROCESSES
Oct. 1987 38 p
(ESA-PSS-01-700-ISSUE-1; ISSN-0379-4059; ETN-88-92781)
Avail: NTIS HC A03/MF A01

Details concerning the documentation requirements relevant to obtaining ESA approval for the use of materials and processes in the fabrication of space systems and associated equipment are provided. ESA

N88-28943# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France). Advanced Studies Dept.
ARIANE 5, HERMES AND EUROPEAN VEHICLES FOR SPACE STATION SERVICING
PATRICK EYMAR and JEAN M. ROUBERTIE 1987 38 p Presented at the French Aerospace 1987 Conference, Groupement des Industries Francaises Aeronautiques et Spatiales, Washington, D.C., 20-23 Jan. 1987
(SNIAS-881-422-102; ETN-88-92846) Avail: NTIS HC A03/MF A01

European space goals for the next decade; space infrastructure and associated logistics and servicing; Ariane 5; Ariane 5 transfer stages and logistic modules; the HERMES spaceplane; reentry vehicles; and intravehicular and extravehicular activities are discussed. ESA

N88-28951# Air Command and Staff Coll., Maxwell AFB, AL.
THE SOVIET MIR SPACE STATION
THOMAS E. SNOOK Apr. 1988 35 p
(AD-A194040; ACSC-88-2445) Avail: NTIS HC A03/MF A01
CSCL 22B

The purpose of this paper was to determine if the Soviet MIR space station represents a significant advance when compared to the Soviets' preceding Salyut 7 space station. A description and comparison of the physical features of Salyut 7 and MIR are presented. A discussion and analysis of the scientific, commercial, military and political uses or missions of the Salyut 7 and MIR space stations are included. The MIR space station is determined to be a significant advance relative to the Salyut 7 space station. GRA

N88-28956# MATRA Espace, Toulouse (France).
STUDY OF STANDARD GENERIC APPROACH FOR SPACECRAFT (S/C) AUTONOMY AND AUTOMATION (PHASE 3). BOOK B: AUTONOMY CONCEPT APPLICATION EXAMPLE Final Report
Paris, France ESA Nov. 1987 324 p Prepared in cooperation with MBB GmbH, Ottobrunn, Fed. Republic of Germany and Dornier-Werke GmbH, Froedrichshafen, Fed. Republic of Germany
(Contract ESTEC-6358/85-NL-PP(SC))
(ESA-CR(P)-2555-VOL-2; ETN-88-92915) Avail: NTIS HC A14/MF A01

A generic system design concept for unmanned spacecraft is applied to EURECA. Allocation of autonomy requirements; system level applications; and subsystems are described. Functional and operational interfaces are discussed. Spacecraft modes of operation and the functional partitioning between the spacecraft and ground control are treated. On-board architecture; functional autonomy and on-board organization, interfaces, and the utilization of a local area network to interconnect the on-board management nodes are outlined. ESA

N88-29827# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany, F.R.).
STUDY ON LONG-TERM EVOLUTION TOWARDS EUROPEAN MANNED SPACEFLIGHT. VOLUME 1: EXECUTIVE SUMMARY Final Report
J. EWALD, ed., L. BASILE, R. LONGSTAFF, and C. COUGNET (MATRA Espace, Toulouse, France) Paris, France ESA Mar. 1988 51 p
(Contract ESA-6669/86-NL-PP(SC))
(ERNO-OX1-002/88-VOL-1; ESA-CR(P)-2627-VOL-1; ETN-88-92799) Avail: NTIS HC A04/MF A01

Safety aspects of a manned European space station were studied. An escape vehicle, a habitation module, and interconnecting elements were examined. Crew sizing analysis was performed. Orbital parameters were analyzed. ESA

N88-29849# Societe Nationale Industrielle Aerospatiale, Les Mureaux (France).
INTERIM FLIGHT OPPORTUNITY (IFO). VOLUME 1: EXECUTIVE SUMMARY Final Report
M. H. AENISHANSLIN Paris, France ESA 16 Dec. 1987 65 p Prepared in cooperation with Construcciones Aeronauticas S.A., Madrid, Spain, Saab Space A.B., Goeteborg, Sweden, Erno Raumfahrttechnik G.m.b.H., Bremen, West Germany, Norsk Forsvarsteknologi A/S, Norway, Sener S.A., Madrid, Spain, and Fokker B.V.
(Contract ESA-6272/85-NL-AB)

(SE/LS/AP-36-818/CN-VOL-1; ESA-CR(P)-2583-VOL-1; COL-TN-AS-0059-VOL-1; ETN-88-93028) Avail: NTIS HC A04/MF A01

A space platform for a wide variety of missions prior to Columbus space station availability is proposed. It can be launched as spare capacity or as main payload on different launchers into a variety of orbits, where it circles for a limited time and then a subset or the whole reenters in a controlled way for recovery on ground. The general configuration is composed of two separable elements: an expendable part, the bus, and a reentry vehicle (REV). Maximum diameter for the bus is 2 m to have an easy and feasible accommodation on a wide variety of launchers. The REV is dimensioned to be able to provide a payload dedicated volume greater than 0.2 cum and the global mass of the platform is not greater than 1500 kg. The BUS is conceived for two alternatives: a battery powered baseline for a ten-day mission, and an option with solar arrays for a 1-month mission. Subsystems are: structure, thermal control, electrical power, attitude control, data handling, communication, and mechanisms. The REV is composed of separable units: a propulsion module and a reentry capsule. The subsystem list is similar to the bus with propulsion and recovery systems added. ESA

N88-29862# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (Germany, F.R.). Inst. for Experimental Fluid Mechanics.

STUDIES ON ROCKET EXHAUST PLUMES AND IMPINGEMENT EFFECTS RELATED TO THE COLUMBUS SPACE STATION PROGRAM: EXECUTIVE SUMMARY

R.-D. BOETTCHER, C. DANKERT, G. DETTLEFF, and H. LEGGE Paris, France ESA Feb. 1988 82 p

(Contract ESA-6829/86-NL-PH(SC))

(DFVLR-IB-222-88-A-12; ESA-CR(P)-2614; ETN-88-93148) Avail: NTIS HC A05/MF A01

Using a plume impingement computer code, possible proximity impingement situations in the Columbus space station were analyzed. Experiments investigated the plume flow immediately downstream of the nozzle. The impingement effects (shear stress and pressure) were measured on a plate inclined with respect to the plume axis up to perpendicular impingement. This situation is considered as typical during rendezvous and docking maneuvers. ESA

N88-29986# Erno Raumfahrttechnik G.m.b.H., Bremen (Germany, F.R.).

DESIGN AND DEVELOPMENT OF A REFUELING TEST BED Summary Report

J. KOWALEK Paris, France ESA Jan. 1988 94 p

(Contract ESA-6827/86-NL-PH(SC))

(FTMS-RP-ER-011; ESA-CR(P)-2623; ETN-88-93150) Avail: NTIS HC A05/MF A01

The specification, design, procurement, and manufacturing of a test bed for ground based studies of in orbit refueling are described. The test bed is mainly built from available commercial standard materials and components. Fluid valves are of flight standard design. The integration and acceptance tests of the various hardware levels are explained. Development tests were performed with the test bed in order to verify the refueling process and to consider specific engineering problems in this area. Propellant gaging methods were also studied. ESA

N88-30328# Selenia Spazio S.p.A., Rome (Italy).

THE LTPP COMMUNICATION PROCESSOR Final Report

A. FRANCIA, F. CANTINI, A. MORANDO, A. SBARDELLATI, D. GALINDO, D. BULLIAT, and M. LELLOUCH Paris, France ESA Dec. 1987 96 p Prepared in cooperation with MATRA Espace, Toulouse, France

(Contract ESTEC-6950/86-NL-IW(SC))

(CL/CP/SES/FR/004; ESA-CR(P)-2579; ETN-88-93024) Avail: NTIS HC A05/MF A01

A spaceborne communication processor to support communications services allowing interconnection between the on board data transport means and external communication facilities (either radiofrequency links or communication means of a docked vehicle) for Hermes and Columbus was defined. The processor is one node of a more global communication system, composed of subnetworks, interconnected with each other, permitting data exchange between users, interfacing with remote and heterogeneous subnetworks. The communication processor requirements are defined by the communication scenarios of the vehicles, and, in particular, for each mission phase by: the end to end transmission scenario, i.e., the definition of the routes used to disseminate data from data generating end users to destination end users, the characteristics, performances, and protocols of the subnetworks crossed by the data; data characteristics; and interfaces. The design specification, problem areas, and recommendations for product development are outlined. ESA

N88-30340*# Computer Sciences Corp., Beltsville, MD.

CANDIDATE FUNCTIONS FOR ADVANCED TECHNOLOGY IMPLEMENTATION IN THE COLUMBUS MISSION PLANNING ENVIRONMENT

AUDREY LOOMIS and ALBRECHT KELLNER (Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen, West Germany) *In* NASA, Goddard Space Flight Center, The 1988 Goddard Conference on Space Applications of Artificial Intelligence p 125-139 Aug. 1988 Prepared in cooperation with Entwicklungsring Nord, Bremen, Fed. Republic of Germany

Avail: NTIS HC A19/MF A01 CSCL 09B

The Columbus Project is the European Space Agency's contribution to the International Space Station program. Columbus is planned to consist of three elements (a laboratory module attached to the Space Station base, a man-tended freeflyer orbiting with the Space Station base, and a platform in polar orbit). System definition and requirements analysis for Columbus are underway, scheduled for completion in mid-1990. An overview of the Columbus mission planning environment and operations concept as currently defined is given, and some of the challenges presented to software maintainers and ground segment personnel during mission operators are identified. The use of advanced technologies in system implementation is being explored. Both advantages of such solutions and potential problems they present are discussed, and the next steps to be taken by Columbus before targeting any functions for advanced technology implementation are summarized. Several functions in the mission planning process were identified as candidates for advanced technology implementation. These range from expert interaction with Columbus' data bases through activity scheduling and near-real-time response to departures from the planned timeline. Each function is described, and its potential for advanced technology implementation briefly assessed. Author

N88-30447# European Space Agency, Paris (France).

WITH AN EYE TO THE FUTURE: ESA GENERAL STUDIES PROGRAM 1988

NORMAN LONDDON, ed. and BRIGITTE KALDEICH, ed. Apr. 1988 38 p Original contains color illustrations

(ESA-SP-1100; ISSN-0250-1589; ETN-88-93047) Avail: NTIS HC A03/MF A01

The ESA programs concerning end-to-end telematics architecture; long-term evolution of telecommunications services and systems; long-term evolution of Earth observation; microgravity utilization; autonomous orbital capability architecture; in-orbit assembly, servicing, and tending; long-term evolution of space transportation systems; and European ground infrastructure are presented. ESA

N88-30556# European Space Agency, Paris (France). Space Science Dept.

ESA REPORT TO THE 27TH COSPAR MEETING

V. DOMINGO, U. O. FISK, R. GRARD, P. JAKOBSEN, M. F. KESSLER, J.-P. LEBRETON, R. MARSDEN, A. PEACOCK, A. PEDERSON, M. A. C. PERRYMAN et al. Jun. 1988 148 p Meeting held in Helskinki, Finland, Jul. 1988 Original contains color illustrations

(ESA-SP-1098; ISSN-0379-6566; ETN-88-93046) Avail: NTIS HC A07/MF A01

The ISEE, IUE, EXOSAT, and Giotto missions are described. The status of the Ulysses, Hubble Space Telescope, HIPPARCOS, ISO, and solar-terrestrial science programs is discussed. The high throughput X-ray spectroscopy mission, submillimeter spectroscopy mission, and the comet nucleus sample return mission are presented. The CASSINI, GRASP, Lyman, Quasat, Vesta, and Giotto extended missions are introduced. The EURECA and Columbus space station programs are reviewed. ESA

N88-30582# Politecnico di Torino (Italy). Dept. of Aerospace Engineering.
ACTIVITIES REPORT OF THE DEPARTMENT OF AEROSPACE ENGINEERING Annual Report, 1986
Dec. 1987 37 p
(ETN-88-91607) Avail: NTIS HC A03/MF A01

Research in aeronautics and astronautics; fluid dynamics and propulsion; structures and materials; and systems engineering and management is summarized. ESA

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SUPPORT SPACECRAFT

Includes design, analysis, requirements, trade studies and simulations of Space Station support spacecraft including the orbital transfer vehicle (OTV) and the orbital manuvering vehicle (OMV).

A88-35059
GSH 35,786 - A GEOSYNCHRONOUS SPACE HABITAT
FRANK LEMOINE, LAURA LOUVIERE, JOHAN MORRIS, CARLA GOULART, and CHRIS MEYER IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 129-151. refs
(AAS PAPER 86-310)

A manned geosynchronous space habitat (GSH) is proposed for the geostationary orbit as a servicing platform and technological proving ground for further space exploration. GSH would incorporate a Controlled Ecological Life Support System (CELSS); the 10-member crew would require 7700 kg of food and water to be delivered every 6 months. Attention is given to the CELSS plant growth area, the use of plasma shielding for radiation protection, and the configuration of the GSH as a spinning torus that would centrifugally generate artificial gravity. O.C.

