ASSESSMENT OF A METAMATERIAL-INSPIRED ACTIVE ACOUSTIC LINER CONCEPT FOR APPLICATION TO AIRCRAFT ENGINE NOISE REDUCTION

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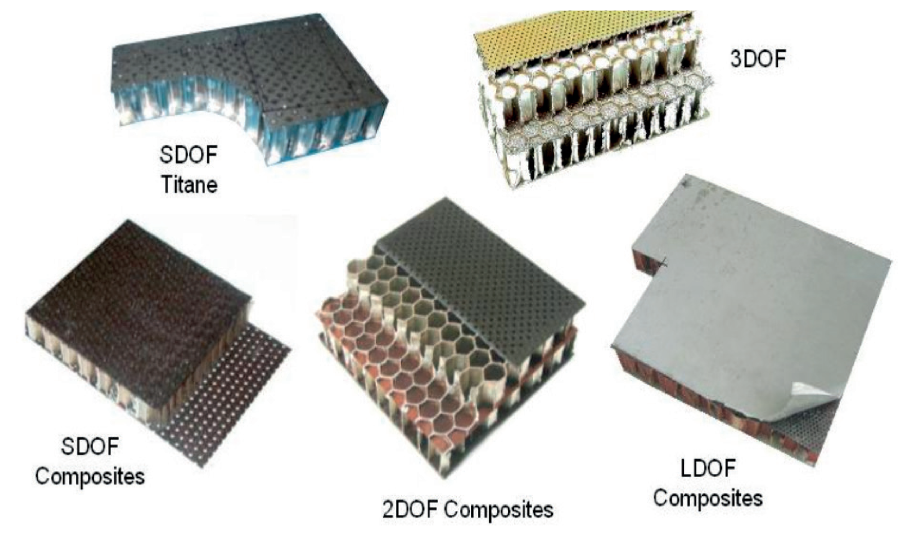
MOTIVATION

Acoustic liners are a widespread solution for noise mitigation at aircraft engine level, thanks to lightweight and relatively small dimensions for integration within nacelles.

However, their passive principle prevents the adaptation to varying engine speeds and therefore lowers their performance during flight, especially in the take-off and landing phases.

Limitations:	Solution:
• narrow-bandwidth (Helmholtz resonators)	• broadband absorber principle (Electroacoustic Absorber)
• too thick for low frequencies	• subwavelength design
• not adjustable to engine regimes	• active control



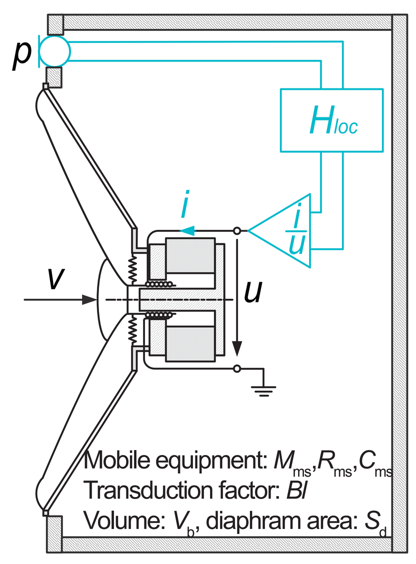
ACTIVE ACOUSTIC LINER CONCEPT

The Electroacoustic Absorber concept: loudspeaker acoustic impedance imposed through a "specific feedforward control":

