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AERODYNAMIC AND AEROACOUSTIC INSTALLATION EFFECTS IN ENVIRONMENTAL CONTROL SYSTEMS

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Environmental Control System (ECS) are used in order to provide equipment cooling and good thermal comfort for passengers in commercial aircrafts. One of the key elements of ECS units is the fan, operating in complex duct systems including bends, junctions and restriction diaphragms. The aerodynamic and acoustic interactions between these elements, also called installation effects, are nowadays very rarely included in the design phase of integrated ECS implementations, while thay can result in substantial extraneous acoustic nuisance within the cabin and around the grounded aircraft.

The present work investigates tonal and broadband noise production by a fan-diaphragm configuration, where the diaphragm is located at varying distances downstream of the fan. Such obstructions are commonly found in complex ECS arrangements in order to balance the mass flow rate accross different branches of the network. The noise generated by the fans operating in off-design conditions has been discussed in previous literature [1-2]. The present study is inscribed in the same line, focusing on the particular case of a fan designed for a typical aircraft ECS.

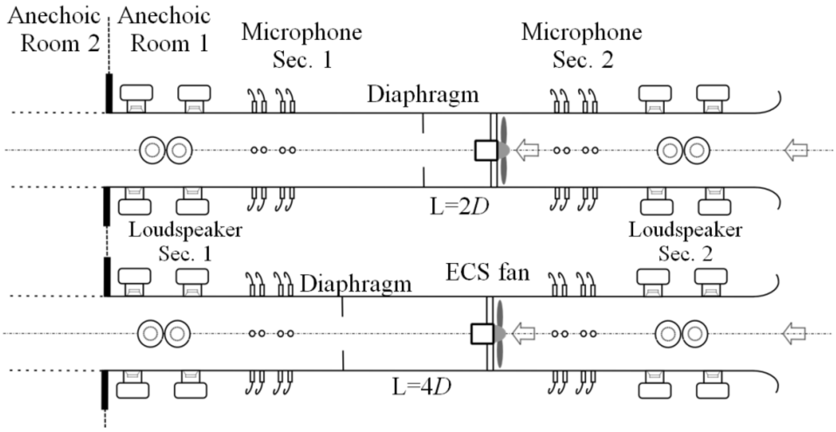

Figure 1: Sketch of the fan-diaphragm aeroacoustic rig.

In order to investigate the aerodynamic sound generated by an ECS fan subjected to installation effects, a modular test-rig has been built at VKI as seen in Figure 1. The modular structure allows investigating the noise generated by the axial fan including both upstream and downstream installation effects. The ECS fan used in the experimental rig has 15 rotor blades and 10 stator blades and is operated at 11,200 rpm. The Blade Passing Frequency (BPF) is equal to 2,800 Hz. The fan is operating in a cylindrical plexiglass duct with inner diameter D = 0.15 m. Upstream and downstream ducted microphone modules have been designed and manufactured by KTH, located upstream and downstream of the fan and diaphragm assembly, used to measure the reflection coefficient downstream of the duct and for modal decomposition measurements [3].

Figure 2 shows as preliminary result the acoustic spectra measured near the outlet of the duct for the fan in clean configuration (no downstream obstacle) and the fan followed by a diaphragm at a distance of 2 duct diameters. It can be shown that the effect of having a downstream obstacle increases substantially the noise emitted in a broad frequency range. The final paper will focus on the acoustic array measurements that have been performed to better understand and quantify the nature of these installation effects (modification of the operating point of the fan, noise generated by the fan wake ingestion through the diaphragm, etc.).

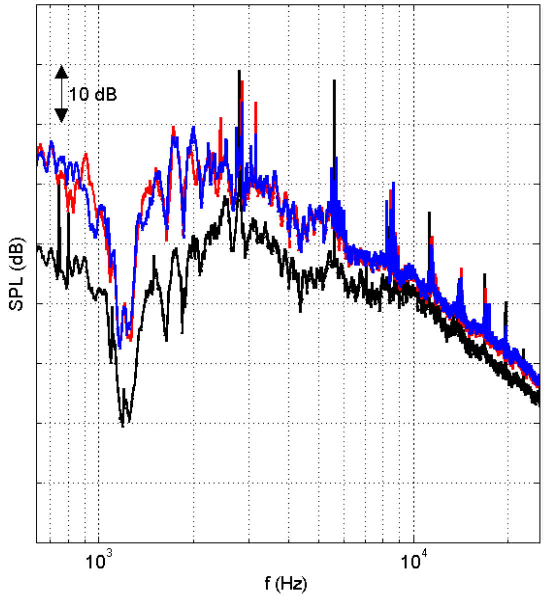

Figure 2: Preliminary acoustic spectra obtained for the fan-diaphragm installation noise. Black: fan in clean duct, red: fan with diaphragm at 2*D* downstream distance, blue: fan with diaphragm at 4*D* downstream distance.

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