Project ACOUDRONE: Towards Silent Micro Air Vehicles

PostDoc @ ISAE-SUPAERO, 12 Months, renewable

PostDoc advisors: Romain Gojon, Thierry Jardin, and Hélène Parisot-Dupuis
Contact: romain.gojon@isae-supaero.fr, Thierry.jardin@isae-supaero.fr, Helene.parisot-dupuis@isae-supaero.fr
Location: Aerodynamics, Energetics and Propulsion Department (DAEP), ISAE-SUPAERO, Toulouse
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Scientific domain: Experimental aeroacoustics, numerical methods (NLVLM, FW-H analogy), aeroacoustic optimisation

Summary:

The demand in Micro-Air Vehicles (MAV) is increasing as well as their potential missions, many of which take place in urban area. Whether for discretion in military operations or noise pollution in civilian use, noise of MAV has to be reduced. So far, beside relatively recent research performed at NASA [1], and TU-Delft [2], aeroacoustic research has mainly been focusing on large high-speed rotorcrafts, now yielding significant improvements and original shape designs. An active field of aeroacoustic research at ISAE-SUPAERO is dedicated to reduce the noise produced by small rotors and their interaction with the fuselage. This is a challenge since MAV's operate at relatively low Reynolds and Mach numbers. A significant first step has been achieved in 2020-2021 using an in-house optimization tool that combines a medium fidelity Non-linear Vortex Lattice Method (NLVLM) with a FW-H analogy [3-4]. Optimized geometries are 3-D printed and tested in an anechoic chamber [5]. In a companion PhD, wall-resolved Large Eddy Simulation (LES) are performed (Figure 1, left). The simulations were based on structured meshes with hundreds of millions of hexahedral elements using our in-house massively parallel compressible Navier Stokes solver IC3. Recently, a characterization of a low Reynolds number two-bladed rotor in interaction with a beam has been performed using both an experimental campaign performed in an anechoic room, LES, and medium fidelity NLVLM methods (Figure 1, right). The Figure 2 presents the experimental setup used for this campaign. This allows ISAE-SUPAERO to be a main actor in the design of stealth MAV's.

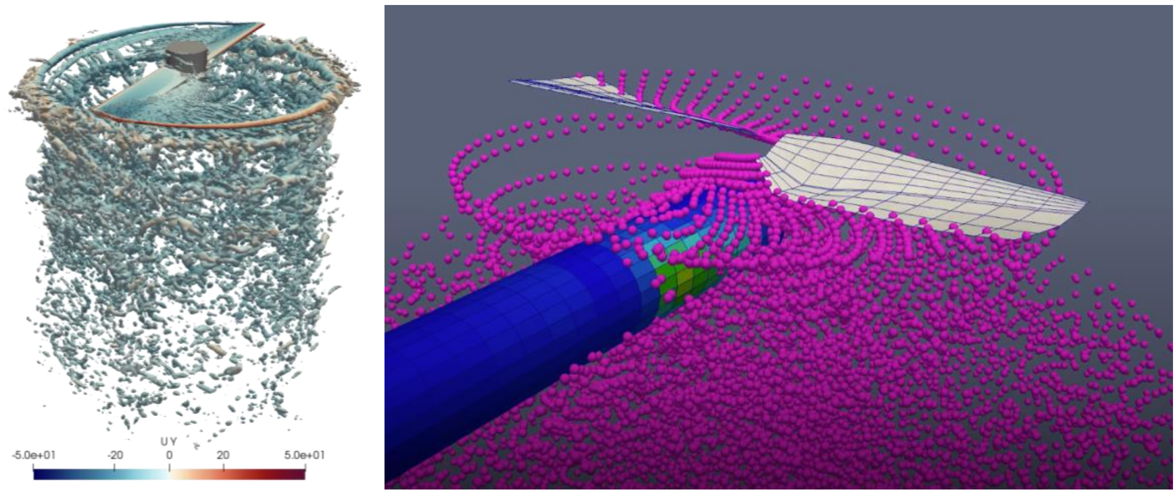

Figure 1: Isosurfaces of Q-criterion (left) from a Large Eddy Simulation of the flow past a two-bladed rotor and NLVLM simulation (right) of the interaction of the same rotor with a beam.

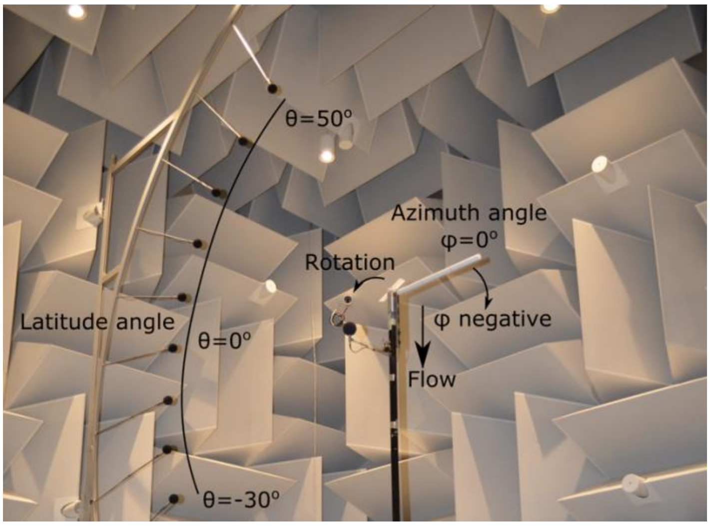

Figure 2: Photography of the experimental setup in the anechoic room.

Work agenda:

In 2022, the plan is to further complexify the geometry by simulating a set of two rotors in tandem or in coaxial configurations. One on hand, the medium fidelity unsteady NLVLM solver will need to be adjusted to adapt to such setup. One the other hand, the experimental setup will need to be re-designed in depth to permit the study of such geometry. The aim being to be able to characterize the physics of multi-rotors configurations and to perform aeroacoustic optimization including these complex interaction phenomena.

Expected skills:

Applicants who are expected to have a PhD in a field related to the subject, should have a firm background in fluid mechanics, applied mathematics, experimental methods, and unsteady CFD methods. More precisely, special skills in aeroacoustics, unsteady aerodynamics, and turbulence are expected to allow for a prompt start. Similarly, some knowledge of data processing, as required to post-process data from flow and sound computations as well as from measurements, are also an important asset. Some practical know-how in experimental techniques and a background in rotor aerodynamics would also be welcome. Furthermore, candidates should feel at ease in the UNIX environment.

References

[1] Zawodny, N. S., Boyd Jr, D. D., & Burley, C. L. (2016, May). Acoustic characterization and prediction of representative, small-scale rotary-wing unmanned aircraft system components. In *American Helicopter Society (AHS) Annual Forum* (No. NF1676L-22587).
[2] Grande, E., Romani, G., Ragni, D., Avallone, F., & Casalino, D. (2021). Aeroacoustic Investigation of a Propeller Operating at Low Reynolds Numbers. *AIAA Journal*, 1-12.
[3] Jo, Y., Jardin, T., Gojon, R., Jacob, M. C., & Moschetta, J. M. (2019). Prediction of noise from low Reynolds number rotors with different number of blades using a non-linear vortex lattice method. In 25th AIAA/CEAS Aeroacoustics Conference (p. 2615).
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[5] Gojon R., Jardin T., Parisot-Dupuis H., (2021), Experimental investigation of low Reynolds number rotor noise, JASA, 149(6), 3813-3829.