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Design of an active fluidic injection system for jet noise reduction through a hybrid CFD-stochastic approach

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The problem of noise generation by compressible turbulent jets has been the subject of studies since the early 1950s, with the introduction of the turbojet also in commercial aircraft. Despite the application of Direct Numerical Simulation to jet-noise prediction, becoming more feasible with the growing advancement in computational resources, industry interest is mainly devoted to fast and reliable numerical tools to be used for design and optimization. Therefore, RANS (Reynolds-Averaged Navier–Stokes) simulations remain the more feasible approach for CFD applications of industrial interest. In this work, the prediction and reduction of noise from subsonic jets through the reconstruction of turbulent fields from RANS calculations are addressed. This approach, known as Stochastic Noise Generation and Radiation, reconstructs the turbulent velocity fluctuations by RANS fields and calculates the source terms of Vortex Sound acoustic analogy. In the first part, numerical and experimental jet-noise test cases have been reproduced to validate the approach for its subsequent use as a design tool. The noise spectra, predicted with SNGR (Stochastic Noise Generation, and Radiation), are in good agreement with both the experimental data and the results of Large-Eddy Simulations. In the last part of this work, an active fluid injection technique, based on extractions from turbine and injections of high-pressure gas into the main stream of exhausts, has been proposed and finally assessed with the aim of reducing the jet-noise through the mixing and breaking of the turbulent eddies. Some tests have been carried out to set the best design parameters in terms of mass flow rate and injection velocity and to design the system functionalities. The approach is suitable to be used for the early design phase of jet-noise reduction technologies and a right combination of injection parameters allows for a reduction of the jet-noise to 3.5 dB, as compared to the baseline case without injections.

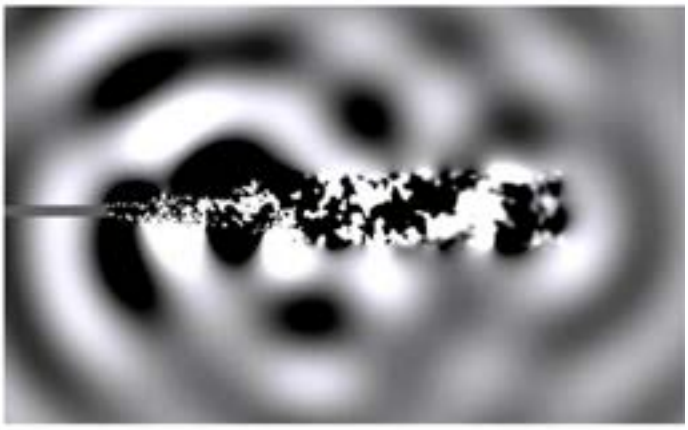

Figure 1: Sound radiation from the jet. Real part of the acoustic pressure [Pa] at 700 Hz.

Biography

Mattia Barbarino has a PhD in Mechanical Systems Engineering, and is responsible for the Computational Acoustics Lab at CIRA, Italy. He has been working at CIRA since 2007 in Aeroacoustics, CAA software development and numerical simulation. He has developed a multi-disciplinary view to the aircraft/rotorcraft noise prediction and reduction problem, being active in several EU funded projects (e.g. Nice trip, Cesar, Clean-Sky JTI GRA and GRC ITD) and collaborative projects (GARTEUR). He is Member of the CEAS Aeroacoustics Specialists Committee and point of contact of the IFAR working group on Noise.

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