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Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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MANUFACTURING AND TESTING OF A TELESCOPE FOR SMALL SATELLITES USING CFRP BOOMS

Abstract

Space technology has long taken advantage of deployable concepts for subsystems and payloads. Mass and volume are critical points when designing a spacecraft, so that deployable structures that can meet the stringent requirements imposed by the launchers are appealing. Earth Observation (EO) is one of the most important asset of space industry, with applications ranging from weathers forecast to security. An increasing demand for EO images has propelled the use of small orbital platforms with optical payloads spacecrafts. EO could benefit from deployable on-board telescopes for constellations of small satellites with high temporal resolution, thus being cost-effective when compared to heavier, cumbersome and complex satellites. In this paper a deployable telescope that fits in a 2Ux2U volume of a 6U nanosatellites is proposed. The design is based on a Cassegrain configuration, with a primary mirror (M1) of 150 mm and the secondary mirror (M2) supported by six tape springs, or booms, made of carbon-fibers reinforced epoxy. The deployable members are lightweight slit tubes that can be coiled around a cylindrical drum in the stowed configuration and provide a good focal length when extended, thus ensuring a convenient packing ratio. The supporting structure deploys thanks to the strain energy stored in each boom separating the mirrors by 300 mm. The deployment can be controlled by co-coiled strips, which can be pulled by a single DC motor in a puller mechanism for a simultaneous deployment. Main advantages of this concept include reduced number of moving parts and high scalability. The stiffness of the supporting structure, due to the open cross-section of the tape springs, and its thermal distortion in the harsh space environment conditions are the biggest challenges for good quality EO images. A homodyne single beam interferometer for three degrees of freedom (DoF) measurements is used in the experimental investigation, in order to assess the dimensional stability of the telescope. The number of components of the measurement system is kept to a minimum, featuring a HeNe laser source, beamsplitter cube, N-BK7 prisms and a CMOS camera. The deployed structure is tested in thermal-vacuum oven to simulate the space environment. Flat mirrors for the interferometric measurements are attached to the mirrors housing brackets, which are made of Invar for its low thermal expansion coefficient. Thermal displacements and tilts are computed using an algorithm based on the discrete Fourier transform of the spatial interference pattern detected by the sensor.