Added drag on acoustic liners in presence of grazing turbulent flow and acoustic waves

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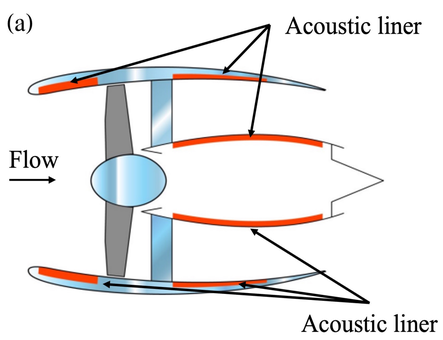
Context & Motivation

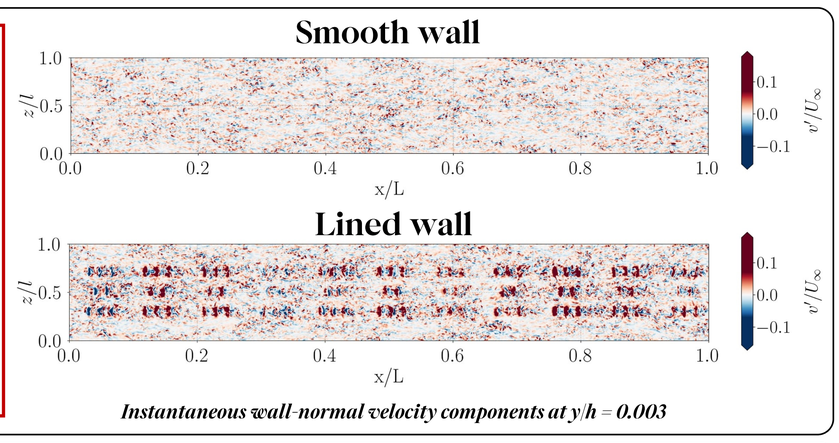


(a) Turbofan engine scheme with detail on location of acoustic liners, (b) Sketch of a single degree of freedom acoustic liner

Reduce aircraft engines' noise

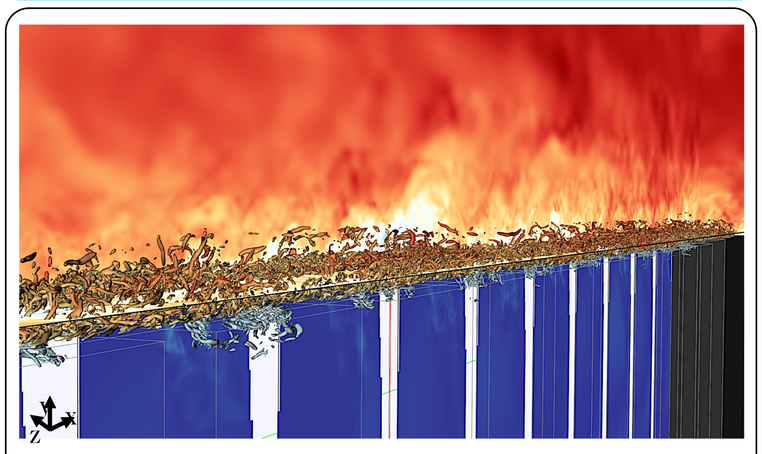
but what is the **aerodynamic penalty**?

- Acoustic liners modify near wall flow behaviour [1-3];
- Lack of knowledge on the effect of acoustic forcing.



Instantaneous wall-normal velocity components at y/h = 0.003

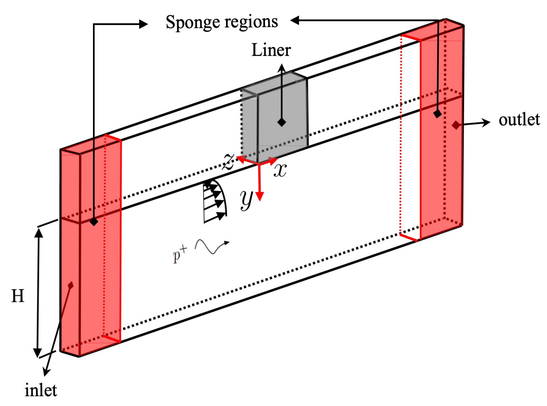
Purpose



Characterize the **added drag** on acoustic liners in the presence of **high SPL acoustic waves** by means of numerical simulations