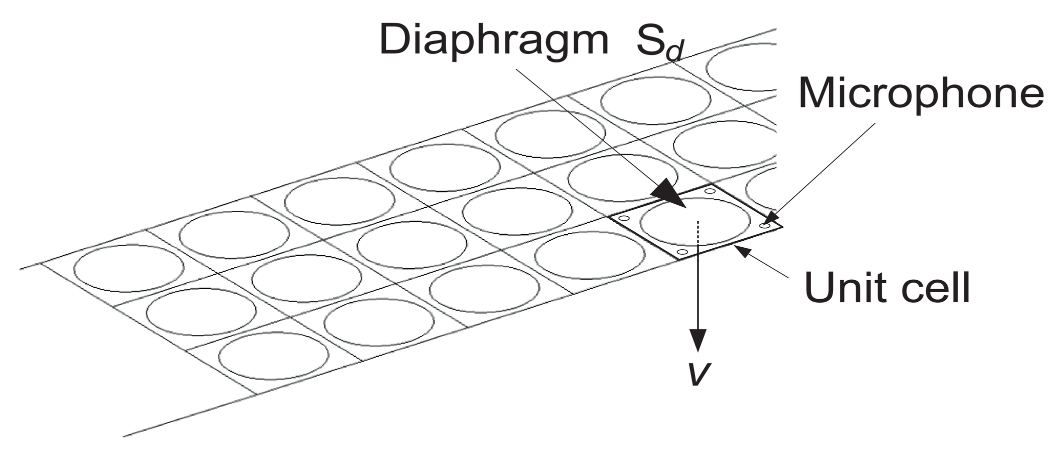
- pressure sensing
- current-driven control

Newton's law :
$Z_{ms}(s).V(s) = S_d P(s) - Bl.I(s)$

with control law :
$I(s) = H_{loc}(s).P(s)$



Network of 10x3 Electroacoustic Absorbers (unit-cell=1 loudspeaker + 4 microphones)



Driving the velocity/pressure response $V(s)/P(s)$ to target (active) impedance:

configuration	acoustic impedance	resonance frequency
passive	$Z_{a0}(s) = \frac{1}{S_d}\left(sM_{ms} + R_{ms} + \frac{1}{sC_{ms}}\right)$	$f_0 = \frac{1}{2\pi\sqrt{M_{ms}C_{ms}}}$
active (target)	$Z_{at}(s) = \frac{1}{S_d}\left(s\mu_1 M_{ms} + S_d R_{at} + \frac{\mu_2}{sC_{ms}}\right)$	$f_t = \sqrt{\frac{\mu_2}{\mu_1}}\, f_0$

yields the control law:

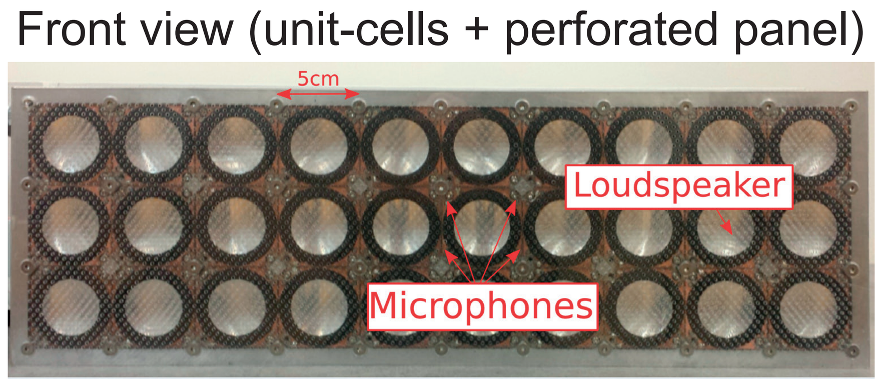
$$H_{loc}(s) = \frac{S_d}{Bl}\cdot\frac{s^2(\mu_1 - 1)M_{ms} + s(S_d R_{at} - R_{ms}) + \frac{\mu_2 - 1}{C_{ms}}}{s^2\mu_1 M_{ms} + s(S_d R_{at}) + \frac{\mu_2}{C_{ms}}}$$

PROTOTYPE

Unit-cell (loudspeaker + microphones + cavity):

