Master Thesis Research Project

Large Eddy Simulation for Fan Broadband Noise Applications

Ecole Centrale de Lyon / LMFA

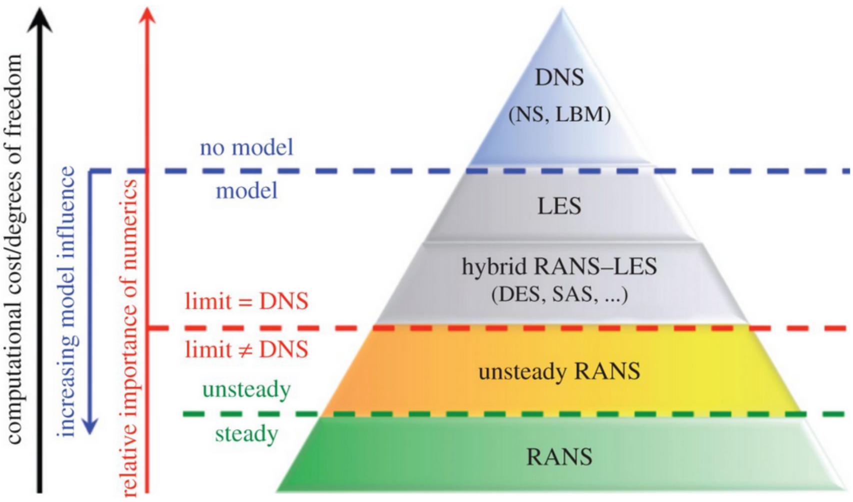

FIGURE 1 – Classification of unsteady approaches according to levels of modelling and readiness (adapted from Sagaut et al. 2013).

Context

With an expected growth rate of 6% within the next 10 years, the air traffic at the scale of the entire planet is expected to double by 2030. In order to reduce the noise experienced in the vicinity of airports, the International Civil Aviation Organization (ICAO) issues stringent regulations to which engine and aircraft manufacturers have to comply.

Aircraft noise sources are numerous and are usually split into two categories : airframe noise (due to landing gears, wing slats and flaps, etc.) and engine noise (due to the jet, the fan, combustion, turbines and compressor stages). The evolutions of turbofan engines architectures during the last decades saw a significant increase of the bypass ratio, and the fan is producing most of the thrust for modern engines. As a result, fan noise, which refers to the noise generated both by the fan and the outlet guide vanes (OGV) located just behind the fan in the bypass duct, has become one of the major source of engine noise, particularly at approach conditions.

Of a large span, in order to increase the aerodynamic efficiency, rotating blades are responsible for both tonal and broadband noise. Tonal noise has received a lot of attention during the last fifty years and theoretical as well as numerical models have been derived that accurately reproduce experimental results. Broadband noise properties have also been studied for a few decades but remain difficult to model because of their stochastic nature.

Broadband noise is related to the fine structure of the turbulence developing in the boundary layers of the fan blades and outlet guide vanes as well as in the wakes of the fan. The diffraction of turbulent structures by trailing edges of the fan and OGV, and the impingement of turbulent fan wakes on the OGV are major contributors to broadband fan noise. Its acoustic signature is usually of smaller amplitude than the tones, but spread over a wide frequency range.

Because of its stochastic nature associated with turbulence, unsteady numerical simulation of the phenomenon based on statistical averages (URANS) cannot be pursued and steady methods (RANS) requires the questionable reconstruction of a synthetic turbulent field. A more accurate way to proceed is to use unsteady methods explicitly solving for as many scales of vortices present in the flow as possible in order to directly represent the turbulent structures at the core of the phenomenon. One possible candidate is Large Eddy Simulation (LES).

Huge progress have been made towards the use of LES for turbomachinery applications and have been fostered by the large increase of available computational resources. Yet, in order to use this method with confidence for complex cases where both the source generation and early acoustic propagation are present, its precision, mesh requirements and computational costs have to be properly assessed.

Objectives and Methodology

This internship will focus on the evaluation of TurboAVBP, a LES solver developed at CERFACS (Toulouse) for turbomachinery applications. The candidate will perform acoustic propagation test-case simulations and compare the results to analytical solutions to assess the properties of the numerical methods implemented in the solver. Thanks to these comparisons, the candidate will propose recommandations to the research team in terms of mesh resolution and numerical models. The candidate will also complete previous work on the assessment of the computational cost of a high fidelity fan-OGV simulation by including the acoustic criteria deduced from his work on the test-cases.

Profile

This 6 months project (starting date march/april 2019) will be carried out in the Fluid Mechanics and Acoustics Laboratory (LMFA) at Ecole Centrale de Lyon (ECL). Technical skills in fluid mechanics, acoustics and numerical simulation are expected from the applicant. A marked taste for modeling, applied mathematics and physical analysis in fluids will be an asset.

To apply : alexis.giauque@ec-lyon.fr ; vincent.clair@ec-lyon.fr