Multi-objective Optimization for the Aerodynamics and Aeroacoustics of an Aircraft Engine Inlet

1 Thesis subject

The thesis addresses the issue of multi-objective optimization of the inlet performance of aircraft engines. A methodology will be developed to simultaneously define the optimal geometries and liner impedance distributions, enabling the determination of the best trade-offs between aerodynamic performance (minimum distortion index, maximum efficiency) and acoustic performance (minimum acoustic efficiency, attenuation of the most critical propagation modes, control of directivity).

The methodology will rely on a shape optimization approach using the adjoint method, which will be applied here to the coupled system of equations governing both the average aerodynamic behavior and the dominant acoustic response. The aerodynamic fields will primarily be modeled using the RANS (Reynolds-Averaged Navier-Stokes) approach and/or URANS (Unsteady RANS) in a compressible flow regime. The aeroacoustic part will be modeled using the linearized Navier-Stokes equations in the so-called resolvent formulation [1, 2, 3, 4, 12, 13]: starting from a mean flow field (RANS), this approach provides a global estimate of the acoustic efficiency of the system, the distribution of sources, propagation within the internal domain, and directivity in the external acoustic field.

The methodology will be developed and initially validated in a canonical configuration (axisymmetric, with a simplified representation of the fan presence). High-fidelity simulation campaigns and experimental validations may be considered for the optimized configurations with simplified geometries, depending on the resources available for the project. Following the validation phase, the methodology will then be adapted for application to 3D configurations that more accurately represent real engine air inlets.

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