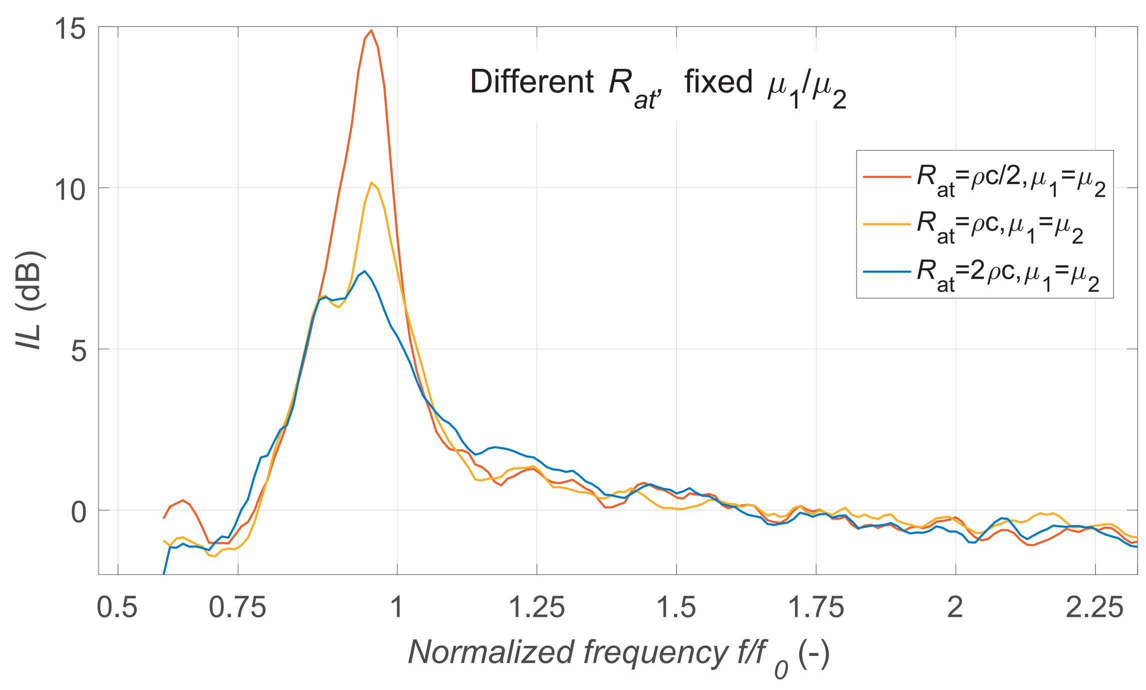
Overall dimensions:
l=50 mm,
w=50 mm,
t=25 mm

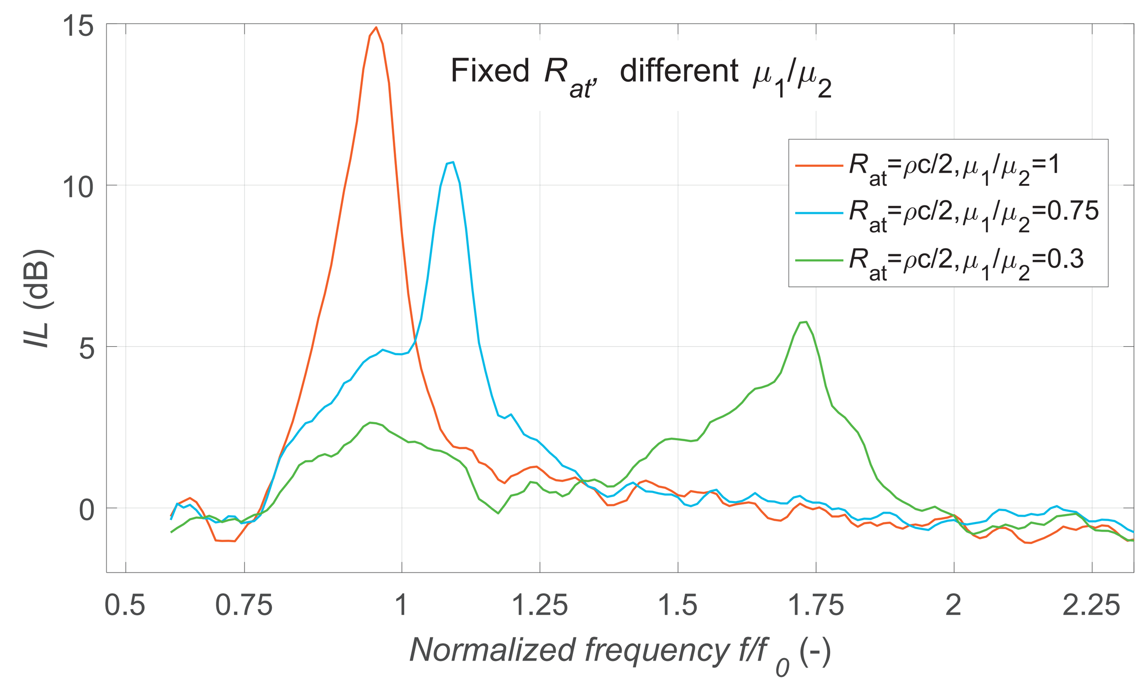
Front view (unit-cells + perforated panel)