A88-41285
TRAJECTORY ANALYSIS OF A LOW LIFT/DRAG AEROASSISTED ORBIT TRANSFER VEHICLE
ROBERT D. BRAUN (Pennsylvania State University, University Park) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 163-174. refs
(AAS PAPER 87-123)

This paper presents the results of an undergraduate thesis pertaining to four significant aspects of an aeroassisted orbit transfer vehicle trajectory analysis. The orbital trajectories were simulated by utilizing the computer optimization program POST at the NASA-Langley Research Center. This optimization was based on the spacecraft's known properties and constraints, in particular the vehicle's heating-rate restriction. Through this analysis, the influence of both aerodynamic and astrodynamic parameters on the vehicle's flight path are determined. Additionally, various means of producing the required orbital transfer energy decrement, as well as the tradeoff between the spacecraft's time-of-flight and propellant expended, are studied. Author

A88-42904#
DEVELOPING STV ACCOMMODATIONS AND OPERATIONS AT THE SPACE STATION
JOHN W. PORTER (General Dynamics Corp., Space Systems Div., San Diego, CA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 9 p. refs
(AIAA PAPER 88-3503)

The Centaur Operations at the Space Station study defines two programs to pave the way for Space Transfer Vehicle basing at the Space Station. The first concept is a technology demonstration program using a current technology launch vehicle as a test bed. The vehicle would simulate STV in drills and experiments to demonstrate the technology to store, maintain, and launch STV from the Space Station. It would be in place two to four years before STV arrival at the Space Station. After completion of the demonstrations, the program's remaining assets would be assimilated into Space Station systems, and into a subsequent STV basing platform. The second program concept postulates a low-cost, 'first step' space-based transportation system. It would simply be an extension of the technology demonstration program. Rather than assimilating the assets of Concept I into Space Station and STV support, they would be left in place to establish the launch program architecture. Author

A88-42909*# George Washington Univ., Hampton, VA.
SYSTEMS ANALYSIS OF A LOW-ACCELERATION RESEARCH FACILITY
GARY L. MARTIN (George Washington University, Hampton, VA), MELVIN J. FEREBEE, JR., and ROBERT L. WRIGHT (NASA, Langley Research Center, Hampton, VA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 13 p. refs
(AIAA PAPER 88-3512)

The Low-Acceleration Research Facility (LARF), an unmanned free-flier that is boosted from low-earth orbit to a desired altitude using an orbital transfer vehicle is discussed. Design techniques used to minimize acceleration-causing disturbances and to create an ultra-quiet workshop are discussed, focusing on residual acceleration induced by the environment, the spacecraft and experiments. The selection and integration of critical subsystems, such as electrical power and thermal control, that enable the LARf to accomodate sub-microgravity levels for extended periods of time are presented, including a discussion of the Low-Acceleration Module, which will supply the payload with 25.0 kW of power, and up to 11.8 kW in the low-power mode. Also, the data management, communications, guidance, navigation and control, and structural features of supporting subsystems are examined. R.B.

A88-42910*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
MULTIMISSION MODULAR SPACECRAFT (MMS)
EDWARD FALKENHAYN, JR. (NASA, Goddard Space Flight Center, Greenbelt, MD) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 6 p.
(AIAA PAPER 88-3513)

This paper discusses the design requirements for the low-cost standard spacecraft development which has come to be known as the Multimission Modular Spacecraft (MMS). The paper presents the wide range of launch configurations of the MMS users, the population of programs using the MMS, and the cost effectiveness of the MMS concept. The paper addresses the in-orbit serviceability of the design as demonstrated by the successful SMM repair, and the recent selection of MMS for the Explorer Platform, which features in-orbit payload exchanges. Author

A88-42911#
OMV MULTIPLE DEPLOYMENTS OF LIGHTSATS
WILLIAM L. SMITH and JAMES D. WALKER (TRW, Inc., Federal Systems Div., Redondo Beach, CA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 7 p.
(AIAA PAPER 88-3518)

The design and capabilities of the NASA Orbital Maneuvering

Vehicle (OMV) are reviewed, and the potential value of the Shuttle-borne OMV for deploying lightweight satellites (lightsats) into different orbits is discussed and illustrated with extensive drawings and diagrams. Assuming 100-lb lightsats in extended GAS canisters, the OMV could separate from the Orbiter at 16 nmi and deploy six lightsats each at altitudes 430, 700, and 970 nmi before rejoining the Orbiter at 160 nmi. Also considered are configurations with 8 or 12 200-lb lightsats and the fittings for Titan-4 launch of OMV/lightsat packages. T.K.

A88-45711* Princeton Univ., NJ.
OPTIMIZATION OF AEROASSISTED ORBITAL TRANSFER - CURRENT STATUS
K. D. MEASE (Princeton University, NJ) Journal of the Astronautical Sciences (ISSN 0021-9142), vol. 36, Jan.-June 1988, p. 7-33. NASA-supported research. refs

This paper presents the theory of optimal aeroassisted orbital transfer, with special consideration given to the transfer about a central body with an atmosphere, with propulsive maneuvers in space modeled as instantaneous changes in the velocity vector. It is shown that there are four potentially optimal transfer modes, two aeroassisted and two all-propulsive, for each point in the two-dimensional transfer space. Aeroassisted orbital transfer introduces a strong coupling between the trajectory design and the vehicle design; a trajectory that minimizes fuel mass without attention to heating may require the vehicle to have a heavy thermal protection system. It is emphasized that, if aeroassisted transfer is to be preferred to all-propulsive transfer, it must offer a reduction in fuel mass greater than the increase in thermal protection mass. I.S.

A88-47974*# Air Force Flight Test Center, Edwards AFB, CA.
DESIGN OF AN INTERIM SPACE RESCUE FERRY VEHICLE
JAMES D. HALSELL, JR. (USAF, Flight Test Center, Edwards AFB, CA), JOSEPH W. WIDHALM (USAF, Institute of Technology, Wright-Patterson AFB, OH), and CHARLES E. WHITSETT (NASA, Johnson Space Center, Houston, TX) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 180-186. refs

This paper proposes a stop-gap nonoptimum vehicle for transferring astronauts from a tumbling stranded spacecraft to a nearby rescue spacecraft. The design is limited to the use of available or 'soon-to-be' available flight-qualified hardware and consists of three major components: the manned maneuvering unit, the personnel rescue enclosure, and the apogee kick motor capture device. The apogee kick motor capture device is modified to serve as the connection between the manned maneuvering unit and the personnel rescue enclosure. The performance of this interim rescue vehicle is analyzed with NASA flight simulation software to test the feasibility of the design. Results show that the control system of the manned maneuvering unit adequately limits uncommanded rotations during all simulated maneuvers in the primary control mode but not during transverse translations in the backup control mode. Impingement of thruster plumes on the personnel rescue enclosure is shown to be of some importance in certain maneuvers. The satellite stabilization mode of the control system is found to have significant rotational-to-translational coupling that has associated adverse effects on flying qualities, making the mode undesirable for the rescue mission. Author

A88-50590#
AEROASSISTED TRANSFER BETWEEN ELLIPTICAL ORBITS USING LIFT CONTROL
DAVID MISHNE (Rafael Armament Development Authority, Haifa, Israel), JOSEF SHINAR (Technion - Israel Institute of Technology, Haifa), and NAHUM MELAMED IN: AIAA Atmospheric Flight Mechanics Conference, Minneapolis, MN, Aug. 15-17, 1988, Technical Papers. Washington, DC, American Institute of Aeronautics and Astronautics, 1988, p. 134-141. refs
(AIAA PAPER 88-4346)

A transfer between two elliptical orbits, using an atmospheric passage, is considered. In the atmosphere, the lift of the spacecraft is controlled to change the line of apsides of the orbit, without changing other orbital parameters. The maneuver includes three propulsive impulses to bring the spacecraft into and out of the atmosphere and to compensate for the velocity loss during the atmospheric passage. The total velocity change during this maneuver is compared to the velocity change of an optimal two-impulse pure propulsive maneuver and of a drag-only aeroassisted maneuver. It is shown that below a certain line of apside rotation angle the lift-controlled maneuver is more fuel economic than the drag-only maneuver. The lift-controlled maneuver is also more fuel economic than the pure propulsive maneuver, provided that the lift-to-drag ratio of the spacecraft is greater than 2. The limits to the rotation angle that can be achieved in a single pass are discussed. Numerical examples are presented. Author

N88-20332# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (Germany, F.R.). Space Div.
STUDY OF THE OPTIMIZATION OF SATELLITE SYSTEM DESIGN FOR TRANSFER ORBIT Final Report
BAETZ, K. FETZER, W. FINK, H. HUFNAGEL, H. KELLERMEIER, KLEINAU, W. MUELLER, and H. CHALMERS (Erno Raumfahrttechnik G.m.b.H., Bremen, West Germany) Paris, France ESA Apr. 1983 349 p
(Contract ESTEC-4908/81-NL-PP(SC))
(MBB-URV-135; ESA-CR(P)-2518; ETN-88-91960) Avail: NTIS HC A15/MF A01

Geostationary transfer orbit (GTO) characteristics of former geosynchronous satellites; satellite configurations as to GTO requirements; telemetry and telecommand, thermal, power, and attitude control subsystems as to stabilization modes and GTO constraints; and apogee injection strategies (single/multiple burn, steering law) were reviewed. The investigations were confined to 2 Ariane 4 payload classes (2500 kg in GTO, dual-launch and 4200 kg in GTO, single launch), three-axis or slow barbecue stabilization during transfer orbit, and use of a liquid apogee injection system with low thrust level (400 N). A recommendation for an overall system optimization is presented. ESA

N88-22060*# Martin Marietta Corp., Bethesda, MD.
ORBITAL TRANSFER VEHICLE: CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY Final Review Report
9 Dec. 1987 403 p
(Contract NAS8-36108)
(NASA-CR-179315; NAS 1.26:179315; MCR-87-2600; DR-3)
Avail: NTIS HC A18/MF A01 CSCL 22B

Previous results, the initial Orbital Transfer Vehicle (OTV) program, advanced mission, safety issues, aeroassist summary, and program summary are presented and discussed. B.G.

N88-24426# Brookhaven National Lab., Upton, NY.
ANALYSIS OF A NUCLEAR ORBITAL TRANSFER VEHICLE REENTRY ACCIDENT
JAMES R. POWELL, HANS LUDEWIG, OTTO W. LAZARETH, and FREDERICK L. HORN *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 257-261 1988 Sponsored by AFRPL, Edwards AFB, Calif.
Avail: NTIS HC A99/MF A01

The possible fission product release and subsequent consequences following a reentry accident of a Nuclear Orbital Transfer Vehicle (NOTV) based on a Particle Bed Reactor (PBR) are reviewed. Three possible missions are analyzed, each involving varying times at full reactor power. However, due to the details of the various missions (full power time versus coasting time) the fission product inventories do not scale linearly with burnup. Thus, the radiological release and estimated dose are not only a function of the burnup but also depend on the mission. Full power in all cases will be assumed to be 200 MWT. The mission, method of analysis, results, and recommendations are outlined. Author

N88-29379*# Alabama Univ., Huntsville.
OMV DOCKING SIMULATOR
W. TEOH and J. HAWKINS (Boeing Aerospace Co., Huntsville, Ala.) *In* NASA, Marshall Space Flight Center, Second Conference

on Artificial Intelligence for Space Applications p 257-276 Aug. 1988
Avail: NTIS HC A99/MF E03 CSCL 14B

The Boeing Orbital Maneuvering Vehicle (OMV) Docking and Proximity Operation System (DAPOS) was completed. The system constructed involves the use of four separate processors. Appropriate software was developed that drives each of these four processors. The hand controller logic coordinates all the activities in the control station, and communicates with the OMV mathematical model. The state vector generated by the model is in turn transmitted to the control station as well as the POLY 2000 (via the ALCYON host computer) for real time graphics generation. The OMV characteristics are stored in a data file which may be easily updated and modified without disturbing the software, thereby making the system very flexible. The current system supports two types of hand controllers. The system was flown by several volunteers, some of whom are airplane pilots. A user manual is also enclosed. Author

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LIFE SCIENCES/HUMAN FACTORS/SAFETY

Includes studies, models, planning, analyses and simulations for biological and medical laboratories, habitability issues for the performance and well-being of the crew, and crew rescue.

