

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)

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

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DESIGN ANALYSIS OF CABLE-ACTUATED CYLINDRICAL TENSEGRITY BOOMS

Abstract

Volume and mass limits of launch vehicles and the severe vibroacoustic environment of launch continue to challenge spacecraft structural designers. Tensegrity structures offer a promising solution, as their composition of struts and cables provide stiff, lightweight, packaging-efficient booms. This research focuses on cylindrical tensegrities with actuated cables, which enable both deployment as well as subsequent shape reconfiguration.

This research addresses the range of achievable shapes for a tensegrity boom with actuated cables. We consider a cylindrical triplex having 3 nodes on each of the top and bottom faces. This tensegrity has 3 struts, and 3 cables connecting the struts on each of the top and bottom faces—all 9 of these members are fixed in length. The remaining 3 cables connect the nodes of the bottom and top faces, and are allowed to change length.

We first find all kinematically possible configurations under these constraints. Then, we refine the solution set by eliminating configurations which are not capable of self-stressed equilibrium. This solution set is characterized by describing a surface of equilibrated positions of the center of the top face in spherical coordinates (with known orientations).

We continue by considering which configurations are reachable from an initial vertical configuration with horizontal end faces, and choose an final configuration in which the center of the top face is at an edge of the reachable space. We check for member collisions along a defined path, thus evaluating a range of positions that can be reached without interference.

We also consider how adding additional bays influences the shape-changing capability. The solution surface for a 2-bay class-2 triplex where equivalent members in each bay move in the same way has been compared to that of a single bay of equal height. Even this constrained movement for the 2-bay case permits a much greater range than the single bay equivalent. This analysis will be extended to include independent movement of both bays as well as different overall heights.

We will also conduct a design analysis for a cylindrical triplex boom, including quantification of packaging efficiency and deployed structural stiffness. We will describe how various design parameters in a cylindrical triplex influence its structural properties. We will also consider the tradeoffs between the range of reachable positions and structural properties for multi-bay structures.

Tensegrity booms offer great promise as lightweight, packaging-efficient structures for space applications, and this research improves our fundamental understanding of their potential.