On the Noise Sources of Jet and Wing Interactions: a LES-RANS study

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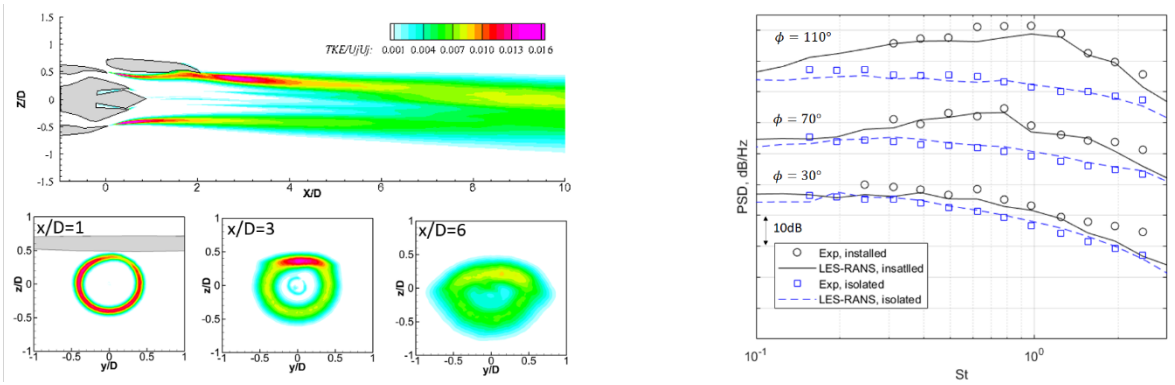
Compared to the isolated engine exhaust noise, extra noise is generated when a propulsive jet is placed near a wing, referred to as installed jet noise. The installed jet noise dominates from low to intermediate frequencies, shown in Fig. 1 from our hybrid LES-RANS results [1]. It becomes a great concern when the aircraft engine is moved even closer to the wing, e.g. the next-generation ultra-high bypass-ratio engine. This close installation configuration will significantly enhance the jet and wing interactions and hence increase the installed jet noise. Therefore, it is important to understand the noise sources of this closely installed jet configuration, which will facilitate the design of an efficient noise reduction strategy.



(a) Turbulence kinetic energy (b) Far-field noise

Figure 1 LES-RANS results of closely installed

If an impermeable Ffwocs-Williams Hawkings integral surface is formed on the wing, the noise sources of noise generation are broken down into a) the quadrupole sources generated by turbulent mixing in jet plume and b) the dipole sources produced by unsteady loading of the wing. For loosely installed jets, the turbulent jet almost remains intact and the far-field noise is contributed only by the dipole source which is caused by the trailing edge scattering. However, when the jet is installed closely to the wing, the turbulent jet is significantly altered by the wing, as shown in Fig. 1. Hence, the quadrupole sources are expected to change and contribute to noise generation. In this research, we will investigate these two noise source changes in this closely installed jet configuration and quantify their contribution to the far-field noise. The quadrupole source is calculated based on Goldstein's acoustic analogy, where noise sources are characterised by four-order space-time correlations and convoluted with Green's function to calculate far-field noise [2]. The dipole noise is approximated by the trailing edge noise, which is calculated by scattering near-field evanescent waves in the turbulent jet [3]. Our preliminary results, in Fig. 2 (a), show that the jet-wing interactions can increase the turbulence mixing noise up to 5 dB from St=0.3 to 1 due to an increased quadruple source. When added to the trailing edge scattering noise, the far-field noise can be recovered with a peak increase of about 15dB around St=1.0. The detailed analysis of noise sources and how they contribute to the far-field noise will be presented at the conference.

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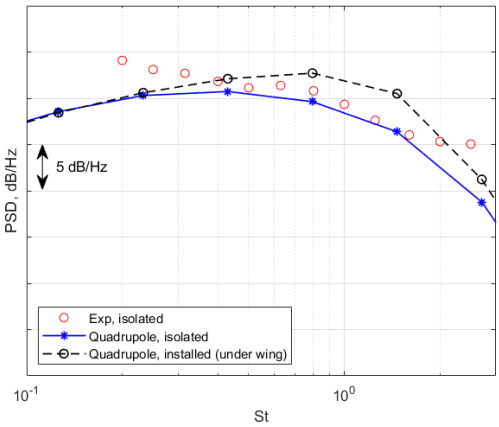
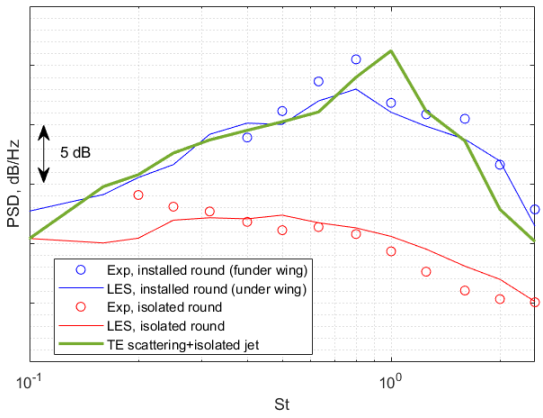


(a) Turbulence mixing noise



(b) Trailing edge scattering noise

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