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Investigation of the acoustic-and flow-fields of the perpendicular rod-airfoil configuration

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During the phase of landing, an important aircraft-noise source emanates from the interaction of the landing-gear wake with the deployed flap. Extensive measurements of the landing-gear-wake/flap interaction noise[1] have shown that when the landing-gear strut is deployed the flap becomes an important noise source. However, the physics related to the sound-generation mechanisms is poorly understood. To cast this problem in an academic framework, a simplified configuration is proposed, that consists of a cylinder placed upstream a symmetrical NACA-00012 airfoil (the cylinder and airfoil spans are perpendicularly aligned, see Fig.1). An extensive experimental campaign is conducted, followed by semi-empirical modelling approaches to explore the flow phenomena associated with the acoustic-field. Simultaneous acoustic and *stereoscopic Particle Image Velocimetry* (sPIV) measurements are taken, to study the sound and flow-fields generated by the interaction of the cylinder-wake with the downstream airfoil, when the span of the two objects are orthogonally aligned. The experimental data highlight the three-dimensional nature of the problem. The maximum sound pressure levels are obtained at frequencies close to $St = fd/U = 0.4$, where also the maximum linear coherence between the acoustic and cylinder-span-aligned fluctuation velocity is observed, demonstrating that the measured acoustic-field is an outcome of the three-dimensional cylinder-wake. *Spectral Proper Orthogonal Decomposition* (SPOD)[2] is employed to extract the coherent structures of the flow field responsible for sound generation. The low-rank reconstructions of the airfoil-span-aligned vorticity field (obtained by SPOD) are combined with an acoustically compact Green function[3] for the NACA-0012 to develop a simplified, linearised aeroacoustic model in the framework of vortex-sound theory. A data-based estimation of the sound field shows an acceptable agreement with the acoustic measurements. Furthermore, a semi-empirical source-model, informed by the experimental data, is proposed to further highlight the key parameters leading to sound generation. The proposed source-model is decomposed in cylinder-span-aligned wave-forms and it is shown that the deformation of the airfoil-span-aligned vortices is influencing significantly the acoustic field. Finally, possible links of the source-term and secondary instabilities in the cylinder's wake are discussed.

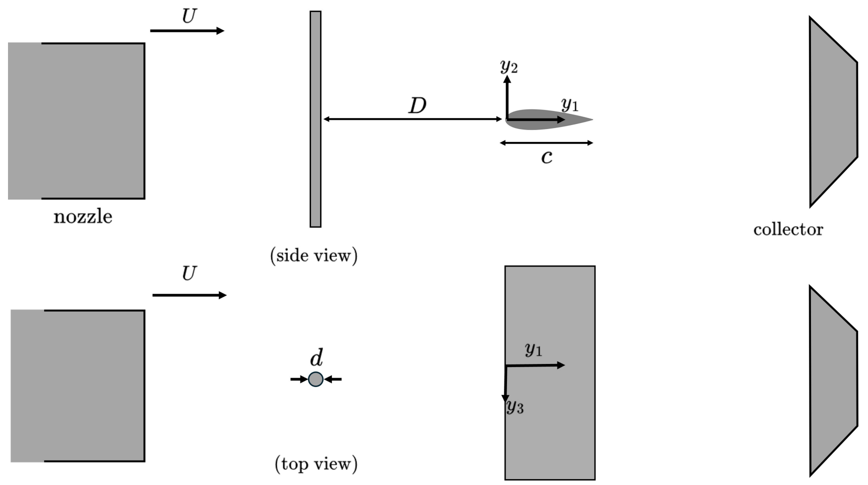

Figure 1: Perpendicular rod-airfoil configuration: side-view (top), top-view (bottom).

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[1] Oellermans and Pollenske, *AIAA/CEAS*, 2004
[2] Picard and Delville, *Int. J. Heat and Fluid Flow*, 359-364, 2000
[3] Howe, *Journal of Fluid Mechanics*, 67(3):597–610, 1975