A88-20353* Texas Univ. at Dallas, Richardson.
IONOSPHERIC CONVECTION SIGNATURES AND MAGNETIC FIELD TOPOLOGY
W. R. COLEY, R. A. HEELIS, W. B. HANSON (Texas, University, Richardson), P. H. REIFF (Rice University, Houston, TX), J. R. SHARBER (Southwest Research Institute, San Antonio, TX) et al. Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Nov. 1, 1987, p. 12352-12364. refs
(Contract NAG5-305; NAG5-306; NGR-44-006-137; NAG5-775; F19628-83-K-0022; NAS5-28712; F4962-85-C-0029; F19628-81-N-0006)
(AD-A191201; AFOSR-TR-88-0113)

A statistical study of signatures of the high-latitude ionospheric convection pattern and the simultaneously observed energetic electron precipitation is presented. Most often found are convection cells in which the sunward flowing region contains auroral particle precipitation but the antisunward flowing region does not. However, observations also show the frequent occurrence of convection cells in which neither the antisunward nor the sunward flowing plasma region contains auroral particle precipitation. These findings may appear within the dawnside or duskside convection pattern and strongly suggest that such convection cells may be associated with open magnetic field lines that thread the magnetotail lobes. Author

A88-21242
A STUDY OF SILICON INTERSTITIAL KINETICS USING SILICON MEMBRANES - APPLICATIONS TO 2D DOPANT DIFFUSION
S. T. AHN, P. B. GRIFFIN, J. D. SHOTT, J. D. PLUMMER, and W. A. TILLER (Stanford University, CA) Journal of Applied Physics (ISSN 0021-8979), vol. 62, Dec. 15, 1987, p. 4745-4755. Research supported by DARPA and Semiconductor Research Corp. refs
(Contract DAAL01-86-K-0101)

To study interface and transport kinetics of interstitials, relative interstitial concentrations at both oxidizing and inert interfaces of Si membrane were monitored simultaneously during oxidation (at 1100 C) of float-zone (FZ) and Czochralski (CZ) silicon, using thin silicon membranes as test structures. The interstitial supersaturation at the oxidizing side was found to be insensitive to both the thickness variation and the interface condition of the other side of the membrane. At the interface opposite the oxidizing side, a delayed buildup of interstitials was observed. Using these results for the FZ Si, an effective interstitial diffusivity of 9 x 10 to the -10th sq cm/s and an effective interface recombination rate of 3 x 10 to the -7th cm/s for a Si/pad-oxide interface were obtained. Interstitial transport across the CZ Si membranes during oxidation was found to be slower than that across the FZ membranes. The parameters obtained from these studies were used to model 2-dimensional dopant diffusion. I.S.

A88-22064# Texas Univ., Austin.
EVALUATION OF CONDITIONAL SAMPLING METHODS FOR ANALYSING SEPARATION SHOCK MOTION
LEON BRUSNIAK (Texas, University, Austin) AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 8 p. NASA-USAF-Navy-supported research. refs
(AIAA PAPER 88-0091)

The interaction of shock waves with turbulent boundary layers can give rise to flow separation, which is frequently unsteady and is accompanied by large scale unsteady motion of the separation shock. An understanding of the physical mechanisms driving the shock unsteadiness is needed before flow models can be derived. A first step in this direction is to determine the shock frequency and frequency distribution which can be done through conditional sampling techniques applied to fluctuating wall pressure data. In this paper it is shown that the use of a single pressure threshold in the conditional sampling algorithm is inadequate due to a high sensitivity to sampling frequency and turbulence. The use of two pressure thresholds provides a higher degree of differentiation between the shock motion and fluctuations associated with the turbulence. A 'best' combination of pressure values for the two-threshold method providing the most reliable shock frequency values is given. Author

A88-34566
CREW ACTIVITIES
WUBBO J. OCKELS (ESA, Columbus Crew Activities Working Group, Noordwijk, Netherlands) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 175-177.

The role of the crew members in planned Columbus science experiments is discussed from the perspective of an astronaut, arguing that the value of a manned presence in increased experimental flexibility and problem solving far outweighs the disadvantages and higher costs of manned missions. Topics addressed include ESTEC efforts to optimize the Columbus man-machine interfaces, recent studies by the Columbus Crew Activities Working Group, lessons learned in the Spacelab program, the need for larger-volume more easily accessible experiment packages to facilitate crew intervention, and the scheduling of a typical day in orbit. It is suggested that having the two crew members responsible for a Station laboratory module work together for 12 h and then leave the module unattended for 12 h may often be more efficient than having them work alternating shifts. T.K.

A88-37450
PSYCHOSOCIAL TRAINING FOR PHYSICIANS ON BOARD THE SPACE STATION
NICK KANAS (USVA, Medical Center, San Francisco, CA) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 59, May 1988, p. 456, 457. refs

The training and specialty areas of the physicians who might be sent to the Space Station is discussed. It is argued that these candidates not only should be broadly trained to handle a number of acute physical problems and to conduct research on the effects of weightlessness on the human body physiology, but be also trained to handle various psychological and interpersonal problems related to long-term isolation and confinement. The knowledge areas that should be included in the psychological training of a space physician are outlined. I.S.

A88-40994
A HUMAN-USE CENTRIFUGE FOR SPACE STATIONS - PROPOSED GROUND-BASED STUDIES
RUSSELL R. BURTON (USAF, School of Aerospace Medicine, Brooks AFB, TX) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 59, June 1988, p. 579-582. refs

This paper discusses the possibility of using human centrifuges in space as means of providing artificial gravity and thus avoiding the effects of prolonged exposures to weightlessness. On the basis of the results of Piemme, et al. (1966) and Schneider (1987), obtained in ground studies on the effect of G levels on the control of fluid volume and bone loss, respectively, it is considered that high-G exposure of several minutes to several hours per day will be sufficient to provide adequate countermeasure, because for many physiological parameters, the necessary G requirements may have a time-intensity summation effect. It is emphasized that on-ground studies should involve exposures greater than 1 G. I.S.

A88-42933*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE VEHICLE APPROACH VELOCITY JUDGMENTS UNDER SIMULATED VISUAL SPACE CONDITIONS
RICHARD F. HAINES (NASA, Ames Research Center, Moffett Field, CA) IN: International Symposium on Aviation Psychology, 4th, Columbus, OH, Apr. 27-30, 1987, Proceedings. Columbus, OH, Ohio State University, 1987, p. 44-50. Previously announced in STAR as N88-19094. refs

Thirty-five volunteers responded when they first perceived an increase in apparent size of a collimated, 2-D image of an Orbiter vehicle. The test variables of interest included the presence of a fixed angular reticle within the field of view (FOV); three initial Orbiter distances; three constant Orbiter approach velocities corresponding to 1.6, 0.8, and 0.4 percent of the initial distance per second; and two background starfield velocities. It was found that: (1) at each initial range, increasing approach velocity led to a larger distance between the eye and Orbiter image at threshold; (2) including the fixed reticle in the FOV produced a smaller distance between the eye and Orbiter image at threshold; and (3) increasing background star velocity during this judgment led to a smaller distance between the eye and Orbiter image at threshold. The last two findings suggest that other detail within the FOV may compete for available attention which otherwise would be available for judging image expansion; thus, the target has to approach the observer nearer than otherwise if these details were present. These findings are discussed in relation to previous research and possible underlying mechanisms. Author

A88-43104
EVALUATION OF PHYSICAL WORK CAPACITY IN CONDITIONS OF HYPOKINESIA [OTSENKA FIZICHESKOI RABOTOSPOSOBNOSTI V USLOVIIAKH GIPOKINEZII]
S. V. KORZH, V. V. POLONSKII, L. A. MOROZOV, and V. N. NOSOV Voenno-Meditsinskii Zhurnal (ISSN 0026-9050), April 1988, p. 50, 51. In Russian.

The effect of prolonged hypokinesia due to severely limited living space, on the orthostatic cardial reflex and on various physiological indices of the cardiovascular system was investigated together with the effect of physical exercise on the results of the test, using human subjects who remained in limited-area living quarters for up to 20 days. The test consisted in measuring ECG indices in subjects before and immediately after a sudden sit-up from a horizontal position. The results of tests were related to the capacity to do physical work, evaluated using dynamocardiography, oxyhemometry, and step test. It was found that prolonged hypokinesia leads to changes of the cardiovascular system indicating gradual lowering of the system's functional level. The orthostatic cardial reflex continued to deteriorate during the whole period of hypokinesia, except in subjects who carried out daily physical exercises, in whom the condition stabilized on the 10th day of the hypokinetic experiment. The results of the orthostatic test could be directly correlated to work capacity. I.S.

A88-43952*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
HEALTH MAINTENANCE ON SPACE STATION
J. S. LOGAN (NASA, Johnson Space Center, Houston, TX) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 35-42. refs

Medical support for extended manned missions aboard such spacecraft as the NASA Space Shuttle must encompass prevention, diagnosis, and therapy capabilities in the preflight and postflight as well as actual mission phases. An evaluation is presently made of the technological and management challenges that must be met in order to furnish an adequate inflight health care delivery system that possesses adequate inflight health care, real-time environmental monitoring, physiological countermeasures, and medical rescue/recovery facilities for ill or injured crew members. O.C.

A88-43962#
USE OF A 2-METER RADIUS CENTRIFUGE ON SPACE STATION FOR HUMAN PHYSIOLOGIC CONDITIONING AND TESTING
PETER H. DIAMANDIS (MIT; Harvard University, Cambridge, MA) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 133-136.

NASA Space Station life sciences experiments are planned to employ two centrifuges of 0.9 and 2.0 m radii; of these, the larger would be used to keep the crew in good health during long duration missions, counteracting the physiologic deconditioning that occurs in extended exposure to microgravity by exerting artificial gravity during sleep. Such exercises as deep knee bands could also be conducted on the 2.0-m centrifuge. The crewmember will be disposed on the centrifuge with head at center and feet at the radially most outward point. O.C.

A88-54011#
COMPARATIVE STUDY OF THE CARDIOVASCULAR ADAPTATION TO ZERO G DURING 7 DAYS SPACE FLIGHTS
J. M. POTTIER, PH. ARBEILLE, F. PATAT, A. RONCIN, M. BERSON (Tours, Universite, France) et al. (International Union of Physiological Sciences Commission on Gravitational Physiology, Annual Meeting, 9th, Nitra, Czechoslovakia, Sept. 28-Oct. 2, 1987) Physiologist, Supplement (ISSN 0031-9376), vol. 31, Feb. 1988, p. S-14, S-15. refs

The effects of microgravity on essential cardiovascular parameters are studied, summarizing the results of experiments using ultrasonic measurement techniques before, during, and after the 7-day space missions Salyut 7 (1982) and STS-51G (1985). Data on left-ventricular systolic and diastolic volume, cardiac output, heart rate, left-ventricular diameter shortening, ejection fraction, carotid and femoral flow, and cerebral and femoral resistance are presented in graphs and briefly characterized. Large individual variations are observed, and it is shown that moderate (30 percent or less) increases in cardiac output and left-ventricular diastolic volume on the first day were correlated with changes in femoral circulation (but not with cerebral circulation) and followed by decreases (to -15 percent or greater) over the following days. T.K.

A88-54027#
IN VITRO INTERFERON PRODUCTION BY HUMAN LYMPHOCYTES DURING SPACEFLIGHT
L. BATKAI, M. TALAS, I. STOGER, K. NAGY (Orszagos Kozegeszsegugyi Intezet, Budapest, Hungary), L. HIROS (Medicor Works, Budapest, Hungary) et al. (International Union of Physiological Sciences Commission on Gravitational Physiology, Annual Meeting, 9th, Nitra, Czechoslovakia, Sept. 28-Oct. 2, 1987)

Physiologist, Supplement (ISSN 0031-9376), vol. 31, Feb. 1988, p. S-50, S-51.

Interferon inducers were added to human lymphocytes on the space station Salyut-6 to study the effects of low gravity on cells which modulate interferon production. The lymphocyte suspensions and interferon inducers were kept at 37 C for periods of 6 days and 4 days in two separate experiments. In both experiments, iterferon titers from flight samples were 4-8 times higher than those of synchronous ground controls. In addition, the natural killer activity of the lymphocytes after the flight were about 4 times lower than before the flight. R.B.

