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Advanced Structures: 2000-2004

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A Custom Bibliography From the
NASA Scientific and Technical Information Program

October 2004

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This custom bibliography from the NASA Scientific and Technical Information Program lists a sampling of records found in the NASA Aeronautics and Space Database. The scope of this topic includes technologies for extremely lightweight, multi-function structures with modular interfaces—the building-block technology for advanced spacecraft. This area of focus is one of the enabling technologies as defined by NASA's *Report of the President's Commission on Implementation of United States Space Exploration Policy*, published in June 2004.

OCTOBER 2004

20040111079 NASA Langley Research Center, Hampton, VA, USA

Clear, Conductive, Transparent, Flexible Space Durable Composite Films for Electrostatic Charge Mitigation

Watson, Kent A.; Connell, John W.; Delozier, Donavon M.; Smith, Joseph G., Jr.; 8th Spacecraft Charging Technology Conference; March 2004; In English; No Copyright; Avail: CASI; A03, Hardcopy

Space environmentally durable polymeric films with low color and sufficient electrical conductivity to mitigate electrostatic charge (ESC) build-up have been under investigation as part of a materials development activity. These materials have potential applications on advanced spacecraft, particularly on large, deployable, ultra-light weight Gossamer spacecraft. The approach taken to impart sufficient electrical conductivity into the polymer film while maintaining flexibility is to use single wall carbon nanotubes (SWNTs) as conductive additives. Approaches investigated in our lab involved an in-situ polymerization method, addition of SWNTs to a polymer containing reactive end-groups, and spray coating of polymer surfaces. The work described herein is a summary of the current status of this project. Surface conductivities (measured as surface resistance) in the range sufficient for ESC mitigation were achieved with minimal effects on the physical, thermal, mechanical and optical properties of the films. Additionally, the electrical conductivity was not affected by harsh mechanical manipulation of the films. The chemistry and physical properties of these nanocomposites will be discussed.
Author

Polymeric Films; Nanocomposites; Thin Films; Spacecraft Charging

20040110506 Virginia Polytechnic Inst. and State Univ., Blacksburg, VA

Vibration Analysis and Control of an Inflatable Structure Using Smart Materials

Inman, Daniel J.; Aug. 2004; In English

Contract(s)/Grant(s): F49620-03-1-0163

Report No.(s): AD-A425363; No Copyright; Avail: CASI; A02, Hardcopy

Lightweight inflatable structures, or Gossamer spacecraft, are very attractive in aerospace applications for several reasons. These structures pose difficult problems, however, in modeling and in control due to their special geometry and material properties. Initially, the proposed work was to examine the nonlinear structural dynamics of an inflated torus with a membrane attached to it for the purpose of providing suitable models for the application of nonlinear control. This work/award commenced in April 2003. In March 2004, after a site visit by the AFOSR Program Manager, the focus of this effort was changed to correspond more closely with AFRL interests. In particular, after conversations with AFRL/DEBS and AFRL/VSSV, both of Kirtland AFB, the focus of the proposed effort was changed to examine the structural dynamics of a pressurized membrane with the goal of providing a sound modeling and theoretical understanding of the coupled structure, fluid, optical and control hardware of AFRL/DEBS's proposed system. The following is a brief report of our activities over 11 months of funding. The section numbers correspond to the categories requested on the AFOSR website for progress reports.
DTIC

Aerospace Systems; Control Systems Design; Controllers; Dynamic Structural Analysis; Inflatable Structures; Smart Materials

20040086439 Air Force Inst. of Tech., Wright-Patterson AFB, OH

Characterization and Ground Test of an Inflatable Rigidizable Space Experiment

Lindemuth, Steven N.; Mar. 2004; In English; Original contains color illustrations

Report No.(s): AD-A424403; AFIT/GSS/ENY/04-M05; No Copyright; Avail: CASI; A06, Hardcopy

As greater capability is demanded of space-based assets, their size and complexity are growing. Inflatable, rigidizable structures offer significant improvements in the areas of weight, size, and complexity over traditional mechanically deployed systems. These structures are not well understood and little testing of them has been done in the space environment.

Widespread acceptance of these technologies will not be achieved without significant reduction in the risk of using inflatable, rigidizable structures in space. The goal of this experiment is to verify and validate ground testing of small tubular truss structures for use in space. This experiment builds on previous research done in this area to reduce the risks involved in testing inflatable, rigidizable structures in space. The Rigidizable Inflatable Get-Away- Special Experiment (RIGEX) is designed to launch as a self- contained experiment on the Space Shuttle. It will inflate and rigidize three redundant experiments in the open space environment. Once these structures are deployed and rigidized, the experiment will vibrationally excite the deployed structures and record the vibrational response. This thesis produced test equipment that would meet the RIGEX Concept of Operations and conducted testing to gain an understanding of the heating, pressurization, and inflation systems of the RIGEX experiment to avoid mission failure. Appendixes contain the following: system weight tabulations, heating test results, inflation test results, success criteria, DoD SERB briefing slides, system architecture, updated NASA payload accommodations requirements, and inflation system calculations. The accommodation plan defines the technical agreement between NASA/Goddard Space Flight Center (GSFC) and the Getaway Special Canister (GAS) customer concerning the unique information needed for the preparation, flight, and disposition of the GAS payload. (12 tables, 32 figures, 32 refs.)
DTIC

Aerospace Engineering; Ground Tests; Heating; Inflatable Structures; Inflating; Spaceborne Experiments; Trusses

20040085023 Air Force Inst. of Tech., Wright-Patterson AFB, OH

Microprocessor-Based Systems Control for the Rigidized Inflatable Get-Away-Special Experiment

Moody, David C.; Mar. 2004; In English; Original contains color illustrations

Report No.(s): AD-A424363; AFIT/GE/ENG/04-17; No Copyright; Avail: CASI; A12, Hardcopy

As the demand for space based communications and faster data throughput increase, satellites are becoming larger. Larger satellite antennas help to provide the needed gain to increase communications in space. Compounding the performance and size trade-offs are the payload weight and size limit imposed by the launch vehicles. Inflatable structures offer a cost saving opportunity since the structure is significantly lighter and has a reduced storage volume. This allows for smaller launch vehicles and for increased performance capabilities. Inflatable structures offer possibilities for increased satellite lifetimes, increased communications capacity, and reduce launch costs. This thesis develops and implements the computer control system and power system to support the Rigidized Inflatable Get-Away-Experiment. The autonomous computer system controls the flow of the experiment while at the same time collecting and recording temperature, pressure, vibration, and image data. The computer system consists of two processors, one for experiment control and sensor data collection and the second for image data collection. These two systems can work simultaneously to control the flow of the experiment and meet the experiment objectives. Examples of the data collection include heating curves, pressure, tube transfer function plots and images. This thesis also develops the Matlab(Registered) tools required to analyze the data collected by the computers for post-flight data processing. This thesis lays the groundwork for a microprocessor-based architecture for autonomous space experiments. This pioneering effort has been selected for flight testing on-board the U.S. Space Shuttle.
DTIC

Computer Networks; Get Away Specials (STS); Microprocessors

20040084908 Air Force Inst. of Tech., Wright-Patterson AFB, OH

Structural Design and Analysis of a Rigidizable Space Shuttle Experiment

Holstein III., Raymond G.; Mar. 2004; In English; Original contains color illustrations

Report No.(s): AD-A424139; AFIT/GAE/ENY/04-M08; No Copyright; Avail: CASI; A06, Hardcopy

AFIT is in the process of designing a Space Shuttle experiment designated as the Rigidized Inflatable Get- Away-Special Experiment (RIGEX) to study the effects of microgravity on the deployment of rigidizable composite structures. Once in space, the experiment will inflate and rigidize three composite structures and perform a vibration analysis on each by exciting the tubes using piezoelectric patches and collecting data via an accelerometer. This paper presents the structural and vibration analysis of the RIGEX assembly and inflatable composite tubes using ABAQUS Finite Element Analysis (FEA) software. Comparison of the analysis has been carried out with Eigenvalue/Eigenvector experimentation by means of ping testing. This FEA analysis has been used to verify the natural frequency and structural integrity of the RIGEX support assemblies. The ABAQUS FEA results correlated to within 20% of experimental values.
DTIC

Design Analysis; Finite Element Method; Piezoelectricity; Space Shuttles; Spaceborne Experiments; Structural Analysis; Structural Design; Structural Engineering; Weightlessness

20040084503 Morgan Aircraft and Consulting, USA

Hanging On by a Thread

Morgan, Ray; ASK Magazine, No. 18; June 2004, 22-23; In English; No Copyright; Avail: CASI; A01, Hardcopy

The first solar plane we developed at AeroVironment was named the Gossamer Penguin. The word 'gossamer' was an apt description of the appearance of this strange-looking aircraft that had a structural weight of only 54 pounds, with a wing span of 71 feet. Much was sacrificed to save weight and maximize span, and this presented serious problems when handling the aircraft on the ground. The Penguin was barely strong enough to stay together in the light winds and low turbulence of the early and low turbulence of the early morning. Moving the Penguin back to the hangar at the end of a morning flight was much like walking a 71-foot span kite home from the park.

Derived from text

Aircraft Design; Structural Weight; Wing Span

20040084277 Able Engineering Co., Inc., Goleta, CA, USA

Rolamite Joints for Spacecraft Subsystem Vibration Isolation

Compton, Gregory A.; Botke, Matthew M.; 37th Aerospace Mechanisms Symposium; May 2004, 163-169; In English; No Copyright; Avail: CASI; A02, Hardcopy

A one-degree of freedom joint with unique performance requirements has been designed and built for use in a passive isolation system for structurally-connected deployable spacecraft subsystems. Using a Rolamite approach, a nearly frictionless and zero spring rate hinged joint can be achieved that is capable of passing significant electrical power and data harnessing. Implementing a Rolamite joint in a system design with requirements typical of spaceflight must be accomplished in a very judicious fashion in order to maintain the expected performance benefits. The following describes the design progression, trades and lessons learned in developing and building this mechanism.

Author

Systems Engineering; Vibration Isolators; Joints (Junctions); Mechanical Drives; Spacecraft Design

20040081112 NASA Goddard Space Flight Center, Greenbelt, MD, USA

Modular, Reconfigurable, and Rapid Response Space Systems: The Remote Sensing Advanced Technology Microsatellite

Esper, Jaime; Andary, Jim; Oberright, John; So, Maria; Wegner, Peter; Hauser, Joe; March 31, 2004; In English, 19-22 Apr. 2004, El Segundo, CA, USA

Report No.(s): AIAA Paper 2004-3002; No Copyright; Avail: CASI; A02, Hardcopy

Modular, Reconfigurable, and Rapid-response (MR(sup 2)) space systems represent a paradigm shift in the way space assets of all sizes are designed, manufactured, integrated, tested, and flown. This paper will describe the MR(sup 2) paradigm in detail, and will include guidelines for its implementation. The Remote Sensing Advanced Technology microsatellite (RSAT) is a proposed flight system test-bed used for developing and implementing principles and best practices for MR(sup 2) spacecraft, and their supporting infrastructure. The initial goal of this test-bed application is to produce a lightweight (approx. 100 kg), production-minded, cost-effective, and scalable remote sensing micro-satellite capable of high performance and broad applicability. Such applications range from future distributed space systems, to sensor-webs, and rapid-response satellite systems. Architectures will be explored that strike a balance between modularity and integration while preserving the MR(sup 2) paradigm. Modularity versus integration has always been a point of contention when approaching a design: whereas one-of-a-kind missions may require close integration resulting in performance optimization, multiple and flexible application spacecraft benefit &om modularity, resulting in maximum flexibility. The process of building spacecraft rapidly (\h 7 days), requires a concerted and methodical look at system integration and test processes and pitfalls. Although the concept of modularity is not new and was first developed in the 1970s by NASA's Goddard Space Flight Center (Multi-Mission Modular Spacecraft), it was never modernized and was eventually abandoned. Such concepts as the Rapid Spacecraft Development Office (RSDO) became the preferred method for acquiring satellites. Notwithstanding, over the past 30 years technology has advanced considerably, and the time is ripe to reconsider modularity in its own right, as enabler of R(sup 2), and as a key element of transformational systems. The MR2 architecture provides a competitive advantage over the old modular approach in its rapid response to market needs that are difficult to predict both from the perspectives of evolving technology, as well as mission and application requirements.

Author

Spacecraft Design; Microsatellites; Test Stands

20040079382 NASA Wallops Flight Center, Wallops Island, VA, USA

Laboratory Analysis of Polymer Thin Films for Planetary Balloons and Gossamer Structures

Sterling, Jerry; Fairbrother, Debora A.; 2004; In English, 19-22 Apr. 2004, Palm Springs, CA, USA; No Copyright; Avail: CASI; A02, Hardcopy

Commercially available polymer thin fdms with thickness of 15 microns or less were evaluated for potential application as the gas envelope material of balloons and other inflated vehicles. Films on this thickness scale are of interest for Earth and Mars ballooning as well as many gossamer space structures. Due to the uniqueness of these missions relative to typical uses of these materials, application-specific materials properties measurements were made. We evaluated numerous polymer chemistries, plus a few variations within one chemistry. The data show that there are often trade-offs among the different materials, such as with polyesters and polyimides having greater stiffness (modulus) but lower tear propagation resistance than polyethylene. Sections of polyethylene films can be joined by heat sealing, while adhesives and their accompanying mass penalty must be used with polyesters and polyimides. When the analysis temperature is reduced to 190 K, polyethylenes display dramatically increased stiffness and yield point, while the increase for other materials is more modest. The data also show that manufacturing processes can significantly affect film properties. To emphasize the need for application-specific properties assessment, we discuss two recent applications using these materials.

Author

Large Space Structures; Balloons; Spacecraft Structures; Polyimides; Thin Films

20040074341 NASA Langley Research Center, Hampton, VA, USA

Validation of Laser-Induced Fluorescent Photogrammetric Targets on Membrane Structures

Jones, Thomas W.; Dorrington, Adrian A.; Shortis, Mark R.; Hendricks, Aron R.; May 04, 2004; In English, 19-22 Apr. 2004, Palm Springs, CA, USA

Contract(s)/Grant(s): 23-090-20-15

Report No.(s): AIAA Paper 2004-1663; Copyright; Avail: CASI; A02, Hardcopy

The need for static and dynamic characterization of a new generation of inflatable space structures requires the advancement of classical metrology techniques. A new photogrammetric-based method for non-contact ranging and surface profiling has been developed at NASA Langley Research Center (LaRC) to support modal analyses and structural validation of this class of space structures. This full field measurement method, known as Laser-Induced Fluorescence (LIF) photogrammetry, has previously yielded promising experimental results. However, data indicating the achievable measurement precision had not been published. This paper provides experimental results that indicate the LIF-photogrammetry measurement precision for three different target types used on a reflective membrane structure. The target types were: (1) non-contact targets generated using LIF, (2) surface attached retro-reflective targets, and (3) surface attached diffuse targets. Results from both static and dynamic investigations are included.

Author

Laser Induced Fluorescence; Membrane Structures; Photogrammetry; Targets; Algorithms

20040073458 NASA Langley Research Center, Hampton, VA, USA

Development of Modal Test Techniques for Validation of a Solar Sail Design

Gaspar, James L.; Mann, Troy; Behun, Vaughn; Wilkie, W. Keats; Pappa, Richard; [2004]; In English, 19-22 Apr. 2004, Palm Springs, CA, USA

Contract(s)/Grant(s): 23-755-06-00

Report No.(s): AIAA Paper 2004-1665; No Copyright; Avail: CASI; A03, Hardcopy

This paper focuses on the development of modal test techniques for validation of a solar sail gossamer space structure design. The major focus is on validating and comparing the capabilities of various excitation techniques for modal testing solar sail components. One triangular shaped quadrant of a solar sail membrane was tested in a 1 Torr vacuum environment using various excitation techniques including, magnetic excitation, and surface-bonded piezoelectric patch actuators. Results from modal tests performed on the sail using piezoelectric patches at different positions are discussed. The excitation methods were evaluated for their applicability to in-vacuum ground testing and to the development of on orbit flight test techniques. The solar sail membrane was tested in the horizontal configuration at various tension levels to assess the variation in frequency with tension in a vacuum environment. A segment of a solar sail mast prototype was also tested in ambient atmospheric conditions using various excitation techniques, and these methods are also assessed for their ground test capabilities and on-orbit flight testing.

