

Japanese Aerospace Literature This month: *Large Space Structures*

A93-56282 High intensity sound generation and control of large acoustic test facility (1600 cu m). TETSUO HIDAKA, TAKESHI KOBAYASHI, MASAOKI MOKUNO, and SATORU ISHIDA, *Proceedings of the 35th Space Sciences and Technology Conference*, Nagaoka, Japan, Oct. 28-31, 1991, (A93-56251 24-12). Tokyo, Japan Society for Astronautical and Space Sciences, 1991, pp. 159, 160. Documents available from AIAA Technical Library.

The large acoustic test facility used for testing large spacecraft has begun to operate as part of the Spacecraft Integration and Test Facilities at the Tsukuba Space Center. A volume of reverberation chamber is about 1,600 cu m and the maximum sound pressure level is 151 dB. The sound pressure level during the acoustic test is automatically controlled in the frequency range of 25 Hz to 10 kHz.

A93-33105 Optimum design of 3-D truss structure and its effect on control. YUKIO TADA and EMIKO MINAMI, *JSME International Journal, Series A: Mechanics and Material Engineering* (ISSN 0914-8809), Vol. 36, No. 1, Jan. 1993, pp. 90-96. 9 Refs. Documents available from AIAA Technical Library.

This paper formulates a weight minimization problem of a 3D truss structure with the constraints on stresses and natural frequencies of specified modes. Cross-sectional areas of truss members are optimized by sequential linear programming. When the object mode is in the same direction as that of the static load considered in the strength problem, the minimization can be carried out effectively. Moreover, it is observed that the structure obtained has good controllability in the context of the optimal regulator theory.

N93-20444 Research on large structure assembly technology: Research on deployable assembly structure Oogata kouzoubutsu kumitate gijutsu no kenkyuu: Tenkai kumitate kouzou no kenkyuu Report No. 3. YOSHIKI MORINO and SHIGETO SHIBUTA, National Space Development Agency, Ibaraki (Japan). Thermal and Structural Engineering Lab. In its Research and Development Activities of the Tsukuba Space Center p 159-162 (SEE N93-20410 07-12) Documents available from AIAA Technical Library.

An overview of the simulation analyses of element mechanisms for deployable assembly structures is presented. System mechanism analyses were conducted using a mathematical model constructed for one unit cell of the deployable trusses. Element mechanism analyses were conducted using mathematical models constructed for each of the critical elements of deployable trusses, such as telescopically deployable section, joint section, deployment and folding driving mechanism, and so forth. Review on the function, characteristics, and the scope of mechanism analysis software to study on ground and on orbit deployment technologies were conducted. Preliminary review was conducted on test equipment and techniques to effectively facilitate the deployment function verification. Conceptual design of the docking mechanism for the Engineering Test Satellite-7 (ETS-7) to acquire the Rendezvous and Docking (RVD) and robotic technologies was conducted. Some examples of the simulation are shown.

A92-53649 Preliminary test results on the berthing and docking mechanisms for future space infrastructures. EIICHI ENDO, HIDEHIKO MITSUMA, YASUAKI TANIGUCHI, KENJI OGIMOTO, and YASUHIRO TAKESHITA, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 2, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 1433-1438. Documents available from AIAA Technical Library.

A development status evaluation is presented for the autonomous berthing and docking system that is envisioned for Japanese orbital infrastructure operations, giving attention to the results of component-level tests; these encompass a berthing probe, structural latches, and an umbilical connection device. Whole-system tests were also conducted on a 2D air-bearing testbed. Attention is given to the detailed design features of the docking/berthing mechanism and to the performance criteria which these designs must meet.

A92-53615 Experiment on wave-absorbing control for flexible space structures. HIRONORI FUJII, KEN MIYACHI, TOSHIYUKI OHTSUKA, and SEIICHI ANAZAWA, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, ACNE Publishing, Inc., 1990, pp. 1171-1176. 10 Refs. Documents available from AIAA Technical Library.

Wave-absorbing control for vibration suppression of flexible space structures is demonstrated experimentally. The experimental model is a hinged-free flexible beam with a sensor and non-collocated torque actuator. The wave-absorbing control employs partial differential equations as the mathematical model of structural dynamics, and the controller can be designed without any use of the modal expansion. The control, thus, is free from the crucial truncation effect. The structural vibration is expressed in terms of propagating disturbances in the frequency domain. The control forces are applied to eliminate outgoing waves at the boundaries of the structure. Experimental results show satisfactory performance of the controller and good agreement with the performance predicted analytically.

