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Composite deployable booms are increasingly used in aerospace applications because they combine lightweight design, compact stowage capability, and high deployment efficiency [1]. However, their structural response is heavily influenced by geometry, which impacts not only the overall nonlinear behavior but also the onset of local failure mechanisms. In this context, understanding how geometric parameters alter the evolution of the failure index is essential for designing reliable next-generation deployable structures. This work explores the relationship between geometric features and failure index in composite deployable booms, considering tape and Triangular Rollable And Collapsible (TRAC) configurations.

The numerical analysis is conducted within the framework of the Carrera Unified Formulation (CUF), using a refined one-dimensional beam model where the deployable boom is described along a single reference axis. The cross-sectional kinematics are enhanced by higher-order expansions [2, 3]. This method enables the capture of the nonlinear response of slender composite deployable members with less computational effort compared to full three-dimensional models, while still accounting for the influence of cross-sectional mechanics on the overall response [4]. Failure assessment involves tracking the evolution of the failure index during loading. In this study, the material behavior is assumed to be linear elastic, without including progressive damage evolution; thus, the computed failure indices serve to identify the onset and development of critical conditions.

The results highlight a clear sensitivity of the nonlinear response to the geometric features of the boom. For both tape and TRAC configurations, longer booms generally show larger achievable rotation angles under the same material and section properties. In the tape case, the peak moment varies non-monotonically with length, while failure consistently begins with matrix compression. At later stages, delamination indicators may also exceed one, although this trend is likely affected by the lack of a progressive damage model. In reverse-sign loading, the same geometric trend appears, but numerical convergence becomes more critical for certain lengths. For TRAC booms, matrix compression again is the main failure mode, while the longest configurations also show coupling with local buckling in the curved region. Overall, these findings confirm that geometry significantly influences moment-rotation behavior, convergence stability, and failure initiation in composite deployable booms, and support a broader parametric study on sectional geometry.

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