Author

Ground Tests; Solar Sails; Design Analysis; Fabrication; Flight Tests

20040073180 NASA Langley Research Center, Hampton, VA, USA

Design Considerations for an Integrated Solar Sail Diagnostics System

Jenkins, Christopher H. M.; Gough, Aaron R.; Pappa, Richard S.; Carroll, Joe; Blandino, Joseph R.; Miles, Jonathan J.; Rakoczy, John; [2004]; In English; 45th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, 19-22 Apr. 2004, Palm Springs, CA, USA

Contract(s)/Grant(s): 23-800-53-05

Report No.(s): AIAA Paper 2004-1510; No Copyright; Avail: CASI; A03, Hardcopy

Efforts are continuing under NASA support to improve the readiness level of solar sail technology. Solar sails have one of the best chances to be the next gossamer spacecraft flown in space. In the gossamer spacecraft community thus far, solar sails have always been considered a 'low precision' application compared with, say, radar or optical devices. However, as this paper shows, even low precision gossamer applications put extraordinary demands on structural measurement systems if they are to be traceable to use in space.

Author

Design Analysis; Systems Integration; Solar Sails; Diagnosis

20040068126 NASA Marshall Space Flight Center, Huntsville, AL, USA

The Development of Solar Sail Propulsion for NASA Science Missions to the Inner Solar System

Montgomery, Edward E, IV; Johnson, Charles Les; March 19, 2004; In English, 10-24 Apr. 2004, Palm Springs, CA, USA

Report No.(s): AIAA Paper 2004-1506; No Copyright; Avail: CASI; A02, Hardcopy

This paper examines recent assessments of the technology challenges facing solar sails, identifies the systems and technologies needing development, and the approach employed by NASA's In-space Propulsion Program in NASA to achieve near term products that move this important technology from low technology readiness level (TRL) toward the goal of application to science missions in near earth space and beyond. The status of on-going efforts to design, build, and test ground demonstrators of alternate approaches to structures (inflatable versus rigid), membrane materials, optical shape sensing, and attitude control will be presented along with planned future investments.

Author

Solar Sails; Technology Assessment

20040066101 NASA Langley Research Center, Hampton, VA, USA

Experimental and Numerical Correlation of Gravity Sag in Solar Sail Quality Membranes

Black, Jonathan T.; Leifer, Jack; DeMoss, Joshua A.; Walker, Eric N.; Belvin, W. Keith; [2004]; In English, 19-22 Apr. 2004, Palm Springs, CA, USA

Contract(s)/Grant(s): 23-755-06-00

Report No.(s): AIAA Paper 2004-1579; Copyright; Avail: CASI; A02, Hardcopy

Solar sails are among the most studied members of the ultra-lightweight and inflatable (Gossamer) space structures family due to their potential to provide propellentless propulsion. They are comprised of ultra-thin membrane panels that, to date, have proven very difficult to experimentally characterize and numerically model due to their reflectivity and flexibility, and the effects of gravity sag and air damping. Numerical models must be correlated with experimental measurements of sub-scale solar sails to verify that the models can be scaled up to represent full-sized solar sails. In this paper, the surface shapes of five horizontally supported 25 micron thick aluminized Kapton membranes were measured to a 1.0 mm resolution using photogrammetry. Several simple numerical models closely match the experimental data, proving the ability of finite element simulations to predict actual behavior of solar sails.

Author

Solar Sails; Membrane Structures; Gravitational Effects

20040058058 NASA Langley Research Center, Hampton, VA, USA

Static Testing of an Inflatable/Rigidizable Hexapod Structure

Berger, K. T.; Horta, L. G.; Taleghani, B. K.; April 02, 2004; In English, 19-22 Apr. 2004, Palm Springs, CA, USA

Contract(s)/Grant(s): 755-06-00

Report No.(s): AIAA Paper 2004-1801; No Copyright; Avail: CASI; A02, Hardcopy

Scientific application of large space antennas and telescopes is fostering the study of ultralightweight and inflatable structures. These so-called gossamer structures are tightly packaged for launch and subsequent deployment. Of particular interest is a hexapod configuration often found in vehicle ride simulators, ground-based telescopes, and antennas. One such

configuration was modeled and tested at NASA Langley. Discrepancies between dynamic test data and predictions from a finite element model prompted additional static testing. This paper discusses static tests that were conducted to update stiffness parameters in the finite element model.
Author
Inflatable Structures; Large Space Structures; Static Tests; Rigid Structures; Dynamic Structural Analysis; Mathematical Models

20040046903 Institute for Scientific Research, Fairmont, WV, USA
The Super Lightweight Interchangeable Carrier (SLIC) Project
March 30, 2004; In English
Contract(s)/Grant(s): NCC5-642; No Copyright; Avail: CASI; A01, Hardcopy

The Super Lightweight Interchangeable Carrier (SLIC) Grant consists of two separate but related phases. The first phase of this grant was conducted under a separate Institute for Scientific Research, Inc. (ISR) subcontract to FMW Composite Systems, Inc., of Bridgeport, West Virginia. FMW conducted early design and engineering associated with the future development of a stronger and lighter Space Shuttle carrier pallet. This improved pallet is intended to support the next and last planned Shuttle servicing mission for the on-orbit Hubble Space Telescope (HST). The salient characteristics of this carrier are increased performance, together with significantly reduced mass. As the next servicing mission is the last planned upgrade mission for the HST, this lighter and stronger pallet will enable greater payload delivery to the HST, potentially increasing the servicing mission effectiveness and science lifetime of the telescope. The second phase of this grant, conducted by ISR, consisted of a data systems study to exploit further the potential of the HST servicing pallet for other space missions, specifically for application of semi-permanent placement of science payloads on the International Space Station (ISS). As in the case of the HST, a lightweight and more rigid pallet could be employed to increase science return for the ISS. A data systems study intended to complement the current ISS s Institutional data system holds the potential of increasing the science return for data efficiency, just as the lightweight pallet serves to increase payload mass efficiency.
Author
Weight Reduction; Weighting Functions; Space Transportation System Flights; Delivery; Data Systems

20040034207 NASA Langley Research Center, Hampton, VA, USA
Preparation and Characterization of Space Durable Polymer Nanocomposite Films from Functionalized Carbon Nanotubes
Delozier, D. M.; Connell, J. W.; Smith, J. G.; Watson, K. A.; [2003]; In English, 10-12 Nov. 2003, San Francisco, CA, USA
Contract(s)/Grant(s): 23-755-06-08; No Copyright; Avail: CASI; A03, Hardcopy

Low color, flexible, space durable polyimide films with inherent, robust electrical conductivity have been under investigation as part of a continuing materials development activity for future NASA space missions involving Gossamer structures. Electrical conductivity is needed in these films to dissipate electrostatic charge build-up that occurs due to the orbital environment. One method of imparting conductivity is through the use of single walled carbon nanotubes (SWNTs). However, the incompatibility and insolubility of the SWNTs severely hampers their dispersion in polymeric matrices. In an attempt to improve their dispersability, SWNTs were functionalized by the reaction with an alkyl hydrazone. After this functionalization, the SWNTs were soluble in select solvents and dispersed more readily in the polymer matrix. The functionalized SWNTs were characterized by Raman spectroscopy and thermogravimetric analysis (TGA). The functionalized nanotubes were dispersed in the bulk of the films using a solution technique. The functionalized nanotubes were also applied to the surface of polyimide films using a spray coating technique. The resultant polyimide nanocomposite films were evaluated for nanotube dispersion, electrical conductivity, mechanical, and optical properties and compared with previously prepared polyimide-SWNT samples to assess the effects of SWNT functionalization.
Author
Polymer Matrix Composites; Polyimides; Aerospace Environments; Carbon Nanotubes; Electrostatic Charge; Nanocomposites

20040031784 NASA Langley Research Center, Hampton, VA, USA
Carbon Nanotube/Conductive Additive/Space Durable Polymer Nanocomposite Films for Electrostatic Charge Dissipation
Smith, Joseph G., Jr.; Watson, Kent A.; Delozier, Donavon M.; Connell, John W.; May 21, 2003; In English, 28 Sep. - 2 Oct. 2003, Dayton OH, USA
Contract(s)/Grant(s): 766-06-00-08; No Copyright; Avail: CASI; A03, Hardcopy

Thin film membranes of space environmentally stable polymeric materials possessing low color/solar absorptivity (alpha) are of interest for potential applications on Gossamer spacecraft. In addition to these properties, sufficient electrical conductivity is required in order to dissipate electrostatic charge (ESC) build-up brought about by the charged orbital environment. One approach to achieve sufficient electrical conductivity for ESC mitigation is the incorporation of single wall carbon nanotubes (SWNTs). However, when the SWNTs are dispersed throughout the polymer matrix, the nanocomposite films tend to be significantly darker than the pristine material resulting in a higher alpha. The incorporation of conductive additives in combination with a decreased loading level of SWNTs is one approach for improving alpha while retaining conductivity. Taken individually, the low loading level of conductive additives and SWNTs is insufficient in achieving the percolation level necessary for electrical conductivity. When added simultaneously to the film, conductivity is achieved through a synergistic effect. The chemistry, physical, and mechanical properties of the nanocomposite films will be presented.
Author
Carbon Nanotubes; Nanocomposites; Thin Films; Dissipation; Mechanical Properties; Electrostatics; Polyimides; Electrostatic Charge

20030105590 NASA Goddard Space Flight Center, Greenbelt, MD, USA
Novel Design Aspects of the Space Technology 5 Mechanical Subsystem
Rossoni, Peter; McGill, William; [2003]; In English, 11 Aug. 2003, Logan, UT, USA; No Copyright; Avail: CASI; A02, Hardcopy

This paper describes several novel design elements of the Space Technology 5 (ST5) spacecraft mechanical subsystem. The spacecraft structure itself takes a significant step in integrating electronics into the primary structure. The deployment system restrains the spacecraft during launch and imparts a predetermined spin rate upon release from its secondary payload accommodations. The deployable instrument boom incorporates some traditional as well as new techniques for lightweight and stiffness. Analysis and test techniques used to validate these technologies are described. Numerous design choices were necessitated due to the compact spacecraft size and strict mechanical subsystem requirements.
Author
Spacecraft Design; Spacecraft Components; Design Analysis; Structural Analysis

20030102564
Modeling of gossamer space structures with distributed transfer function method
Fang, Houfei; Lou, Michael; Yang, Bingen; Yang, Yaubin; Journal of Spacecraft and Rockets; July/August 2003; ISSN 0022-4650; Volume 40, Issue no. 4, p. 548-552; In English; Copyright; Avail: Other Sources

A new structural modeling and analysis method, the distributed transfer function method, is presented for application to gossamer space structures. The distributed transfer function method uses distributed transfer functions, instead of shape function used by traditional finite element solvers, to represent the displacement field. The distributed transfer function method maintains the modeling flexibility of the finite element method, so that it is capable of modeling multibody complex structures, but it requires much fewer nodes and results in a significant reduction of computational time. The distributed transfer functions give rise to closed-form analytical solutions of both displacement and strain fields. As a result, the distributed transfer function method only decomposes a structure at those points where multiple components are connected, to keep each component as large as possible. Gossamer space structures are generally composed of several long booms and large membranes. Therefore, the distributed transfer function method can be used to model a gossamer structure with a small number of unknowns and matrices of low order. It offers very accurate results with high computational efficiency. The distributed transfer function method is applied to investigate the sensitivity of buckling strength of an inflatable/rigidizable boom to the variations in bending stiffness.
EI
Aerospace Engineering; Bending; Buckling; Deformation; Strain Distribution; Technology Utilization

20030085718
Fabrication and testing of ultra lightweight Gossamer class composite mirrors
Chen, Peter C.; Oliversen, Ronald J.; Romeo, Robert C.; Proceedings of SPIE - The International Society for Optical Engineering; 2002; ISSN 0277-786X; Volume 4849, p. 339-347; In English; Highly Innovative Space Telescope Concepts, Aug. 22-23, 2002, Waikoloa, HI, USA; Copyright; Avail: Other Sources

The development of composite mirror technology under NASA Gossamer Spacecraft Initiative program was reported. The objectives were to produce moderate aperture, extremely low areal density mirrors with smooth surfaces and good optical

figure. Preliminary examinations of the optical surfaces showed that the 3.4 kg/m(sup 2) mirror, made using extremely thin 35 gsm material and a stiffening ring, had a fair optical figure but showed some mid - and high - frequency features.
EI
Composite Materials; Mirrors; Optics; Stiffness

20030068267 NASA Glenn Research Center, Cleveland, OH, USA
Durability of ITO-MgF2 Films for Space-Inflatable Polymer Structures
Kerslake, Thomas W.; Waters, Deborah L.; Schieman, David A.; Hambourger, Paul D.; July 2003; In English, 17-21 Aug. 2003, Portsmouth, VA, USA; Original contains color illustrations
Contract(s)/Grant(s): NCC3-740; NCC3-1023; NCC3-1033; WBS-22-757-01-12
Report No.(s): NASA/TM-2003-212512; E-14072; NAS 1.15:212512; AIAA Paper 2003-5919; No Copyright; Avail: CASI; A03, Hardcopy

This paper presents results from ITO-MgF2 film durability evaluations that included tape peel, fold, thermal cycle, and AO exposure testing. Polymer coupon preparation is described as well as ITO-MgF2 film deposition equipment, procedures and film characterization. Durability testing methods are also described. The pre- and post-test condition of the films is assessed visually, microscopically, and electrically. Results show that at ~500 ITO - 9 vol% MgF2 film is suitable to protect polymer surfaces, such as those used in space-inflatable structures of the PowerSphere microsatellite concept, during a 1-year Earth orbiting mission. Future plans for ground-based and orbital testing of this film are also discussed.
Author
Magnesium Fluorides; Durability; Protective Coatings

20030065917 NASA Langley Research Center, Hampton, VA, USA
Photogrammetric Measurement of Gossamer Spacecraft Membrane Wrinkling
Pappa, Richard S.; Black, Jonathan T.; Blandino, Joseph R.; [2003]; In English, 2-4 Jun. 2003, Charlotte, NC, USA; Original contains color illustrations; Copyright; Avail: CASI; A01, Hardcopy

Photogrammetry methods are being developed for measuring the shape and dynamics of future gossamer spacecraft structures, which characteristically contain large areas of thin-film membranes. Examples include solar sails, large membrane antennas, telescope sun shields, inflatable solar arrays, space solar power collectors and transmitters, radar arrays, and planetary balloons and habitats. Membrane wrinkling (and slackening)--caused by various sources including seaming and folding, nonuniform tensioning, thermal effects, and creep--can potentially reduce performance or cause overheating or structural fatigue in space. This paper documents an experimental photogrammetric technique capable of measuring membrane wrinkle patterns and amplitudes using thousands of projected dots of light and multiple synchronized cameras. Typical results are presented for a 0.5 m x 1.0 m area of interest on a 2m square solar sail model. In this application, the photogrammetric measurement precision was approximately 25 microns (0.001 inches). The paper closes by mentioning a promising extension of existing techniques using a laser-induced fluorescence approach.
Author
Photogrammetry; Spacecraft Structures; Wrinkling

20030065897 NASA Glenn Research Center, Cleveland, OH, USA
Solar Electric Propulsion Mission Architectures
Kerslake, Thomas W.; June 2003; In English, 21-24 Apr. 2003, Redondo Beach, CA, USA; Original contains color illustrations
Contract(s)/Grant(s): WBS-22-755-12-16
Report No.(s): NASA/TM-2003-212456; NAS 1.15:212456; E-13995; No Copyright; Avail: CASI; A03, Hardcopy

This presentation reviews Solar Electric Propulsion (SEP) Mission Architectures with a slant towards power system technologies and challenges. The low-mass, high-performance attributes of SEP systems have attracted spacecraft designers and mission planners alike and have led to a myriad of proposed Earth orbiting and planetary exploration missions. These SEP missions are discussed from the earliest missions in the 1960's, to first demonstrate electric thrusters, to the multi-megawatt missions envisioned many decades hence. The technical challenges and benefits of applying high-voltage arrays, thin film and low-intensity, low-temperature (LILT) photovoltaics, gossamer structure solar arrays, thruster articulating systems and microsat systems to SEP spacecraft power system designs are addressed. The overarching conclusion from this review is that SEP systems enhance, and many times enable, a wide class of space missions.
Author
Space Missions; Solar Electric Propulsion; Propulsion System Configurations; Interplanetary Spacecraft

20030065296 Air Force Inst. of Tech., Wright-Patterson AFB, OH, USA

Development, Fabrication and Ground Test of an Inflatable Structure Space-Flight Experiment

Philley, Thomas L., Jr; Mar. 2003; In English; Original contains color illustrations

Contract(s)/Grant(s): Proj-03-299

Report No.(s): AD-A413193; AFIT/GA/ENY/03-3; No Copyright; Avail: CASI; A08, Hardcopy

Inflatable, rigidizable structures provide a solution to reduce the costs associated with design, fabrication and launch of a space system while simultaneously increasing the deployment reliability and mission success of the system%. This research focused on the follow on design, fabrication, and ground test of the Rigidizable Inflatable Get-Away-Special Experiment (RIGEX). RIGEX is a self-contained experiment that will test the deployment and structural characteristics of three inflatable rigidizable tubes. Once inflated and rigidized, each tube will be excited using piezoelectric transducers in order to collect vibration data for structural characterization. The goal of this research was to collect ground testing data that will later be used in conjunction with actual space flight results in an effort to validate ground testing methodologies.