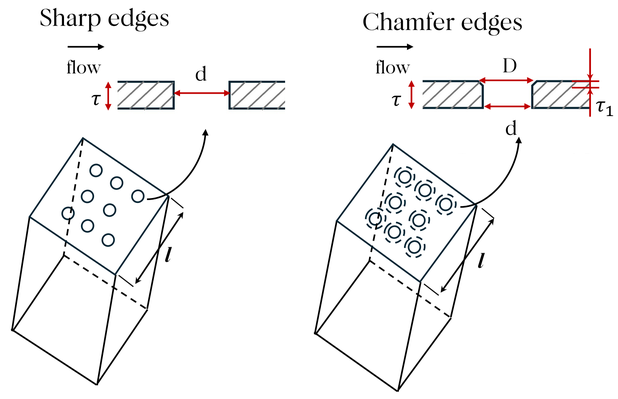
Methodology

Very Large Eddy Simulation



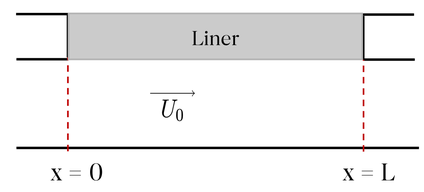
Sketch of the channel with a lined wall

Liner geometries



Detailed view of a cavity with different edges shape

Drag calculation



Bulk quantities:

$$P = \int_y \int_z p \, dz \, dy$$

$$U_b = \int_y \int_z U \, dz \, dy$$

Skin friction evaluation:

$$\tau_w = -h \frac{dP}{dx} \qquad C_f = \frac{\tau_w}{\frac{1}{2}\rho U_b^2}$$

Test Matrix:

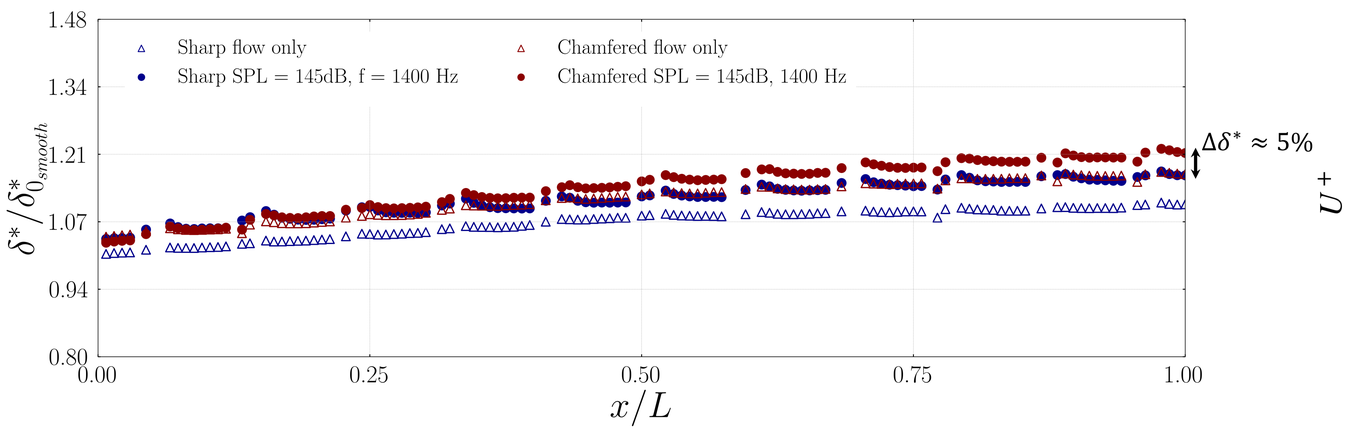
Mach = 0.3 SPL = 130, 145 dB

$Re_\tau \approx 4000$ f = 800, 1400, 2000 Hz

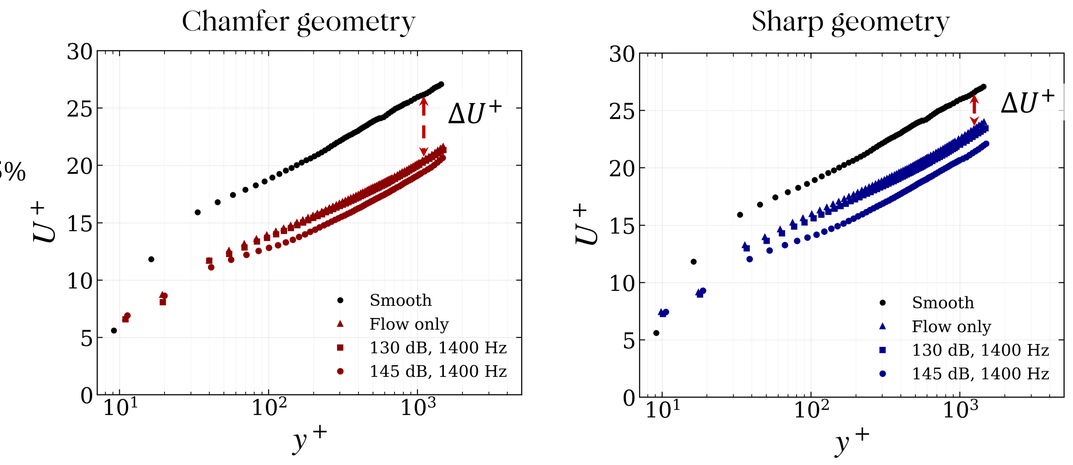
l [mm]	d [mm]	D [mm]	τ [mm]	τ_1 [mm]
9.94	1.00	1.20	0.64	0.10

