SmartAnswer - Fan Proximity Acoustic Treatments for Improved Noise Suppression in Turbofan Engines

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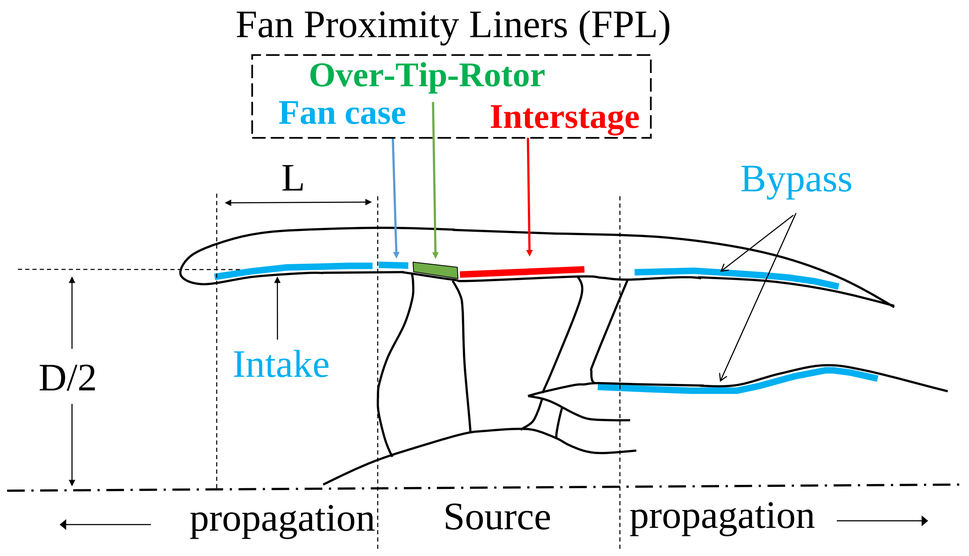
Smart Mitigation of flow-induced Acoustic Radiation and Transmission for reduced Aircraft, surface traNSport, Workplaces and wind enERgy noise

Host institution

Partnerships

Motivation & Background

- Fan noise reduction remains a key challenge for the next generation of Ultra-High Bypass-Ratio engines.
- Over-Tip-Rotor (OTR) liners have shown PWL Insertion Loss of up to 3.5 dB [1] with minimal impact in the fan aerodynamic performance [2].
- OTR liners have a potential for source noise reduction as well as conventional noise attenuation and fan/OGV interaction noise, which needs further investigation [3].



Standard liners (Intake and Bypass) and Fan Proximity Liners (FPL).

Main Objective

Develop an understanding and prediction capability for the **noise reduction of fan proximity liners**, and in particular, Over-Tip-Rotor acoustic treatments, through the development of **analytical models**, **numerical verifications** and **experimental validation.**

Methodology

Analytical Approach

- Modelling of OTR liner as a cylindrical finite lined section connected to infinite hard wall duct extensions or terminated with an unflnged inlet.
- Analysis with various source models including distributions of rotating dipoles and monopoles.
- Modelling of acoustically treated OTR circumferential grooves.

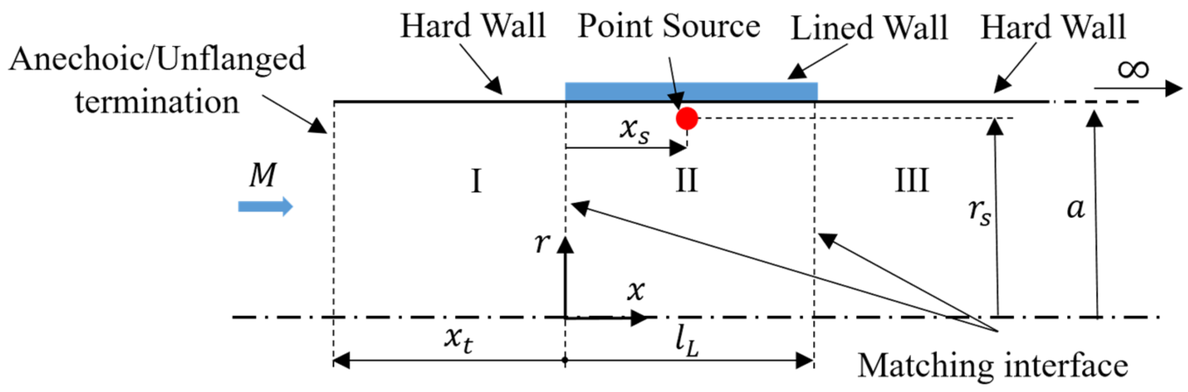


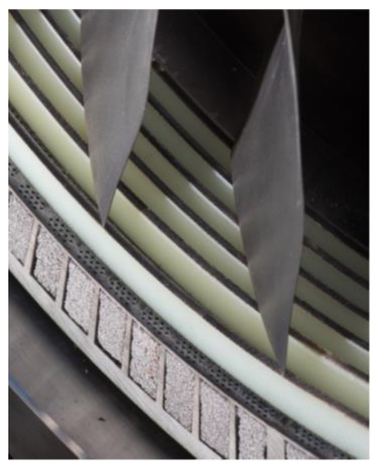
Diagram of the OTR model as a hard-lined-hard duct configuration.

Numerical Approach

- Production of FE solutions to cross-verify the analytical groove impedance model, the mode-matching schemes and back-reaction effects using Simcenter 3D Acoustics.