DTIC

Fabrication; Get Away Specials (STS); Ground Tests; Inflatable Structures; Spaceborne Experiments

20030065173 Institute for Computer Applications in Science and Engineering, Hampton, VA, USA

Space Durable Polyimide/Carbon Nanotube Composite Films for Electrostatic Charge Mitigation

Watson, Kent A.; Smith, Joseph G., Jr.; Connell, John W.; [2003]; In English, 11-15 May 2003, Long Beach, CA, USA

Contract(s)/Grant(s): NAS1-97046; No Copyright; Avail: CASI; A03, Hardcopy

Low color, space environmentally durable polymeric films with sufficient electrical conductivity to mitigate electrostatic charge (ESC) build-up have been under investigation as part of a materials development activity. These materials have potential applications on advanced spacecraft, particularly on large, deployable, ultra-light weight Gossamer spacecraft. The approach taken to impart sufficient electrical conductivity into the polymer film is based on the use of single walled carbon nanotubes (SWNT) as conductive additives. Earlier approaches investigated in our lab involved both an in-situ polymerization approach and addition of SWNT to an oligomer containing reactive end-groups as methods to improve SWNT dispersion. The work described herein is based on the spray coating of a SWNT/solvent dispersion onto the film surface. Two types of polyimides were investigated, one with reactive end groups that can lead to bond formation between the oligomer chain and the SWNT surface and those without reactive end-groups. Surface conductivities (measured as surface resistance) in the range sufficient for ESC mitigation were achieved with minimal effects on the mechanical, optical, thermo-optical properties of the film as compared to the other methods. The chemistry and physical properties of these nanocomposites will be discussed.

Author

Carbon Nanotubes; Polymeric Films; Electrostatic Charge; Electrical Resistivity; Electric Conductors; Polyimides; Nanocomposites

20030064329 Air Force Research Lab., Edwards AFB, CA, USA

Synthesis and Atomic Oxygen Erosion Testing of Space-Survivable POSS (polyhedral Oligomeric Silsesquioxane) Polyimides

Gonzalez, Rene L.; Tomczak, Sandra J.; Hoflund, Gar B.; Minton, Timothy K.; Brunsvold, Amy; Dec. 16, 2002; In English

Contract(s)/Grant(s): Proj-2303

Report No.(s): AD-A411707; AFRL/PRS-ED-AB-2002-312; No Copyright; Avail: CASI; A01, Hardcopy

The harsh environment present in both low-earth and geosynchronous orbit combined with the need for lighter weight and lower cost man-made orbiting bodies necessitates the design of multi-functional, space-survivable materials. Over the last two decades it has been well established that conventional polymers used in the construction of space vehicles undergo severe degradation resulting in reduced spacecraft lifetimes. In particular, the polyimide Kapton has been studied at length since it is widely used as a flexible substrate for lightweight high power solar arrays because of its inherent strength and desirable thermal properties. In addition to Kapton, thin films of fluorinated polymers such as Teflon FEP are used as the outer layer of multi-layer thermal control insulation because of their superior optical properties, including low solar absorptance and high thermal reflectance. These polymeric materials degrade because spacecraft surfaces must endure a high incident fluences of atomic oxygen (AO), bombardment by low and high-energy charged particles, and thermal cycling along with the full spectrum of solar radiation. Hybrid inorganic/organic polymers have the potential to meet the requirements of space-survivable materials by bridging the gap between ceramics and plastics, resulting in the prevention of AO and radiation damage that has hampered the widespread application of organic polymers in space. The Polymer Working Group at the Air Force Research Laboratory at Edwards AFB has incorporated inorganic POSS (Polyhedral Oligomeric Silsesquioxane) frameworks into traditional polymer systems resulting in hybrid POSS-polymers with dramatic property enhancements.

Addition of these POSS nanostructured frameworks into polymers results in increased use and decomposition temperatures, improved mechanical properties, and oxidation resistance.
DTIC
Mechanical Properties; Spacecraft Components; Organic Materials; Polyimides

20030063167 NASA Langley Research Center, Hampton, VA, USA
Laser-Induced Fluorescence Photogrammetry for Dynamic Characterization of Transparent and Aluminized Membrane Structures
Dorrington, Adrian A.; Jones, Thomas W.; Danehy, Paul M.; Pappa, Richard S.; [2003]; In English, 20-23 Jul. 2003, Huntsville, AL, USA
Report No.(s): AIAA Paper 2003-4798; No Copyright; Avail: CASI; A02, Hardcopy

Photogrammetry has proven to be a valuable tool for static and dynamic profiling of membrane based inflatable and ultra-lightweight space structures. However, the traditional photogrammetric targeting techniques used for solid structures, such as attached retro-reflective targets and white-light dot projection, have some disadvantages and are not ideally suited for measuring highly transparent or reflective membrane structures. In this paper, we describe a new laser-induced fluorescence based target generation technique that is more suitable for these types of structures. We also present several examples of non-contact non-invasive photogrammetric measurements of laser-dye doped polymers, including the dynamic measurement and modal analysis of a 1m-by-1m aluminized solar sail style membrane.
Author
Laser Induced Fluorescence; Membrane Structures; Photogrammetry; Large Space Structures

20030062825 Florida Inst. of Tech., FL, USA
Collapsible Cryogenic Storage Vessel Project
Fleming, David C.; 2002 Research Reports: NASA/ASEE Fellowship Program; December 2002, 71-80; In English; Original contains black and white illustrations; No Copyright; Avail: CASI; A02, Hardcopy

Collapsible cryogenic storage vessels may be useful for future space exploration missions by providing long-term storage capability using a lightweight system that can be compactly packaged for launch. Previous development efforts have identified an 'inflatable' concept as most promising. In the inflatable tank concept, the cryogen is contained within a flexible pressure wall comprised of a flexible bladder to contain the cryogen and a fabric reinforcement layer for structural strength. A flexible, high-performance insulation jacket surrounds the vessel. The weight of the tank and the cryogen is supported by rigid support structures. This design concept is developed through physical testing of a scaled pressure wall, and through development of tests for a flexible Layered Composite Insulation (LCI) insulation jacket. A demonstration pressure wall is fabricated using Spectra fabric for reinforcement, and burst tested under noncryogenic conditions. An insulation test specimens is prepared to demonstrate the effectiveness of the insulation when subject to folding effects, and to examine the effect of compression of the insulation under compressive loading to simulate the pressure effect in a nonrigid insulation blanket under the action atmospheric pressure, such as would be seen in application on the surface of Mars. Although pressure testing did not meet the design goals, the concept shows promise for the design. The testing program provides direction for future development of the collapsible cryogenic vessel concept.
Author
Cryogenic Storage; Inflatable Structures; Storage Tanks

20030052892
Gossamer Superconductor, Mott Insulator, and Resonating Valence Bond State in Correlated Electron Systems
Zhang, F. C.; Physical Review Letters; May 23, 2003; ISSN 0031-9007; Volume 90, Issue no. 20, 207002-207002-4; In English
Contract(s)/Grant(s): FG03-01ER45687; Copyright

Gutzwiller variational method is applied to an effective two-dimensional Hubbard model to examine the recently proposed gossamer superconductor by Laughlin (LANL cond-mat/0209269). The ground state at half filled electron density is a gossamer superconductor for smaller intrasite Coulomb repulsion U and a Mott insulator for larger U. The gossamer superconducting state is similar to the resonating valence bond superconducting state, except that the chemical potential is approximately pinned at the mid of the two Hubbard bands away from the half filled.
Author (AIP)
Electronic Structure; Ground State; High Temperature Superconductors; Joints (Junctions); Superconductivity; Superconductors (Materials); Two Dimensional Models

20030046844

Sail deployment by microwave beam--experiments and simulations

Benford, Gregory; Goronostavea, Olga; Prichard, Alan; Benford, James; Nakodym, Lisa; Vaughan, David; Harris, Henry; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, Issue no. 1, 447-451; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNATIONAL FORUM- STAIF 2002, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

Unfurling and deployment of large-area, membrane structures in space is essential for many NASA purposes, such as large ultralight antennas and mirrors, occulters, collectors for SPS, and sailcraft for deep space exploration. Deployment is a complicated electromechanical problem, exacerbated by the difficulty and expense of realistic lab or space experiments. The requirement is to open and control very light but very large structures with a minimum of mechanical contact ('hands-off'), deployed from a minimum stowed volume (maximum packing fraction), while providing for control after deployment. We report here on a project that addresses deployment of carbon and other light materials by use of spin, charge and elastic forces. Last year we demonstrated microwave-driven spin of several types of sail by using polarized microwaves at JPL. In the first phase, we conducted experiments to study microwave beam-driven spin deployment, simulating this deployment and its extension to large structures in space. We will determine how efficiently spin forces couple to sail materials, what geometric shapes and material factors influence this electrodynamic efficiency, and develop analytical scaling rules for spin unfurling. This work is conducted under the Gossamer Program. [copyright] 2002 American Institute of Physics.

Author (AIP)

Deep Space; Large Space Structures; Membrane Structures; Microwave Equipment; Space Exploration; Spacecraft; Spacecraft Propulsion

20030046838

UV rigidized carbon-reinforced isogrid boom for Gossamer applications

Allred, Ronald E.; Hoyt, Andrea E.; McElroy, Paul M.; Scarborough, Stephen; Cadogan, David P.; AIP Conference Proceedings; January 14, 2002; ISSN 0094-243X; Volume 608, Issue no. 1, 406-413; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNATIONAL FORUM- STAIF 2002, 3-6 Feb 2002, Albuquerque, New Mexico, USA; Copyright

This work examined the feasibility of curing carbon fiber-reinforced open isogrid structures using sunlight. An orbital thermal analysis was conducted for these Gossamer structures with no insulation to determine the temperature profiles during the cure process. An epoxy-based resin was developed that showed near complete cure on carbon and hybrid carbon/glass tows and also cured at low temperatures. Demonstration hardware cured in sunlight and tested in compression to failure performed as well as similar thermally cured isogrid composites. [copyright] 2002 American Institute of Physics.

Author (AIP)

Carbon Fiber Reinforced Plastics; Carbon Fibers; Composite Materials; Compression Tests; Fiber Composites; Polymer Matrix Composites; Radiation Effects; Sunlight; Temperature Distribution; Thermal Analysis; Ultraviolet Radiation

20030019308 Air Force Research Lab., Kirkland AFB, NM USA

A Systems Engineering Study of Gossamer Optical Satellites

Robertson, Lawrence M.; Jan. 2002; In English

Contract(s)/Grant(s): Proj-8809

Report No.(s): AD-A409966; AFRL-VS-TR-2002-1007; No Copyright; Avail: CASI; A03, Hardcopy

This paper describes a systems engineering modeling effort for very large, Gossamer, space optical systems. The focus of this effort was to determine the effect proposed Gossamer technology has on top-level performance parameters and total systems weight and power. For each technology chosen, system performance was evaluated using 'first principals' approaches and then de-convolved into its specific hardware items. These specific hardware items and their performance, once identified, were flowed up into a single payload weight estimate. The payload weight was then combined with mission and spacecraft performance variables to create a single satellite system weight estimate. Finally, sensitivity of payload performance parameters within the payload weight estimate was performed in an attempt to understand the importance of the assumed technology performance.

DTIC

Systems Engineering; Payloads; Spacecraft Performance

20030015805 NASA Langley Research Center, Hampton, VA USA

Microwave-Driven Multifunctional Capability of Membrane Structures

Choi, Sang H.; Chu, Sang-Hyong; Song, Kyo D.; King, Glen C.; [2002]; In English, 9-12 Sep. 2002, Houston, TX, USA; Original contains color illustrations

Contract(s)/Grant(s): NCC1-280; No Copyright; Avail: CASI; A02, Hardcopy

A large, ultra lightweight space structure, such as solar sails and Gossamer spacecrafts, requires a distributed power source to alleviate wire networks, unlike the localized on-board power infrastructures typically found in most small spacecrafts. The concept of microwave-driven multifunctional capability for membrane structures is envisioned as the best option to alleviate the complexity associated with hard-wired control circuitry and on-board power infrastructures. A rectenna array based on a patch configuration for high voltage output was developed to drive membrane actuators, sensors, probes, or other devices. Networked patch rectenna array receives and converts microwave power into a DC power for an array of smart actuators. To use microwave power effectively, the concept of a power allocation and distribution (PAD) circuit is adopted for networking a rectenna/actuator patch array. The use of patch rectennas adds a significant amount of rigidity to membrane flexibility and they are relatively heavy. A dipole rectenna array (DRA) appears to be ideal for thin-film membrane structures, since DRA is flexible and light. Preliminary design and fabrication of PAD circuitry that consists of a few nodal elements were made for laboratory testing. The networked actuators were tested to correlate the network coupling effect, power allocation and distribution, and response time.

Author

Large Space Structures; Membrane Structures; Smart Structures; Microwaves; Spacecraft Power Supplies; Actuators; Rectennas

20030014744 NASA Marshall Space Flight Center, Huntsville, AL USA

Structural Modeling of a Five-Meter Thin Film Inflatable Antenna/Concentrator

Smalley, Kurt B.; Tinker, Michael L.; Taylor, W. Scott; Brunty, Joseph A., Technical Monitor; [2002]; In English; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

Inflatable structures have been the subject of renewed interest in recent years for space applications such as communications antennas, solar thermal propulsion, and space solar power. A major advantage of using inflatable structures in space is their extremely light weight. An obvious second advantage is on-orbit deployability and related space savings in the launch configuration. A recent technology demonstrator flight for inflatable structures was the Inflatable Antenna Experiment (IAE) that was deployed on orbit from the Shuttle Orbiter. Although difficulty was encountered in the inflation/deployment phase, the flight was successful overall and provided valuable experience in the use of such structures. Several papers on static structural analysis of inflated cylinders have been written, describing different techniques such as linear shell theory, and nonlinear and variational methods, but very little work had been done in dynamics of inflatable structures until recent years. In 1988 Leonard indicated that elastic beam bending modes could be utilized in approximating lower-order frequencies of inflatable beams. Main, et al. wrote a very significant 1995 paper describing results of modal tests of inflated cantilever beams and the determination of effective material properties. Changes in material properties for different pressures were also discussed, and the beam model was used in a more complex structure. The paper demonstrated that conventional finite element analysis packages could be very useful in the analysis of complex inflatable structures. The purposes of this paper are to discuss the methodology for dynamically characterizing a large 5-meter thin film inflatable reflector, and to discuss the test arrangement and results. Nonlinear finite element modal results are compared to modal test data. The work is significant and of considerable interest to researchers because of 1) the large size of the structure, making it useful for scaling studies, and 2) application of commercially available finite element software for modeling pressurized thin-film structures.

