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Folding and deployment analysis of a composite deployable spacecraft

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ABSTRACT

Deployable structures are becoming increasingly prominent in space engineering due to their capacity to reduce mass, volume, and cost [1]. Typically fabricated from thin or ultra-thin composite materials, these structures are frequently employed for space applications such as antennas [2]. Among deployable booms, tape springs are the most common type. While they were originally made of metal, carbon fiber–reinforced plastic has emerged as the preferred material in recent years because it provides greater stiffness while keeping mass to a minimum. Of particular interest is the Triangular Rollable and Collapsible (TRAC) design, which consists of two circular flanges joined along their shared edge.

In this work, attention is focused on the folding behavior of a double-strip assembly comprising two pairs of TRACs. The upper pair measures 600 mm in length, and the lower pair measures 400 mm. The nonlinear equations governing the system are derived from the principle of virtual displacements, framed within the Carrera Unified Formulation (CUF) [3]. Under CUF, the three-dimensional displacement field is subdivided into axial and cross-sectional components, allowing higher-order modeling to capture the deformations within the cross-section. In this study, nine-point Lagrange expansions are used to describe the cross-sectional domain.

A quasi-static analysis is conducted to simulate folding and deployment, using the Newton-Raphson linearization procedure with a displacement control approach. Additionally, contact effects are included by introducing nonlinear springs that act between predefined pairs of nodes.

References

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