Linearized Navier-Stokes for Aeroacoustics: Assessment of Aft Fan Noise Radiated from Business Jet Engines Nozzles

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ABSTRACT

Fan noise is one of the leading source of aircraft noise. The CleanSky European project is aimed at developing environmentally friendly airplanes, which would burn less fuel and also emit less noise. As part of the Smart Fixed Wing Aircraft, one of the six platforms of the CleanSky project, Dassault Aviation is working on the integration of aft-body concept for engine noise shielding [1]. An innovative U-tail aircraft model equipped with turbine powered simulators was wind-tunnel tested to assess the acoustic shielding effect of the U-tail on a typical business jet with side-mounted engines.

As part of the modeling of the noise shielding effect, the acoustic propagation of a known mode in the jet engine to the surrounding space has to be computed. As the flow of the engine considerably changes the way the acoustic waves propagate, pure Helmholtz equations are not sufficient. Linearized Euler or Navier-Stokes equations are needed to take into account the acoustic refraction induced by the mean flow.

Aether is a finite element solver on unstructured meshes for the compressible Navier-Stokes equations, stabilised using the SUPG method. It was fully developed in-house at Dassault Aviation. It was linearized for aeroelasticity applications [2], and shape optimisation [3]. For aeroacoustics, the high-order capability of Aether was kept [4].

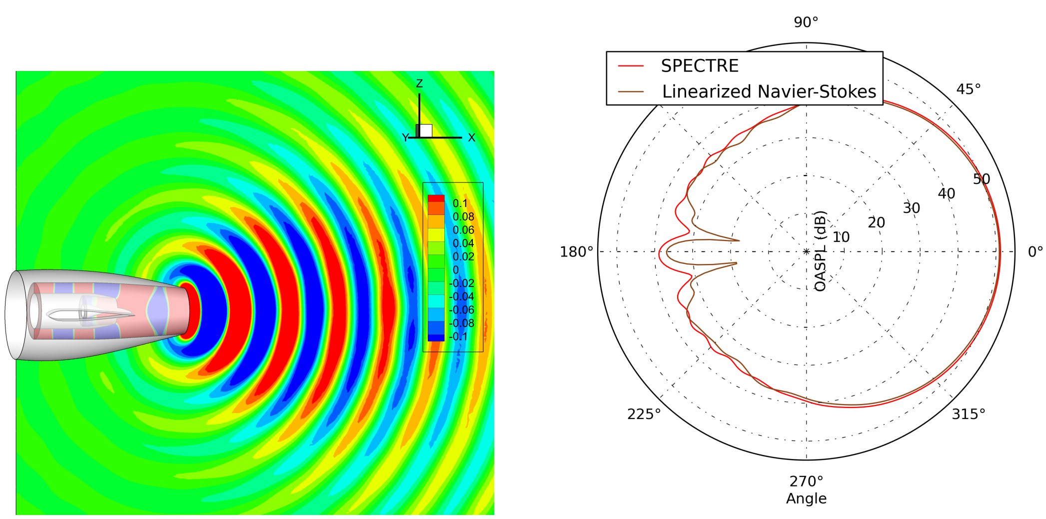

Figure 1: Plane mode at 2000Hz with no base flow. Left: real part of the pressure variation in Pa. Right: comparison of directivities between linearized Navier-Stokes and a BEM method (SPECTRE)

For validation purpose, computations were done without mean flow, and the results were compared with SPECTRE, an in-house boundary element code solving the Helmholtz equations. Good agreement was found on several acoustic modes. Figure 1 shows the geometry of the jet-engine nozzle used in our computations superimposed with the real part of the acoustic pressure in the computational domain, and the comparison of the directivity of the linearized Navier-Stokes method with the BEM code, for the plane mode at 2000Hz with no flow.

The effect of imposing different boundary conditions on quality of the result will be studied. The simulation of higher radial modes, which are harder to predict well as they have complex waveforms which interact non-trivially with the geometry, will provide highly discriminating test cases.

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