Author

Inflatable Space Structures; Thin Films; Antennas; Reflectors; Dynamic Structural Analysis

20030014135 NASA Langley Research Center, Hampton, VA USA

Reliability Testing of NASA Piezocomposite Actuators

Wilkie, W.; High, J.; Bockman, J.; [2002]; In English, 10-12 Jun. 2002, Bremen, Germany; Original contains color illustrations; No Copyright; Avail: CASI; A01, Hardcopy

NASA Langley Research Center has developed a low-cost piezocomposite actuator which has application for controlling vibrations in large inflatable smart space structures, space telescopes, and high performance aircraft. Tests show the NASA piezocomposite device is capable of producing large, directional, in-plane strains on the order of 2000 parts-per-million peak-to-peak, with no reduction in free-strain performance to 100 million electrical cycles. This paper describes methods,

measurements, and preliminary results from our reliability evaluation of the device under externally applied mechanical loads and at various operational temperatures. Tests performed to date show no net reductions in actuation amplitude while the device was moderately loaded through 10 million electrical cycles. Tests were performed at both room temperature and at the maximum operational temperature of the epoxy resin system used in manufacture of the device. Initial indications are that actuator reliability is excellent, with no actuator failures or large net reduction in actuator performance.
Author
Piezoelectric Actuators; Fiber Composites; Reliability; Tests

20030012920 NASA Langley Research Center, Hampton, VA USA
Microwave Power for Smart Membrane Actuators
Choi, Sang H.; Song, Kyo D.; Golembiewski, Walter T.; Chu, Sang-Hyon; King, Glen C.; [2002]; In English, 28 Jul. - 1 Aug. 2002, Washington, DC, USA; Original contains color illustrations
Contract(s)/Grant(s): NCC1-280
Report No.(s): IECEC-2002-Paper-20100; No Copyright; Avail: CASI; A02, Hardcopy

The concept of microwave-driven smart membrane actuators is envisioned as the best option to alleviate the complexity associated with hard-wired control circuitry. A large, ultra-light space structure, such as solar sails and Gossamer spacecrafts, requires a distribution of power into individual membrane actuators to control them in an effective way. A patch rectenna array with a high voltage output was developed to drive smart membrane actuators. Networked patch rectenna array receives and converts microwave power into a DC power for an array of smart actuators. To use microwave power effectively, the concept of a power allocation and distribution (PAD) circuit is developed and tested for networking a rectenna/actuator patch array. For the future development, the PAD circuit could be imbedded into a single embodiment of rectenna and actuator array with the thin-film microcircuit embodiment. Preliminary design and fabrication of PAD circuitry that consists of a sixteen nodal elements were made for laboratory testing.
Author
Actuators; Membrane Structures; Large Space Structures

20030003695 NASA Langley Research Center, Hampton, VA USA
Description of New Inflatable/Rigidizable Hexapod Structure Testbed for Shape and Vibration Control
Adetona, O.; Keel, L. H.; Horta, L. G.; Cadogan, D. P.; Sapna, G. H.; Scarborough, S. E.; [2002]; In English, 22-25 Apr. 2002, Denver, CO, USA
Report No.(s): AIAA Paper 2002-1451; Copyright; Avail: CASI; A01, Hardcopy; Distribution as joint owner in the copyright

Larger and more powerful space based instruments are needed to meet increasingly sophisticated scientific demand. To support this need, concepts for telescopes with apertures of 100 meters are being investigated, but the required technologies are not in hand today. Due to the capacity limits of launch vehicles, the idea of deploying, erecting, or inflating large structures in space is being considered. Recently, rigidization concepts of large inflatable structures have demonstrated the capability of weight reductions of up to 50% from current concepts with packaging efficiencies near 80%. One of the important aspects of inflatable structures is vibration mitigation and line-of-sight control. Such control tasks are possible only after actuators/sensors are properly integrated into a rigidizable concept. To study these issues, we have developed an inflatable/rigidizable hexapod structure testbed. The testbed integrates state of the art piezo-electric self-sensing actuators into an inflatable/rigidizable structure and a flat membrane reflector. Using this testbed, we plan to experimentally demonstrate achievable vibration and line-of-sight control. This paper contains a description of the testbed and an outline of the test plan.
Author
Inflatable Structures; Large Space Structures; Test Stands; Vibration Damping; Shape Control; Research and Development; Design Optimization; Structural Stability

20030002828 NASA Marshall Space Flight Center, Huntsville, AL USA
Deployment, Foam Rigidization, and Structural Characterization of Inflatable Thin-Film Booms
Schnell, Andrew R.; Leigh, Larry M., Jr.; Tinker, Michael L.; McConnaughey, Paul R., Technical Monitor; [2002]; In English; AIAA Stuctures, Structural Dynamics, and Materials Conference, 22-25 Apr. 2002, Denver, CO, USA
Contract(s)/Grant(s): RTOP 903-01-94
Report No.(s): AIAA Paper 2002-1376; Copyright; Avail: CASI; A02, Hardcopy; Distribution as joint owner in the copyright

Detailed investigation of the construction, packaging/deployment, foam rigidization, and structural characterization of polyimide film inflatable booms is described. These structures have considerable potential for use in space with solar

concentrators, solar sails, space power systems including solar arrays, and other future missions. Numerous thin-film booms or struts were successfully constructed, inflated, injected with foam, and rigidized. Both solid-section and annular test articles were fabricated, using Kapton polyimide film, various adhesives, Styrofoam end plugs, and polyurethane pressurized foam. Numerous inflation/deployment experiments were conducted and compared to computer simulations using the MSC/DYTRAN code. Finite element models were developed for several foam-rigidized struts and compared to model test results. Several problems encountered in the construction, deployment, and foam injection/rigidization process are described. Areas of difficulty included inadequate adhesive strength, cracking of the film arid leakage, excessive bending of the structure during deployment, problems with foam distribution and curing properties, and control of foam leakage following injection into the structure. Many of these problems were overcome in the course of the research.
Author
Booms (Equipment); Foams; Structural Analysis; Fabrication; Performance Tests; Inflatable Structures; Stiffness; Mathematical Models; Performance Prediction

20030002751 NASA Goddard Space Flight Center, Greenbelt, MD USA
Finite Element Analysis of Wrinkled Membrane Structures for Sunshield Applications
Johnston, John D.; Brodeur, Stephen J., Technical Monitor; [2002]; In English; 43rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 22-25 Apr. 2002, Denver, CO, USA
Report No.(s): AIAA Paper 2002-1456; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

The deployable sunshield is an example of a gossamer structure envisioned for use on future space telescopes. The basic structure consists of multiple layers of pretensioned, thin-film membranes supported by deployable booms. The prediction and verification of sunshield dynamics has been identified as an area in need of technology development due to the difficulties inherent in predicting nonlinear structural behavior of the membranes and because of the challenges involved. in ground testing of the full-scale structure. This paper describes a finite element analysis of a subscale sunshield that has been subjected to ground testing in support of the Next Generation Space Telescope (NGST) program. The analysis utilizes a nonlinear material model that accounts for wrinkling of the membranes. Results are presented from a nonlinear static preloading analysis and subsequent dynamics analyses to illustrate baseline sunshield structural characteristics. Studies are then described which provide further insight into the effect of membrane. preload on sunshield dynamics and the performance of different membrane modeling techniques. Lastly, a comparison of analytical predictions and ground test results is presented.
Author
Finite Element Method; Membrane Structures; Structural Analysis; Prediction Analysis Techniques; Scale Models; Sun

20030002750 NASA Langley Research Center, Hampton, VA USA
Photogrammetry Methodology Development for Gossamer Spacecraft Structures
Pappa, Richard S.; Jones, Thomas W.; Walford, Alan; Black, Jonathan T.; Robson, Stuart; Shortis, Mark R.; [2002]; In English, 22-25 Apr. 2002, Denver, CO, USA
Report No.(s): AIAA Paper 2002-1375; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

Photogrammetry--the science of calculating 3D object coordinates from images-is a flexible and robust approach for measuring the static and dynamic characteristics of future ultralightweight and inflatable space structures (a.k.a., Gossamer structures), such as large membrane reflectors, solar sails, and thin-film solar arrays. Shape and dynamic measurements are required to validate new structural modeling techniques and corresponding analytical models for these unconventional systems. This paper summarizes experiences at NASA Langley Research Center over the past three years to develop or adapt photogrammetry methods for the specific problem of measuring Gossamer space structures. Turnkey industrial photogrammetry systems were not considered a cost-effective choice for this basic research effort because of their high purchase and maintenance costs. Instead, this research uses mainly off-the-shelf digital-camera and software technologies that are affordable to most organizations and provide acceptable accuracy.
Author
Inflatable Space Structures; Mathematical Models; Photogrammetry; Methodology; Dynamic Characteristics

20030002240 NASA Langley Research Center, Hampton, VA USA
Computational Analysis of Towed Ballute Interactions
Gnoffo, Peter A.; Anderson, Brian P.; [2002]; In English, 24-26 Jun. 2002, Saint Louis, MO, USA; Original contains color illustrations
Report No.(s): AIAA Paper 2002-2997; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

A ballute (balloon-parachute) is an inflatable, aerodynamic drag device for application to planetary entry vehicles. Ballutes may be directly attached to a vehicle, increasing its cross-sectional area upon inflation, or towed behind the vehicle as a semi-independent device that can be quickly cut free when the requisite change in velocity is achieved. The aerothermodynamics of spherical and toroidal towed ballutes are considered in the present study. A limiting case of zero towline length (clamped system) is also considered. A toroidal system can be designed (ignoring influence of the tethers) such that all flow processed by the bow shock of the towing spacecraft passes through the hole in the toroid. For a spherical ballute, towline length is a critical parameter that affects aeroheating on the ballute being towed through the spacecraft wake. In both cases, complex and often unsteady interactions ensue in which the spacecraft and its wake resemble an aero spike situated in front of the ballute. The strength of the interactions depends upon system geometry and Reynolds number. We show how interactions may envelope the base of the towing spacecraft or impinge on the ballute surface with adverse consequences to its thermal protection system. Geometric constraints to minimize or eliminate such adverse interactions are discussed. The towed, toroidal system and the clamped, spherical system show greatest potential for a baseline design approach.
Author
Atmospheric Entry; Ballutes; Spacecraft Control; Flight Control; Towed Bodies; Computerized Simulation

20030001574 Virginia Polytechnic Inst. and State Univ., Blacksburg, VA USA
Dynamics and Control of Inflated Satellite Components
Inman, Daniel J.; Oct. 15, 2002; In English
Contract(s)/Grant(s): F49620-01-1-0213
Report No.(s): AD-A407918; No Copyright; Avail: CASI; A01, Hardcopy

The instrumentation purchased under this DURIP (Defense University Research Instrumentation Program) was in support of an ongoing effort to understand the dynamics of inflated satellite components and then to provide both shape and vibration control based on the discovered dynamics. Inflatable space-based devices have become popular over the past decade due to their minimal launch-mass and launch-volume. Once inflated, these space structures are subject to vibrations induced mechanically by guidance systems and space debris, as well as thermally-induced vibrations from variable amounts of direct sunlight during orbit around the Earth. Understanding the dynamics of inflated components and controlling the shape and vibrations of spaced-based structures is critical to ensuring optimal performance.
DTIC
Inflatable Structures; Large Space Structures; Vibration Damping; Spacecraft Structures

20030000796 NASA Langley Research Center, Hampton, VA USA
Close-Range Photogrammetry & Next Generation Spacecraft
Pappa, Richard S.; Professional Surveyor; June 2002; In English; Original contains color illustrations; Copyright; Avail: Other Sources

NASA is focusing renewed attention on the topic of large, ultra-lightweight space structures, also known as ‘gossamer’ spacecraft. Nearly all of the details of the giant spacecraft are still to be worked out. But it’s already clear that one of the most challenging aspects will be developing techniques to align and control these systems after they are deployed in space. A critical part of this process is creating new ground test methods to measure gossamer structures under stationary, deploying and vibrating conditions for validation of corresponding analytical predictions. In addressing this problem, I considered, first of all, the possibility of simply using conventional displacement or vibration sensor that could provide spatial measurements. Next, I turned my attention to photogrammetry, a method of determining the spatial coordinates of objects using photographs. The success of this research and development has convinced me that photogrammetry is the most suitable method to solve the gossamer measurement problem.
Derived from text
Large Space Structures; Photogrammetry; Ground Tests; Inflatable Space Structures; Dimensional Measurement; Coordinates

20030000594 Aerospace Corp., Los Angeles, CA USA
Comparison of the Electrical Performance of Various Amorphous Silicon Thin Film Solar Cells Produced for the PowerSphere Concept
Simburger, Edward J.; Ross, Jasen; Matsumoto, James; Baer, Jean; Presser, Nathan; Jeffery, Frank R.; 17th Space Photovoltaic Research and Technology Conference; October 2002, 65-73; In English; No Copyright; Avail: CASI; A02, Hardcopy

The Aerospace Corporation has independently developed conceptual designs for microsatellites and nanosatellites. This

development of microsatellites and nanosatellites for low earth orbits requires the collection of sufficient power for onboard instruments with a low weight, low volume spacecraft. Because the overall surface area of a microsatellite or nanosatellite is small, body-mounted solar cells are incapable of providing enough power. Deployment of traditional, rigid, solar arrays necessitates larger satellite volumes and weights, and also requires extra apparatus needed for pointing. One potential solution to this 'power choke' problem is the deployment of a large, spherical, inflatable power system. This power system, termed the 'PowerSphere', would offer a high collection area, low weight, and low stowage volume, and eliminate the need for a pointing mechanism. A laboratory model of a PowerSphere populated with Iowa Thin Film Technologies (ITFT) Amorphous Silicon Solar Cells is presented. Development of a thin film amorphous silicon solar cell for the PowerSphere concept has focused on the impact that the size of an individual cell and top contact design has on the electrical performance of these cells. PowerSpheres ranging in size from approximately 7 inches in diameter to 2 feet in diameter are under investigation. Aerospace Corporation contracted with ITFT to produce amorphous silicon solar cells in hexagonal and pentagonal shapes with the sides of individual pentagons and hexagons ranging from 1 inch to 5 inches. These cells were fabricated with three different grid patterns using the standard printed silver ink used for ITFT's standard terrestrial product. In addition a number of cells were produced on which Aerospace vapor deposited silver metal contacts.
Author (revised)
Amorphous Silicon; Microsatellites; Nanosatellites; Fabrication; Solar Cells; Thin Films; Electrical Properties; Performance Tests

20030000481 TRW, Inc., Redondo Beach, CA USA
Compositionally-Graded Shape Memory Film for Self-Deployment of Membrane Reflectors and Optics
Hill, Lisa; Carman, Greg; Brantley, Lott W., Sr., Technical Monitor; [2002]; In English; 2002 ASME International Mechanical Engineering Congress and Exposition, 17-22 Nov. 2002, New Orleans, LA, USA
Contract(s)/Grant(s): NAS8-01127; No Copyright; Avail: Other Sources; Abstract Only

The next generation of space systems will require large apertures in order to image faint targets or cover large areas of Earth. These large apertures must be able to fit inside a launch vehicle fairing, be light enough for launch into orbit, and deploy on orbit with repeatability and reliability. The current state-of-the-art in flight optics is represented by the 4 meter LAMP telescope, with an areal density of 10 km sq m. Development of a Beryllium mirror demonstration article for NGST (Next Generation Space Telescope) at the University of Arizona indicate areal densities of 0.5 kg sq m with flight hardware in the 12 meter range. With progressive improvements in existing deployment, packaging, and structural technologies, the size of optics and reflectors will continue to increase, while mass is reduced. However, without a breakthrough in materials, packaging and/or deployment technologies, the goal for Gossamer structures of 0.1 kg sq m is unachievable for the near and mid-term NASA missions. Membrane technology provides the best hope of achieving such low areal densities. In combination with advances in membrane materials and structures, development of revolutionary techniques for deployment systems can provide significant improvements in large aperture technology. In this paper, the results of a six-month Phase I research effort to demonstrate the application of thin film NiTi to aerospace-qualified membrane and mesh materials are presented. Deposition of shape memory thin film was achieved Astromesh (trademark) metal mesh and CP-1, and optical-quality polymer membrane. Not only was full-coating deposition demonstrated, but also small segment deposition which holds potential for local surface control. Deployment of these materials was also demonstrated, setting the stage for the development of a larger test article. Author
Apertures; Spaceborne Telescopes; Research and Development; Thin Films; Materials Selection; Membrane Structures; Deposition

20020090908 NASA Goddard Space Flight Center, Greenbelt, MD USA
The Effect of Asymmetric Mechanical and Thermal Loading on Membrane Wrinkling
Blandino, Joseph R.; Johnston, John D.; Miles, Jonathan J.; Dharamsi, Urmil K.; Brodeur, Stephen J., Technical Monitor; [2002]; In English; AIAA Structural Dynamics and Materials Conference (SDM), 22-25 Apr. 2002, Denver, CO, USA
Contract(s)/Grant(s): NAG5-10701
Report No.(s): AIAA Paper 2002-1371; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

