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Industrial prediction of jet-flap interaction noise with advanced hybrid RANS-LES methods

C. Mockett[1], M. Fuchs[1], T. Knacke[1], F. Kramer[1], U. Michel[1], M. Steger[2], F. Thiele[1]

[1]CFD Software E+F GmbH, Berlin, Germany
[2]Rolls-Royce Deutschland Ltd. & Co KG, Dahlewitz, Germany

Abstract

Jet-flap interaction noise has become a greater problem as ever-increasing bypass ratios lead to reductions of pure jet noise and greater jet-wing proximity. The simulation of such phenomena in an industrial context is challenging for a variety of reasons. This contribution describes ongoing efforts towards the industrialisation of jet noise prediction methods on a number of fronts. The methodology is centred on an advanced formulation of Detached-Eddy Simulation (DES), which combines the robust and mature features of Delayed DES (DDES) with recent modifications to mitigate the Grey Area problem in the early shear layer [1]. The latter is essential for jet prediction, since such flows are strongly affected by the Grey Area. The shielding functionality of DDES is particularly important for the accurate and efficient handling (by RANS) of extensive, thin turbulent boundary layers present in installed jet/wing configurations.

Complementing the DES modelling advances, a number of "infrastructure" improvements have been made to the underlying code and the overall simulation process [2]. These include a robust low-dissipation numerical scheme, an unstructured meshing strategy allowing local azimuthal refinement, a sensor function to optimise the placement of Ffowcs-Williams & Hawkings (FWH) data surfaces and approaches for automatic detection and efficient simulation of initial transient.

Validation results for the enhanced methods are shown for a static, single-stream jet at $M = 0.875$ and $Re = 2.05 \times 10^6$ in Fig. 1. The unstructured mesh approach and low-dissipation numerical scheme improve the prediction of the early shear layer and no spurious noise is detected. The agreement with far-field spectra is excellent (the peak observer location at $\theta = 30°$ to the jet axis is shown).

In the full paper, results from a complex installed jet noise case will be presented, the geometry of which is shown in Fig. 2. Furthermore, a

detailed examination of the functionality of the advanced DES formulation will be given.

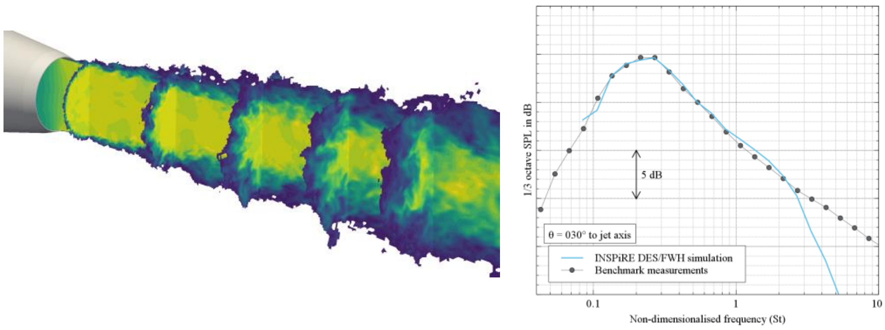

Fig. 1 Snapshot of velocity magnitude (left) and validation of far-field spectra with measurements (right) for DES of a static, single-stream jet

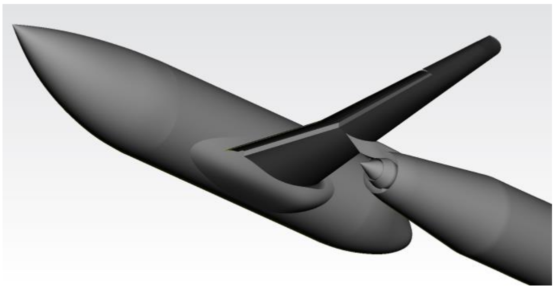

Fig. 2 Geometry of installed jet configuration showing coaxial jet with pylon and bifurcations, wing, flap and fuselage

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