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

Author: Mr. Shuhei Yamada
University of Tokyo, Japan

Mr. Yuichiro Tsukamoto
Tokyo Institute of Technology, Japan
Dr. Osamu Mori
Japan Aerospace Exploration Agency (JAXA), Japan
Mr. Ahmed Kiyoshi Sugihara
Japan Aerospace Exploration Agency (JAXA), Japan
Prof.Dr. Nobukatsu Okuizumi
ISAS/JAXA, Japan

DEPLOYMENT SIMULATION OF SOLAR SAIL WITH ROTATIONALLY SKEW FOLDING : PARAMETRIC ANALYSIS BY DEPLOYMENT STRUCTURE CONFIGURATION

Abstract

Membrane space structure has thin membrane, and by attaching solar cells and antennas on the membrane structure, power generation and telecommunication become possible. Deployment behavior and reliability depends on the folding and deployment method. Past deployable membrane structures include IKAROS solar sail demonstrator and OrigamiSat-1 multi-functional membrane structure. In the near future, HELIOS will demonstrate power generation and telecommunication on board a thin and small membrane.

Membrane structure is expected to promise future missions. However, it has various folding and deployment methods, and comparison between them is necessary to allow future missions to select the suitable configuration. It is important issue to understand the deployment behavior characteristics because it also affects the attitude stability of the spacecraft. In this study, boom deployed membrane structure with rotationally skew folding is performed with different deployment methods and the difference between each configuration is discussed. Although these methods were experimented on ground, gravity dominated the deployment modes and on-orbit conditions could not be replicated. Therefore, the deployment simulation using a combination of rotationally skew folding and boom deployment is to be newly established, and the motion characteristics under various configurations are discussed.

The simulation is conducted with Multi-Particle Method, which discretizes the membrane to a set of point-masses, springs and dampers and is well established through the deployment simulation in IKAROS. Boom deployment uses a bi-convex structure and deploys the membrane with restoring force. The movement of booms and the central hub that delivers the booms is simulated by forced displacement.

4 types of boom deployment are considered in this study. (1) the central hub is fixed and four booms extend with rotating. (2) the central hub rotates and four booms extend linearly. (3) one tip of the boom is fixed to the spacecraft and the other three booms and the central hub extend. (4) spacecraft has another deployment mechanism same as (3) on the opposite side. Each configuration is useful in some situations, and it is estimated that they show different motion characteristics. Under these configurations, the effects on the spacecraft are also clarified. Therefore, each feature is discussed and explained.

From the above deployment simulations, each deployment behavior characteristic under different configurations is evaluated by considering torque applied to the spacecraft. From this study, the range of

applicable mission can be predicted and it can be judged what kind of future mission is appropriate for a given folding and deployment configuration.