Subgrid Scale Noise Models for Aeroacoustic Prediction

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There is significant interest within the aircraft engine industry to be able to accurately predict the noise generated by a jet engine design. Current prediction methods are RANS-based (Reynolds-averaged Navier-Stokes) where the entire sound generation process is semi-empirically modeled. It has been found that for complex nozzle designs, such as nozzles with tabs or chevrons, the RANS predictions are not sufficiently accurate. It is believed that the discrepancies arise due to the modeling of the flow unsteadiness, whose characteristics are subtly changed by the chevrons/tabs. It is hoped that a LES-based (large-eddy simulation) prediction, where the flow unsteadiness occurs naturally, would be able to capture the observed changes in the jet exhaust plume and thus better predict the far-field sound.

Two difficulties with the LES predictions are that the Reynolds numbers typically used are two to three orders of magnitude below those found in practical applications and that the affordable grid resolution may be quite modest. As a result, the frequency spectrum of the LES predicted far-field sound is artificially truncated at the higher frequencies. This is due, in part, to the absence of the sound generated by the interaction of fluid motions near the grid cut-off scale with the larger, resolved motions.

To recover the higher frequency sound, two subgrid noise models are proposed that attempt to estimate the 'missing' sound produced by the turbulent motion. The first noise model is kinematic and uses the approximate deconvolution model of Stolz *et al.* [*Phys. Fluids*, vol. 13, no. 4, 2001, pp. 997–1015] to extrapolate the near grid scale motions from the resolved field. Model tests using a fully resolved simulation of a turbulent, spatially developing shear layer, which idealizes the near-nozzle region of the exhaust plume, will be presented and discussed. The second model is based on a WKB representation of the subgrid scale motions and aims to correctly capture the acoustically important space-time dynamics of the near grid scales. At the same time the model provides a comprehensive closure for the subgrid scale mass, momentum, and energy fluxes. The WKB model's formulation and preliminary results will be presented.

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