Novel orifice configurations for aerodynamically and acoustically optimised acoustic liner geometries

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Acoustic liners cover the inside of a nacelle and consist of a porous top plate, a solid back plate and a honeycomb core between the two. They exhibit a resonant frequency that can be tuned to the dominant engine frequency to help dissipate engine noise, representing the state of the art in engine noise reduction. An undesirable side effect of these surfaces is that they increase the total aircraft drag, essentially behaving as distributed surface roughness [1]. Conventional acoustic liners generally consist of cylindrical orifices in the facesheet. However, recent experimental research has suggested that the orifice shape of conventional orifices is not optimal from an aerodynamic perspective [2]. Orifice shape can be optimised to reduce the added drag penalty of acoustic liners while maintaining the desired acoustic noise attenuation. We perform unprecedented Direct Numerical Simulation (DNS) of plane turbulent channel flow over an array of conventional and novel fully resolved acoustic liner geometries, see figure 1. We perform simulations at a friction Reynolds number $Re_\tau = 500$, bulk Mach number, $M_b = 0.3$ and porosity $\sigma = 0.322$. All flow cases show an increase in drag compared to the smooth wall. However, by simply changing the shape of the orifice or the orientation in the case of a non-circular orifice, the added drag can be reduced by as much as 70%, as compared to the baseline conventional acoustic liner orifice. In addition, the acoustic noise attenuation is much less sensitive to the shape of the orifice and as long as the porosity of the facesheet is constant, the noise attenuation of novel acoustic liner geometries does not appear to suffer, highlighting the potential for optimisation for orifice geometry.

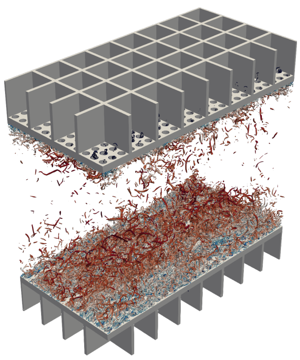

Figure 1: Instantaneous flow field from DNS of a conventional acoustic liner with circular orifices. Vortical structures are visualised using the Q-Criterion.

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[1]Shahzad, H., Hickel S. and Modesti D., *arXiv* **arXiv:2210.17354**, (2022).

[2]Howerton, B.M. and Jones, M.G., *AIAA.* **2979**, (2016).