Large, tensioned membranes are being considered for future gossamer spacecraft systems. Examples include sunshields, solar sails, and membrane optics. In many. cases a relatively flat membrane with minimal wrinkling is desired. Developing methods to predict and measure membrane wrinkling is important to the future development of gossamer spacecraft. Numerical and experimental data are presented for a 0.5 m square, tensioned membrane. The membrane is subjected to symmetric and asymmetric mechanical loading. Data are also presented for a symmetrically loaded membrane subjected to spot heating in the center. The numerical model shows good agreement with the experiment for wrinkle angle data. There is.

also reasonable agreement for the wrinkled area for both isothermal and elevated temperature tests.
Author
Membranes; Asymmetry; Wrinkling; Solar Sails; Membrane Structures

20020084568 NASA Goddard Space Flight Center, Greenbelt, MD USA
Parametric Study of the Effect of Membrane Tension on Sunshield Dynamics
Ross, Brian; Johnston, John D.; Smith, James; Feb. 04, 2002; In English, 22-25 Apr. 2002, Denver, CO, USA
Report No.(s): AIAA Paper 2002-1459; No Copyright; Avail: CASI; A03, Hardcopy

The NGST sunshield is a lightweight, flexible structure consisting of pretensioned membranes supported by deployable booms. The structural dynamic behavior of the sunshield must be well understood in order to predict its influence on observatory performance. A 1/10th scale model of the sunshield has been developed for ground testing to provide data to validate modeling techniques for thin film membrane structures. The validated models can then be used to predict the behaviour of the full scale sunshield. This paper summarizes the most recent tests performed on the 1/10th scale sunshield to study the effect of membrane preload on sunshield dynamics. Topics to be covered include the test setup, procedures, and a summary of results.
Author
Membrane Structures; Dynamic Structural Analysis; Sun; Tension; Scale Models; Acceleration (Physics)

20020068820 South Dakota State Univ., Brookings, SD USA
Finite Element Modeling of Deployment, and Foam Rigidization of Struts and Quarter Scale Shooting Star Experiment
Leigh, Larry, Jr.; Research Reports: 2001 NASA/ASEE Summer Faculty Fellowship Program; July 2002, XXX-1 - XXX-5; In English; No Copyright; Avail: CASI; A01, Hardcopy

Inflated cylindrical struts constructed of kapton polyimide film and rigidized with foam have considerable practical application and potential for use as components of inflatable concentrator assemblies, antenna structures and space power systems, Because of their importance, it is of great interest to characterize the dynamic behavior of these components and structures both experimentally and analytically. It is very helpful to take a building-block approach to modeling and understanding inflatable assemblies by first investigating in detail the behavior of the components such as the struts. The foam material used for rigidization of such cylinders has varying modulus, which is a function of different factors, such as density of the foam. Thus, the primary motivation of the tests and analytical modeling efforts was to determine and understand the response of foam-rigidized cylinders for different densities, sizes, and construction methods, In recent years, inflatable structures have been the subject of renewed interest for space applications such as communications antennae, solar thermal propulsion, and space solar power. A major advantage of using inflatable structures in space is that they are extremely lightweight. This makes inflatables a perfect match for solar thermal propulsion because of the low thrust levels available. An obvious second advantage is on-orbit deployability and subsequent space savings in launch configuration. It can be seen that inflatable cylindrical struts and torus are critical components of structural assemblies. In view of this importance, structural dynamic and static behaviors of typical rigidized polyimide struts are investigated in this paper. The paper will focus on the finite element models that were used to model the behavior of the complete solar collector structure, and the results that they provided, as compared to test data.
Derived from text
Finite Element Method; Kapton (Trademark); Foams; Inflatable Space Structures; Spacecraft Structures; Struts; Cylindrical Shells

20020066590 Cornerstone Research Group, Inc., USA
Conformal Membrane Reflectors for Deployable Optics
Hood, Patrick J.; Keys, Andrew S., Technical Monitor; May 20, 2002; In English; 2nd Annual Technology Days, 22-24 May 2002, Huntsville, AL, USA
Contract(s)/Grant(s): NAS8-01115; No Copyright; Avail: Other Sources; Abstract Only

This presentation reports the Phase I results on NASA's Gossamer Spacecraft Exploratory Research and Technology Program. Cornerstone Research Group, Inc., the University of Rochester, and International Photonics Consultants collaborated to investigate the feasibility of free-standing, liquid-crystal-polymer (LCP) reflectors for integration into space-based optical systems. The goal of the program was to achieve large-diameter, broadband. reflective membranes that are resistant to the effects of space, specifically cryogenic environments and gamma-ray irradiation. Additionally, we assessed the applicability of utilizing the technology as tight sails, since, by their very nature, these films offer high-reflectivity at specified wavelengths.

Previous research programs have demonstrated all-polymer, narrow-band Specular reflectors and diffuse membrane reflectors. The feasibility of fabricating an all-polymer broadband specular reflector and a narrow-band specular membrane reflector was assessed in the Phase I Gossamer program. In addition, preliminary gamma irradiation studies were conducted to determine the stability of the polymer reflectors to radiation. Materials and process technology were developed to fabricate coupon-scale reflectors of both broad- and narrow-band specular reflectors in Phase 1. This presentation will report the results of these studies, including, the performance of a narrow-band specular membrane. Gamma irradiation exposures indicate limited impact on the optical performance although additional exposure studies are warranted. Plans to scale up the membrane fabrication process will be presented.
Author
Membranes; Reflectors; Sails; Spacecraft Propulsion; Space Flight

20020052243 Air Force Inst. of Tech., Wright-Patterson AFB, OH USA
Experimental Vibration Analysis of Inflatable Beams for an AFIT Space Shuttle Experiment
Single, Thomas G.; Mar. 2002; In English
Contract(s)/Grant(s): Proj. 02-131
Report No.(s): AD-A401458; AFIT/GSO/ENY/02-2; No Copyright; Avail: CASI; A09, Hardcopy

The Department of Defense, NASA, and others, are considering space-based inflatable structures to reduce the costs' associated with the design, manufacturing, and launch of space structures. The Rigidized Inflatable Get-Away-Special Experiment (RIGEX) is an autonomous, self-contained Space Shuttle experiment that will inflate and rigidize several cylindrical beam structures. After inflation and rigidization, the experiment will perform a vibration analysis by exciting the rigidized beams with piezoelectric transducers (PZTs) and collecting the acceleration at the tip of the beam via a tri-axial accelerometer in the zero-g vacuum of space. This thesis presents the experimental vibration analysis for the beams on the ground, using a shaker for excitation to characterize the modal properties. Piezoelectric transducers are then used for excitation in modal tests in a near-vacuum. The test data for the bending modes are compared to all Euler-Bernoulli beam theory model to determine its validity for analytic prediction.
DTIC
Get Away Specials (STS); Inflatable Structures; Autonomy; Vibration Tests; Space Shuttles; Beams (Supports)

20020044829 NASA Marshall Space Flight Center, Huntsville, AL USA
Ultralightweight Space Deployable Primary Reflector Demonstrator
Montgomery, Edward E., IV; Zeiders, Glenn W.; Smith, W. Scott, Technical Monitor; [2002]; In English; 43rd AIAA/ASME/ASCE/AHS Structures, Structural Dynamics and Materials Conference, 21-25 Apr. 2002, Denver, CO, USA; No Copyright; Avail: CASI; A01, Hardcopy

A concept has been developed and analyzed and several generational prototypes built for a gossamer-class deployable truss for a mirror or reflector with many smaller precisely-figured solid elements attached will, for at least the next several decades, minimize the mass of a large primary mirror assembly while still providing the high image quality essential for planet-finding and cosmological astronomical missions. Primary mirror segments are mounted in turn on ultralightweight thermally-formed plastic panels that hold clusters of mirror segments in rigid arrays whose tip/tilt and piston would be corrected over the scale of the plastic panels by the control segments. Prototype panels developed under this program are 45 cm wide and fabricated from commercially available Kaplan sheets. A three-strut octahedral tensegrity is the basis for the overall support structure. Each fundamental is composed of two such octahedrons, rotated oppositely about a common triangular face. Adjacent modules are joined at the nodes of the upper and lower triangles to form a deployable structure that could be made arbitrarily large. A seven-module dowel-and-wire prototype has been constructed. Deployment techniques based on the use of collapsing toggled struts with diagonal tensional elements allows an assembly of tensegrities to be fully collapsed and redeployed. The prototype designs will be described and results of a test program for measuring strength and deformation will be presented.
Author
Segmented Mirrors; Panels; Prototypes; Trusses

20020039136 NASA Glenn Research Center, Cleveland, OH USA

Simulated Space Vacuum Ultraviolet (VUV) Exposure Testing for Polymer Films

Dever, Joyce A.; Pietromica, Anthony J.; Stueber, Thomas J.; Sechkar, Edward A.; Messer, Russell K.; January 2002; In English; 39th Aerospace Sciences Meeting and Exhibit, 8-11 Jan. 2001, Reno, NV, USA

Contract(s)/Grant(s): RTOP 755-1A-13

Report No.(s): NASA/TM-2002-211337; E-13148; NAS 1.15:211337; AIAA Paper 2001-1054; No Copyright; Avail: CASI; A03, Hardcopy

Vacuum ultraviolet (VUV) radiation of wavelengths between 115 and 200 nm produced by the sun in the space environment can cause degradation to polymer films producing changes in optical, mechanical, and chemical properties. These effects are particularly important for thin polymer films being considered for ultra-lightweight space structures, because, for most polymers, VUV radiation is absorbed in a thin surface layer. NASA Glenn Research Center has developed facilities and methods for long-term ground testing of polymer films to evaluate space environmental VUV radiation effects. VUV exposure can also be used as part of sequential simulated space environmental exposures to determine combined damaging effects. This paper will describe the effects of VUV on polymer films and the necessity for ground testing. Testing practices used at Glenn Research Center for VUV exposure testing will be described including characterization of the VUV radiation source used, calibration procedures traceable to the National Institute of Standards and Technology (NIST), and testing techniques for VUV exposure of polymer surfaces.

Author

Aerospace Environments; Far Ultraviolet Radiation; Spacecraft Structures; Thin Films; Environmental Tests; Polymeric Films

20020024648 Cordant Technologies, Inc., Brigham City, UT USA

Materials for Space-Formed, Rigidized Structures Used in Solar Thermal Propulsion Concepts

Lester, D. M.; Cannon, D. M.; McWhorter, B. B.; Jan. 31, 2000; In English; Original contains color images

Contract(s)/Grant(s): F04611-97-C-0033; AF Proj. 1011

Report No.(s): AD-A397990; AFRL-PR-ED-TP-2000-027; No Copyright; Avail: CASI; A02, Hardcopy

Large, inflatable, solar collector support structures that can be conveniently stowed, deployed, and efficiently rigidized are important components of solar thermal propulsion systems. Spacecraft powered by solar propulsion engines will be able to provide the velocity change required to economically maneuver large payloads from one orbit to another. This is an innovative concept, that when applied, will double the efficiency of currently used LH2/LO2 chemical engines. The Air Force Research Lab (AFRL) has funded Thiokol Propulsion to develop rigidized solar collector support structures. This paper will address the properties of materials used for the in situ construction of rigidized structures in space. Photo-polymerization, thermal curing using resistive heating and the use of thermoplastics will be discussed. Space processing of polymeric materials presents significant issues including outgassing, required cure energy, and the thermal extremes of the orbital environment. These issues will be addressed and the current status will be reviewed.

DTIC

Solar Thermal Propulsion; Solar Collectors; Inflatable Structures; Rigid Structures

20020024629 Cordant Technologies, Inc., Brigham City, UT USA

Solar Concentrator Inflation Control System

Lester, D. M.; Wassom, S. R.; Hancey, B. D.; Siefkas, P. L.; Jan. 31, 2000; In English; Original contains color images

Contract(s)/Grant(s): F04611-97-C-0033; AF Proj. 1011

Report No.(s): AD-A397989; AIAA-2000-1571; AFRL-PR-ED-TP-2000-024; No Copyright; Avail: CASI; A03, Hardcopy

An important component of any space-rated inflatable structure is the inflation system. Precise control of the inflation pressure during deployment and operation prevents unwanted dynamic responses in the structure. This paper describes the development and operation of an inflation control system used during low pressure (5E-5 torr) testing of an inflatable solar concentrator. An advanced rapid prototyping method was used to go from concept to vacuum chamber deployment in 6 weeks. A block diagram of the dynamic system was graphically constructed and the closed-loop controller was designed and simulated. This model was then automatically converted to optimized C code. This code was compiled. linked. downloaded. and run in real time on a special Pentium-based PC. Connections between the real hardware and the simulation program were formed and edited graphically. A user-built interactive animation interface on the host PC enabled the user to monitor all outputs and change controller parameters 'on the fly' with graphical sliders, buttons, and switches. The inflation control system uses special logic to send out very small pulses of gas during inflation. This slow inflation dramatically reduced the violent effects of gas expansion under vacuum conditions. The controller proved successful in controlling both torus and concentrator

pressures to pre-set values during a 6 hour thermal vacuum test in a large NASA vacuum chamber.
DTIC
Solar Collectors; Solar Thermal Propulsion; Inflatable Space Structures; Inflating; Controllers

20020017457 Joint Inst. for the Advancement of Flight Sciences, Hampton, VA USA
Pathfinder Photogrammetry Research for Ultra-Lightweight and Inflatable Space Structures
Giersch, Louis Roy Miller; November 2001; In English
Contract(s)/Grant(s): NCC1-01017; RTOP 755-06-00-03
Report No.(s): NASA/CR-2001-211244; NAS 1.26:211244; No Copyright; Avail: CASI; A05, Hardcopy

The defining characteristic of ultra-lightweight and inflatable space structures is that they are both very large and very low mass. This makes standard contacting methods of measurement (e.g. attaching accelerometers) impractical because the dynamics of the structure would be changed by the mass of the contacting instrument. Optical measurements are therefore more appropriate. Photogrammetry is a leading candidate for the optical analysis of gossamer structures because it allows for the measurement of a large number of points, is amenable to time sequences, and offers the potential for a high degree of accuracy. The purpose of this thesis is to develop the methodology and determine the effectiveness of a photogrammetry system in measuring ultra-lightweight and inflatable space structures. The results of this thesis will be considered in the design of an automated photogrammetry system for the l6m-diameter vacuum chamber at the NASA Langley Research Center.
Author
Photogrammetry; Inflatable Space Structures; Optical Measurement; Structural Analysis

20020005989
The development of inflatable array antennas
Huang, J.; IEEE Antennas & Propagation Magazine; Aug 2001; ISSN 1045-9243; Volume 43, Issue No. 4, 44-50; In English; Copyright; Avail: Other Sources

Inflatable array antennas are being developed to significantly reduce the mass, the launch vehicle's stowage volume, and the cost of future spacecraft systems. Three inflatable array antennas, recently developed for spacecraft applications, are a 3.3 m x 1.0 m L-band synthetic-aperture radar (SAR) array, a 1.0 m-diameter X-band telecom reflectarray, and a 3 m-diameter Ka-band telecom reflectarray. All three antennas are similar in construction, and each consists of an inflatable tubular frame that supports and tensions a multi-layer thin-membrane RF radiating surface with printed microstrip patches. The L-band SAR array achieved a bandwidth of 80 MHz, an aperture efficiency of 74%, and a total mass of 15 kg. The X-band reflectarray achieved an aperture efficiency of 37%, good radiation patterns, and a total mass of 1.2 kg (excluding the inflation system). The 3 m Ka-band reflectarray achieved a surface flatness of 0.1 mm RMS, good radiation patterns, and a total mass of 12.8 kg (excluding the inflation system). These antennas demonstrated that inflatable arrays are feasible across the microwave and millimeter-wave spectrums. Further developments of these antennas are deemed necessary, in particular, in the area of qualifying the inflatable structures for space-environment usage.
Author (CSA)
Inflatable Structures; Launching; Satellite Communication; Synthetic Aperture Radar; Antenna Radiation Patterns; Directional Antennas; Antennas; Reflectors; Microwave Antennas; Bandwidth; Technology Utilization; Computerized Simulation; Aerospace Environments; Antenna Arrays; Extremely High Frequencies; Launch Vehicles; Microstrip Antennas; Millimeter Waves; Radio Frequencies; Reflector Antennas; Superhigh Frequencies; Ultrahigh Frequencies

20010106118 NASA Goddard Space Flight Center, Greenbelt, MD USA
Corner Wrinkling at a Square Membrane Due to Symmetric Mechanical Loads
Blandino, Joseph R.; Johnston, John D.; Dharamsi, Urmil K.; Brodeur, Stephen J., Technical Monitor; [2001]; In English; No Copyright; Avail: CASI; A03, Hardcopy

Thin-film membrane structures are under consideration for use in many future gossamer spacecraft systems. Examples include sunshields for large aperture telescopes, solar sails, and membrane optics. The development of capabilities for testing and analyzing pre-tensioned, thin film membrane structures is an important and challenging aspect of gossamer spacecraft technology development. This paper presents results from experimental and computational studies performed to characterize the wrinkling behavior of thin-fi[m membranes under mechanical loading. The test article is a 500 mm square membrane subjected to symmetric comer loads. Data is presented for loads ranging from 0.49 N to 4.91 N. The experimental results show that as the load increases the number of wrinkles increases, while the wrinkle amplitude decreases. The computational model uses a finite element implementation of Stein-Hedgepeth membrane wrinkling theory to predict the behavior of the membrane.