N88-22540*# Stanford Univ., CA. Center for Design Research.
DESIGN, DEVELOPMENT AND EVALUATION OF STANFORD/AMES EVA PREHENSORS Final Report
LARRY J. LEIFER, J. ALDRICH, M. LEBLANC, E. SABELMAN, and D. SCHWANDT May 1988 10 p
(Contract NCC2-295)
(NASA-CR-182688; NAS 1.26:182688) Avail: NTIS HC A02/MF A01 CSCL 05H

Space Station operations and maintenance are expected to make unprecedented demands on astronaut EVA. With Space Station expected to operate with an 8 to 10 psi atmosphere (4 psi for Shuttle operations), the effectivness of pressurized gloves is called into doubt at the same time that EVA activity levels are to be increased. To address the need for more frequent and complex EVA missions and also to extend the dexterity, duration, and safety of EVA astronauts, NASA Ames and Stanford University have an ongoing cooperative agreement to explore and compare alternatives. This is the final Stanford/Ames report on manually powered Prehensors, each of which consists of a shroud forming a pressure enclosure around the astronaut's hand, and a linkage system to transfer the motions and forces of the hand to mechanical digits attached to the shroud. All prehensors are intended for attachment to a standard wrist coupling, as found on the AX-5 hard suit prototype, so that realistic tests can be performed under normal and reduced gravity as simulated by water flotation.
Author

N88-24145*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION HUMAN FACTORS RESEARCH REVIEW. VOLUME 1: EVA RESEARCH AND DEVELOPMENT
MARC M. COHEN, ed. and H. C. VYKUKAL, ed. Apr. 1988 136 p Workshop held at Moffett Field, Calif., 3-6 Dec. 1985
(NASA-CP-2426-VOL-1; A-87163-VOL-1; NAS 1.55:2426-VOL-1)
Avail: NTIS HC A07/MF A01 CSCL 06B

An overview is presented of extravehicular activity (EVA) research and development activities at Ames. The majority of the program was devoted to presentations by the three contractors working in parallel on the EVA System Phase A Study, focusing on Implications for Man-Systems Design. Overhead visuals are included for a mission results summary, space station EVA requirements and interface accommodations summary, human productivity study cross-task coordination, and advanced EVAS Phase A study implications for man-systems design. Articles are also included on subsea approach to work systems development and advanced EVA system design requirements.

N88-24146*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SUBSEA APPROACH TO WORK SYSTEMS DEVELOPMENT
M. L. GERNHARDT, F. R. FRISBIE, and C. E. BROWN *In its* Space Station Human Factors Research Review. Volume 1: EVA Research and Development p 69-84 Apr. 1988 Sponsored by Oceaneering International
Avail: NTIS HC A07/MF A01 CSCL 05H

Self-contained undersea working environments with applications to space station EVA environments are discussed. Physiological limitations include decompression, inert gas narcosis, high-pressure nervous system, gas toxicity, and thermal limitations. Work task requirements include drilling support, construction, inspection, and repair. Work systems include hyperbaric diving, atmospheric work systems, tele-operated work systems, and hybrid systems. Each type of work system is outlined in terms of work capabilities, special interface requirements, and limitations. Various operational philosophies are discussed. The evolution of work systems in the subsea industry has been the result of direct operational experience in a competitive market. J.P.B.

N88-24148*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPACE STATION HUMAN FACTORS RESEARCH REVIEW. VOLUME 4: INHOUSE ADVANCED DEVELOPMENT AND RESEARCH
TRIEVE TANNER, ed., YVONNE A. CLEARWATER, ed., and MARC M. COHEN, ed. May 1988 135 p Workshop held at Moffett Field, Calif., 3-6 Dec. 1985
(NASA-CP-2426-VOL-4; A-87247-VOL-4; NAS 1.55:2426-VOL-4)
Avail: NTIS HC A07/MF A01 CSCL 06B

A variety of human factors studies related to space station design are presented. Subjects include proximity operations and window design, spatial perceptual issues regarding displays, image management, workload research, spatial cognition, virtual interface, fault diagnosis in orbital refueling, and error tolerance and procedure aids.

N88-24150*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
IMAGE MANAGEMENT RESEARCH
ANDREW B. WATSON *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 23-28 May 1988
Avail: NTIS HC A07/MF A01 CSCL 05H

Two types of research issues are involved in image management systems with space station applications: image processing research and image perception research. The image processing issues are the traditional ones of digitizing, coding, compressing, storing, analyzing, and displaying, but with a new emphasis on the constraints imposed by the human perceiver. Two image coding algorithms have been developed that may increase the efficiency of image management systems (IMS). Image perception research involves a study of the theoretical and practical aspects of visual perception of electronically displayed images. Issues include how rapidly a user can search through a library of images, how to make this search more efficient, and how to present images in terms of resolution and split screens. Other issues include optimal interface to an IMS and how to code images in a way that is optimal for the human perceiver. A test-bed within which such issues can be addressed has been designed. J.P.B.

N88-24151*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
NASA-AMES WORKLOAD RESEARCH PROGRAM
SANDRA HART *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 29-76 May 1988
Avail: NTIS HC A07/MF A01 CSCL 05H

Research has been underway for several years to develop valid and reliable measures and predictors of workload as a function of operator state, task requirements, and system resources. Although the initial focus of this research was on aeronautics, the underlying principles and methodologies are equally applicable to space, and provide a set of tools that NASA and its contractors can use to evaluate design alternatives from the perspective of the astronauts. Objectives and approach of the research program are described, as well as the resources used in conducting research and the conceptual framework around which the program evolved. Next, standardized tasks are described, in addition to predictive models and assessment techniques and their application to the space program. Finally, some of the operational applications of these tasks and measures are reviewed. Author

N88-24152*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
SPATIAL COGNITION

MARY KISTER KAISER and ROGER REMINGTON *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 77-83 May 1988
Avail: NTIS HC A07/MF A01 CSCL 05I

Spatial cognition is the ability to reason about geometric relationships in the real (or a metaphorical) world based on one or more internal representations of those relationships. The study of spatial cognition is concerned with the representation of spatial knowledge, and our ability to manipulate these representations to solve spatial problems. Spatial cognition is utilized most critically when direct perceptual cues are absent or impoverished. Examples are provided of how human spatial cognitive abilities impact on three areas of space station operator performance: orientation, path planning, and data base management. A videotape provides demonstrations of relevant phenomena (e.g., the importance of orientation for recognition of complex, configural forms). The presentation is represented by abstract and overhead visuals only. Author

N88-24153*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, CA.
VIRTUAL INTERFACE ENVIRONMENT
SCOTT S. FISHER *In its* Space Station Human Factors Research Review. Volume 4: Inhouse Advanced Development and Research p 85-87 May 1988 Previously announced in IAA as A87-31494
Avail: NTIS HC A07/MF A01 CSCL 05H

A head-mounted, wide-angle, stereoscopic display system controlled by operator position, voice and gesture is under development for use as a multipurpose interface environment. Initial applications of the system are in telerobotics, data-management and human factors research. System configuration and research directions are described. Author

N88-25155*# Maryland Univ., College Park. Biomechanics Lab.
THE EFFICACY OF USING HUMAN MYOELECTRIC SIGNALS TO CONTROL THE LIMBS OF ROBOTS IN SPACE Final Report, 15 Apr. 1987-1988
JANE E. CLARK and SALLY J. PHILLIPS 20 Jun. 1988 289 p (Contract NAG5-895)
(NASA-CR-182901; NAS 1.26:182901) Avail: NTIS HC A13/MF A01 CSCL 05H

This project was designed to investigate the usefulness of the myoelectric signal as a control in robotics applications. More specifically, the neural patterns associated with human arm and hand actions were studied to determine the efficacy of using these myoelectric signals to control the manipulator arm of a robot. The advantage of this approach to robotic control was the use of well-defined and well-practiced neural patterns already available to the system, as opposed to requiring the human operator to learn new tasks and establish new neural patterns in learning to control a joystick or mechanical coupling device. Author

N88-25156*# McDonnell-Douglas Astronautics Co., Huntington Beach, CA.
HUMAN PERFORMANCE ISSUES ARISING FROM MANNED SPACE STATION MISSIONS
WILLIAM K. DOUGLAS Washington NASA Oct. 1986 61 p (Contract NAS2-11723)
(NASA-CR-3942; NAS 1.26:3942; MDC-H1363) Avail: NTIS HC A04/MF A01 CSCL 05H

Ten former NASA astronauts were interviewed using a set of 51 questions developed to encourage the contacts to discuss any thoughts, opinions, conclusions, or suggestions which might have evolved since they left the astronaut program. Strict confidentiality was maintained. At least one astronaut from each of the NASA manned space flight programs, excluding the Space Transportation System (Shuttle), was interviewed. The report records the answers to the questions asked, spontaneous comments, and the investigator's own personal evaluations of the material obtained. No statistical analysis of the material was attempted. The professional opinions of these ten experienced astronauts will be of value to persons concerned with the design and operation of manned spacecraft and manned space stations. Author

N88-26021# Bergen Univ. (Norway). Inst. of Physiological Psychology.
SELECTING THE RIGHT CREW FOR FUTURE SPACE STATIONS: AN ANALYSIS OF SELECTION RESEARCH ON OFFSHORE DIVERS, AVIATION PILOTS AND OTHER HIGH RISK GROUPS IN SCANDINAVIA
R. J. VAERNES, M. WARNCKE, T. BERGAN, and HOLGER URSIN *In* ESA, Proceedings of the Colloquium on Space and Sea p 47-51 Mar. 1988
Avail: NTIS HC A15/MF A01

Selection for high risk occupations, mainly pilots and offshore divers, using the Defense Mechanism Test (DMT) of Kragh (1960) is described. Longitudinal studies on serious nearmiss and fatal accidents (i.e., loss of aircraft); relationships to performance impairment in threatening situations; relationships to endocrine activation in threatening situations; and relationships to perceived health complaints and to physiological stress markers such as immunoglobuline levels are discussed, in view of selection criteria for manned space flights. Evidence shows that people with high defense strategies tend to have inadequate performance and high autonomic activation in threatening situations. Such subjects tend not to cope during training, and in the long term develop burn out problems. Multivariate analysis reveals three orthogonal (independent) endocrine factors with specific relations to psychological traits. A catecholamine factor relates to ambition and time urgency, and seems close to the Type A behavior described as being a cardiovascular risk. A cortisol factor relates to high defense mechanisms. The relation between an androgen and estrogen factor and personality is less stable. When an individual is faced with unsolved problems activation may become sustained and produce pathology through these personality-dependent endocrine reaction systems. It is shown that DMT level of prediction is many times greater than for other psychological tests which ignore the role of unconscious mental processes. ESA

N88-26033# Bell and Trotti, Inc., Houston, TX.
HABITABILITY OF THE SPACE STATION: FROM VEHICLE TO LIVING SPACE [HABITABILITE DE LA STATION SPATIALE. DU VEHICULE AU LIEU DE VIE]
FRANCIS WINISDOERFFER *In* ESA, Proceedings of the Colloquium on Space and Sea p 125-134 Mar. 1988 In FRENCH
Avail: NTIS HC A15/MF A01

Constraints, design rules, and requirements influencing the interior design of the Space Station inhabited module are reviewed. Main constraints on the envelope are the dimensions of the shuttle cargo bay and gravitational effects at the different flight phases. The interior is based on the four standoff configuration, consisting of a free space inside a tube formed by four standard double racks. The manned module has a galley, a central area for meals, teleconferences, and recreation equipped with tables, medical unit, hygiene equipment, command post, and individual cabins. Orientation in microgravity is helped by the choice of lighting and colors, which mimic patterns found on Earth, i.e., darker colors towards the floor. Human factors which must be allowed for include noise, eating (habits and taste), smells, exercise, and free time (passive recreations such as reading or looking at the Earth are favored by crews). ESA

N88-26039# Southern California Inst. of Architecture, Santa Monica. Space Projects Group.
RECENT RESEARCH ON CREW WARDROOM HABITABILITY FOR THE SPACE STATION
D. NIXON, REGIS FAUQUET, and T. TAYLOR *In* ESA, Proceedings of the Colloquium on Space and Sea p 169-173 Mar. 1988
Avail: NTIS HC A15/MF A01

The design of the crew Wardroom for the U.S./International Space Station, required to support a maximum eight-person Space

Station crew for periods as long as 6 months is discussed. Research techniques involve the construction and evaluation of a simulated Wardroom with meeting, meal, galley, exercise, and workstation facilities. The research shows that much opportunity exists to improve the design of crew accommodation and facilities beyond the standards accepted or specified for initial Space Station application. Successive future Space Station crews can benefit by greater attention to good facilities and equipment design. The introduction of appropriate innovative architectural and industrial design features can help to achieve and sustain optimum operational efficiency and enhanced environmental habitability throughout the Space Station life-cycle. 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.

A88-33426
EASCON '87; PROCEEDINGS OF THE TWENTIETH ANNUAL ELECTRONICS AND AEROSPACE SYSTEMS CONFERENCE, WASHINGTON, DC, OCT. 14-16, 1987
Conference sponsored by IEEE, Armed Forces Communications and Electronics Association, and National Space Club. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, 217 p. For individual items see A88-33427 to A88-33449.

Various papers on space endeavors are presented. The general topics addressed include: U.S. space policy and goals revisited, from earth to orbit and return, science in space, enhanced security from space, and the capabilities of the Space Station. Also discussed are: commercial use of space, general Space Station technology, signal processing technology, leadership in space, and international cooperation and leadership in space. C.D.

