FUN3D Analyses in Support of the 1st AIAA Stability and Control Prediction Workshop

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Abstract:

The 1st AIAA Stability and Control Prediction Workshop was created to establish best practices for the prediction of stability & control derivatives using computational fluid dynamics and assess the limitations of these computational methods when those best practices are applied. The inaugural workshop considers the ONERA version of the NASA/Boeing Common Research Model (CRM), which includes the wing, body, horizontal tail, and a vertical tail designed by ONERA. Wind tunnel tests have been conducted for this configuration with longitudinal tests having been previously published, in addition to unpublished data at small sideslip angles that will serve as 'blind' data for workshop data comparisons.

Participants were provided a 'family' of unstructured grids for the full-span ONERA CRM model with the wind-tunnel sting included. This family of mixed-element grids consists of 5 levels of refinement (tiny, coarse, medium, fine, and extra fine) with surface and volume mesh scaling, resulting in a size range of 14.6 to 53.4 million nodes. In addition, a medium refinement mesh has been provided for the ONERA CRM configuration without a sting to evaluate the sting's impact on static longitudinal stability characteristics. In addition to these workshop-provided grids, the present work also considers an equivalent 'family' of computational grids generated using Heldenmesh™, a rapid grid generation software by Helden Aerospace Corporation for creating high-quality, three-dimensional, mixed-element unstructured meshes. Because of the authors' familiarity with this software, these additional grids were generated as a comparison to the workshop-provided grids and to better understand the implications of using volume-mirrored grids for stability and control predictions.

The present work will contribute to the workshop with test case data generated using the NASA FUN3D code, a parallelized, unstructured, node-based, finite-volume discretization, Reynolds-averaged Navier-Stokes flow solver. Numerical simulations will be conducted using the Quadratic Constitutive Relationship (QCR) version of the Spalart-Allmaras (SA) turbulence model with negative turbulence variable provisions. Both steady and 2nd-order, time-accurate simulation results are to be generated and compared for select test cases, as time permits, to investigate their impact on FUN3D predictions. The present work will consider the three primary workshop test cases: (1) grid convergence study, (2) Mach number effect on static stability, and (3) wind tunnel sting increments. Additionally, data will be provided for the two optional test cases, which include: (1) static stability derivative calculations and (2) sideslip angle sweeps. In each of the test cases, the vehicle is stationary, and the body is assumed to be rigid, where vehicle deformation has been accounted for in the model configuration geometry. For all test cases, longitudinal and lateral force and moment aerodynamic coefficients will be provided for the total configuration, in addition to a component-level breakdown that includes the port wing, starboard wing, fuselage, and tail.