# High-fidelity flow and noise simulation of a double-stream jet installed in a T-tail configuration

**F. Sartor[1], M. Huet[2], T. Renaud, F. Gand**

**Office National d'Etudes et de Recherches Aerospatiales (ONERA)**
**Chemin de la Hunière, 91120 Palaiseau - France**

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## Introduction

Jet flows are responsible for thermal, vibrational and acoustic sources that must be taken into the account when designing an aircraft. Coupling effects as noise reflections or acoustic fatigue are common when considering industrial configurations and installation effects. In order to predict these phenomena, reliable unsteady approaches are needed to reproduce the aerodynamic flow field and accurate acoustic propagations are fundamental for the evaluation of the generated noise. In this framework, advanced CFD approaches coupled with aeroacoustics analysis are tested on a simplified industrial configuration. This work will present the results of a high-fidelity CFD simulation of a double-stream mixed nozzle installed in a T-tail configuration representative of a business jet. The time-accurate evolution of the fluctuating field is then used to feed an integral formulation allowing for the radiation of the acoustic waves and the characterisation of the radiated noise.

## Aerodynamics simulation

The CFD simulations were performed with the unstructured solver of the elsA software [1]. The turbulence modelling approach used is a Zonal Detached Eddy Simulation (ZDES) [2] which allows for a wall-modelled LES resolution in the nozzle boundary layer, a LES resolution in the jet and a RANS modelling elsewhere. The turbulence generation is performed using tripping dots included in the computational domain using Immersed Boundary Conditions (IBC). The adopted approach has already shown accurate results in jet-flow aeroacoustics simulations [3] and has been improved via the use of unstructured meshes adapted to the jet flow topology [4], a more accurate turbulence modelling strategy and an increased CPU efficiency thanks to solver improvements.

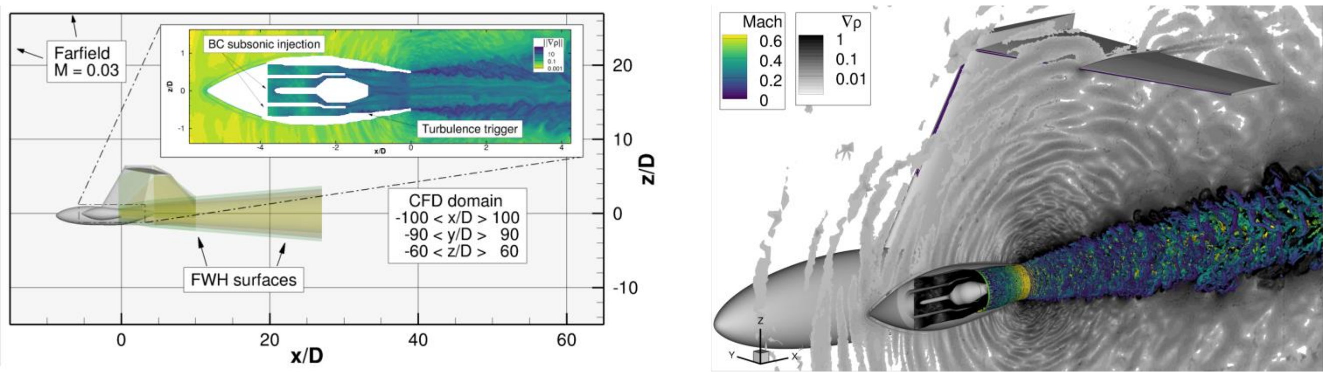


**Figure 1**: Schematic representation of the computational domain, including the acoustic surfaces and the boundary conditions for the far-field, the jet, and the triggering of the turbulence (left). Iso-surface of Q criterion superposed to a vertical slice of density gradient (right).

The configuration is presented on the left side of Figure 1, where the nozzle installed in the T-tail configuration is represented in grey. The shaded regions indicate the location of the porous surfaces used for acoustic radiation [5]. The turbulent triggers, visible inside the nozzle in the top-right rectangle, are responsible for the creation of the turbulent structures that are feeding the mixing layers downstream of the nozzle trailing edge. The turbulent structures, represented on the right side of Figure 1 thanks of an iso-surface of Q criterion, are responsible for

[1] fulvio.sartor@onera.fr
[2] maxime.huet@onera.fr

the generation of acoustic waves, as indicated by the fluctuations of the density gradient (greyscale on the vertical plane).

The results of the time-accurate simulation have been time-averaged for a direct comparison with the experimental data available and pressure sensors located on the horizontal tail plane have been used to compute the power spectral densities. Both the mean flow and spectra presents a favourable comparison with the experimental data (Pitot and Kulite sensors) obtained at AWB facility.

## Noise radiation

Unsteady flow fields surrounding the jet were then used for the reconstruction of time-pressure histories at experimental microphone locations using the Ffowcs-Williams and Hawkings integral method [5]. The five experimental microphone arrays illustrated in Figure 2 left were reproduced in the simulation. Numerical data were found to reproduce the experimental pressure levels with a very good agreement, both for the shape of the spectra and the absolute levels.

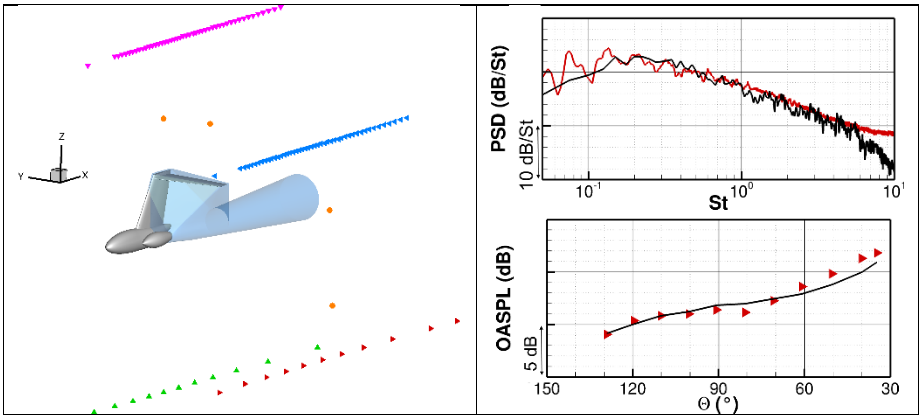


**Figure 2**: Position of the microphones used for noise-radiation (left). Power-spectral density at sideline position, (top right) and integrated pressure levels (bottom right). Experimental data are in red and simulated data in black.

As visible in Figure 2 right for the sideline microphone array, the grid grid-off frequency is observed to lie above St=5 for most of the observation angles, the simulation hence captures most of the acoustic energy radiated and integrated pressure levels match with the experiments within 1 dB. The final presentation will include comparisons on the other microphone arrays as well as experimental data of the isolated jet to investigate the role of the fuselage and tailplane on azimuthal noise distribution and the capacity of the simulation to reproduce such effects.

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