Experimental Approach

- Comparison of the predicted noise reductions with NASA OTR experimental data.
- Wind tunnel experiments conducted at ECL using a simplified fan-OTR static configuration.



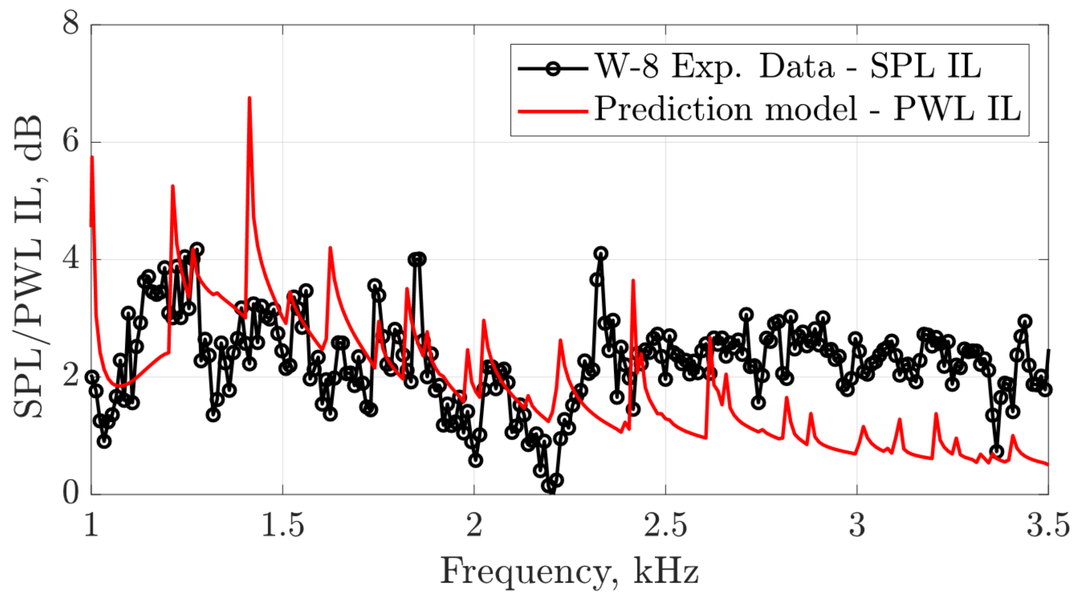
OTR liner installed in the NASA W-8 fan rig [1]

Results

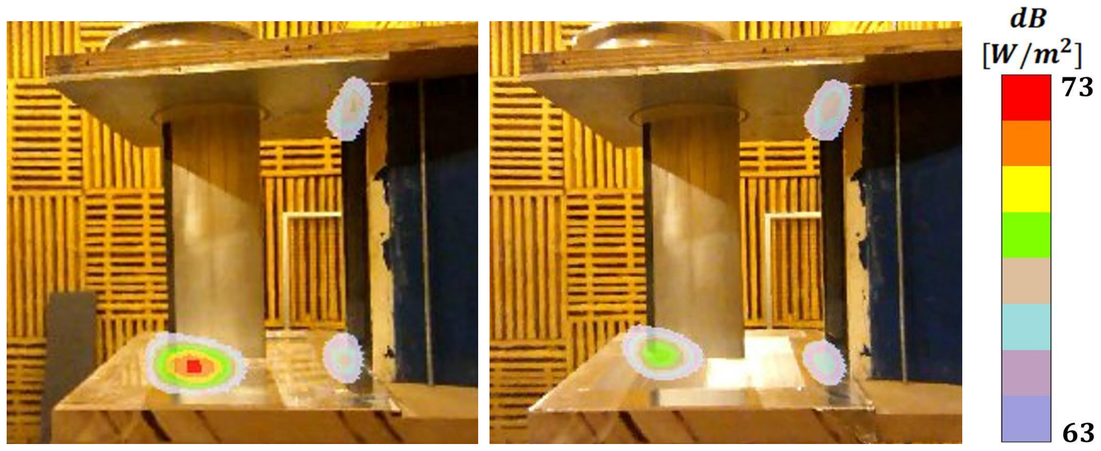
Analytical – Numerical: Satisfactory cross-verification of the analytical grove impedance model and prediction model with FE solutions.

Analytical – Experimental: Analytical estimates and experiments show 1-4 dB of noise reduction with partial agreement in the spectral shape and under-prediction above 2.5 kHz.

Wind tunnel tests: Measured PWL gap noise reductions of 5-10 dB with reduction of trailing edge (TE) noise in the vicinity of the acoustic treatment of up to 5 dB without gap.



Comparison of the experimental SPL IL and analytical PWL IL predictions using distributed rotating dipoles at 25% and 75% of the chord. Mach≈0.2



PWL maps for a hard (left) and lined (right) cases for the frequency range of f=[9-12] kHz, Mach≈0.1

References

[1] Bozak, R. F., and Dougherty, R. P., "Measurement of Noise Reduction from Acoustic Casing Treatments Installed Over a Subscale High Bypass Ratio Turbofan Rotor," AIAA/CEAS Aeroacoustics Conference, 2018

[2] Bozak, R. F., and Podboy G. G., "Evaluating the Aerodynamic Impact of Circumferentially Grooved Fan Casing Treatments With Integrated Acoustic Liners on a Turbofan Rotor," ASME Turbo Expo, 2019

[3] Sutliff, D. L. et. al., "High-Speed Turbofan Noise Reduction Using Foam-Metal Liner Over-the-Rotor," Journal of Aircraft, 2013

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