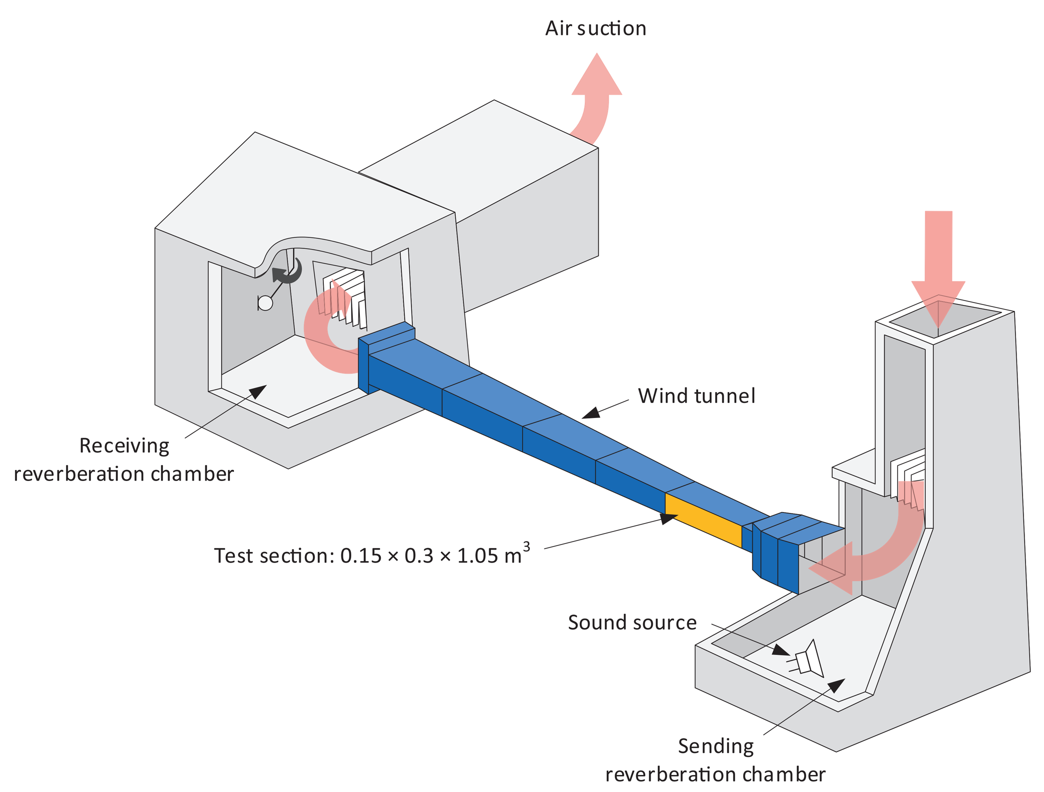
Back view (electronic boards)

EXPERIMENTAL ASSESSMENT





Transmission-loss measurements in NLR Acoustic Flow Duct Facility, in presence of flow



This active acoustic liner concept surpasses conventional passive liners, both in terms of IL amplitude and frequency coverage:

- IL up to 15 dB at f_0
- tunable center frequencies, from $f_0/2$ to $2.f_0$

REFERENCES:

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