Computational Aeroacoustic Noise Predictions of a 30P30N Three-Element High-Lift Device

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ABSTRACT

In recent decades, it was discovered that airframe-induced aircraft noise poses a significant threat to public health due to its negative physiological effects that are imposed through chronic noise exposure. Particularly, high lift devices (HLD) are one of the most prominent broadband and narrowband sources of airframe noise which has made it an active subject of research. Generally comprised of slats, a main element, and flaps, recent HLD research has limited its scope of interest to the slat cove and slat trailing edge as they are the loudest recorded noise sources. However, multi-dimensional flap noise has become of particular interest given the growing popularity of two-element HLD configurations (i.e., only flaps and the main element) which are generally found in smaller commercial aircraft and business jets – thereby making flaps the biggest source of HLD noise. In this paper, the most recent computational aeroacoustic (CAA) results of an ongoing simulation campaign series to benchmark a fully configured 30P30N high lift device inside the University of Toronto’s Hybrid Anechoic Wind Tunnel (HAWT) will be presented and discussed. First, the subject matter will feature aerodynamic comparisons between quasi-two-dimensional unsteady Reynolds-Averaged Navier-Stokes (uRANS) simulations and Large Eddy Simulations (LES), and the current experimental results gathered at the HAWT. These statistically converged results will investigate Reynolds number dependency via surface pressure measurements and integral force characteristics such as lift and drag – all while comparing CAA results to the experimental results subjected to the installation effects of the HAWT. Second, computational acoustic results will be compared with experiments wherein dominant acoustic modes, tones and noise sources will be examined. Lastly, low-fidelity two-dimensional steady RANS simulations using a modified version of Amiet’s acoustic model will be compared with high-fidelity unsteady RANS (uRANS) and wall-resolved LES featuring a Flowcs-Williams and Hawking’s (FW-H) far-field acoustics code. The emphasis of this section will be to contrast the flap self-noise induced by edge scattering at the trailing edge, and to analyze the feedback loop induced by laminar recirculation bubble instability against the flap suction surface into the far-field. The topics covered in this paper will be further refined and expanded by the group, and the goal of fully benchmarking the HAWT while investigating the capacities of numerical schemes in CAA solvers will be attained in subsequent papers.