ISAE Institut Supérieur de l'Aéronautique et de l'Espace SUPAERO

PhD position VELAS: Laser velocimetry for wind tunnel acoustic source localization

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Today, the economic and demographic expansion of large cities leads to an increase in air traffic and associated noise pollution, especially in the vicinity of airports. However, as ecology and the notion of sustainable development are increasingly important in political decisions, regulations (taxes...) concerning the environmental impact of this traffic are becoming more stringent. The reduction of noise emitted by aircraft is therefore becoming a major challenge for aircraft manufacturers. Nevertheless, the sources of aerodynamic noise, so-called aeroacoustics, produced by aircraft are multiple and complex. A better knowledge of these sources is therefore essential to be able to develop an effective strategy for reducing the noise generated. The characterization of aeroacoustic sources in the preliminary design phase on models in wind tunnel is therefore a major issue for aeronautics.

In the field of experimental characterization of acoustic sources, different imaging methods such as intensimetry, beamforming and holography can be used and have already been implemented in closed environments and in the presence of parasitic sources [1]. At the same time, the feasibility of measuring acoustic velocity in flow using laser Doppler velocimetry has been demonstrated. This non-intrusive measurement technique makes possible to access information until then impossible to have in a confined environment in the presence of flow [2,3]. This work provided the basis for the development of a new method for characterizing aeroacoustic sources in wind tunnels combining near-field acoustic holography (NAH) with non-intrusive measurements performed by laser Doppler velocimetry (LDV) [4]. One of the advantages of this approach lies in the use of an acoustic velocity hologram field, which is more robust for the reconstruction of the acoustic field (pressure or velocity) towards the source plane than by using an acoustic pressure hologram field.

The near-field application of beamforming [5] in wind tunnel could be interesting for locating or quantifying the contribution of nearby aeroacoustic sources, but this presupposes the possibility of having sensors placed in the flow, which is difficult to achieve for reasons of size, diffraction and measurement noise. It may then make sense to use the non-intrusive LDV measurement technique implemented with the NAH. The objective of this thesis is therefore to extend the field of application of beamforming by using in-flow fields of acoustic velocity obtained by LDV, to carry out simulations to evaluate the accuracy of the technique and to validate it using microphone array measurements performed in anechoic wind tunnel. To do this, the thesis will be carried out in cooperation with ONERA DMPE and DSFM having closed test section wind tunnels allowing also to deal with the aspects of reverberations from a methodological point of view [6].

The first step would be to identify, based on a bibliographical study, the various measurements techniques derived from beamforming to assess their advantages and disadvantages and propose modifications compatible with the measurement of in-flow acoustic speed. A parametric study will be conducted using simulations, and different experimental reference configurations (ex. loudspeaker source) will be tested in ONERA small wind tunnels. Two large test campaigns will then be carried out on the same reference model: in the ISAE-SUPAERO aeroacoustic wind tunnel (SAA) (see Figure 1) and in the ONERA wind tunnel F2, thus providing a database to validate the methodology by comparing the results obtained in the different wind tunnels (anechoic/closed test section) with the various means of measurement (microphones/LDV).

Figure 1: ISAE-SUPAERO SAA anechoic wind tunnel with the 120-channels microphone array used for aeroacoustic source localization.

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