A88-33434*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
TECHNOLOGY ADVANCEMENTS FOR THE U.S. MANNED SPACE STATION - AN OVERVIEW
WILLIAM E. SIMON (NASA, Johnson Space Center, Houston, TX) IN: EASCON '87; Proceedings of the Twentieth Annual Electronics and Aerospace Systems Conference, Washington, DC, Oct. 14-16, 1987. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 75-87. refs

The structure and methodology of the Johnson Space Center (JSC) advanced development program is described. An overview of the program is given, and the technology transfer process to other disciplines is described. The test bed and flight experiment programs are described, as is the technology assessment which was performed at the end of the Phase B program. The technology program within each discipline is summarized, and the coordination and integration of the JSC program with the activities of other NASA centers and with work package contractors are discussed. C.D.

A88-33743
SPACE FOR RENT
DAVID MACLENNAN (New Zealand Spaceflight Association) Spaceflight (ISSN 0038-6340), vol. 30, April 1988, p. 138-140.

Two private-sector space projects that could provide important research and commercial manufacturing facilities in space in the early 1990s are discussed. The Spacehab module will be mounted in the Space Shuttle cargo bay to provide more experimental space, while the Industrial Space Facility will have two modules, one used for housing basic utilities needed for production and the other used to transport raw materials and to resupply equipment and finished products. The building and deployment schedules for these two projects are reviewed and their applications are discussed. C.D.

A88-34564
VIEWS ON COMMERCIAL PAYLOADS
P. A. KALLENBACH (ESA, Space Commercialisation Office, Paris, France) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 163-165.

Opportunities for private-sector participation in ESA Columbus remote-sensing and microgravity programs are discussed, and a number of obstacles to such participation are examined critically. Topics addressed include the highly competitive nature of the market for remote-sensing services, the need for better user information on the advantages of the space microgravity environment, and the problems posed by the lack of flight opportunities before about 1996. Ongoing efforts to facilitate participation are described, including commercial distribution of Landsat data, remote-sensing workshops, technical and financial support for potential commercial users of microgravity facilities, market analyses, and negotiations for interim flight opportunities. T.K.

A88-34573* National Aeronautics and Space Administration, Washington, DC.
THE INTERNATIONAL SPACE STATION COMPLEX - PROMISE AND PROBLEMS
RICHARD E. HALPERN (NASA, Utilization Office of Space Station, Washington, DC) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 213-219.

The current planning status of the International Space Station is reviewed from a NASA perspective, with a focus on aspects affecting the contributions of the international partners ESA, Japan, and Canada. The modifications implied by the shift from the previous double-keel configuration to the current phased-deployment (Block 1-Bock 2) approach are considered in detail and illustrated with drawings and a table listing the baseline assembly sequence. It is pointed out that the originally proposed non-NASA components can all be accommodated in the new configuration. The need for intermodule commonality of equipment form, fit, and function is discussed, and it is recommended that independent user boards be set up to select and coordinate experiments, and that the user boards of the partners open channels of cooperation and mutual support. T.K.

A88-34575
COOPERATIVE UTILIZATION OF THE SPACE STATION INFRASTRUCTURE - A CANADIAN VIEWPOINT
PARVEZ KUMAR (National Research Council of Canada, Space Div., Ottawa) (CNR and Aeritalia S.p.A., Columbus Symposium, 3rd, Capri, Italy, June 30-July 2, 1987) Space Technology - Industrial and Commercial Applications (ISSN 0277-4488), vol. 8, no. 1-2, 1988, p. 229, 230.

Canada's involvement in space activities has been, in the past, based essentially upon collaboration with other countries either in the build and supply of specialized hardware, the conducting of joint experiments in space, or using facilities which it does not have. In the latter category are included launch facilities, and ground stations when not located in preferred Canadian locations. Participation in the CTS in 1976 helped to open up the lucrative satellite communications industry, while the supply of the Canadarm for the Space Shuttle helped to put Canada on the map as a spacefaring nation. In the field of space science, Canada has been involved in cooperative ventures with Europe, Japan, and the U.S. The remote-sensing radar satellite Radarsat is currently a joint venture with the UK and the U.S., while the Msat communications satellite would have brought together the user communities of North America. Looking to the future, the Space

Station will provide the opportunities to work together for mutual scientific and economic benefits. Author

A88-35055* Rockwell International Corp., Downey, CA.
PANEL ON SPACE STATION UTILIZATION BENEFITS
SY Z. RUBENSTEIN (Rockwell International Corp., Downey, CA), FRANK DRAKE (California, University, Santa Cruz), STANLEY C. WHITE (Bionetics Corp., Pasadena, CA), JAMES V. TARANIK (Nevada, University, Reno), HERMANN JORDAN (DFVLR, Cologne, Federal Republic of Germany), and RAY ARNOLD (NASA, Office of Space Science and Applications, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 77-87.
(AAS PAPER 86-421)

An account is given of recent changes in the NASA Space Station, under the guidance of updated user community payload requirements. The user communities are those of astronomy, the life sciences, earth observation, and international applications. Attention is given to the resolutions that will be achievable by astronomical instruments aboard the Space Station, the testing of prototype earth observation instruments aboard the Station's manned module, and the microgravity research efforts planned in conjunction with ESA. O.C.

A88-35074
REPORT OF THE NATIONAL COMMISSION ON SPACE - ONE COMMISSIONER'S VIEW
JACK L. KERREBROCK (MIT, Cambridge, MA) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 435-440.
(AAS PAPER 86-250)

The National Commission on Space has recommended a trippling of the NASA R&D budget, as well as the aggressive development of seven critical technology-demonstration fields: (1) flight research on aerospaceplane aerodynamics and propulsion; (2) advanced rocket technologies; (3) aerobraking maneuvers; (4) long-duration, closed ecosystems; (5) electric propulsion systems; (6) nuclear-electric space power, and (7) space tethers and artificial gravity. Attention is given to the unique consequentiality of scramjet propulsion development for airbreathing launch vehicle propulsion to speeds above Mach 20. O.C.

A88-35075* National Aeronautics and Space Administration, Washington, DC.
THE SPACE STATION AND RECOMMENDATIONS OF THE NATIONAL COMMISSION ON SPACE
E. LEE TILTON (NASA, Washington, DC) and THEODORE R. SIMPSON (General Research Corp., McLean, VA) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 441-446.
(AAS PAPER 86-263)

The planned NASA Space Station, and its associated orbit transfer vehicle, are only the first of a series of Space Stations and transfer vehicles that the United States will need to pioneer the space frontier in the 21st century. The initial station and transfer vehicle will develop some of the technology and systems needed for follow-on stations, vehicles, and bases on the moon and Mars. Author

A88-35076
CONGRESSIONAL VIEWS ON COMMERCIAL SPACE
LILLIAN M. TRIPPETT (U.S. House of Representatives, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 447-451.
(AAS PAPER 86-454)

For commercial space, the 99th Congress was a period of learning, some disappointments and setbacks and yet, despite them, some progress on the policy front. The Committee on Science and Technology made headway in understanding the optimum level of government involvement in space commercialization and an appropriate government role in stimulating private investment in space activities. Congressional efforts to ensure the availability of low cost, reliable access to space for commercial and foreign users intensified following the Challenger accident, when it was learned that the U.S. could not rely solely on the Space Shuttle for access to space. Congressional efforts to ensure the development of a domestic expendable launch vehicle industry will be discussed. The placement of a permanently manned Space Station in orbit will further extend commercial opportunities in space. How U.S. laws and regulations apply to the Space Station will significantly affect the character of private sector interest and participation in the Space Station. Congressional action to extend patent and other laws to U.S. activities conducted in space will be described. Finally, prospects for the 100th Congress will be explored. Author

A88-35077
COMPETITION AND COOPERATION IN INTERNATIONAL JOINT PROJECTS
BRENDA FORMAN (Lockheed Corp., Calabasas, CA) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 455-462.
(AAS PAPER 86-342)

An analysis is undertaken of the tension between cooperation and competition in joint endeavors, beginning with the company-to-company teaming arrangement, through large-scale R&D consortia formed under the National Cooperative Research Act of 1984, to major international undertakings such as the U.S. Space Station. Examples are discussed of various techniques used to protect proprietary information while furthering the goals of the joint undertaking. Author

A88-35083
SOME RECENT DEVELOPMENTS IN UNITED STATES COMMERCIAL SPACE POLICY AND LAW
JOHN B. GANTT (Hunton and Williams, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 495-505.
(AAS PAPER 86-363)

The author examines several recent U.S. legal and policy developments that reflect a growing interest of Congress and the Executive Branch (and even the Supreme Court) as to space commercialization matters. These developments evidence a determination by Congress and the President to overhaul previous policy with respect to access to space. Even so, the author believes a greater bi-partisan effort is required to shape a U.S. civilian space policy and legal environment conducive to long-term space commercialization investment decisions. Author

A88-35084
CONCEPT FOR PRIVATE FINANCING AND OPERATION OF THE SPACE STATION
PETER M. STARK (Stark and Strobel Associates, Reston, VA) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 507-511.
(AAS PAPER 86-453)

The paper considers a possible future in which the Space Station is operated by an international partnership of private sector firms. It considers the desirability of this scenario by examining its effects on the various players. It then suggests a series of steps by which such an arrangement might be brought about, including the agreements which would be necessary between the involved governments and the private sector, and the activities each would have to undertake to carry out its part of the bargain. Finally, it

addresses whether NASA's baseline Space Station Operations Management Concept offers an indication that the Agency might be more willing to consider a private alternative than might otherwise be thought. Author

A88-35090
RECRUITMENT TECHNOLOGY - ENGINEERING PUBLIC SUPPORT FOR SPACE SETTLEMENT
GREGORY P. BARR (National Space Society, Washington, DC) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 571-587. refs
(AAS PAPER 86-387)

A development history is presented for the public relations efforts of the L5 Society. A structural framework for the rallying of public support for space settlement projects should incorporate a long range fundraising strategy involving several sources, reliable avenues through which volunteer members can move upwards in their participatory activities, and the creation of outreach materials that expand the membership base. In addition, concrete research and 'hardware' projects should be engaged in to enhance communications and networking for the organization. O.C.

A88-35091
BUILDING COMMUNITY SUPPORT FOR SPACE
KENNETH B. MALPASS (L-5 Society, Tucson, AZ) IN: Aerospace century XXI: Space missions and policy; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 589-593.
(AAS PAPER 86-388)

Public perception of space determines public receptiveness to space advocacy. Any plan for space development must link to positive values held by the public. The public's image of space is analyzed using a subjective perspective. The goal of permanent human settlement of space is compared to the public's preference system. A strategy for organizing the public is presented. A case study of Colorado's L5 chapters is offered. Author

A88-35163
HARVESTING NONTERRESTRIAL RESOURCES - A STATUS REPORT
GREGG E. MARYNIAK (Space Studies Institute, Princeton, NJ) IN: Aerospace century XXI: Space sciences, applications, and commercial developments; Proceedings of the Thirty-third Annual AAS International Conference, Boulder, CO, Oct. 26-29, 1986. San Diego, CA, Univelt, Inc., 1987, p. 1735-1746. refs
(AAS PAPER 86-341)

The principal barrier to space exploration and development is the cost of launching materials from the surface of the earth into orbit. This seemingly inescapable obstacle can be overcome by using resources already in space for propellants, shielding, life support and construction. This paper outlines the work of the Space Studies Institute in developing the tools and techniques which will enable the space program to reach a new level of maturity characterized by the use of locally-available resources for space operations. Author

A88-37833
IMPLEMENTATION OF SDI RESOURCES FOR MILSATCOM USER SUPPORT
PAUL M. CHAPELL (M/A-COM Government Systems, Inc., Vienna, VA) IN: MILCOM '87 - IEEE Military Communications Conference, Washington, DC, Oct. 19-22, 1987, Conference Record. Volume 2. New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 433-437. DCA-supported research.

A study was recently undertaken which investigated means by which MILSATCOM users could benefit from the use of SDI (Strategic Defense Initiative) resources. The study developed several operational concepts to achieve this goal. The concepts were developed around a generic SDI architecture framework and were tailored to address MILSATCOM defenses in a timeframe corresponding to the SDI system deployment. The author examines the performance, feasibility, and deployment considerations of these concepts. I.E.

A88-38304
30 YEARS OF PROGRESS IN SPACE; PROCEEDINGS OF THE THIRTY-EIGHTH INTERNATIONAL ASTRONAUTICAL CONGRESS, BRIGHTON, ENGLAND, OCT. 10-17, 1987
L. G. NAPOLITANO, ED. (Napoli, Universita, Naples, Italy) Congress sponsored by IAF. Acta Astronautica (ISSN 0094-5765), vol. 18, 1988, 398 p. For individual items see A88-38305 to A88-38307.

