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Fast Prediction of Broadband Rotor Noise in Hover

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ABSTRACT

The use of Unmanned Aerial Vehicles (UAV) has increased significantly in recent years, and it is expected to keep growing in the next decade. The myriad of applications ranging from transport, goods-delivery, and leisure to military, made regulatory agencies impose stringent rules on noise emissions, particularly in populated areas. Therefore, a critical part of UAV design is a fast and accurate model for noise prediction. While in hover, noise from the scattering of the turbulent boundary layer at the trailing edge is expected to dominate the rotor broadband spectrum, making it imperative to have a reliable model that can be quickly implemented in the design process. Additional broadband sources, such as turbulence-interaction noise, are not expected to greatly contribute to the spectrum in this flight condition, given the weak Blade Vortex Interaction (BVI) and the expected trajectory of the blade wakes.

In this study, a fast prediction method for trailing edge noise of a rotor in hover is presented. It is based on the use of fast, steady aerodynamic models, obtained for instance with Reynolds-Averaged Navier-Stoker (RANS) simulations coupled with a broadband analytical model for the rotor blade. To validate the latter, the recent propeller benchmark proposed by TU Delft is used. For the aerodynamic inputs, the same data from BEMT (Blade Element Momentum Theory) combined with coupled panel/boundary layer XFOIL calculations are used as in the benchmark. The present noise predictions are then validated with the available benchmark experimental and numerical data for a rotor in hover. After the validation, the same methodology is implemented in a different test case of a rotor in hover that was recently measured in the ISAE anechoic chamber, which has provided abundant additional noise data. The results show that the proposed approach is accurate enough to predict hover noise, and its simplicity makes it ideal to integrate it into the design process. Furthermore, it validates the use of low-order models for low Reynolds number propeller noise prediction.