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Space Structures II Development and Verification (Orbital deployable and dimensionally stable structures, including mechanical and robotic systems and subsystems) (2)

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FAILURE ONSET EVALUATION OF DEPLOYABLE ROLLED-UP COMPOSITE SYNTHETIC APERTURE RADAR (DERAC-SAR) ANTENNA VIA GLOBAL/LOCAL APPROACH

Abstract

Synthetic Aperture Radar (SAR) technology has emerged as a highly effective tool for space observation, as it guarantees an economical and efficient option for creating radar constellations. Addressing the challenges of limited space for installations, as well as the constraints on weight and volume, and aiming for efficient packing and deployment in space, the solution adopted by this work is based on a Deployable Rolled-Up Composite Synthetic Aperture Radar (DERAC-SAR) structure. It is inspired by the design of a tape-measure, and it supports the SAR reflectarray and allows for its compact storage through a rollable deployment mechanism. To ensure structural stiffness, a fixed boundary condition is applied to preserve the naturally curved cross-section during storage.

Due to this boundary restriction, the deployment triggers complicated three-dimensional (3D) stress fields within a localized area of the structure, in particular in the ploy region close to the fixed root. Consequently, to accurately describe these complex stress fields, the use of higher-order models and 3D elements becomes essential. However, analyses would demand significant computational resources, and it is usually preferred to employ 2D elements, losing the capability to evaluate out-of-plane strains. The development of a numerical tool able to accurately predict 3D failures in critical areas, overcoming computational constraints, would mark a significant progression in this field.

The solution proposed in this work is to perform the failure onset analysis of DERAC-SAR using an innovative global/local approach. It consists in a multi-step procedure. As a first step, a global analysis with 2D elements is conducted with commercial software Abaqus to evaluate displacements. Subsequently, most critical areas are analyzed locally using the previously determined displacements as boundary constraints, opportunely manipulated, of a refined higher-order local model of the selected elements. The local domains are modeled recalling the Carrera Unified Formulation (CUF), which allows for the use of higher-order plate elements. In addition, the conducted analyses include large displacements and rotations, and then the geometrical nonlinear formulation is included at both global and local levels. At the latter, the nonlinear governing equations are solved in a total lagrangian scenario using a Newton–Raphson linearization scheme along with a displacement-control constraint.

By adopting this strategy, it is possible to overcome the limitations of standard commercial software, thus reducing computational demands while maintaining high accuracy levels. By applying this global-local analysis method, a critical length at which failure occurs during the stowing process will be determined.