The present conference gives attention to orbital maneuvering vehicle capabilities, the impact of launch vehicle constraints on NASA Space Station design and operations, the Office of Space Flight satellite servicing program plan, an end-to-end analysis and demonstration of telerobotics and orbital laboratories, a development scenario for the H-II orbiting spaceplane HOPE, navigation of the Hermes spaceplane, and a postoperational disposal strategy for a space nuclear reactor. Also discussed are combined cycle propulsion systems for hypersonic flight, hybrid boosters for future launch vehicles, nuclear rocket safety, the development history of NASA tracking and data acquisition networks, the Indian remote sensing program, remote mineralogical and vegetation mapping using imaging spectrometry, and solar system colonization and interstellar migration. O.C.

A88-39050
SPACE: COUNTDOWN TO THE FUTURE; NATIONAL SPACE SYMPOSIUM, 3RD, COLORADO SPRINGS, CO, JAN. 20-23, 1987, REPORT
STEVEN D. MITCHELL, ED. Symposium sponsored by the United States Space Foundation, Aerospace Education Foundation, Boeing Aerospace Co. et al. Colorado Springs, CO, United States Space Foundation, 1987, 314 p. No individual items are abstracted in this volume.

Technological and political aspects of the U.S. civilian and military space programs are examined in individual presentations and panel discussions reflecting a wide spectrum of viewpoints. Topics addressed include the current status of SDI, space goals and strategy, launch options and the new emphasis on ELVs, space commercialization, military R&D options, DOD programs, space militarization, the U.S. space program in the year 2000, space law and policy, and space education. Also considered are the current space activities of ESA, the FRG, Japan, China, France, the UK, and Canada. T.K.

A88-39500
SPACE PHOENIX
RANDOLPH H. WARE, THOMAS F. ROGERS, DAVID J. PADUA (External Tanks Corp., DE), and WALTER ORR ROBERTS (University Corporation for Atmospheric Research, Boulder, CO) Space Policy (ISSN 0265-9646), vol. 4, May 1988, p. 143-150. refs

The Space Phoenix Program to develop the Space Shuttle fleet's expended external fuel tanks for scientific and commercial use is discussed. The program is run through cooperation between the federal government and three private organizations, the University Corporation for Atmospheric Research (UCAR), the UCAR Foundation, and the External Tanks Corporation (ETCO). The 27.6 ft X 153 ft external tanks (ETs), which are jettisoned from the Shuttle to eliminate potentially harmful impact, are made of high-grade aluminum and are used to carry 70,000 cu ft of separate, pressurized hydrogen and oxygen. The Space Phoenix Program is studying the commercial and non-profit use of ETs in space for purposes such as manufacturing, research, and storage. One of its major objectives is to try to save ETs and park them in a high-altitude orbit to safeguard their potential value. The program is exploring the possible use of ETs to fulfill the need for space facilities and laboratories, and working to obtain the rights from the government to use, modify, and operate ETs. R.B.

A88-40524
SIMULATION - ANTIDOTE TO RISK
LEE DAY and GRAHAM SPEED (Singer Link-Miles, Ltd., Lancing, England) Spaceflight (ISSN 0038-6340), vol. 30, June 1988, p. 240-243.

The use of simulators to reduce risk in space programs is discussed. Simulation is used in system verification during the early phases of a project to substitute for missing system elements, allowing for verification of the overall system design, so that modifications can be made before hardware is manufactured. The new focus in developing simulators is on training analysis to provide a system tailored to the tasks and characteristics of trainees. This involves a structured progression incorporating only those stages of training found necessary through analysis. A number of simulators are networked in the final stage of training the flight crew, ground controllers, and the mission-related payload user and control personnel. In the development of the Columbus Attached Pressurized Module or the Japanese Experimental Module, software models and hardware mock-ups are linked together so that progressively larger simulations of the system can be performed. Prototype equipment is substituted for the models until the entire system is in place. The need for simulation continues after a mission launch because of the remoteness of support activity from the home base. R.B.

A88-41276* National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, MD.
VISIONS OF TOMORROW: A FOCUS ON NATIONAL SPACE TRANSPORTATION ISSUES; PROCEEDINGS OF THE TWENTY-FIFTH GODDARD MEMORIAL SYMPOSIUM, GREENBELT, MD, MAR. 18-20, 1987
GERALD A. SOFFEN, ED. (NASA, Goddard Space Flight Center, Greenbelt, MD) Symposium sponsored by AIAA, AAS, National Space Club, et al. San Diego, CA, Univelt, Inc. (Science and Technology Series. Volume 69), 1987, 338 p. For individual items see A88-41277 to A88-41290.

The present conference on U.S. space transportation systems development discusses opportunities for aerospace students in prospective military, civil, industrial, and scientific programs, current strategic conceptualization and program planning for future U.S. space transportation, the DOD space transportation plan, NASA space transportation plans, medium launch vehicle and commercial space launch services, the capabilities and availability of foreign launch vehicles, and the role of commercial space launch systems. Also discussed are available upper stage systems, future space transportation needs for space science and applications, the trajectory analysis of a low lift/drag-aeroassisted orbit transfer vehicle, possible replacements for the Space Shuttle, LEO to GEO with combined electric/beamed-microwave power from earth, the National Aerospace Plane, laser propulsion to earth orbit, and a performance analysis for a laser-powered SSTO vehicle. O.C.

A88-41283
BEYOND LOW EARTH ORBIT - A SURVEY OF UPPER STAGES
DAVID W. THOMPSON (Orbital Sciences Corp., Fairfax, VA) IN: Visions of tomorrow: A focus on national space transportation issues; Proceedings of the Twenty-fifth Goddard Memorial Symposium, Greenbelt, MD, Mar. 18-20, 1987. San Diego, CA, Univelt, Inc., 1987, p. 131-136.
(AAS PAPER 87-115)

An account is given of foreseeable prospects for relatively near-term supplements to the U.S.'s OTV inventory. This inventory currently encompasses the Payload Assist Module, the Inertial Upper Stage, and the Transfer Orbit Stage (TOS). Prospective systens are the Orbital Maneuvering Vehicle, which is an autonomous modular bipropellant vehicle; the TOS/Apogee and Maneuvering Stage, which would be capable of placing 65,000 lbs into GEO on the basis of derivative technology; the Adaptable Space Propulsion System, which would be compatible with the Titan 4 launcher; the Aeroassist Flight Experiment of NASA's Civil Space Technology Initiative; and the Orbital Transfer Vehicle, which will be both man-rated and reusable. O.C.

A88-43951
SPACE MANUFACTURING 6 - NONTERRESTRIAL RESOURCES, BIOSCIENCES, AND SPACE ENGINEERING; PROCEEDINGS OF THE EIGHTH PRINCETON/AIAA/SSI CONFERENCE, PRINCETON, NJ, MAY 6-9, 1987
BARBARA FAUGHNAN, ED. and GREGG E. MARYNIAK, ED. Conference sponsored by AIAA and Space Studies Institute. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, 412 p. For individual items see A88-43952 to A88-43972, A88-43974 to A88-43993.

The present conference on the colonization and economic exploitation of space considers topics in biomedics, space transportation, nonterrestrial resources, the use of launch vehicle external tanks as structural bases for space habitats, international law and economics considerations, the technological bases of space manufacturing plant and solar power satellites, artificial biospheres and closed-cycle life-support systems, and the social aspects of spaceflight. Attention is given to bone and muscle response to long-duration space missions, the energetics of closed biological life-support systems, a LEO space farm, crew factors in NASA Space Station design, the economic impact of extraterrestrial medicine, beamed energy for spacecraft propulsion, the electric rail rocket, and the extraction of silicon, aluminum, and oxygen from lunar ore. O.C.

A88-43954#
CLOSED ECOLOGICAL SYSTEMS TRANSPLANTING EARTH'S BIOSPHERE TO SPACE
CLAIR E. FOLSOME (Hawaii, University, Honolulu) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 71-75. refs

Recyclable or regenerative life support systems must be devised to allow indefinitely extended manned missions in space, balancing all crew inputs and outputs and closing cyclic circles for all biological and nonbiological matter. All food, water, and oxygen required would in these systems be reprocessed from metabolic wastes at the microbial and/or chemical level. It is presently shown on the basis of extensive experimental evidence that the foundation for stable closed ecologies of all types is microbial; microbes can be solely responsible for the closing of the bioelemental cycles of all known and foreseeable ecologies. O.C.

A88-43955#
AN INTRODUCTION TO THE INTENSIVE AGRICULTURE BIOME OF BIOSPHERE II
LINDA LEIGH (Space Biospheres Ventures, Oracle, AZ) and KEVIN FITZSIMMONS (Arizona, University, Tucson) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 76-81. refs

Biosphere II is a one-hectare, materially-closed, energetically and informationally open ecological system of seven biomes (tropical rainforest, savannah, marine, marsh, desert, intensive agriculture and human habitat) being designed as a scientific and management tool for ecological research applicable to the biosphere of the earth and regenerative life habitats in space or on the moon or Mars. This paper discusses the Intensive Agriculture Biome, which has an area of 2069 sq m and a volume of 35,456 cu m. System design is based upon local environmental conditions in Oracle, Arizona, and a cropping scheme to provide recommended dietary allowances for eight adults over a two-year initial closure period has been developed. Water and nutrient recycling, soil mix and development, integrated pest management, and use of expert systems and computer models are discussed. Author

A88-43959#
LOW EARTH ORBIT SPACE FARM
STEPHEN M. BULL, NILS BRUNN, and RANDOLPH LIEBELT

(Medaris Industries, New York) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 102-111. refs

The paper proposes a modular low earth orbit space farm which combines the current CELSS technology with a single launch, artificial gravity space vehicle to provide fresh produce to a nearby space station crew in a balanced exchange for their biodegradable waste and carbon dioxide. While growing a substantial amount of produce, the space farm will also be developing the plant propagation technology for transfer to future lunar colonies and to accompany long range space missions, i.e., interplanetary exploration. The components of the space farm will be launched by conventional booster, then manned, assembled and operated by a crew of two. Since the space farm is habitable during all stages of development, the Shuttle rendezvous to deliver the crew will be brief. Adding modules will facilitate increasing crop yields. Author

A88-43961#
THE OVERVIEW EFFECT - A STUDY OF THE IMPACT OF SPACE EXPLORATION ON INDIVIDUAL AND SOCIAL AWARENESS
FRANK WHITE (Human Systems Inc., Newton, MA) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 120-125. refs

This paper discusses the changes in awareness caused by spaceflight in astronauts, cosmonauts, and society as a whole. The paper reports findings based on interviews with sixteen people who have been in space as well as an examination of secondary materials. The Overview Effect is defined as viewing the earth from space and experiencing its inherent unity as a whole system. In addition, other changes in awareness are described, as are the conditions producing the shifts in perception. A series of propositions is offered as the foundation for continuing research into the philosophy and psychology of the new civilizations now being created on earth and in space. Author

A88-43963#
THE FUTURE OF COMMERCIAL SPACE MANUFACTURING - RESULTS OF A DELPHI SURVEY
TODD B. HAWLEY IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 137-139.

Prospective commercialization lifetimes have been projected for 12 proposed space commercialization products and processes, using the 'Delphi' method for obtaining a convergence of opinion on a given line of speculation from a body of experts in the fields pertinent to such projections. Fifty experts participated in a two-round Delphi survey concerning the commercially feasible autonomous spaceborne manufacturing of pharmaceuticals (1993), weapons systems (1996), semiconductors (1997), optics (2000), metallurgy (2002), tourism (2002), large-scale space structures (2005), lunar mining (2007), genetic engineering (2008), solar power satellites (2008), asteroid mining (2014), and self-replicating machines (2014). O.C.

A88-43965#
LADY BASE ONE CORPORATION AND THE MARKET FOR SPACE DEVELOPMENT
W. F. MITCHELL, JR. (Lady Base One Corp., Friendswood, TX) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 153-157. refs

A proprietary commercialization scheme is presented for the development of market opportunities for lunar manufacturing and mining products, identifying the technology development requirements for which the launch vehicle, satellite industry, space research management, defense, and scientific communities will be responsible. The lunar base's construction should proceed concurrently with that of the NASA Space Station project; the base should be operational and profitable by 1994. While it costs $3000 to deliver LOX from the earth to orbit, it may cost as little as $136 to deliver it to earth orbit from the moon. O.C.

A88-43966#
A JOB FOR SPACE MANUFACTURING
J. W. STRYKER IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 158-163.

Space habitation will create a need for a general purpose repair, rebuilding, and manufacturing facility. The self-contained 'job shop' concept fits this need. A single, multi-purpose machine tool combined with a large variety of accessories is proposed. This uses existing and proven technology, requiring only some minor adaption for work in space. Also, there is a large experience base of job shop techniques which can be drawn upon. A job shop can modify tools and equipment already in orbit. It can perform production manufacturing for many of the sub-components needed in the construction of additional habitats. This adaptability also provides valuable capacity when Shuttle or other transportation links may experience delays. It creates a 'bootstrapping' capability which can significantly lower manufacturing costs in space. This paper presents specific design aspects which can help achieve this goal. Author

A88-43968#
THE SPACE PHOENIX PROGRAM - A PROGRESS REPORT
T. F. ROGERS (External Tanks Corp., Boulder, CO) IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 171-174.

