PostDoc offer at ISAE-SUPAERO

Location : ISAE SUPAERO & AIRBUS, Toulouse, France

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Keywords : Aeroacoustics, LES, HPC, propeller noise

POSTDOC DESCRIPTION

Title: INPRO – High-order LES of a propeller and of its interaction with a profile

Proposed duration and period: 24 months, 2022-2023

Context

Recently, in order to tackle environmental challenges, new aircraft designs have been proposed by AIRBUS. Designs with propellers are particularly studied as they offer serious advantages to reach ambitious decreases in energy consumption. The removal of the nacelle permits it to have a larger propeller diameter compared to a turbofan engine, which permits to increase the efficiency of the propulsion system. However, even if propellers are used since the beginning of aviation, challenges in terms of integration arise and aircraft and engine manufacturers are exploring several architectures. One of those challenges is the interaction of the wake with the aircraft, which is a major source of noise. And the absence of the nacelle makes it impossible to treat with conventional acoustic liners. Thus, simulation tools permitting to test those different designs are needed to understand the key phenomena in noise generation mechanisms. At ISAE-SUPAERO, we are developing since several years body force models permitting to simulate a fan of a turbofan engine with source terms without having a sliding mesh. One of the purposes of the project is to use this modelling for propellers, this will be done in a companion PhD. To do so, high-fidelity simulations of such configurations are needed to validate the body force approach. High-fidelity simulations of such configurations will also permit to study the noise coming from the interaction between the propeller wake and a profile for example, in order to derive notably broadband noise models.

Figure : Exemple of a concept studied at AIRBUS

Objectives and work

In this PostDoc position, High-Order Large Eddy Simulation (HO-LES) will be performed; First, a single propeller blade will be simulated and its noise studied. This simulation will serve as a validation to body force modelling used in a companion thesis. In a second part, HO-LES of the interaction of a propeller with a pylon and or a profile will be performed. The noise source mechanisms will be sought via advanced post-treatments methodology (SPOD, DMD) in order to draw models, especially for the broadband noise, usually inaccessible with lower-fidelity simulations. To perform those simulations, an in-house HO-LES code solving the 3D compressible Navier-Stokes equations, named IC3 and developed at ISAE-SUPAERO, will be used. It is based on high-order spectral methods for the spatial discretization, which allow high order of convergence, up to 5^{th} order **[1,2]**. These methods are well adapted to propagate the turbulent structures inside the wake of the propeller, as well as the acoustic waves with a very

low dissipation. To apply this approach and reproduce accurately the interaction between the wake and a profile, a critical ingredient is the application of a sliding mesh. Such methods have been developed, validated, and implemented in our in-house solver recently **[3]**. It is currently used for the simulation of a turbofan engine and of drone rotors as illustrated in Figure 1.

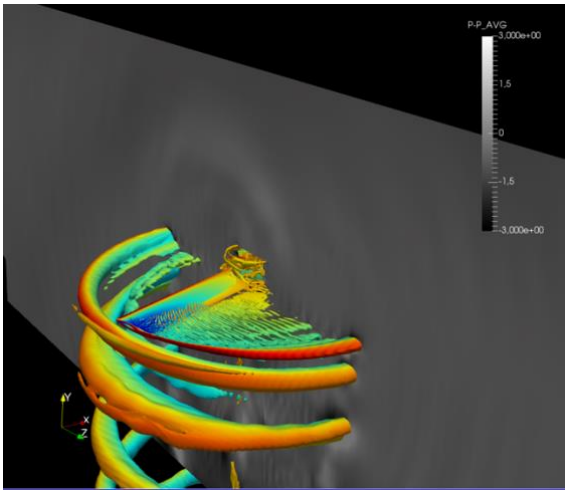

Fig. 1 Example of a drone rotor simulated using the code IC3 at ISAE-SUPAERO.

References

[1] Lamouroux, R., Gressier J., and Grondin G. "A High-Order Compact Limiter Based on Spatially Weighted Projections for the Spectral Volume and the Spectral Differences Method." *Journal of Scientific Computing*, 67.1 (2016): 375-403.

[2] Lamouroux, R. Méthodes compactes d'ordre élevé pour les écoulements présentant des discontinuités. *PhD Thesis*, ISAE-SUPAERO, 2016.

[3] Sáez-Mischlich, G., Grondin, G., Bodart, J., & Jacob, M. C. (2019, June). Assessment of LES Using Sliding Interfaces. In *ERCOFTAC Workshop Direct and Large Eddy Simulation* (pp. 405-410).

REQUIRED APPLICANT PROFILE AND SKILLS	
Study level	**PhD students**
Required profile and skills	The PostDoc candidate will have a strong background in either fluid mechanics, CFD and/or acoustics. Curiosity and self-working skills will be necessary to tackle this advanced topic. In particular, a desire to explore the capabilities of advanced simulation tools and physics of turbulent flows and acoustics is needed. Working in group is essential for this PostDoc, since in close collaboration with other PhDs and PostDocs working on the code IC3 and acoustics, as well as communicating results with Airbus. Programming skills (C++, python, etc.) will be appreciated. English and/or French is mandatory.