PostDoc: Installed propeller acoustics via Body Force Modeling

PARTENAIRES

AIRBUS

Keywords : Numerical simulation (Body Force Modeling, acoustical analogy), Aeroacoustics, Post-treatments

Department : DAEP, ISAE-SUPAERO, Toulouse

Summary:

To reduce fuel consumption or to try other energetics vectors, future aircraft architectures may consist of turbopropeller or open fan engines mounted near fuselage elements. The absence of nacelle will make the rotating blades noisier than in classical turbojet engines used today. It is thus of primary interest to predict the noise signature of such architectures at the design level. For design loops, efficient modelling methods are needed. The Body Force Modeling (BFM) approach has proved its capacity to accurately represent the impact of rotating machinery in installed configurations. It consists in replacing the propeller by a volumic source term distributed in the volume swept by the blades, reproducing the work and losses generated by the blades. The concept is illustrated in Figure 1.

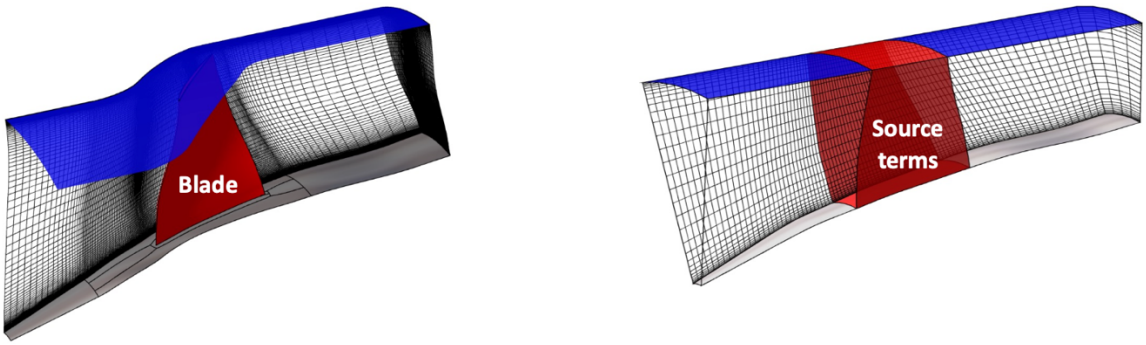


Figure 1: Body Force Modelling conceptual presentation.

Recent work has demonstrated that this method, originally designed for internal flow, gives good results for installed propeller aerodynamics [1]. Moreover, acoustic estimations of steady and unsteady loading noise from an installed propeller based on BFM results, and using an acoustical analogy, seem to provide acceptable results compared with the use of results from far more costly unsteady blade calculations [2]. However, some discrepancies have been identified, notably in the reconstruction of the fluctuating radial loading, leading to discrepancies in the amplitude of the corresponding noise source.
In this context, the main purpose of the proposed PostDoc position is to improve the aeroacoustic predictions by improving the radial load predictions of the BFM applied to propeller blades. This improvement is expected to be obtained by changing the calibration procedure of the modelled forces replacing the blades.

ISAE-SUPAERO activity

In 2025, an academic propeller whose characteristics mimic the ones from a standard propeller has been designed. Notably, its tip Mach number is equal to M=0.6 and its diameter is 44 cm. This propeller has been studied in isolated condition numerically using RANS simulations and its performance reach the target discussed with our industrial partner AIRBUS. However, this academic open geometry permits to publish and share future numerical and experimental results with the research community, making this propeller the ideal candidate for the present PostDoc work.

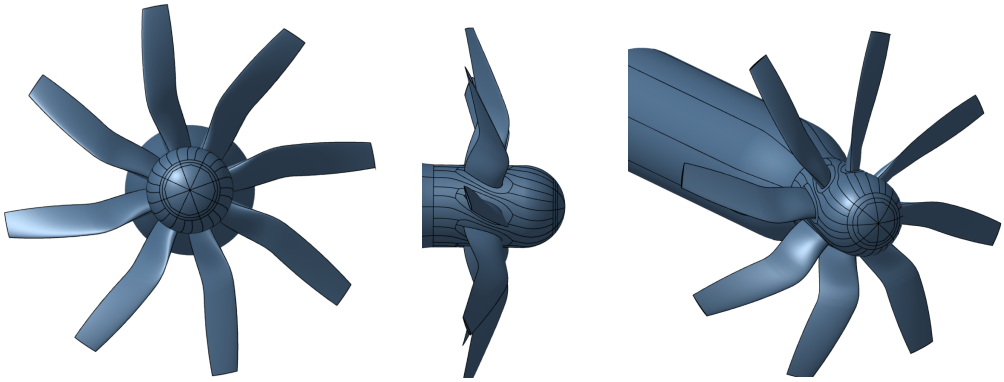


Figure 1 : Geometry of the turbopropeller designed at ISAE-SUPAERO

Moreover, this propeller has been designed to be studied in in the large aeroacoustic wind tunnel of ISAE-SUPAERO (nozzle exit of $180 \times 180\ cm^2$ and maximum velocity of $80\ m/s$). This experimental campaign, planned in 2027, will consist of studying first the isolated propeller but with an incidence angle compared to the wind tunnel direction, to trigger deterministic unsteady loading noise sources that should be reproducible with the proposed BFM approach.

The PostDoc will be able to attend the experimental campaign, and to compare his numerical results with the experimental ones.

Work agenda:

In 2026, the plan is to propose a new calibration procedure for the BFM methodology to be able to reproduce accurately the radial unsteady loading on the blade. This will permit, together with a Hanson acoustical analogy, to derive the acoustic signature of unsteady loading noise for an installed turbopropeller from a steady BFM simulation. The BFM approach would therefore provide a rapid tool for estimating sound levels generated by the presence of inhomogeneities in the propeller disk, like an incidence angle or the presence of a wing nearby. This will permit to consider the acoustic signature of the installation effects at the design phase for future turbopropeller aircraft.

Expected skills:

Applicants are expected to have a PhD in a field related to the subject, and in particular should have a firm background in fluid mechanics, numerical methods, and CFD methods. More precisely, special skills in aeroacoustics and unsteady aerodynamics, or in turbomachinery simulation, are expected to allow for a prompt start. Similarly, some knowledge of data processing, as required to post-process data from RANS simulations to perform model calibration, are also an important asset. Some practical know-how in python programming and a background in propeller aerodynamics would also be welcomed. Furthermore, candidates should feel at ease in the UNIX environment. Finally, the candidate is expected to present his work in international conferences on the subject and to publish in journals.

DURATION: One year

RYTHM: Full time

LOCATION: TOULOUSE

RESPONSIBLES OF THE SUBJECT:

NAME : DUFOUR Guillaume and GOJON Romain
E-MAIL : guillaume.dufour@isae-supaero.fr, romain.gojon@isae-supaero.fr

BILBIOGRAPHY :

[1] Kiffer, T., Dufour, G., Gojon, R., Thollet, W., & López de Vega, L. (2023). *Extension and validation of the Body Force Method to a propeller blade*. In AIAA AVIATION 2023 Forum (p. 3378).
[2] Kiffer, T. (2025). *Modélisation Body-Force d'une hélice installée* (PhD manuscript, Toulouse, ISAE).