The primary concern of the Space Phoenix Program is the beneficiation of the discarded, orbiting external tanks (ETs) of the Space Shuttle in order to transform them into safe, sanitary and durable habitable space structures whose volume will be made available to commercial users on a leasing basis. The program is currently drawing upon the interests and capabilities of over 50 universities, in active cooperation with U.S. agencies, and has chosen as its first objective the creation of a general-purpose scientific research facility, 'Labitat', using aforementioned Space Shuttle ETs, in which scientists will be able to both reside and work. O.C.

A88-43977#
IMPROVING EFFICIENCY OF EXPENDABLE LAUNCH VEHICLES IN THE FUTURE SPACE TRANSPORTATION SYSTEM
DOUGLAS A. COMSTOCK IN: Space manufacturing 6 - Nonterrestrial resources, biosciences, and space engineering; Proceedings of the Eighth Princeton/AIAA/SSI Conference, Princeton, NJ, May 6-9, 1987. Washington, DC, American Institute of Aeronautics and Astronautics, 1987, p. 283-290. refs

The utilization of launch vehicle resources in orbit and the synergism resulting from concurrent design and development of the advanced space transportation system and space manufacturing facilities are discussed. The possiblity of changing the role of the expendable launch vehicle to that of a partially reusable/recyclable launch vehicle (RELV) to improve system efficiency and cost is examined. The role of RELV in space manufacturing, candidate vehicles for a mission, and the viability of such a mission are discussed and a RELV mission scenario is given. R.B.

A88-44001
ADVANCED TOPICS IN MANUFACTURING TECHNOLOGY: PRODUCT DESIGN, BIOENGINEERING; PROCEEDINGS OF THE SYMPOSIUM, ASME WINTER ANNUAL MEETING, BOSTON, MA, DEC. 13-18, 1987
PHILIP H. FRANCIS, ED. Symposium sponsored by ASME. New York, American Society of Mechnical Engineers, 1987, 106 p. For individual items see A88-44002 to A88-44007.

Papers on manufacturing technology related to engineering are presented in the fields of product design, bioengineering, and space commercialization. Aspects of product design and bioengineering covered included design issues in mechanical tolerance analysis, computer-aided product design for economical manufacture, gestural control of industrial robots applied to surgical instrument positioning, voice control of manufacturing systems, eye tracking control of robotic systems, and man-machine interaction. Topics in space commercialization include an overview of space commercialization by an aerospace corporation, commercial development of space, power system technology, welding in space, remote sensing technology and applications, commercial materials processing in the space station, and microgravity science and applications projects and payloads. R.B.

A88-44007#
COMMERCIAL MATERIALS PROCESSING IN THE SPACE STATION
H. J. WILLENBERG (Boeing Aerospace Co., Huntsville, AL) IN: Advanced topics in manufacturing technology: Product design, bioengineering; Proceedings of the Symposium, ASME Winter Annual Meeting, Boston, MA, Dec. 13-18, 1987. New York, American Society of Mechanical Engineers, 1987, p. 89-102. refs

The Space Station, its U.S. laboratory module, and commercial materials processing which would take place in the Space Station are examined. Specific subsystems and man systems of the laboratory module and laboratory support equipment are presented. The Space Station would provide for the processing of electronic and electrooptical materials, metals, glasses and ceramics, polymers and biotechnology. The growth of industrial interest in the Space Station and opportunities for early commercial involvement in materials processing in space are discussed. R.B.

A88-44065
SOCIETY IN ORBIT
W. PAUL BLASE (DCS Corp., Alexandria, VA) and JOHN CAMP (USAF, Wright-Patterson AFB, OH) Space World (ISSN 0038-6332), vol. Y-7-295, July 1988, p. 16-19.

It is argued that, if colonization of space is to be a smooth transition, the political, social, and economic aspects of individual societies and interactions between societies must be addressed well in advance. One important aspect of understanding and planning any space community will be its infrastructure: the physical shell and life support systems that facilitate life in a vacuum. Cost, structural inflexibility, and the extreme danger inherent in space life will influence the social structure and the government of the people that inhabit the structure. It is suggested that the best method of funding a space community is the corporate method, in which the colonists form their own corporation. K.K.

A88-44527#
COST EFFECTIVENESS OF ON-ORBIT SERVICING FOR LARGE CONSTELLATIONS
WILLIAM ROBERTSON, JACK SLINEY, and JOEL LUNA (Dynamics Research Corp., Systems Div., Arlington, VA) AIAA, Space Programs and Technologies Conference, Houston, TX, June 21-24, 1988. 22 p. refs
(AIAA PAPER 88-3519)

This paper examines the cost effectiveness of on-orbit support for large constellations with the use of a space-based support infrastructure, a concept whereby space assets are serviced and repaired in their operational orbits using a space-based support platform and an appropriate servicing subsystem, such as an OMV. The characteristics of a viable on-orbit maintenance and servicing concept are considered together with the systems/subsystems that are necessary to perform on-orbit maintenance and servicing. The cost analyses performed are structured to maintain consistency and balance between the competing support alternatives, using the launch-to-replace concept as a baseline against which the on-orbit support alternatives are compared. I.S.

A88-44613
NASA'S PATHFINDER PLOTS FUTURE US SPACE ACTIVITIES
ANDREW WILSON Interavia (ISSN 0020-5168), vol. 43, June 1988, p. 591-593.

NASA's $850-million 'Pathfinder' project has as its goal the definition and development of generic technologies for future missions beyond earth orbit; these are grouped under the categories of 'exploration', 'operations', 'transfer vehicles', and 'human life support'. Pathfinder will attempt to define advanced capabilities for both manned and unmanned ventures, of which the latter may be typified by a Mars sample-return mission by 1998. A Mars mission would entail substantial development of such techniques as aerobraking, in order to reduce spacecraft earth departure masses by up to 50 percent, as well as electric propulsion and controlled-environment life-support systems. O.C.

A88-45603
SPACE RESOURCES - BREAKING THE BONDS OF EARTH
JOHN S. LEWIS (Arizona, University, Tucson) and RUTH A. LEWIS New York, Columbia University Press, 1987, 428 p.

It is shown how space resources can be used to make a prospective space program affordable. Ways of reducing costs through the use of new technologies based on space resources are suggested. It is maintained that space activities can provide a net economic as well as scientific and technological gain for earth. The space races before and after 1968 are discussed together with lunar resource exploitation, the emergence of near-earth asteroids, current plans and goals for space development, and a proposal for a renewed space program. K.K.

A88-45605* Delaware Univ., Newark.
SPACE 2000: MEETING THE CHALLENGE OF A NEW ERA
HARRY L. SHIPMAN (Delaware, University, Newark) Research supported by the John Simon Guggenheim Memorial Foundation, Research Corp., NASA, and NSF. New York, Plenum Press, 1987, 439 p. refs

The focus of the present book is on the variety of past and future human activities in space. NASA's response to the Challenger explosion is discussed and an overview is given of the agency's relations with foreign competitors in the 1980s. The practical uses of space are described with attention given to communications satellites, the orbital high ground (weather watching, spying, and SDI), earth science, and materials processing in space. Other topics include the exploration of the near and distant universe, and permanent stations in space and on the moon. K.K.

A88-49821#
COST-FACTOR ANALYSIS OF PAYLOADS ON MANNED SPACE FLIGHTS [ANALYSE DES FACTEURS DE COUTS DES EXPERIENCES EMBARQUEES SUR VOL HABITE]
G. NAJA (ESA, Paris, France) and D. KAPLAN (Matra Espace, Velizy-Villacoublay, France) ESA Bulletin (ISSN 0376-4265), no. 54, May 1988, p. 30-33. In French.

A cost-factor analysis of the use of Doppler echocardiographs for monitoring astronaut cardiovascular functioning during manned space flights is presented based on data from the 1982 Salyut and 1985 Space Shuttle missions. The two missions are compared with respect to the effect of flight delays on costs, the astronaut's roles and training, and the significance of the science/industry/agency relationship. The impact of the study results for future mission preparation, the Columbus program, documentation problems, and astronaut training are discussed. R.R.

A88-51133
SPACE FOR RENT?
ANDREW LAWLER Space World (ISSN 0038-6332), vol. Y-9-297, Sept. 1988, p. 15-19.

Plans to build an industrial space facility which would consist of a manned, free-flying platform and would be serviced by the Shuttle are discussed. The plan was sponsored by the Space Industries Partnerships, made up of several private aerospace companies. Efforts to gain governmental support for the project are examined, and the possiblities for the future of the plan are considered. R.B.

A88-51742
PUBILC POLICY ISSUES IN SATELLITE COMMUNICATIONS AND REMOTE SENSING
THOMAS L. MCPHAIL (Calgary, University, Canada) IN: Satellites international. New York, Stockton Press, 1987, p. 57-60. refs

Policy issues relating to telecommunications are discussed, including international use of the geostationary satellite orbit, remote sensing of earth resources, and direct satellite broadcasting of television signals. The UN provisions for international activities in outer space are examined, pointing out which issues have yet to be resolved. The question of the sovereignty of equatorial countries over the space above their nations, and the relationship between sensed states and states with remote sensing capabilities are considered. Other issues include whether or not individuals should have the right to receive any broadcast information they wish to receive, the problem of broadcasting propaganda, and the question of whether or not a nation must give prior consent before a program is broadcast to that nation. R.B.

A88-52317
SPACE CONGRESS, 25TH, COCOA BEACH, FL, APR. 26-29, 1988, PROCEEDINGS
Congress sponsored by the Canaveral Council of Technical Societies. Cape Canaveral, FL, Canaveral Council of Technical Societies, 1988, 592 p. For individual items see A88-52318 to A88-52373.

Papers are presented dealing with commercial aspects of space, space business, robotics, space station technologies, artificial intelligence applications in space, lunar and Mars exploration concepts, launch vehicles, and systems automation. Topics covered include ground processing of experiments conducted in space, the development of a commercial expendable launch vehicle industry, a small LEO satellite bus, epitaxial thin film growth in space, development of space enterprise, negotiating governmental contracts, robots in Shuttle hardware, telerobotic Space Station applications, simulation of an articulated transporter/manipulator system, welding the Space Station common module prototype, modeling the environment of the Man Tended Free Flyer, and Space Station rapid sample return. Ground operations support by AI, expert system prototype developments, Mars mission profile options and opportunities, launch vehicle operations analyses, space launch systems resiliency, model-based reasoning for knowledge-based software project management, technology advances for Space Shuttle processing, real-time fault management for large-scale systems, information systems for Shuttle processing, orbiter maneuvering vehicle support to the Space Station, and hydrogen-air-steam combustion regimes in large volumes are also discussed. R.B.

A88-53749
SECOND THOUGHTS ON THE WAY TO THE STATION
DAVID BAKER New Scientist (ISSN 0028-6664), vol. 119, Aug. 25, 1988, p. 41-44.

The development of the Space Station is discussed. The stages of constructing the Station are presented, including an outline of the flights involved and what they would carry. The Station design is described and illustrated, including the elements of the Space Station contributed by Europe and Japan. Economic considerations, the problem of debris in space, and problems which might be caused by a delay during the stages of construction are considered. R.B.

A88-54851*# National Aeronautics and Space Administration, Washington, DC.
GETTING READY TO GO
THOMAS L. MOSER (NASA, Space Station Program Office, Washington, DC) Aerospace America (ISSN 0740-722X), vol. 26, Sept. 1988, p. 16-18.

The reevaluation of the Space Station that has occurred over the past two and a half years is reviewed, and the system development that has been recently initiated is discussed. Upcoming developments with regard to laboratory outfitting, extended duration Orbiter, and logistics operations are summarized. The goals of the first launches are discussed, and the aims of the succeeding manned flights are examined. C.D.

A88-55331#
RISK MANAGEMENT FOR THE SPACE STATION PROGRAM
BAL KRISHAN (McDonnell Douglas Astronautics Co., Huntington Beach, CA) IAF, International Astronautical Congress, 39th, Bangalore, India, Oct. 8-15, 1988. 7 p.
(IAF PAPER 88-061)

A risk management approach for the Space Station is presented, based on the principle that system acquisition is founded on the interrelation between design, testing, and production. A definition of risk is presented, and risk sources and control are discussed. The architecture of the risk management system is given. The three steps of the system's methodology are risk identification and assessment, risk prioritization, and risk resolution and statusing. A quantitative risk assessment model has been developed, identifying the most sensitive risk items. A production schedule and control system is being established to provide early warning and control of potential problems to ensure smooth transition from design to production and deployment. R.B.