Comparisons were made with experimental results for the wrinkle angle and wrinkled region. There was reasonably good agreement between the measured wrinkle angle and the predicted directions of the major principle stresses. The shape of the wrinkle region predicted by the finite element model matches that observed in the experiments; however, the size of the predicted region is smaller than that determined in the experiments.
Author
Thin Films; Membrane Structures; Loads (Forces); Mathematical Models

20010089255 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA
Modeling and Analysis of Wrinkled Membranes: An Overview
Yang, B.; Ding, H.; Lou, M.; Fang, H.; Broduer, Steve, Technical Monitor; [2001]; In English; FEMCI Workshop 2001: Innovative FEM Solutions to Challenging Problems, 16-17 May 2001, Greenbelt, MD, USA; No Copyright; Avail: Other Sources; Abstract Only

Thin-film membranes are basic elements of a variety of space inflatable/deployable structures. Wrinkling degrades the performance and reliability of these membrane structures, and hence has been a topic of continued interest. Wrinkling analysis of membranes for general geometry and arbitrary boundary conditions is quite challenging. The objective of this presentation is two-fold. Firstly, the existing models of wrinkled membranes and related numerical solution methods are reviewed. The important issues to be discussed are the capability of a membrane model to characterize taut, wrinkled and slack states of membranes in a consistent and physically reasonable manner; the ability of a wrinkling analysis method to predict the formation and growth of wrinkled regions, and to determine out-of-plane deformation and wrinkled waves; the convergence of a numerical solution method for wrinkling analysis; and the compatibility of a wrinkling analysis with general-purpose finite element codes. According to this review, several opening issues in modeling and analysis of wrinkled membranes that are to be addressed in future research are summarized, The second objective of this presentation is to discuss a newly developed membrane model of two viable parameters (2-VP model) and associated parametric finite element method (PFEM) for wrinkling analysis are introduced. The innovations and advantages of the proposed membrane model and PFEM-based wrinkling analysis are: (1) Via a unified stress-strain relation; the 2-VP model treat the taut, wrinkled, and slack states of membranes consistently; (2) The PFEM-based wrinkling analysis has guaranteed convergence; (3) The 2-VP model along with PFEM is capable of predicting membrane out-of-plane deformations; and (4) The PFEM can be integrated into any existing finite element code. Preliminary numerical examples are also included in this presentation to demonstrate the 2-VP model and PFEM-based wrinkling analysis approach.
Author
Membrane Structures; Wrinkling; Large Space Structures; Computerized Simulation

20010089252 Swales Aerospace, Beltsville, MD USA
Structural Qualification Testing of the WindSat Payload Using Sine Bursts Near Structural Resonance
Pontius, Jim; Barnes, Donald; Broduer, Steve, Technical Monitor; [2001]; In English; FEMCI Workshop 2001: Innovative FEM Solutions to Challenging Problems, 16-17 May 2001, Greenbelt, MD, USA; No Copyright; Avail: Other Sources; Abstract Only

Sine burst tests are often used for structural qualification of space flight hardware. In most instances, the driving frequency of the shaker is specified far below the structure's first resonant mode, such that the entire test article sees uniform acceleration. For large structures, this limits qualification testing to lower parts of the structure, or else it over-tests the lower structure to achieve qualification of the upper structure. The WindSat payload, a 10.5 foot tall graphite/epoxy, titanium, and aluminum radiometer, experiences accelerations at the six foot diameter reflector nearly four times that at the spacecraft interface. Due to size of the payload, the number of bonded joints, and the lightweight reflector support structure design and construction, using static pull testing to qualify all of the bonded joints in the upper structure would result in large, expensive, and extensive test fixturing. Sine burst testing near the first two structural resonant modes was performed on the WindSat payload to achieve the correct load factor distribution up the stack for structural qualification. In this presentation, how finite element method (FEM) sine burst predictions were used in conjunction with low level random and sine burst tests to achieve correct qualification test load factor distribution on the WindSat payload is discussed. Also presented is the risk mitigation approach for using the uncorrelated FEM in this procedure.
Author
Performance Tests; Qualifications; Structural Analysis; Radiometers

20010089251 Veridian Systems, Inc., Yorktown, VA USA

Challenges Facing Design and Analysis Tools

Knight, Norman F., Jr.; Broduer, Steve, Technical Monitor; [2001]; In English; FEMCI Workshop 2001: Innovative FEM Solutions to Challenging Problems, 16-17 May 2001, Greenbelt, MD, USA; No Copyright; Avail: Other Sources; Abstract Only

The design and analysis of future aerospace systems will strongly rely on advanced engineering analysis tools used in combination with risk mitigation procedures. The implications of such a trend place increased demands on these tools to assess off-nominal conditions, residual strength, damage propagation, and extreme loading conditions in order to understand and quantify these effects as they affect mission success. Advances in computer hardware such as CPU processing speed, memory, secondary storage, and visualization provide significant resources for the engineer to exploit in engineering design. The challenges facing design and analysis tools fall into three primary areas. The first area involves mechanics needs such as constitutive modeling, contact and penetration simulation, crack growth prediction, damage initiation and progression prediction, transient dynamics and deployment simulations, and solution algorithms. The second area involves computational needs such as fast, robust solvers, adaptivity for model and solution strategies, control processes for concurrent, distributed computing for uncertainty assessments, and immersive technology. Traditional finite element codes still require fast direct solvers which when coupled to current CPU power enables new insight as a result of high-fidelity modeling. The third area involves decision making by the analyst. This area involves the integration and interrogation of vast amounts of information - some global in character while local details are critical and often drive the design. The proposed presentation will describe and illustrate these areas using composite structures, energy-absorbing structures, and inflatable space structures. While certain engineering approximations within the finite element model may be adequate for global response prediction, they generally are inadequate in a design setting or when local response prediction is critical. Pitfalls to be avoided and trends for emerging analysis tools will be described.

Author

Mathematical Models; Design Analysis; Decision Making; Aerospace Systems

20010089139 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA

DTFM Modeling and Analysis Method for Gossamer Structures

Fang, Hou-Fei; Lou, Michael; Broduer, Steve, Technical Monitor; [2001]; In English; FEMCI Workshop 2001: Innovative FEM Solutions to Challenging Problems, 16-17 May 2001, Greenbelt, MD, USA; No Copyright; Avail: Other Sources; Abstract Only

Gossamer systems are mostly composed of support structures formed by highly flexible, long tubular elements and pre-tensioned thin-film membranes. These systems offer order-of-magnitude reductions in mass and launch volume and will revolutionize the architecture and design of space flight systems that require large in-orbit configurations and apertures. A great interest has been generated in recent years to fly gossamer systems on near-term and future space missions. Modeling and analysis requirements for gossamer structures are unique. Simulation of in-space performance issues of gossamer structures, such as inflation deployment of flexible booms, formation and effects of wrinkle in tensioned membranes, synthesis of tubular and membrane elements into a complete structural system, usually cannot be accomplished by using the general-purpose finite-element structural analysis codes. This has led to the need of structural modeling and analysis capabilities specifically suitable for gossamer structures. The Distributed Transfer Function Method (DTFM) can potentially meet this urgent need. Additional information is contained in the original extended abstract.

Author

Membrane Structures; Computerized Simulation; Spacecraft Structures

20010067327 Touchstone Research Lab. Ltd., Triadelphia, WV USA

Polymer Matrix Composite (PMC) Analog Processes for Lightweight Aluminum Matrix Composite (AMC) Structures

Gordon, B.; Proceedings of The 4th Conference on Aerospace Materials, Processes, and Environmental Technology; February 2001; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Next-generation hypersonic aircraft, reusable launch vehicles, and low-cost spacecraft require new materials to meet decreasing vehicle weights, increasing payload capacity, and dramatically lower operating costs. Materials that have improved specific strength and specific stiffness, especially at cryogenic and elevated temperatures, enable commercial and Government customers to meet these aggressive program goals by supporting development of stronger, lighter, and more thermally stable integrated components. Touchstone's Brazed Aluminum Matrix Composite (AMC) material has nearly twice the specific strength and specific stiffness of structural aluminum alloys and maintains these properties at higher temperatures than current aerospace alloys. When in situ brazed from thin tape, the manufacturing of large highly integrated structures is possible with

minimal tooling. As such, this material and associated manufacturing process can serve as an enabling technology for many aircraft and spacecraft applications, including engine and thrust structures, feed lines and ducts, propellant tanks, and thermally stable satellite structures. This poster presentation discusses a new material and, more specifically, a new manufacturing system that enables development of high-performance aircraft and spacecraft components.
Author
Composite Structures; Polymer Matrix Composites; Aluminum Alloys; Manufacturing

20010067237 Physical Sciences, Inc., Andover, MA USA
Lightweight Multi-Layer Structural Materials
Legner, H. H.; DiCristina, V.; Marshall, D.; Singler, R.; Proceedings of The 4th Conference on Aerospace Materials, Processes, and Environmental Technology; February 2001; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

A new lightweight composite material with combined structural and thermal protection capability has been developed for both air vehicle and spacecraft applications. The basic concept consists of the integration of a high-density outer layer with a low-density foam core, using stitching loops to integrate the material three-dimensionally. The layers are chemically bonded and mechanically linked. The generalization of this technique to integrated structural materials with two high-density face plates sandwiching the low-density inner layer provides an entirely new approach to fabricating cost-effective aero-shell and spacecraft structural materials. These materials have been evaluated structurally, as well as thermally in arc-jet and laser tests. Thermal insulation performance exceeds that of standard heat protection materials. Measured compressive and bending strengths have shown substantial residual load-carrying capabilities. In addition, damage tolerance and crush strength properties have been demonstrated to be superior to comparable honeycomb structures.
Author
Composite Materials; Thermal Protection; Mechanical Properties

20010066834 Air Force Inst. of Tech., Wright-Patterson AFB, OH USA
RIGEX: Preliminary Design of a Rigidized Inflatable Get-Away-Special Experiment
DiSebastian, John D.; Mar. 2001; In English
Report No.(s): AD-A390157; No Copyright; Avail: CASI; A07, Hardcopy

As space structures grow in size and complexity, their weight and cost increase considerably. The use of inflatable and rigidizable structures offers drastic improvements in all areas of spacecraft design. The goal of this experiment is to verify and validate ground testing of inflation and rigidization methods for inflatable space structures. The Rigidized Inflatable Get-Away-Special Experiment is an autonomous, self-contained space shuttle experiment that will inflate and rigidize several structures. After inflation, the experiment will perform a structural analysis by exciting the rigidized structures and collecting vibration data. A systems engineering approach is utilized to make design decisions based on a total system and life-cycle perspective.
DTIC
Inflatable Space Structures; Large Space Structures; Spacecraft Design; Structural Analysis; Systems Engineering; Get Away Specials (STS)

20010066587 Air Force Inst. of Tech., Wright-Patterson AFB, OH USA
Environmental Disturbance Modeling for Large Inflatable Space Structures
Davis, Donald J.; Mar. 08, 2001; In English
Report No.(s): AD-A390192; AFIT/GSO/ENY/01M-02; No Copyright; Avail: CASI; A10, Hardcopy

Tightening space budgets and stagnating spacelift capabilities are driving the Air Force and other space agencies to focus on inflatable technology as a reliable, inexpensive means of deploying large structures in orbit. Recent improvements in rigidization techniques make the use these inflatable structures feasible for a growing number of missions. For many of these missions, the primary design requirement is dimensional accuracy of the structure. Finite element analysis offers a means of predicting structural behavior in orbit. The analysis requires knowledge of external loads. This thesis examines the environmental disturbances which act upon large, orbiting structures. Calculations are made on a base model to relate the torques generated by these disturbances to the orbital altitude. This facilitates identification of the critical loads. An environmental disturbance model is then developed in MATLAB. The model calculates the critical loads on each element of a faceted structure as it propagates through its orbit. A basic structure is defined and run through the model. Results and

analysis for various orbits are presented to verify accuracy of the code and validate the derived torque-altitude relationships. DTIC

Large Space Structures; Inflatable Structures; Mathematical Models; Disturbances

20010055272 NASA Ames Research Center, Moffett Field, CA USA

Refractory Oxidative-Resistant Ceramic Carbon Insulation

Leiser, Daniel B., Inventor; Hsu, Ming-Ta S., Inventor; Chen, Timothy S., Inventor; May 01, 2001; In English

Patent Info.: Filed 2 Nov. 1998; US-Patent-6,225,248; US-Patent Appl-SN-184415; NASA-Case-ARC-14202-1; No Copyright; Avail: CASI; A02, Hardcopy

High-temperature, lightweight, ceramic carbon insulation is prepared by coating or impregnating a porous carbon substrate with a siloxane gel derived from the reaction of an organodialkoxy silane and an organotrialkoxy silane in an acid or base medium in the presence of the carbon substrate. The siloxane gel is subsequently dried on the carbon substrate to form a ceramic carbon precursor. The carbon precursor is pyrolyzed, in an inert atmosphere, to form the ceramic insulation containing carbon, silicon, and oxygen. The carbon insulation is characterized as a porous, fibrous, carbon ceramic tile which is particularly useful as lightweight tiles for spacecraft.

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

Carbon; Ceramics; Insulation

20010054454 NASA Johnson Space Center, Houston, TX USA

Advanced Structural and Inflatable Hybrid Spacecraft Module

Schneider, William C., Inventor; delaFuente, Horacio M., Inventor; Edeen, Gregg A., Inventor; Kennedy, Kriss J., Inventor; Lester, James D., Inventor; Gupta, Shalini, Inventor; Hess, Linda F., Inventor; Lin, Chin H., Inventor; Malecki, Richard H., Inventor; Raboin, Jasen L., Inventor; May 15, 2001; In English

Patent Info.: Filed 25 Jan. 1999; US-Patent-6,231,010; US-Patent-Appl-SN-236785; NASA-Case-MSC-22900-1; No Copyright; Avail: CASI; A03, Hardcopy

An inflatable module comprising a structural core and an inflatable shell, wherein the inflatable shell is sealingly attached to the structural core. In its launch configuration, the wall thickness of the inflatable shell is collapsed by vacuum. Also in this configuration, the inflatable shell is collapsed and efficiently folded around the structural core. Upon deployment, the wall thickness of the inflatable shell is inflated; whereby the inflatable shell itself, is thereby inflated around the structural core, defining therein a large enclosed volume. A plurality of removable shelves are arranged interior to the structural core in the launch configuration. The structural core also includes at least one longeron that, in conjunction with the shelves, primarily constitute the rigid, strong, and lightweight load-bearing structure of the module during launch. The removable shelves are detachable from their arrangement in the launch configuration so that, when the module is in its deployed configuration and launch loads no longer exist, the shelves can be rearranged to provide a module interior arrangement suitable for human habitation and work. In the preferred embodiment, to provide efficiency in structural load paths and attachments, the shape of the inflatable shell is a cylinder with semi-toroidal ends.

