

Post-doctoral position of 24 months in aeroacoustics: modeling and simulation of aerodynamic and acoustic installation effects of a small-size quadcopter drone

Context

Multicopter drones are increasingly being used for civil and military applications such as delivery, building inspection, or monitoring. The objective of the project *Aeroacoustics for drone PROpulsion* (APRO) is to better understand and model the noise-generating mechanisms in multicopter drones in order to reduce their noise impact and to improve their social acceptability. During the first part of the project, experimental setups have been built in the anechoic chamber of ENSTA Paris in order to characterize the aerodynamic performance and acoustic radiation of isolated propellers and of a small-size quadcopter drone in hover, as can be seen in Figure 1.



Figure 1: Experimental setups in the anechoic chamber of ENSTA Paris: (a) isolated propeller with robotic arm [1] and (b) quadcopter model mounted on a force balance.

In a quadcopter drone architecture, several aerodynamic and acoustic installation effects are present that will modify the radiated noise spectrum and directivity with respect to an isolated propeller configuration [2, 3]. Aerodynamic installation effects are associated to aerodynamic interactions that cause an increase in tonal noise (unsteady loading noise) and potentially in broadband noise too. As shown in Figure 2, these installation effects can be associated with the interactions between propellers and their supporting struts, on one side, and the interactions between rotors, on the other side. Acoustic installation effects are associated with the scattering of the propeller noise by the fuselage or other components of the drone, that can yield to amplification or shielding of the noise. Predicting drone noise is thus a complex challenge, especially for small-size drones that operate at relatively low Reynolds numbers, corresponding to transitional regimes on the propeller blades [4].

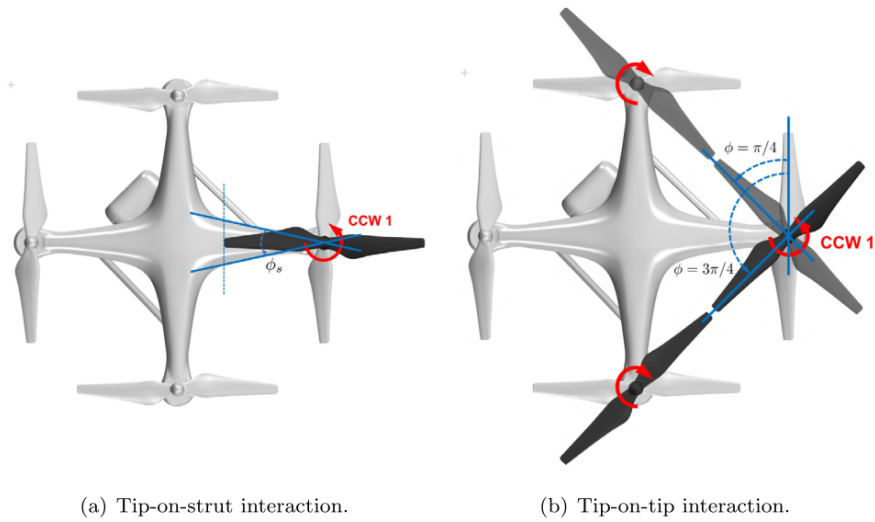


Figure 2: Types of interaction on a quadcopter drone. Taken from Zarri *et al.* [3]

Objectives and workplan

The objectives of this post-doctoral position are to study numerically and theoretically the aerodynamic and acoustic installation effects of a small-size quadcopter drone. This will be used eventually to build a simplified source model in order to optimize its shape and its trajectory. The workplan is divided into two main work packages:

1. Numerical investigation of aerodynamic and acoustic installation effects

In order to understand the interaction mechanisms between propellers and supporting struts, on one side, and between propellers, on the other side, high-fidelity large eddy simulations will be performed using the Lattice Boltzmann Method (LBM). This numerical method has been shown to provide accurate predictions of tonal and broadband noise for low-Reynolds number propellers [5]. The aerodynamic installation effects will also be predicted using a low-fidelity method based on surface panels of vortex lattice methods. Finally, it can be envisaged to predict the acoustic diffraction effects associated with the drone body and supporting struts using a Boundary Element Method (BEM).

2. Semi-analytical modeling of aerodynamic and acoustic installation effects

Several analytical models have been proposed in the literature to predict the rotor-strut interaction [6, 7]. Several mechanisms are involved, namely sound generation by the rotor operating in the potential distortion of the strut, noise generation by the strut because of impinging wakes from the rotor blades, and scattering of each emitted sound by the other solid surfaces. Modeling of the noise due to the interaction between rotors is quite difficult, and generally relies on numerical aerodynamic calculations [8, 9]. Constructive and destructive interference effects between the different propellers can be observed, and some modulations in time can be present since the different propellers have slightly different rotational frequencies.

Practical information

- **Profile:** the candidate must hold a PhD degree in Fluid Mechanics or Acoustics, with a significant experience in numerical techniques and aeroacoustics.
- **Supervision:** : Benjamin Cotté, Associate Professor at ENSTA Paris.
- **Duration and location:** funding for 24 months. The work will take place at ENSTA Paris (<https://www.ensta-paris.fr/>) in Palaiseau (20 km south of Paris).
- **Salary :** gross annual salary between 36 and 46 k€ depending on applicant's experience.
- **To apply:** send a detailed CV with a list of publications, a short cover letter and a list of references to benjamin.cotte@ensta-paris.fr

References

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