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JISFA3#2 - Modeling the wall pressure of a turbulent flow to predict the noise radiated by a structure

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The internal noise inside an aircraft induced by a turbulent flow results from a coupling between aerodynamics and vibroacoustics through the turbulent wall pressure (TWP). By applying instationary forces on a structure, this pressure initiates a vibratory motion which will generate noise by acoustic radiation. Modeling these phenomena is equivalent to solving a filtering problem. The input is the TWP spectrum in the frequency/wave-number domain while the output is the acoustic pressure radiated by the structure.
The link between these quantities is realized through a modal decomposition. A mode will contribute significantly to the radiation at a given frequency only if its resonance or radiation frequency and the wave-numbers associated are aligned with the characteristics of the TWP spectrum. Therefore, modelling this spectrum is a key step in the determination of the internal noise. The most common model was established by Corcos and is based on empirical observations. The only mechanism involved is the convection and the boundary layer profile is averaged. These hypothesis limit the frequency range scope of this model and those developed latter on the same basis.
In order to improve the estimation of the internal noise, a more realistic model of the TWP spectrum has been developed. It is based on the resolution of Poisson's equation. In this model, the full profile of the boundary layer is used and four mechanisms are involved, each one acting as a filter in the final formulation through four characteristic lengths based on convection, turbulence, altitude and thickness of the boundary layer.
With this model, new modes can contribute to the radiation and sometimes much more significantly than those selected by Corcos's model. In particular, the importance of the low part of the boundary layer has been highlighted.

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