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

Spacecraft Modules; Inflatable Spacecraft; Assemblies; Racks (Frames)

20010052923 NASA Goddard Space Flight Center, Greenbelt, MD USA

Achieving the Earth Science Enterprise Vision for the 21st Century: Platform Challenges

Lemmerman, Loren; Komar, George, Technical Monitor; [2001]; In English; IGARSS 2001, Jul. 2001, Sydney, Australia; No Copyright; Avail: Other Sources; Abstract Only

The ESE observational architecture of the future vision is dramatically different from that of today. The vision suggests observations from multiple orbits, collaborating space assets, and even seamless integration of space and other assets. Observations from GEO or from Libration points rather than from LEO suggest spacecraft carrying instruments with large deployable apertures. Minimization of launch costs suggests that these large apertures have long life, be extremely mass and volume efficient, and have low life cycle cost. Another significant challenge associated with high latitude orbits is high precision pointing and control. Finally, networks of spacecraft flying in predetermined constellation will be required either to apply complementary assets to an observation or to extend the virtual aperture beyond that attainable with a single spacecraft. These changes dictate development of new technology on several fronts, which are outlined in this paper. A section on high speed communications will outline requirements and approaches now envisioned. Sensorwebs will be developed from the viewpoint of work already begun for both space and for terrestrial networks. Precision guidance, navigation and control will

be addressed from the perspective of precision flying for repeat pass interferometry and extreme pointing stability for advanced altimetry. A separate section will address requirements for distributed systems. Large lightweight deployables will be discussed with an emphasis on inflatable technology and its predicted benefits for large aperture instruments. For each technology area listed, current state-of-the-art, technological approaches for future development, and projected levels of performance are outlined.
Author
Constellations; Earth Sciences; Interferometry; Navigation; Optimization; Pointing Control Systems; Spacecraft Instruments

20010049267 NASA Langley Research Center, Hampton, VA USA
Structural Dynamics Experimental Activities in Ultra-Lightweight and Inflatable Space Structures
Pappa, Richard S.; Lassiter, John O.; Ross, Brian P.; May 2001; In English, 16-19 Apr. 2001, Seattle, WA, USA
Contract(s)/Grant(s): RTOP 755-06-00-03
Report No.(s): NASA/TM-2001-210857; NAS 1.15:210857; L-18073; No Copyright; Avail: CASI; A03, Hardcopy

This paper reports recently completed structural dynamics experimental activities with new ultra-lightweight and inflatable space structures (a.k.a., 'Gossamer' spacecraft) at NASA Langley Research Center, NASA Marshall Space Flight Center, and NASA Goddard Space Flight Center. Nine aspects of this work are covered: 1) inflated, rigidized tubes, 2) active control experiments, 3) photogrammetry, 4) laser vibrometry, 5) modal tests of inflatable structures, 6) in-vacuum modal tests, 7) tensioned membranes, 8) deployment tests, and 9) flight experiment support. Structural dynamics will play a major role in the design and eventually in-space deployment and performance of Gossamer spacecraft. Experimental research and development such as this is required to validate new analysis methods. The activities discussed in the paper are pathfinder accomplishments. conducted on unique components and prototypes of future spacecraft systems.
Author
Active Control; Dynamic Response; Dynamic Structural Analysis; Inflatable Space Structures; Prototypes; Vacuum Tests; Vibration Measurement

20010041248 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA
Inflatable Vehicles for In-Situ Exploration of Titan
Jones, J. A.; Forum on Innovative Approaches to Outer Planetary Exploration 2001-2020; 2001, 46; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

Space Inflatable vehicles have been finding popularity in recent years for applications as varied as spacecraft antennas, space-based telescopes, solar sails, and manned habitats. Another branch of space inflatable technology has also considered developing ambient-filled, solar balloons for Mars as well as ambient-filled inflatable rovers. More recently, some of these inflatable technologies have been applied to the outer solar system bodies with the result that there are some rather unique and compelling inflatable mission capabilities for in situ explorations of Titan, Triton, Uranus, and Neptune. Additional information is contained in the original extended abstract.
Derived from text
Inflatable Spacecraft; Balloons; Space Exploration; Natural Satellites

20010012829 Air Force Office of Scientific Research, Bolling AFB, Washington, DC USA
An Innovative Approach to Satellite Technology
Janni, Joseph F.; King, Yolanda Jones; Witt, Gerald; Space-Based Observation Technology; October 2000, 17-1 - 17-7; In English; Copyright; Avail: CASI; A02, Hardcopy

Innovation and rapid prototyping using advanced technologies are the hallmarks of new initiatives coming from the USAF Research Laboratory's Office of Scientific Research (AFOSR). University Nanosatellite Program AFOSR, in conjunction with DARPA, is sponsoring ten universities, formed into small teams and challenged with paving the way to novel space capabilities. The satellites leverage innovative thinking within our universities, leading to flight experiments of state-of-technologies and advanced mission concepts. Experiments range from micro-propulsion to formation flying. These miniaturized satellites will be prototyped and launched. We describe the philosophy, approach, and results to date of the program. TechSat21 Program. Recent progress in the miniaturization of key satellite technologies enables innovative solutions for space missions. AFOSR, in Conjunction with ARFL'S Space Vehicles Directorate, has developed the TechSat 21 program. This low-cost, lightweight cluster of cooperating microsatellites may eventually replace today's heavy and more expensive systems. Each microsatellite will communicate with other members of the cluster to share information and mission functions, thus comprising a 'virtual' satellite. TechSat 21 offers the flexibility to incorporate cutting edge technology in a reconfigurable

constellation. This unusual approach offers multi-mission capability as well as a reduced life cycle cost. It is envisioned that new technology may be inserted by replacing members of the cluster with enhanced versions. Research and technology investments include sparse aperture sensing, local communications in space and microsatellite bus technologies. The investment in innovative. basic research areas to make TechSat 21 a viable alternative as well as the overall program approach will be covered. Many of the techniques and technologies being demonstrated in the University Satellite program have application to the TechSat2l program.
Derived from text
Microsatellites; Microminiaturization; Small Satellite Technology; Nanosatellites

20010011568 Aerospace Corp., El Segundo, CA USA
Solar Ultraviolet and Space Radiation Effects on Inflatable Materials
Stuckey, W. K.; Meshishnek, M. J.; Aug. 20, 2000; In English
Contract(s)/Grant(s): F04701-93-C-0094
Report No.(s): AD-A384429; TR-2000(8565)-9; SMC-TR-00-33; No Copyright; Avail: CASI; A03, Hardcopy

Inflatable structures are being developed for use in space to take advantage of the potential for lower packaging volumes and lighter weights. These structures may consist of thin polymer membranes as well as more robust inflatable, then rigidizable, structural elements. For space applications, it must be shown that the materials can tolerate the orbital environment. This includes the effects of solar radiation and electron/proton radiation on the optical properties and mechanical response of the materials, as well as atomic oxygen effects for possible LEO applications. The highest radiation concern is with the thin-film materials, e.g., the canopy and reflector of an antenna or components of a sun shade or solar sail. All materials used in an inflatable structure need to be capable of tolerating the orbital environment and maintaining properties within the mission requirements. The approach to assessing the effects of space environment on materials begins with consideration of the orbital environment. The solar radiation spectrum is not orbital dependent, but the radiation from electrons and protons varies by orders of magnitude, depending on the particular orbit. The atomic oxygen environment is strongly dependent on altitude and solar activity. Once an orbit has been defined, the atmospheric models are available to calculate the flux and energy of the particle radiation. The orbital lifetime then is used to calculate dose levels and solar exposures that the materials must tolerate. With the environment specified, the expected dose in the materials can then be calculated. If damage thresholds are available for the particular materials involved, possible degradation can be predicted; if not, a ground or orbital test is needed. For a ground test to assess the durability of a material in orbit, the methodology is to predict the dose levels in the materials, which then drive the test parameters.
DTIC
Inflatable Structures; Solar Activity; Solar Radiation; Ultraviolet Radiation; Radiation Effects; Extraterrestrial Radiation

20010005255 NASA Langley Research Center, Hampton, VA USA
Photogrammetry of a 5m Inflatable Space Antenna With Consumer Digital Cameras
Pappa, Richard S.; Giersch, Louis R.; Quagliaroli, Jessica M.; December 2000; In English; 19th, 5-8 Feb. 2001, Kissimmee, FL, USA
Contract(s)/Grant(s): RTOP 632-40-00-03
Report No.(s): NASA/TM-2000-210627; NAS 1.15:210627; L-18044; No Copyright; Avail: CASI; A03, Hardcopy

This paper discusses photogrammetric measurements of a 5m-diameter inflatable space antenna using four Kodak DC290 (2.1 megapixel) digital cameras. The study had two objectives: 1) Determine the photogrammetric measurement precision obtained using multiple consumer-grade digital cameras and 2) Gain experience with new commercial photogrammetry software packages, specifically PhotoModeler Pro from Eos Systems, Inc. The paper covers the eight steps required using this hardware/software combination. The baseline data set contained four images of the structure taken from various viewing directions. Each image came from a separate camera. This approach simulated the situation of using multiple time-synchronized cameras, which will be required in future tests of vibrating or deploying ultra-lightweight space structures. With four images, the average measurement precision for more than 500 points on the antenna surface was less than 0.020 inches in-plane and approximately 0.050 inches out-of-plane.
Author
Photogrammetry; Inflatable Structures; Spacecraft Structures; Large Space Structures; Digital Cameras; Radiometers; Spacecraft Antennas; Shape Control

20010002414 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA

A Novel Approach to Exploring the Mars Polar Caps

Brophy, John R.; Carsey, Frank D.; Rodgers, David H.; Soderblom, L. A.; Wilcox, Brian H.; International Conference on Mars Polar Science and Exploration; August 2000, 14; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

The Martian polar caps contain some of the most important scientific sites on the planet. There is much interest in exploring them with a view to understanding their role in the Mars climate system. By gaining access to the stratigraphy of the polar terrain, it is probable that one can access the climate history of the planet. Additionally, investigations aimed at localizing subsurface water--liquid or solid--are not only of great scientific interest but are also germane to the long-term interests of the manned space flight program. A major difficulty with polar exploration is access. Current techniques using chemical propulsion, Holman transfers, and direct-entry landers with aeroshells have limited capability to access the polar terrain. For the near term the authors propose a new approach to solving this transportation issue by using Solar Electric Propulsion (SEP), recently flight demonstrated on NASA's DS1 Mission to an asteroid and a comet. For a longer-term approach there are additional ways in which access to Mars, as well as other planets, can be significantly improved. These include the use of Chaos orbit theory to enable transportation between LaGrange points in the solar system, gossamer structures enabling very low-mass mobility, and advanced ascent vehicles. In this paper the authors describe how a 1000-kG payload can be transported to the surface of Mars and a polar sample obtained and returned to Earth in less than five years using SEP. A vision of how this approach can be integrated into a long-term Mars exploration strategy building toward the future is also discussed.

Author

Mars (Planet); Mars Surface; Mars Exploration; Polar Caps

20000120599 Naval Postgraduate School, Monterey, CA USA

A Study of the Feasibility and Applicability of Shape Controlled Space Based Inflatable Membrane Structures

Whittinghill, Craig M.; September 2000; In English

Report No.(s): AD-A383387; No Copyright; Avail: CASI; A09, Hardcopy

Inflatable structures used for space applications offer mass, volume, and cost savings to spacecraft programs, allowing larger space structures to be built. For certain space applications, there are advantages to using large structures. For example, antennas achieve higher gains when they are increased in size. Higher gains equate to higher data throughputs. Therefore, inflatable structures offer improvements in performance to certain types of spacecraft components. Environmental factors induce surface errors on large inflatable structures, though. This degrades performance, especially for inflatable antennas. To reduce this degradation, active and passive control systems can be used to sense errors and control the shape of the antenna. One method of applying an active and passive control system is by using piezoelectric films that are either attached to or are part of the inflatable structure. The research performed for this thesis explored the theoretical performance of a large inflatable space-based antenna via spreadsheet analysis and the physical performance of a piezoelectric film via laboratory experimentation. For the laboratory experiment, the film was attached to a drum and varying internal pressures and voltages were applied. Also, in order to validate the experimental results, an analytical model was created using MSC/PATRAN and MSC/NASTRAN software.

DTIC

Inflatable Structures; Large Space Structures; Spacecraft Components; Spacecraft Structures; Shapes; Active Control

20000116404 NASA Langley Research Center, Hampton, VA USA

Advanced Concepts, Technologies and Flight Experiments for NASA's Earth Science Enterprise

Meredith, Barry D.; [2000]; In English, 19-21 Sep. 2000, Long Beach, CA, USA

Report No.(s): AIAA Paper 2000-5177; Copyright; Avail: CASI; A02, Hardcopy

Over the last 25 years, NASA Langley Research Center (LaRC) has established a tradition of excellence in scientific research and leading-edge system developments, which have contributed to improved scientific understanding of our Earth system. Specifically, LaRC advances knowledge of atmospheric processes to enable proactive climate prediction and, in that role, develops first-of-a-kind atmospheric sensing capabilities that permit a variety of new measurements to be made within a constrained enterprise budget. These advances are enabled by the timely development and infusion of new, state-of-the-art (SOA), active and passive instrument and sensor technologies. In addition, LaRC's center-of-excellence in structures and materials is being applied to the technological challenges of reducing measurement system size, mass, and cost through the development and use of space-durable materials; lightweight, multi-functional structures; and large deployable/inflatable structures. NASA Langley is engaged in advancing these technologies across the full range of readiness levels from concept,

to components, to prototypes, to flight experiments, and on to actual science mission infusion. The purpose of this paper is to describe current activities and capabilities, recent achievements, and future plans of the integrated science, engineering, and technology team at Langley Research Center who are working to enable the future of NASA's Earth Science Enterprise.
Author
Earth Sciences; Research and Development; Spacecraft Construction Materials; Technologies; Technology Utilization

20000110624 NASA Johnson Space Center, Houston, TX USA
Nanotube Production and Applications at Johnson Space Center
Nikolaev, Pavel; Files, Bradley; Arepalli, Sivaram; Scott, Carl; Holmes, William; Nicholson, Leonard S., Technical Monitor; [2000]; In English; Nanotube 1999: Science and Application of Nanotubes, 24-27 Jul. 1999, East Lansin, MI, USA
Contract(s)/Grant(s): RTOP 953-36-EM; No Copyright; Avail: Other Sources; Abstract Only

Promise of applications of carbon nanotubes has led to an intense effort at NASA/JSC, especially in the area of nanotube composites. Using the extraordinary mechanical strength of nanotubes, NASA hopes to design this revolutionary lightweight material for use in aerospace applications. Current research focuses on structural polymeric materials to attempt to lower the weight of spacecraft necessary for interplanetary missions. Other applications of nanotubes are also of interest for energy storage, gas storage, nanoelectronics, field emission, and biomedical applications. In pursuit of these goals, we have set up both laser and arc production processes for nanotubes. An in-depth diagnostic study of the plasma plume in front of the laser target has been studied to try to determine nanotube growth mechanisms. Complementary studies of characterization of nanotube product have added to knowledge of growth conditions. Results of our preliminary experiments in incorporating nanotubes into composites will be presented. Morphology and mechanical properties of the nanotubes composites will be discussed.
Author
Carbon; Nanotubes; Product Development; Products; Production Engineering; Nanotechnology; Technology Utilization; NASA Programs; Research and Development

20000094325 Air Force Inst. of Tech., Wright-Patterson AFB, OH USA
Optical Metrology of Adaptive Membrane Mirrors
Wagner, John W.; Mar. 2000; In English
Report No.(s): AD-A380352; AFIT/GA/ENY/00M-05; No Copyright; Avail: CASI; A08, Hardcopy

Current space-based imaging platforms are significantly constrained in both size and weight by the launch vehicle. Increased payload size and weight results in increased cost and a decrease in launch responsiveness. The USAF Scientific Advisory Board (SAB) identified 'Large lightweight structures for optics and antennas' as a revolutionary primary technology to be developed for the Air Force of the 21st Century. A membrane primary mirror in a space-based imaging system has the ability to overcome current payload constraints and meet evolutionary needs of the future. The challenge of membrane optics in space is the process of implementing adaptive optics technology to the membrane surface that will provide at least rough order of magnitude imaging, where small aberrations can be removed downstream in the system. The objective of this research was to develop a system to categorize surface properties of optical quality membrane material with the ability to interpret membrane mirror deformation. Coincident with this objective was the design and construction of membrane mirrors and associated test tooling, the design and application of in-plane zonal control for membrane mirrors, and mirror deformation analysis. The system provides wavefront analysis with both optical interferometry and Shack-Hartmann wavefront sensing, with good correlation, which compares favorably to Zygo interferometer data. Results from membrane static testing will be presented.
DTIC
Metrology; Membranes; Deformable Mirrors; Design Analysis

