High-Fidelity Nonlinear Analysis of Wingbox Structures: Resolving Nastran-CUF Discrepancies through Refined 1|3D Modeling

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Abstract.
The continuous drive toward lighter and more aerodynamically efficient aircraft has established aeroelastic optimization as one of the primary design tools for wingbox structures. To overcome artificial sizing limits imposed by linear buckling, recent frameworks allow stable postbuckling through the continuous monitoring of the tangent stiffness matrix. However, accurately assessing the nonlinear structural stability of large wingboxes introduces a massive computational burden. To address this, 1|3D finite elements have been integrated with the geometrically nonlinear Carrera Unified Formulation (CUF) framework. Previous applications of this methodology to the Simple Transonic Wing (STW) benchmark revealed significant discrepancies with Nastran shell models. This work presents a methodological evolution to resolve these discrepancies. By applying an outward offset to Nastran shell elements and refining the CUF cross-sectional expansion using Q9 elements, a stricter topological alignment is achieved. The results demonstrate that the initial divergence in predicted instability load can be reconciled through modeling refinements.