Results

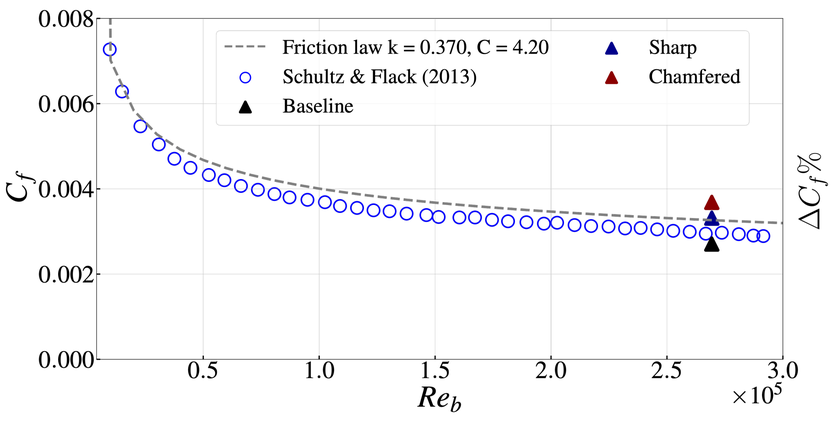
Boundary layer displacement thickness growth over the liner



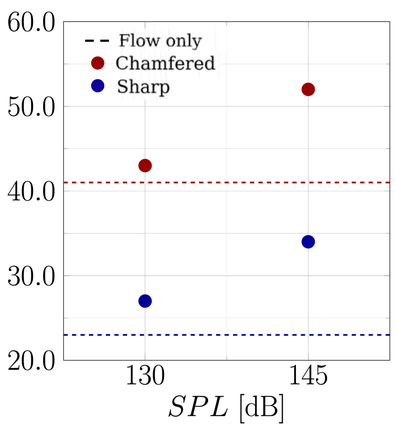
Mean velocity profiles at the end of the liner



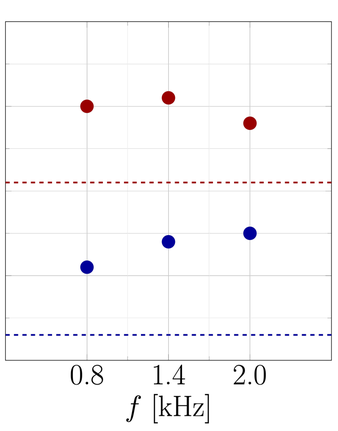
Skin friction coefficient in the absence of acoustic forcing



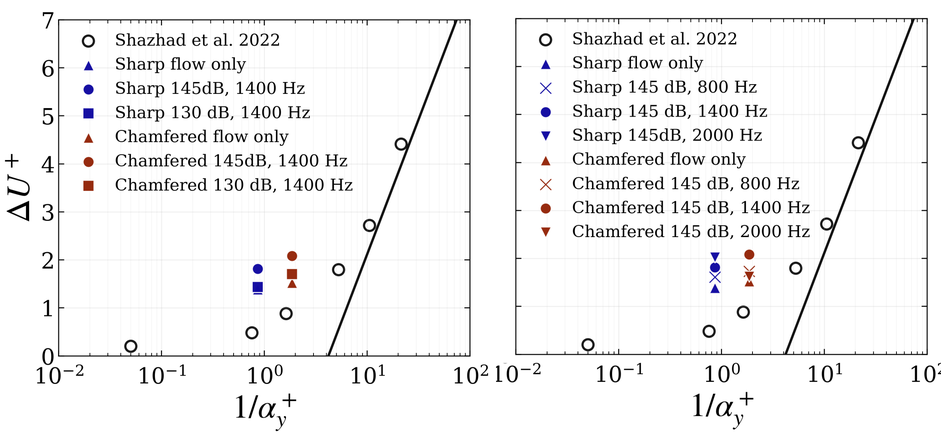
Effect of SPL @1400 Hz



Effect of frequency @145 dB



ΔU⁺ as a function of the inverse of the Forchheimer coefficient



References

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