Source localization and far-field extrapolation for wind-tunnel measurements of jet installation noise

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Acoustic Measurement Campaign at the Aeroacoustic Wind Tunnel Braunschweig

As part of the Horizon 2020 EU project ``Decrease Jet INstallation Noise" (DJINN), two engine-airframe platforms have been studied experimentally in the Aero-acoustic Wind Tunnel Braunschweig (AWB). The DJINN platforms represent the following architectures:

1. Under-wing engine. Here the aero-acoustic interaction mechanisms occur between the propulsive jet, the pylon, the wing and its high-lift devices at the trailing edge.
2. Engine mounted in the rear part of the fuselage, where the interaction mechanisms occur between the propulsive jet and the tail planes.

In the present paper, we present and discuss analyses of acoustic measurements acquired in the AWB campaign for the mentioned platforms. These measurements have been performed with 4 linear microphone arrays. The schematic in Fig. 1 reports the geometrical distribution of the sensors in the AWB. The linear arrays with 47 microphones, labelled in Fig. 1 as BC-CE and BC-SL, are the ones we adopt to perform source localization in the present paper.

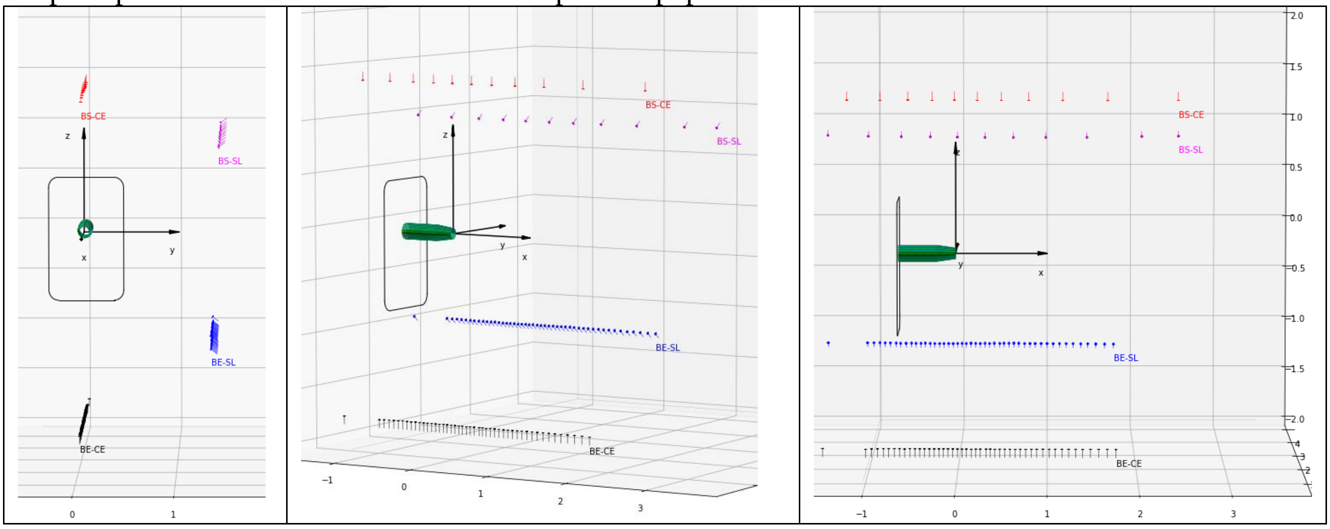

Fig. 1 Schematic diagrams representing the nozzle exit contour of the flight-simulation nozzle, the engine-exhaust simulator (green pipe extruding from the nozzle exit of the flight stream) and the linear microphone arrays in the AWB. The reference-system origin is at the centre of the engine-exhaust exit, with the x axis in the flow direction. The units are in meters. The present paper deals with the analysis of the 47-sensor arrays labelled BE-CE (in black and in fly-over position with respect to the nozzle) and BE-SL (in blue and on the sideline position to the nozzle).

