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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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STUDY ON SHAPE REPEATABILITY OF A FLEXIBLE SPACE STRUCTURE WITH HYSTERESIS

Abstract

High performance space antennas are required for future communications and observations to obtain high gain and to be operated in high frequency. To realize such requirements, antennas need to be large and precise. Because of capacities of launch vehicles, large space antennas are required to be ultra-light weight and deployable. Deployable antennas consisting of cable networks are widely used for ultra-light weight and precise with deployable antenna reflectors.

Cables used for cable networks have hysteresis and material nonlinearities between tensile load and elongation. Therefore, the shapes of cable networks have some uncertainty and that leads to worse shape repeatability.Deployable antennas consisting of cable networks have latches in the deployment mechanism. Therefore, cable tensions vary while an antenna is deployed in orbit. An antenna is packaged in a launch vehicle, after some deployment tests are carried out on ground. Accordingly, the shapes of cable networks are affected with material nonlinearities of the cables. Therefore, the shapes of cable networks have some uncertainty. It is necessary to estimate precisely the shape repeatability to realize high precise antennas.

In this study, some experiments and numerical simulations are carried out and the shape repeatability is investigated. To simplify complex cable networks of an antenna surface, an experimental model is designed to represent a part of the antenna surface. The self-equilibrated stresses of experimental model in a nominal state are calculated and the cable lengths are determined by the force density method. The experimental model is made of aramid fiber cables and urethane resin nodes in designed lengths and tensions. Some kind of repetitious loads are applied on the experimental model to investigate the effects of material nonlinearities and hysteresis of the cables. Digital images are taken by digital cameras at each cycle. The shapes of the experimental model are measured from the digitized images. Each cable tension is calculated from measured frequencies of each cable. Changes in shapes and the tensions are measured when the repeated load is put on the experimental model. Changes in shapes caused by the hysteresis and the material nonlinearities of the model are quantified. A numerical model is developed based on these results and changes of the model shapes including the uncertainty are examined.