Mid-Fidelity Aeroacoustic Prediction of Scaled eVTOL Rotors

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The growth of interest in electric vertical take-off and landing (eVTOL) aircraft for operation in urban environments has raised the demand for a low computational cost method of predicting the tonal and broadband acoustics for electrically driven rotors. A computationally efficient method is developed to obtain predictions for acoustic radiation produced by a scaled two-blade rotor. The aerodynamic flow-field is modeled through DUST, a medium-fidelity aerodynamic solver, which allows for fast and reliable aerodynamic simulations of unconventional systems with low computational costs. The tonal acoustic pressure at an observed location is found through the implementation of the Farassat 1A solution to the Ffowcs William and Hawkings equation utilizing the aerodynamic flow-field. The model for trailing edge acoustics developed by Sinayoko et al. is applied to capture the broadband spectrum of the rotor. This model is modified with the Lee empirical model for the turbulent boundary-layer wall pressure spectrum to account for non-zero pressure gradients. The coefficients of Lee's model are optimized to match broadband noise radiation measured at the University of Florida's anechoic wind tunnel. The tonal and trailing edge broadband models are combined to predict the acoustics generated by a two-blade rotor in hover and low-speed forward flight conditions. These results are compared to wind tunnel experimental data measured at the University of Florida. This combined approach allows us to quickly predict acoustic radiation from small eVTOL rotors and eventually integrate prediction methodologies into the design process. The predicted tonal acoustics matched the experimental results within 1.8 dB at the operational rotation speed for the rotor at all locations below the rotor plane while in hover. Additionally, the broadband model achieves results within 2.5 dB directly below the rotor plane before optimization.

Acknowledgements

The authors are grateful for continual funding from Archer Aviation Inc.