PhD offer

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PHD DESCRIPTION	
Title: MAMBO – High-order LES of the vortex-noise coupling in deep cavities at high speed flows **Proposed duration and period**: 36 months, 2021-2023	
Context	Certification in icing conditions of aircraft door openings requires the design of a small cavity along the interface between the door and the fuselage. The high-speed turbulent flow over this deep cavity can lead to strong noise generation, especially at cruise operating conditions. It results in undesired, and unacceptable, whistling sounds inside the cabin. From an industrial point of view, this issue should be taken into account at the design stage to avoid late and costly re-designs during flight tests. However, the underlying physics due to the coupling between the grazing turbulent boundary layer and the acoustics inside the cavity is still not fully understood. Thus, it requires advanced simulations tools to further understand the key phenomena generating this noise, in order to improve the current industrial method to predict this high-speed cavity noise at the design stage.
Objectives and work (max 20 lines)	The underlying noise mechanism in the door's cavity configuration is associated with an aeroacoustic coupling between the cavity and the grazing turbulent shear layer issued from the fuselage. A pure acoustic modelling of the modes inside the cavity with a standard CAA method is not able to reproduce this coupling, but only to find the relevant tonal frequencies that might emerge. First results based on a hybrid RANS/LES approach provided qualitative trends, but the high complexity of the interaction between the turbulent boundary layer and acoustic waves requires more advanced simulation tools. The goal of this PhD thesis is to predict accurately this noise spectrum using a state-of-the-art simulation method, namely High-Order Large Eddy Simulations (HO-LES) of the full 3D Navier-Stokes problem. To do so, 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. These methods are well adapted to propagate the turbulent structures inside the boundary layer, as well as the acoustic waves with a very low dissipation. To apply this approach and reproduce accurately the whistling noise, a critical ingredient is the simulation of the large turbulent boundary layer, representative of the one developing on the fuselage in cruise conditions, upstream of the cavity. To reach this goal, a synthetic turbulence will be implemented at the inlet of the HO-LES. This method needs the knowledge of the several characteristics of the boundary layer (mean flow, Reynolds tensor, etc.), in order to generate the synthetic turbulence by deconvolution. While this method has been already applied to other configurations, research efforts towards a robust and reliable method is still needed: this constitutes a second objective of this PhD. In addition, the effects of the spectral content of the turbulent boundary layer, as well as the geometry of the cavity on the noise spectrum will be investigated. Both academic (working with DLR, Germany) and industrial (from Airbus) geometries will be studied during this PhD. HO-LES simulations will be compared with the wind tunnel experiments carried out by DLR, as well as with the industrial tool available at AIRBUS. The goal is to provide a new insight on the main mechanisms driving this whistling sound, in order to propose relevant improvements of the current industrial method employed to predict this high-speed cavity noise at the design stage.

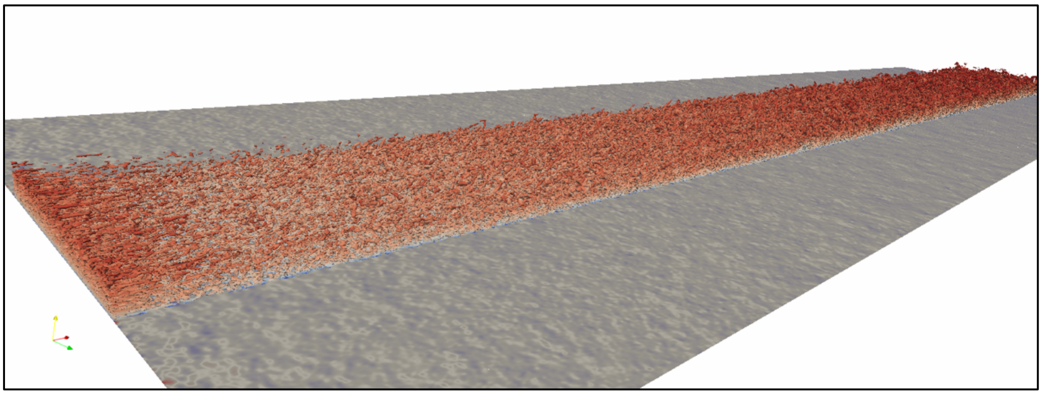

Fig. Example of a synthetic turbulence injected at the inlet of the HO-LES code IC3 at ISAE-SUPAERO (M = 0.1, Re_θ =4000)

REQUIRED APPLICANT PROFILE AND SKILLS

Study level	☐ ~~Undergraduate students (3rd or 4th year)~~ ☑ **Master students (2nd year, graduated and eligible for PhDs)** ☐ ~~PhD students~~
Required profile and skills	The PhD 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 PhD, since in close collaboration with other PhDs 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.
Other useful information	