A92-56099 Space environment resistance of CFRP for use in space infrastructure. SHIGEKAZU HIGUCHI, *Proceedings of the 29th Aircraft Symposium*, Gifu, Japan, Oct. 7-9, 1991, (A92-56001 24-01). Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, pp. 448-452. Documents available from AIAA Technical Library.

Structural materials for use in low earth orbit or geostationary orbit are discussed. Forming conditions of carbon fiber reinforced plastics (CFRP) are presented. Radiation-resistance testing of CFRP composite is discussed.

A92-53690 A study on technology of a large deployable antenna for a mobile communications satellite. TERUAKI ORIKASA, SHIN-ICHI SATO, AKIO ISO, and TOSHIO SUGIMOTO, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 2, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 1715-1720. 7 Refs. Documents available from AIAA Technical Library.

An account is given of the tradeoffs and key technologies of large deployable reflector antennas, as well as of their performance evaluation in light of their effective mass. A mesh-and-truss-type reflector deployable system is devised, and its performance is evaluated in view of an electrical scale model; measured radiation characteristics are determined and compared with calculated results. The cross-polarization level is very low, and dual-polarization-based frequency reuse may be implemented.

A92-53614 Antenna Pointing System on flexible space structures. TAKASHI KIDA, ISAO YAMAGUCHI, SEIYA UENO, MASAKI TANAKA, and KEIICHI HIRAKO, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, ACNE Publishing, Inc., 1990, pp. 1165-1170. Documents available from AIAA Technical Library.

The dynamic interaction between the Antenna Pointing System and the structural vibration of large space structures is studied experimentally. The role of the damping improvement of the structure is discussed and demonstrated. All of the experimental results are verified by numerical evaluation.

A92-53612 A robust adaptive attitude control for a large space structure with non-collocated actuators and sensors. YUZO SHIMADA, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, ACNE Publishing, Inc., 1990, pp. 1151-1158. Research supported by Nihon University. 4 Refs. Documents available from AIAA Technical Library.

A 'design method for a model reference adaptive control' (DMMRAC) for the slewing control of a flexible space structure is presented. A rigid spacecraft with flexible appendages in which a smaller number of actuators than sensors have been installed is considered. To apply the DMMRAC theory to this spacecraft, sensors' signals are combined to make a p-input/p-output system.

A92-53611 Analytical aspect of a large space telescope drive system dynamics. S. J. MORIZUMI, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, ACNE Publishing, Inc., 1990, pp. 1143-1150. 11 Refs. Documents available from AIAA Technical Library.

A preliminary study of the transient response characteristics of a large telescope pointing mechanism is presented. The mathematical model described is useful in examining the effects of various design parameters on the dynamic response of the space telescope. Results of sample calculations demonstrate the effects of important design parameters on the dynamic response and stability.

A92-53540 Fundamental studies of designing a solar sail orbit. SATOSHI EGUCHI, NOBUAKI ISHII, and HIROKI MATSUO, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 661-666. 14 Refs. Documents available from AIAA Technical Library.

Fundamental studies for a preliminary design of solar sail orbits are described. A closed-form equation is derived from a perturbation equation in order to evaluate analytically an increment of the semimajor axis. This closed-form equation can be used to estimate the orbital period easily without numerical integration. A simple control algorithm with a constant precession rate can lessen the operational task of sail axis orientation.

A92-35624 Adaptive control of large space structures and sensor collocation. R. OGURA, I. TANAKA, and YUZO SHIMADA, *Proceedings of the 7th Space Station Conference*, Tokyo, Japan, Apr. 16, 17, 1991, (A92-35601 14-12). Tokyo, Japan Society for Aeronautical and Space Sciences, 1991, pp. 43, 44. 6 Refs. Documents available from AIAA Technical Library.

The equations of motion for large space structures (LSS) are considered. Adaptive control design is given and sensor collocation is presented. Numerical simulations are discussed.

A92-53536 An experimental study on vibration suppression by piezoelectric actuators. JUNJIRO ONODA, TOSHIO TOMIZAWA, AT-SUSHI NAKADA, TAKAO ENDO, and HIDEHIKO TAMAOKI, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 635-640. 4 Refs. Documents available from AIAA Technical Library.