Data analysis

The SODIX method, introduced by Michel and Funke [1] and further developed at the DLR Engine Acoustics division by Funke et al., Refs. [2] and [3], and by Oertwig et al., see Refs. [4] and [5], is used here to analyze the acquired acoustic data. We perform source localization analyses based on the experience described by Siller et al. in Ref. [6], where data acquired in a very large jet-aeroacoustics facility (the QinetiQ NTF in Farnborough, UK, see Ref. [7]) at the presence of a round flight stream

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were analyzed. The size of the AWB anechoic test cell and of the exhaust simulation models restricted the acoustic measurements to the geometrical near field of the jet-noise source: the microphones are at a distance of up to 20 jet diameters from the jet centerline. Due to the positioning of the microphone arrays in the vicinity of our experimental jet, we will use the equivalent sources from the SODIX source-localization solutions to make noise estimations at positions 100 jet diameters away from the nozzle exit. This exercise gives us an estimation of the necessary correction of the measured data, due to geometrical near field effects. For test condition including the flight simulation, the equivalent sources from the SODIX solutions need to be corrected for the wave-convection and shear-layer effects associated with the flight stream of the open jet wind tunnel. A ray tracing method for a general flow-column wave guide has been developed which determines the ray path by assuming phase-speed conservation in the direction of flow. In Fig. 2, on the right-side diagram, we show the ray tracing between a generic source on the jet centerline (red cross) and a receiver at the furthest upstream microphone of the array BE-CE, assuming a rectangular flow column with zero-thickness shear layer. For the ray tracing, we assumed constant speed of sound in the whole volume. This means that the refraction in our model is a consequence of the sound-convection variation alone. The SODIX method identifies a distribution of virtual point sources on the jet centerline (blue cross, in Fig. 2, right-side diagram) with varying directivity at varying quiescent-medium polar angles. The resulting source maps are corrected a-posteriori by using the ray tracing method, which estimates a source map for the real sources (red cross in Fig. 2) along the jet centerline. The ray-tracing method can be used to estimate amplitude corrections for both the convection and shear-layer effects.

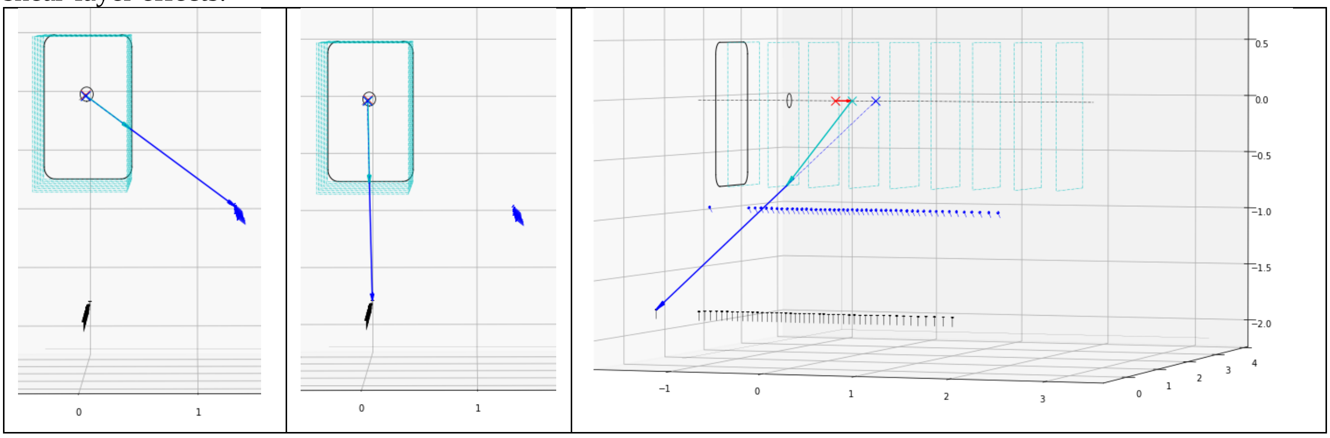

Fig. 2 Schematics representing the ray path for a point source located on the jet axis about 5D downstream the nozzle exit (black circle in the diagrams). The side view on the right indicates the path between source (red x), the convected wave centre (cyan x) and the observer located at the upstream microphone position of the fly-over array. The ray path in the flow column is in cyan. A rectangular flow-column at 60 m/s is used here, whose shear layer is traced at constant axial positions with segmented lines in cyan. The front views in the left side show how the sideline- or the fly-over arrays present ray paths, crossing the flow-column shear layer through the vertical or the horizontal sections, respectively.

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