Achieving Full-Scale Slat Cove Flow Without Large Wind Tunnels: Design and Characterization of a Swept Truncated Wing Model of the DLR-F16 Slat Cove

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A swept, truncated wing model is being developed to replicate near-full-scale slat-cove flow conditions within a moderate-size wind tunnel. As a reference, the available aerodynamic data from the small-scale DLR-F16 three-element high-lift profile [1] is used. With a geometric scaling factor of 4.17 over the reference DLR-F 16 model, the truncated configuration achieves an equivalent stowed chord of 1.251 m, approaching the scale of a full-size airplane wing near the wing tip. Operation at this scale introduces significant experimental challenges, particularly the three-dimensional end effects arising in closed-section wind tunnels become more pronounced for a very low-aspect-ratio model, which is just under unity. Nevertheless, the successful design of this novel model can allow for full-scale testing of structural and mechanical components present in the slat cove, such as slat tracks, cut-outs and side-edges, allowing high geometric fidelity as well as minimizing aeroacoustic artifacts associated with small-scale testing.

The present study characterizes the aerodynamics of a baseline swept truncated wing configuration, intended to guide the development of subsequent design iterations that closely match the flow characteristics of a near-real-aircraft-scale slat cove region, where slat elements, such as tracks, reside. This model is based on the airfoil profile of an unswept, full-scale, truncated model, designed by Roy et al [2] to simulate the slat flow conditions of the same unswept DLR-F16 profile. The tests were performed in the Hybrid Anechoic Wind Tunnel (HAWT) located at the University of Toronto Institute for Aerospace Studies (UTIAS). The hard-walled test section configuration was used for most aerodynamic testing, while the Kevlar walled configuration was employed for aeroacoustic measurements and some aerodynamic characterization.

Aerodynamic characterization of the model involved steady surface pressure measurements over the slat and the truncated main element surfaces, as well as planar three-component velocity measurements within the slat cove region obtained using stereo particle image velocimetry (PIV). Surface flow features were further examined using oil flow visualization on the wing surface. Aeroacoustic characterization was performed using single- and phased-array microphone measurements. Acquired aerodynamic and aeroacoustic data are compared with available experimental and computational results from the SWAHILI [3] and INVENTOR [4] projects carried out by DLR and ONERA-Le Fauga, as well as the results obtained from the un-swept full-scale hybrid model at UTIAS within our group.

References:

[1] E. Manoha and M. Pott-Pollenske, "LEISA2: An experimental database for the validation of numerical predictions of slat unsteady flow and noise," in 21st AIAA/CEAS Aeroacoustics Conference, 2015.

[2] A. Roy, D. Foster and A. Ekmekci, Design and analysis of full-scale truncated wind tunnel slat model for aeroacoustic testing, in the 7th Symposium on Fluid-Structure-Sound Interactions and Control, 2025.

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[3] E. Manoha, R. Davy, M. Pott-Pollenske, and S. Barre, “SWAHILI: An experimental aero-dynamic and acoustic database of a 2D high lift wing with sweep angle and flap side edge,” in 2018 AIAA/CEAS Aeroacoustics Conference, 2018.

[4] R. Davy, E. Manoha, and M. Terracol, “Slat track noise and flow measurements in noisy aerodynamic closed section windtunnel and associated cfd/caa computations,” in 30th AIAA/CEAS Aeroacoustics Conference, 2024.

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