Higher Education and Research Institute in Aeronautics and Space, ISAE-SUPAERO, Toulouse, FRANCE

Post-doctoral research position

Noise prediction for ultra-low emissions boundary-layer ingestion airframe shapes and electric propulsion layouts

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Context and motivation

Air transportation contributes to global warming both directly through greenhouse gas emissions, and indirectly through soot and contrails[1]. Aviation produces 2.1 % of global CO_2 emissions[2] and, with an average air traffic growth of 5 %, aligning with the trajectory set by the COP21 target for global temperature increase requires introducing disruptive technological evolutions. The CO_2 emissions reductions are currently addressed by novel energy sources (such as hybrid-electric propulsion) and thruster layouts, with radically different aero-propulsive integration. These novel shapes can drastically modify the noise sources on the airframe, as well as its propagation into the far-field (e.g. to the ground) and inside the cabin, compromising the noise certification. Assessment of new concepts aeroacoustic performance is therefore essential at the earliest, to ensure the best chances of passing the certification, and act as an enabler for a new generation of aircraft.

Fig.1. Slotted-inlet nacelle (left) and boundary-layer ingestion aircraft concept[3] (center and right)

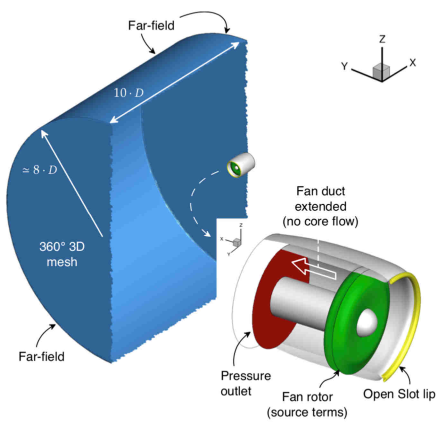
In this context ISAE-SUPAERO develops new aero-propulsive concepts targeting short-medium range aircraft as well as long-range aircraft. For long-range aircraft, ultra-short and thin nacelles are a well-known solution to compensate the weight and drag penalties related to the increased fan diameters of ultra-high bypass ratio engines (UHBR). However, short nacelles are subject to flow separation in off-design conditions (especially take-off and climb), which creates distortion and severely penalizes the fan efficiency, overweighing all the initial benefits[4]. In the framework of the EU-funded project ULTIMATE[5], we have proposed a slotted-inlet variable geometry concept (Fig. 1-left) as a potential enabler for ultra-short inlets, by reducing the flow distortion at take-off and climb. However the slot can be a new source of noise, as it happens with high-lift devices during landing. Similarly, for short-medium range aircraft, semi-embedded distributed electric propulsors (Fig. 1-right) are being widely studied for their aero-propulsive benefits. However, the distorted inflow can influence the fan noise sources. Validating the acoustic performance of these developments would enable their further development into experimental demonstrators.

Methodology and planning

The proposed project aims at studying the acoustic propagation of the fan tonal noise in the potentially complex flows generated in two integration scenarios of increasing complexity.

Predicting whether a configuration is subject to the tunnel effect or not requires the prediction of the noise propagation in a complex geometry subject to a complex flow, with strong gradients of air density. Studying sound propagation in these configurations require the knowledge of the steady airflow. To this end, Reynolds-Averaged Navier-Stokes (RANS) numerical simulations will be performed. For increased predictability, the effect of the fan propulsors inside the nacelles needs to be taken into account. This will be done using body-force models. Finally, the sound propagation will be solved using a dedicated solver (Actran).

We will begin with the slotted-inlet nacelle case, in which we aim first at refining the fan source model and simulating the propagation in the slotted case with the aim of determining the directivity of the fan noise and to what extent the tunnel effect is observed in this case. After this first step, a mitigation strategy of the radiated noise could be conducted by looking at different slot geometries and at optimal positions and characteristics of acoustic liners to be deployed for such nacelles.



Tackling the over-wing distributed propulsor configuration, we need to further refine the fan source model to take into account the non-homogeneous inflow. Indeed, under a BLI-type inflow distortion, the fan blades are alternatively subject to clean and distorted flow. The first objective will be to estimate the periodic blade loading of the fan using the body-force model. This development, once validated, will lead us to study the impact of the ingested boundary layer on the fan tonal noise at a relatively low cost. Finally, we will study the propagation inside the partially-embedded inlet (first considering one propulsor) and study the noise shielding potential of this installation, and whether the tunnel effect may occur through an eventual slat open at the leading edge of the wing. This will open the way to studying the influence of design parameters such as the number of propulsors and their interactions.

Requirements for the applicant

We are looking for an enthusiastic researcher for this study, interested in transition from fossil fuels towards innovative zero carbon energy sources for a green aviation, in order to diminish the global greenhouse gas emissions. A PhD degree in Fluid Mechanics and a strong background in aero-acoustics and computational fluid dynamics is required. Experience in CFD of turbomachinery or optimization will be highly appreciated.

Excellent English, communication and reporting skills are required. Comfort with working both independently and in a team, as well as a pro-active, problem-solving and result-oriented work attitude is highly regarded. The candidate is expected to publish and participate in international conferences.

Eligibility: the candidates must

- possess a PhD degree for less than five years on the date of application submission
- not have resided in France after September 1st, 2019, and have exclusively nationality of one of the following eligible countries: Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, Germany, Greece, Hong-Kong, Hungary, Iran, Ireland, Island, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New-Zeland, Norway, Poland, Portugal, Romania, Russia, Singapour, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taïwan, United Kingdom, United States of America

Duration: at least 1 year starting from January 2021. The position is potentially extendable.

Application deadline: June 17, 2020

Applicants should submit their cover letter, presenting their motivation, a detailed curriculum vitae, a list of publications, title and abstract of PhD dissertation, contact information of at least one academic reference and all other relevant details to Dr. Romain Gojon (romain.gojon@isae-supaero.fr), copying Mikhaïl Stepanov (mikhail.stepanov@isae-supaero.fr). **For more information** please contact Dr. Romain Gojon.

The preselected candidate will have to finalize the application to the **"Make Our Planer Great Again"** French government initiative fellowship with our support before July 5, 2020.
See https://www.campusfrance.org/en/financing-12-month-post-doctoral-research-contracts

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[1] B. Owen, D. S. Lee and L. Lim. (2010). *J. of Env. Science and Technology*, 44(7), pp. 2255-2260
[2] EASA European aviation environmental report (2019)
[3] E. Benichou *et al*, *1st Aerospace Europe Conference*, 2020.
[4] A. Peters et al. *Journal of Turbomachinery*, 137(2):021001, 2015.
[5] www.ultimate.aero