20000090512 NASA Goddard Space Flight Center, Greenbelt, MD USA
Preventing Damaging Pressure Gradients at the Walls of an Inflatable Space System
Scialdone, John J.; Powers, Edward I., Technical Monitor; [2000]; In English; 45th Optical System Contamination and Degradation, 20 Jul. 2000, San Diego, CA, USA; No Copyright; Avail: CASI; A02, Hardcopy

An inflatable structural system to deploy a space system such as a solar shield, an antenna or another similar instrument requires a stiffening element after it is extended by the inflated gas pressure. The stiffening element has to be packaged in folded configuration before the deployment. It must be relatively small, lightweight, non-damaging to the inflated system and be able to become stiff in a short time. One stiffening method is to use a flexible material inserted in the deployable system,

which, upon a temperature curing, can become stiff and is capable of supporting the entire structure. There are two conditions during the space operations when the inflated volume could be damaged: during the transonic region of the launch phase and when the curing of the rigidizing element occurs. In both cases, an excess of pressure within the volume containing the rigid element could burst the walls of the low-pressure gas inflated portion of the system. This paper investigates those two conditions and indicates the vents, which will prevent those damaging overpressures. Vent openings at the non-inflated volumes have been calculated for the conditions existing during the launch. Those vents allow the initially folded volume to exhaust the trapped atmospheric gas at approximately the same rate as the ambient pressure drops. That will prevent pressure gradients across the container walls which otherwise could be as high as 14.7 psi. The other condition occurring during the curing of the stiffening element has been investigated. This has required the testing of the element to obtain the gas generation during the curing and the transformation from a pliable material to a rigid on The tested material is a composite graphite/epoxy weave. The outgassing of the uncured sample at 121 deg Celcius was carried with the Cahn Microbalance and with other outgassing facilities including the micro-CVCM ASTM E-595 facility. The test provided the mass of gas evolved during the test. That data, including the chemical nature of the evolved gas, provided the data for the calculation of the pressure produced within the volume. The evaluation of the areas of the vents that would prevent excessive pressures and provide a rapid release of the gas away from contamination sensitive surfaces has be carried out. The pressure decay with time has been indicated. Author

Pressure Gradients; Inflatable Space Structures; Damage; Walls; Prevention

20000088652 Lockheed Martin Corp., Houston, TX USA

Item Description: ISS TransHab Restraint Sample and Photo Documentation

Adams, Constance; [2000]; In English, 1 Feb. 2000, Chicago, IL, USA

Contract(s)/Grant(s): NAS9-18800; No Copyright; Avail: CASI; A01, Hardcopy

The yellow strap seen in the display is a piece of the main restraint layer of a test article for the ISS TransHab spacecraft, First conceived as a technology which is capable of supporting a [human] crew of six on an extended space journey such as the six-month trip to Mars, TransHab (short for 'Transit habitat') is the first space inflatable module ever designed. As this text is written it is being considered as a replacement for the Habitation module on the International Space Station (ISS). It constitutes a major breakthrough both in technology and in tectonics: capable of tight packaging at light weight for efficient launch, the vehicle can then be inflated to its full size on orbit via its own inflation tanks. This is made possible by the separation of its main structural elements from its pressure-shell. In other words, all spacecraft flown to date have been of an exoskeletal type---i.e., its hard outer shell acts both as a pressure container and as its main channel for structural loading This includes the ISS, which is currently under construction in Low Earth Orbit [275 miles above the Earth]. By contrast TransHab is the first endoskeletal space Habitat, consisting of a dual system: a light, reconfigurable central structure of graphite composite and a multilayered, deployable pressure shell.

Derived from text

Habitats; Manned Mars Missions; Interplanetary Spacecraft; Manned Spacecraft; Space Capsules

20000085858 NASA Glenn Research Center, Cleveland, OH USA

A Deep Space Power System Option Based on Synergistic Power Conversion Technologies

Schreiber, Jeffrey G.; July 2000; In English, 30 Jan. - 3 Feb. 2000, Albuquerque, NM, USA

Contract(s)/Grant(s): RTOP 839-20-00

Report No.(s): NASA/TM-2000-210232; NAS 1.15:210232; E-12352; No Copyright; Avail: CASI; A03, Hardcopy

Deep space science missions have typically used radioisotope thermoelectric generator (RTG) power systems. The RTG power system has proven itself to be a rugged and highly reliable power system over many missions, however the thermal-to-electric conversion technology used was approximately 5% efficient. While the relatively low efficiency has some benefits in terms of system integration, there are compelling reasons why a more efficient conversion system should be pursued. The cost savings alone that are available as a result of the reduced isotope inventory are significant. The Advanced Radioisotope Power System (ARPS) project was established to fulfill this goal. Although it was not part of the ARPS project, Stirling conversion technology is being demonstrated with a low level of funding by both NASA and DOE. A power system with Stirling convertors. although intended for use with an isotope heat source. can be combined with other advanced technologies to provide a novel power system for deep space missions. An inflatable primary concentrator would be used in combination with a refractive secondary concentrator (RSC) as the heat source to power the system. The inflatable technology as a structure has made great progress for a variety of potential applications such as communications reflectors, radiators and solar arrays. The RSC has been pursued for use in solar thermal propulsion applications, and it's unique properties allow some advantageous system trades to be made. The power system proposed would completely eliminate the isotope heat source and

could potentially provide power for science missions to planets as distant as Uranus. This paper will present the background and developmental status of the technologies and will then describe the power system being proposed.
Author
Technology Transfer; Thermoelectric Power Generation; Systems Integration; Stirling Cycle; Spacecraft Power Supplies; Solar Thermal Propulsion; Radioisotope Batteries; Deep Space

20000074639 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA
The Deep Space 4/Champollion Comet Rendezvous and Lander Technology Demonstration Mission
Smythe, William D.; Weissman, Paul R.; Muirhead, Brian K.; Tan-Wang, Grace H.; Sabahi, Dara; Grimes, James M.; [2000]; In English; No Copyright; Avail: Other Sources; Abstract Only

The Deep Space 4/Champollion mission is designed to test and validate technologies for landing on and anchoring to small bodies, and sample collection and transfer, in preparation for future sample return missions from comets, asteroids, and satellites. in addition, DS-4 will test technologies for advanced, multi-engine solar electric propulsion (SEP) systems, inflatable-rigidizable solar arrays, autonomous navigation and precision guidance for landing, autonomous hazard detection and avoidance, and advanced integrated avionics and packaging concepts. Deep Space-4/Champollion consists of two spacecraft: an orbiter/carrier vehicle which includes the multi-engine SEP stage, and a lander, called Champollion, which will descend to the surface of the 46P/Tempel 1 cometary nucleus. The spacecraft will launch in April, 2003 and land on the comet in September, 2006 Deep Space 4/Champollion is a joint project between NASA and CNES, the French space agency.
Author
Deep Space; Space Missions; Mission Planning; Landing; Comets; Asteroids

20000074083 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA
A Light-Weight Inflatable Hypersonic Drag Device for Planetary Entry
McRonald, Angus D.; [2000]; In English; No Copyright; Avail: Other Sources; Abstract Only

The author has analyzed the use of a light-weight inflatable hypersonic drag device, called a ballute, for flight in planetary atmospheres, for entry, aerocapture, and aerobraking. Studies to date include Mars, Venus, Earth, Saturn, Titan, Neptune and Pluto, and data on a Pluto lander and a Mars orbiter will be presented to illustrate the concept. The main advantage of using a ballute is that aero, deceleration and heating in atmospheric entry occurs at much smaller atmospheric density with a ballute than without it. For example, if a ballute has a diameter 10 times as large as the spacecraft, for unchanged total mass, entry speed and entry angle,the atmospheric density at peak convective heating is reduced by a factor of 100, reducing the heating by a factor of 10 for the spacecraft and a factor of 30 for the ballute. Consequently the entry payload (lander, orbiter, etc) is subject to much less heating, requires a much reduced thermal. protection system (possibly only an MLI blanket), and the spacecraft design is therefore relatively unchanged from its vacuum counterpart. The heat flux on the ballute is small enough to be radiated at temperatures below 800 K or so. Also, the heating may be reduced further because the ballute enters at a more shallow angle, even allowing for the increased delivery angle error. Added advantages are less mass ratio of entry system to total entry mass, and freedom from the low-density and transonic instability problems that conventional rigid entry bodies suffer, since the vehicle attitude is determined by the ballute, usually released at continuum conditions (hypersonic for an orbiter, and subsonic for a lander). Also, for a lander the range from entry to touchdown is less, offering a smaller footprint. The ballute derives an entry corridor for aerocapture by entering on a path that would lead to landing, and releasing the ballute adaptively, responding to measured deceleration, at a speed computed to achieve the desired orbiter exit conditions. For a lander an accurate landing point could be achieved by providing the lander with a small gliding capacity, using the large potential energy available from being subsonic at high altitude. Alternatively the ballute can be retained to act as a parachute or soft-landing device, or to float the payload as a buoyant aerobot. As expected, the ballute has smaller size for relatively small entry speeds, such as for Mars and Titan, or for the extensive atmosphere of a low-gravity planet such as Pluto. Details of a ballute to place a small Mars orbiter and a small Pluto lander will be given to illustrate the concept. The author will discuss presently available ballute materials and a development program of aerodynamic tests and materials that would be required for ballutes to achieve their full potential.
Author
Aerodynamic Heating; Research; Ballutes; Buoyancy; Drag Devices; Floats; Inflatable Structures; Microgravity; Planetary Atmospheres; Spacecraft Design

20000056613 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA

Electroactive Polymers as Artificial Muscles: Capabilities, Potentials and Challenges

Bar-Cohen, Yoseph; [2000]; In English; No Copyright; Avail: CASI; A03, Hardcopy

The low density and the relative ease of shaping made polymers highly attractive materials and they are increasingly being chosen for aerospace applications. Polymer matrix composite materials significantly impacted the construction of high performance aircraft components and structures. In recent years, the resilience characteristics of polymers made them attractive to the emerging field of inflatable structures. Balloons were used to cushion the deployment of the Mars Pathfinder lander on July 4, 1997, paving the way for the recent large number of related initiatives. Inflatable structures are now being used to construct a rover, aerial vehicles, telescopes, radar antennas, and others. Some of these applications have reached space flight experiments, whereas others are now at advanced stages of development.

Derived from text

Activation; Bionics; Electrical Properties; Muscles; Inflatable Structures; Polymer Matrix Composites

20000056083 Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA USA

The Gossamer Initiative

Chmielewski, Artur B.; Moore, Chris; Howard, Rick; [2000]; In English; Copyright; Avail: Other Sources

The Gossamer Spacecraft Initiative is a new NASA program to begin long-range development of enabling technologies for very large, ultra-lightweight structures and apertures. Large apertures include optical, infrared and submillimeter telescopes, 'photon buckets' for optical communications and 'non-coherent' imaging, solar concentrators, and radio frequency antennas. Developments in the very large ultra-light structures will be forces on one of their most challenging applications-solar sails. The sail structures will include both 3-axis stabilizing and spinning. Gossamer spacecraft technology will eventually allow NASA to undertake bold new missions of discovery, such as searching for the signs of life on planets orbiting nearby stars and sailing through space on beams of light of places beyond our solar system.

Author

Apertures; Infrared Telescopes; Solar Optical Telescope; Solar Instruments; Spacecraft Instruments; Spacecraft Equipment

20000036609 NASA Goddard Space Flight Center, Greenbelt, MD USA

Design and Flight Testing of an Inflatable Sunshield for the NGST

Adams, Michael L.; Culver, Harry L.; Kaufman, David M.; Pacini, Linda K.; Sturm, James; Lienard, Sebastien; 20000403; In English; 41st Structures, Structural Dynamics and Materials Conference and Exhibit, 3-6 Apr. 2000, Atlanta, GA, USA

Report No.(s): AIAA Paper 2000-1797; No Copyright; Avail: CASI; A02, Hardcopy

The Next Generation Space Telescope (NGST) mission is scheduled to launch in 2007 and be stationed at L2 for a mission life of ten years. The large aperture mirror and optical detectors aboard NGST require shielding from the constant solar energy seen at this orbit. The government reference NGST design, called the Yardstick, baselined a sunshield using an inflation deployment system. During the formulation phase, NGST is spending approximately 25% of the overall budget to foster the development of new technology. The goal is to develop and demonstrate enabling or enhancing technology and provide innovative solutions for the design of the NGST observatory. Inflatable technology falls in the category of enhancing technology due to its advantages in weight, stowed volume and cost. The Inflatable Sunshield in Space (ISIS) flight experiment will provide a realistic space flight demonstration of an inflatable sunshield. The supporting technology development program will provide an information base for the design, manufacture, assembly and testing of large thin membranes and inflatable structural elements for space structures. The ISIS experiment will demonstrate the feasibility of using inflatable technology to passively cool optical systems for NGST and provide correlation between analytical predictions and on orbit results. The experiment will be performed on a Hitchhiker/Space Shuttle mission in late 2001. The ISIS mission is an effort to address several major technical challenges of the NGST inflatable sunshield, namely controlled inflation deployment, plenarity and separation of large stretched membranes, space rigidization of inflatable booms, and dynamic modeling and simulation. This paper will describe the design of the flight experiment and the testing to be performed on-orbit.

Author

Flight Tests; Design Analysis; Inflatable Space Structures; Deployment; Experiment Design; Prediction Analysis Techniques; Shielding; Solar Energy; Spaceborne Experiments

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Comparison of Dynamic Characteristics for an Inflatable Solar Concentrator in Atmospheric and Thermal Vacuum Conditions

Slade, Kara N.; Tinker, Michael L.; Lassiter, John O.; Engberg, Robert; [2000]; In English; 41st, 3-6 Apr. 2000, Atlanta, GA, USA

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Dynamic testing of an inflatable solar concentrator structure in a thermal vacuum chamber as well as in ambient laboratory conditions is described in detail. Unique aspects of modal testing for the extremely lightweight inflatable are identified, including the use of a noncontacting laser vibrometer measurement system. For the thermal vacuum environment, mode shapes and frequency response functions are compared for three different test article inflation pressures at room temperature. Modes that persist through all the inflation pressure regimes are identified, as well as modes that are unique for each pressure. In atmospheric pressure and room temperature conditions, dynamic measurements were obtained for the expected operational inflation pressure of 0.5 psig. Experimental mode shapes and frequency response functions for ambient conditions are described and compared to the 0.5 psig results from the thermal vacuum tests. Only a few mode shapes were identified that occurred in both vacuum and atmospheric environments. This somewhat surprising result is discussed in detail, and attributed at least partly to 1.) large differences in modal damping, and 2.) significant differences in the mass of air contained by the structure, in the two environments. Results of this investigation point out the necessity of testing inflatable space structures in vacuum conditions before they can be launched. Ground testing in atmospheric pressure is not sufficient for predicting on-orbit dynamics of non-rigidized inflatable systems.

Author

Dynamic Characteristics; Dynamic Tests; Inflatable Space Structures; Inflatable Structures; Solar Collectors; Thermal Vacuum Tests; Vacuum Chambers

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Satellite Attitude Control Using Magnetic Torquers, a Periodic Time-Varying Control Problem

Psiaki, Mark L.; D'Andrea, Raffaello; Jan. 26, 2000; In English

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Satellite attitude controllers have been designed for a rigid spacecraft whose only actuators are magnetic torque rods. This effort's goals have been to develop a new class of lightweight, moderate accuracy attitude controllers and to evaluate and further develop general methods for the control of time varying systems. Three different classes of controllers have been developed and simulation tested. one based on linear quadratic regulator techniques, one based on sliding mode like concepts, and one based on new H infinity techniques for time varying systems. These H infinity controllers achieve the best performance. In addition to the controller design studies. the issue of attenuation of constant 3 axis disturbances has been addressed. Disturbance attenuation is difficult for this system because it can apply torques only about the 2 axes that are perpendicular to the Earth's magnetic field. It is a challenge to determine how best to counteract a low frequency 3 axis disturbance torque, on average, via judicious use of the fact that the Earth's magnetic field direction varies in time as the spacecraft moves along its orbit. Pointing accuracies on the order of 1 deg or better have been demonstrated in the presence of typical levels of disturbance torque.

DTIC

Space Navigation; Satellite Attitude Control; Torquers; Actuators; Controllers; Control Systems Design

Subject Terms

Corporate Sources

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