Two types of approaches for active or semiactive vibration suppression of space truss structures, including a newly proposed one, are experimentally studied. One approach is to use the internal force generated by the elongation/contraction action of variable-length truss member which is composed of piezoelectric actuators. The other new approach is to use the dry frictional force where the normal force is controlled by piezoelectric actuators. The experiments demonstrate the effectiveness of both approaches.

A92-53535 Adaptive structures to enable ground test validation of precision structures. BEN K. WADA, JAMES F. FANSON, GUN-SHING CHEN, and CHIN-PO KUO, *Proceedings of the 17th Jet Propulsion Lab., California Inst. of Tech., Pasadena. International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 629-634. 18 Refs. Documents available from AIAA Technical Library.

The use of analytical models and ground-based experimental validation of precision space structures is addressed. The application of adaptive structures to such validation of precision space structures is addressed, with the focus on adaptive truss structures.

A92-53533 Research on a reflector structure composed of inflatable elements. SUMIO KATO, TOKIO OHNISHI, OSAMU MURAGISHI, and MICHIOHITO NATORI, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 611-622. 13 Refs. Documents available from AIAA Technical Library.

This paper presents recent results of research on a modularized inflatable reflector structure for high precision reflector missions in the relatively near future. The structure consists of inflatable elements and a back-up structure. An appropriate reflector system including inflatable elements and a back-up structure is presented from the various viewpoints of technology development. Some fundamental characteristics of surface accuracy of inflatable elements are studied. Results of rigidization tests of inflatable elements, interface test of inflatable elements, and back-up truss, etc. are described.

A92-53532 Development of a precision large deployable antenna. YOJI IWATA, KAZUO YAMAMOTO, TAKAHIKO NODA, YASUO TAMAI, TAKASHI EBISUI, KORYO MIURA, and TADASHI TAKANO, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 605-610. 5 Refs. Documents available from AIAA Technical Library.

This paper describes the results of a study of a precision large deployable antenna for the space VLBI satellite 'MUSES-B'. An antenna with high gain and pointing accuracy is required for the mission objective. The frequency bands required are 22, 5 and 1.6 GHz. The required aperture diameter of the reflector is 10 meters. A displaced axis Cassegrain antenna is adopted with a mesh reflector formed in a tension truss concept. Analysis shows the possibility to achieve aperture efficiency of 60 percent at 22.15 GHz and surface accuracy of 0.5 mm rms. A one-fourth scale model of the reflector has been assembled in order to verify the design and clarify problems in manufacturing and assembly processes.

A92-53531 Deployable modular mesh antenna—Concept and feasibility. JIN MITSUGI and TETSUO YASAKA, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 599-604. 8 Refs. Documents available from AIAA Technical Library.

The feasibility of a 10m aperture deployable modular mesh antenna is evaluated by integrating the results of a statistical surface accuracy estimation and of surface shape adjustment experiments. It has been clarified that by combining seven 4m aperture modules, a 10m aperture deployable modular mesh antenna can be constructed, preserving the surface accuracy that is applicable to C band mission.

A92-38202 Intelligent adaptive structures. BEN K. WADA, *Proceedings of the Jet Propulsion Lab., California Inst. of Tech., Pasadena. International Aerospace Symposium 90*, Nagoya, Japan, Nov. 26, 27, 1990, (A92-38201 15-01). Nagoya, Japan, Nagoya Chamber of Commerce and Industry, 1990, pp. 6-13. 8 Refs. Documents available from AIAA Technical Library.

'Intelligent Adaptive Structures' (IAS) refers to structural systems whose geometric and intrinsic structural characteristics can be automatically changed to meet mission requirements with changing operational scenarios. An IAS is composed of actuators, sensors, and a control logic; these are integrated in a distributed fashion within the elements of the structure. The IAS concepts thus far developed for space antennas and other precision structures should be applicable to civil, marine, automotive, and aeronautical structural systems.

A92-53529 A note on the accuracy adjustment of reflector structures. KOJI NATORI, MICHIOHITO MIYAZAKI, YASUYUKI KATO, and YOSHIHIDE SEKINE, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 585-592. 9 Refs. Documents available from AIAA Technical Library.