N88-21076*# National Aeronautics and Space Administration. Lyndon B. Johnson Space Center, Houston, TX.
JOHNSON SPACE CENTER'S STRATEGIC GAME PLAN: CHARTING A COURSE TO THE YEAR 2000 AND BEYOND
Oct. 1987 45 p
(NASA-TM-89733; NAS 1.15:89733) Avail: NTIS HC A03/MF A01 CSCL 05A

The Johnson Space Center has established five major goals to meet the Nation's expectation of maintaining U.S. preeminence in space. The first three are technical in nature. They define the basic mission-the reason for being. The two goals relating to the Space Shuttle and Space Station are obviously the most demanding in their immediate claim for major resources. The third goal is equally important in that the technical competence must be maintained and enhanced. The remaining two goals address the two critical success factors required for achieving the first three. One goal pertains to maintaining and enhancing the highly skilled work force. The other goal concerns the important relations with other key members of the U.S. space team. Each goal is listed along with a proposed strategy or approach for implementing each goal. Subsequently, each goal is accompanied by a brief explanation and a set of objectives. These objectives provide the specific targets of opportunity for focusing the immediate efforts. B.G.

N88-21087# Executive Office of the President, Washington, DC.
AERONAUTICS AND SPACE REPORT OF THE PRESIDENT: 1986 ACTIVITIES
1986 141 p
Avail: NTIS HC A07/MF A01

The achievements of aeronautics and space programs in the United States for 1986 are summarized in the areas of communications: Earth atmosphere, environment, and resources; space science; space transportation; commercial use of space; space tracking and data systems, space station; and aeronautics and space research and technology. The achievements of each of the following organizations are described: NASA, the Departments of Defense, Commerce, Energy, Interior, Agriculture, Transportation and State, the Federal Communications Commission, Environmental Protection Agency, National Science

Foundation, Smithsonian Institution, Arms Control and Disarmament Agency and USIA. Appendices provide historical information on launches, satellites, manned and ummanned spacecraft, and Federal budgets for aeronautical and astronautical activities.
Author

N88-21475*# Old Dominion Univ., Norfolk, VA.
ON THE DANGER OF REDUNDANCIES IN SOME AEROSPACE MECHANISMS
M. CHEW *In* NASA. Langley Research Center, The 22nd Aerospace Mechanisms Symposium, p 87-98 May 1988
(Contract NAS1-17993)
Avail: NTIS HC A18/MF A01 CSCL 13I

An attempt is made to show that redundancies in some aerospace mechanisms do not generally improve the odds for success. Some of these redundancies may even be the very cause for failure of the system. To illustrate this fallacy, two designs based on the Control of Flexible Structures I (COFS I) Mast deployer and retractor assembly (DRA) are presented together with novel designs to circumvent such design inadequacies, while improving system reliability. Author

N88-22219# Joint Publications Research Service, Arlington, VA.
SPACE UTILIZATION PLANS
TETSUHISA SHIRAKAWA *In its* JPRS Report: Science and Technology. Japan p 1-5 3 Mar. 1988 Transl. into ENGLISH from Ceramics Japan (Tokyo, Japan), Apr. 1987 p 262-268
Avail: NTIS HC A05/MF A01

Space utilization used to be an issue in fields such as communications, broadcasting, and meteorology. Such space utilization counts on the high altitudes of artificial satellites. Recently, the additional interest was shown in the utilization of such aspects of the space environment as microgravity and high vacuum. More concretely, interest is present regarding the possibility of material development, e.g., crystal growth, in a microgravitational environment where there is little difference in gravity between different materials and where no thermal convection is caused. Movements in that direction are already active in the United States and Europe. In Japan, space environment utilization is being tackled, regarding it as a field of space utilization, coming after rockets and artificial satellites. The present status of the Japanese space utilization programs is discussed. Author

N88-23689# Committee on Appropriations (U.S. House).
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT INDEPENDENT AGENCIES APPROPRIATIONS FOR 1989. PART 7: NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington GPO 1988 1137 p Hearings before a subcommittee of the Committee on Appropriations, 100th Congress, 2d Session, 19 Apr. 1988, part 7
(GPO-85-166) Avail: Committee on Appropriations, House of Representatives, Washington, D.C. 20515 HC free

Hearings before a subcommittee of the House Committee on Appropriations are presented along with the budget estimates for the National Aeronautics and Space Administration for the fiscal year 1989. All written testimony and submittals for the record are also included. The budget estimates provide a detailed outline of budgetary information and justifications for research and development, construction of facilities, space flight and communications, and research and program management. M.G.

N88-24172*# General Electric Co., Philadelphia, PA. Astro Space Div.
THE MULTI-DISCIPLINARY DESIGN STUDY: A LIFE CYCLE COST ALGORITHM Final Contractor Report
R. R. HARDING and F. J. PICHI Washington NASA Jun. 1988 30 p
(Contract NAS1-18032)
(NASA-CR-4156; NAS 1.26:4156) Avail: NTIS HC A03/MF A01 CSCL 09B

The approach and results of a Life Cycle Cost (LCC) analysis of the Space Station Solar Dynamic Power Subsystem (SDPS) including gimbal pointing and power output performance are documented. The Multi-Discipline Design Tool (MDDT) computer program developed during the 1986 study has been modified to include the design, performance, and cost algorithms for the SDPS as described. As with the Space Station structural and control subsystems, the LCC of the SDPS can be computed within the MDDT program as a function of the engineering design variables. Two simple examples of MDDT's capability to evaluate cost sensitivity and design based on LCC are included. MDDT was designed to accept NASA's IMAT computer program data as input so that IMAT's detailed structural and controls design capability can be assessed with expected system LCC as computed by MDDT. No changes to IMAT were required. Detailed knowledge of IMAT is not required to perform the LCC analyses as the interface with IMAT is noninteractive. Author

N88-24440# Orion International Technologies, Albuquerque, NM.
SPACE POWER REFERENCE SOURCE (SPRS): A USER'S GUIDE TO SDI SPACE POWER TECHNOLOGY PROGRAMS
L. B. LATHAM *In* New Mexico Univ., Transactions of the Fifth Symposium on Space Nuclear Power Systems p 325-328 1988
(Contract F29601-85-C-0060)
Avail: NTIS HC A99/MF A01

At present, there are numerous proposed systems designed to provide housekeeping, alert, and burst power to all space based Strategic Defense Initiative platform concepts. Previously the defense community has had no means to monitor all activities and parameters associated with space power development programs. The Space Power Reference Source (SPRS) is a comprehensive Information Management System (IMS) programmed in Revelation (TM), which allows the user to link bidirectionally for systems, subsystems, critical components, and government work package descriptions. SPRS also has a preprogrammed Figure of Merit algorithm that permits the ranking of systems based on user specified parameters. SPRS is an effective tool for tracking space power trends, comparing technologies for similar applications, and facilitating budget appropriations. However, further work is needed to optimize the Figure of Merit hierarchy, and to further evaluate the types of data needed to optimize SPRS for use as an administrative tool.
Author

N88-25371*# Taylor and Associates, Inc., Wrightwood, CA.
SPACE STATION ARCHITECTURAL ELEMENTS AND ISSUES DEFINITION STUDY
T. C. TAYLOR, J. S. SPENCER, and C. J. ROCHA May 1986 78 p
(Contract NASA ORDER A-16516-C)
(NASA-CR-3941; NAS 1.26:3941) Avail: NTIS HC A05/MF A01 CSCL 22B

A study was conducted to define the architectural elements and issues of the Space Station. The objective of the study was to identify those questions which require further research and suggest ways in which the research can be undertaken. The study examined five primary topics, asked salient questions and described the merits of alternative solutions. Author

N88-26031# Methodist Hospital, Indianapolis, IN. Research and Development Dept.
THE US SPACE PROGRAMME
SPACEWALK/EXTRAVEHICULAR ACTIVITY EXPERIENCE: PAST, PRESENT AND FUTURE
THOMAS P. MOORE *In* ESA, Proceedings of the Colloquium on Space and Sea p 115-120 Mar. 1988
Avail: NTIS HC A15/MF A01

The history and prospects of extravehicular activity (EVA) in NASA space programs are reviewed. The first EVA in the United States program took place on Gemini 4 in 1965. Lunar exploration was accomplished by 14 two-crewmember EVAs during the Apollo program which began in 1968. The United States' only long duration space flight experience took place in 1973 to 1974 aboard Skylab,

with 10 EVAs being performed. Since the beginning of the Space Shuttle program in 1981, there have been 13 two-crewmember EVAs. Space Station is planned for component construction during EVAs for initial operation during the mid 1990s. Physiological effects on crews, particularly metabolic rate, are mentioned. ESA

N88-28077# Air Command and Staff Coll., Maxwell AFB, AL.
SOVIET SPACE PROGRAM HANDBOOK
ROY LONGSTAFFE Apr. 1988 90 p
(AD-A194332; ACSC-88-1610) Avail: NTIS HC A05/MF A01
CSCL 22A

This study establishes the need for a handbook on the Soviet space program. The first section describes the three Soviet space launch sites. The second describes the operational Soviet space launch vehicles including their dimensions, capabilities, and payloads. Each major Soviet satellite program is then described in detail. Included here are orbital parameters, constellation sizes and phasings, mission profiles, and vehicle descriptions. And finally, the handbook contains several useful appendices such as launch azimuth vs. inclination graphs for each launch site, a geosynchronous coverage schematic, and several historical analyses. GRA

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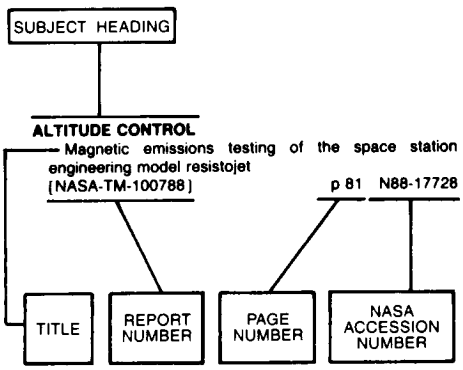

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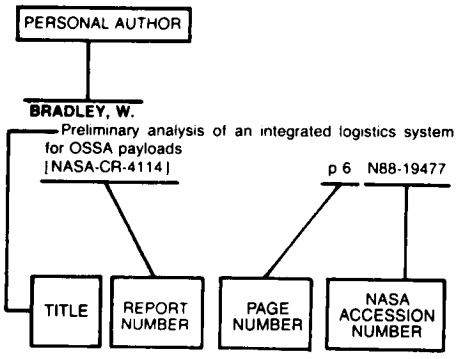

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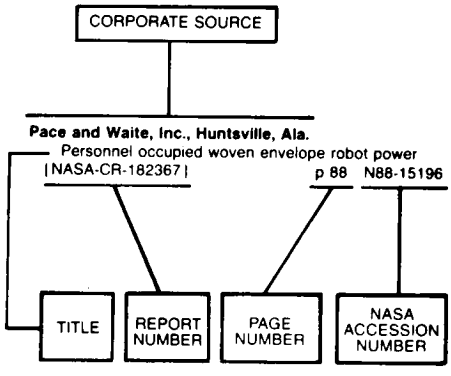

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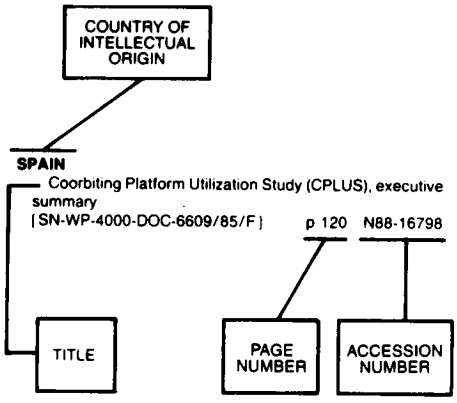

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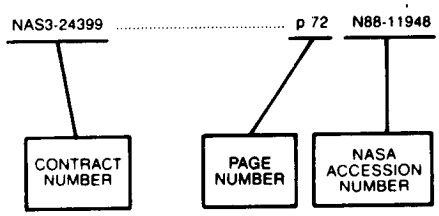

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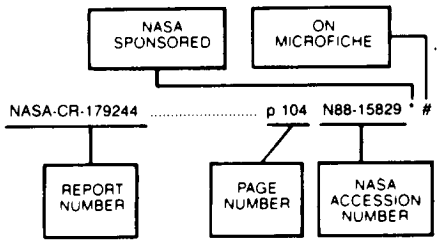

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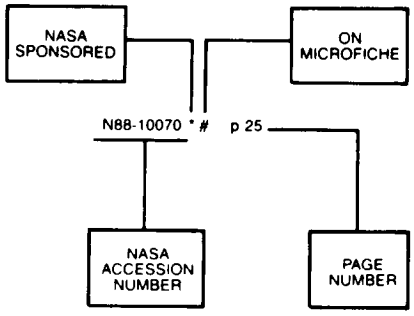

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