A concept for an active accuracy adjustment of reflector surfaces by changing the element boundary planar shape is studied. The effectiveness of the concept is demonstrated by a linear and nonlinear deflection analysis of initially curved beam strips. The analysis shows that the surface accuracy error of a parabolic strip deformed by thermal distortion, which is of primary significance in space, can be greatly improved by a slight change of the element boundary.

A92-53525 Experimental study of air mass effect (on vibration mode of space structures). SHUN-ICHI ODA and YOSHITSUGU YASUI, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 551-556. 4 Refs. Documents available from AIAA Technical Library.

An experimental investigation in a vacuum chamber has been conducted to confirm and quantify the air mass effect on space structures. A theoretical equation derived by Lamb (1921) expressing the ratio of the resonant frequency in a vacuum to that in air is confirmed, and the free-free disk parameters are determined. It is shown that the air mass effect can be computed with sufficient accuracy using the virtual mass method.

A92-53510 Evaluation of solid-lubricated ball-screw in a vacuum. MASATOSHI CHIBA, TORU GYOGI, MAKOTO NISHIMURA, and KATSUMI SEKI, *Proceedings of the 17th International Symposium on Space Technology and Science*, Vol. 1, Tokyo, Japan, May 20-25, 1990, (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, pp. 439-443. Documents available from AIAA Technical Library.

Ball screws lubricated by solid lubricants are a key component for large space constructions with linearly moving parts. This paper reports a study aimed at understanding lubricating performance and lifetime of ball screws lubricated by solid lubricant films containing molybdenum disulfide under a simulated space environment. It is found that ball screws made of bearing steel SUS 440C and 6Al-4V-titanium have a wear life of more than 10 million revolutions.

A92-42375 Development of large high strength aluminum alloy component for spacecraft. NAOTAKE YOSHIHARA, SEISHI TSUYAMA, YOSHIMICHI HINO, and KATSUHIKO HIROKAMI, *NKK Technical Review* (ISSN 0915-0544), No. 64, April 1992, pp. 21-27. 7 Refs. Documents available from AIAA Technical Library.

Journal Announcement: IAA9217 NKK developed and supplied a large aluminum alloy (7075-T7352) spacecraft component. Two major problems could arise in manufacturing this part by conventional production methods: difficulty in achieving the specified strength because of the very thick sections and difficulty in removing the residual stress from quenching because of the complex shape. NKK developed a production method that solved these problems. This paper describes the results of theoretical analysis on the generation and removal of residual stress, experimental studies on the removal of residual stress in small blocks, and full-scale tests to verify the selected method.

A92-41832 A new control technique based on the LAC/HAC concept for flexible structures. SHINJI HOKAMOTO and NORIHIRO GOTO, *Japan Society for Aeronautical and Space Sciences, Transactions* (ISSN 0549-3811), Vol. 34, No. 106, Feb. 1992, pp. 240-249. 9 Refs. Documents available from AIAA Technical Library.

Journal Announcement: IAA9217 A new control technique based on the LAC/HAC concept is proposed to suppress the vibration of flexible space structures. The new technique employs the mechanism to turn on or off the HAC part of the LAC/HAC system in such a manner as to suppress the spillover effects as quickly as possible. The control system designed by the new technique has global stability and is more effective than a pure LAC system, even when an ordinary LAC/HAC system results in failure because of spillover instability. To show the characteristic features of the new technique and how to implement the system, computer simulation examples are given. The technique is applied to the transversal vibration control of a cantilever beam to show its effectiveness and practicality.

N92-18241 Damping enhancement of large space structures by proof-mass-actuators. TAKASHI KIDA, ISAO YAMAGUCHI, SEIYA UENO, and MASAKI TANAKA, National Aerospace Lab., Tokyo (Japan). Space Technology Research Group. 23 pp. (ISSN-0389-4010) (NAL-TR-1114). Documents available from AIAA Technical Library, Other Availability: NTIS HC/MF A03.

The enhancement of modal damping is a key technology in Large Space Structures (LSS) robust control. A controller design is examined which actively augments substantial damping factors to LSS. The stability analysis of the closed loop system is discussed, and was subsequently confirmed by a ground based control experiment which used a newly developed pivoted type Proof Mass Actuator (PMA). The controller uses a direct velocity feedback control. A multi-input multi-output control system was examined using two PMAs, in addition to the single-input single-output case. In both cases, the experimental results showed excellent vibration suppression capability. A sizing problem of the PMAs is also discussed.