SmartAnswer – Airfoil-Turbulence Interaction Noise Reduction by Means of Serrations and Structural Modifications

G. Bampanis[1], M.Roger[2]

[1]PhD Student, [2]Professor, Fluid Mechanics and Acoustic Laboratory, École Centrale de Lyon

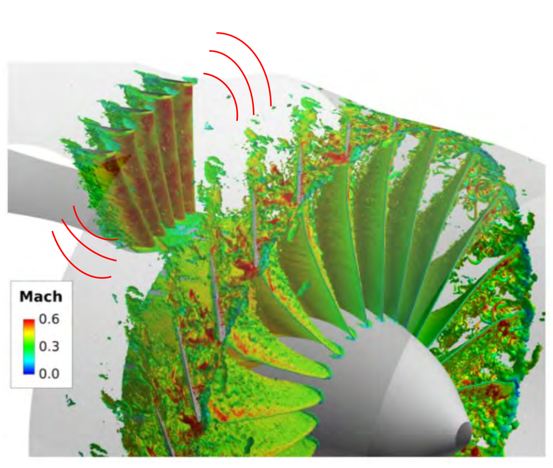
Smart Mitigation of flow-induced Acoustic Radiation and Transmission for reduced Aircraft, surface traNSport, Workplaces and wind enERgy noise

Host institution: École Centrale Lyon

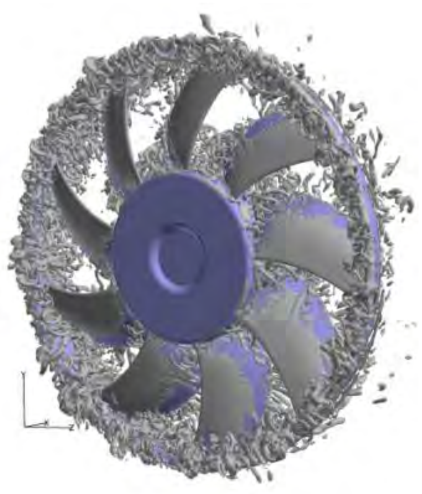
Partnership: Valeo, TU Delft, CETIAT (ensemble, innover et valider)

Motivation

In fan applications, the turbulence-impingement noise (TIN) of an airfoil placed in a highly disturbed flow is considered a generic problem of primary engineering and research interest.



by Moreau, S. (Acoustics, MDPI, 2019)



by Sanjose, M (ASME Turbo Expo, 2015)

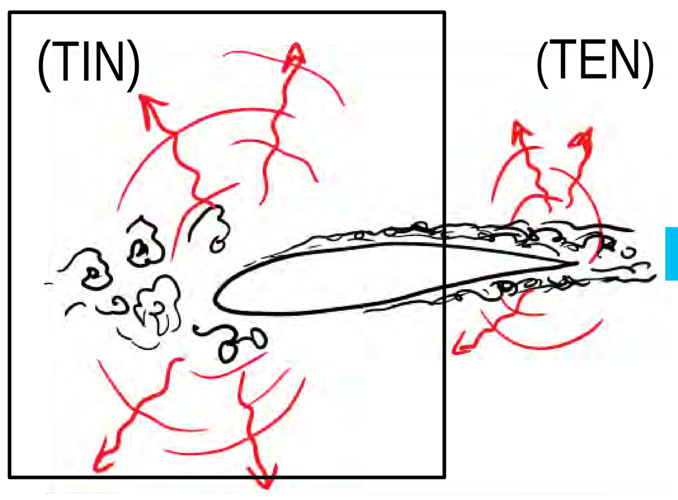
What TIN in disturbed flows means?

Broadband airfoil noise is generated by the interaction between incoming turbulence and an airfoil. It includes partially the following noise mechanisms [1]:

1) Turbulence-impinged noise (TIN) produced by the impinging vortices on the leading edge.
2) Trailing-edge noise (TEN) generated by the scattering of boundary-layer turbulence at the airfoil trailing-edge.

So, both mechanisms contribute to airfoil noise.

Indeed, nevertheless the TIN is the most significant in this case and the main research interest focused on TIN.



Turbulence-impingement noise mechanism [1] [3]

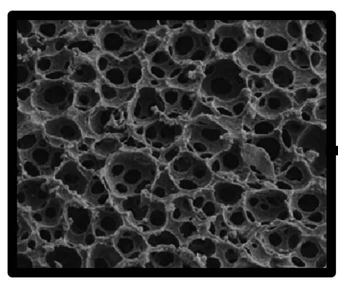
Source identification

Reduction

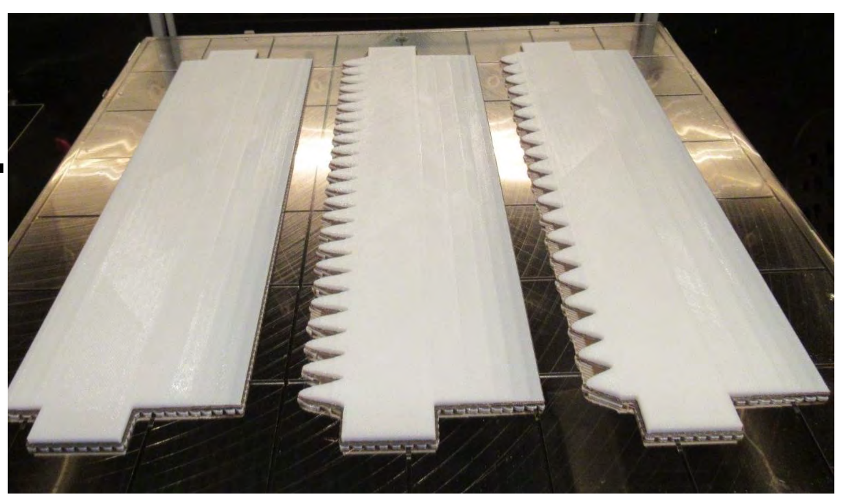
Main Objective

Airfoil-turbulence interaction noise source identification and its reduction by means of serrations and structural modifications.

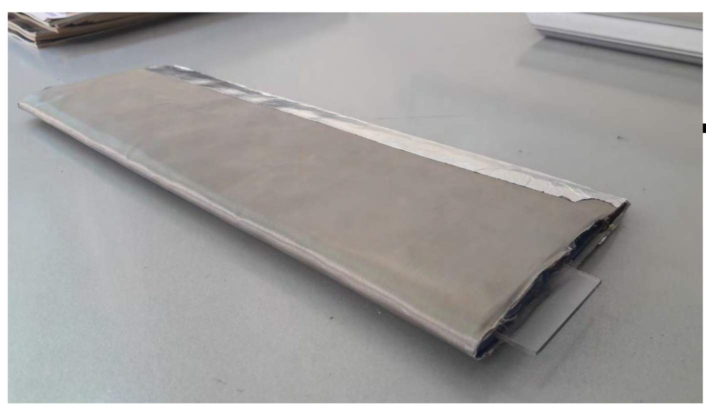
Simple and isolated airfoil profiles have been chosen for investigating the noise mechanisms.



Leading-edge serrations and/or porosity are already recognized as turbulence-impingement noise reduction means, even with non-optimized implementation. More investigations are needed.



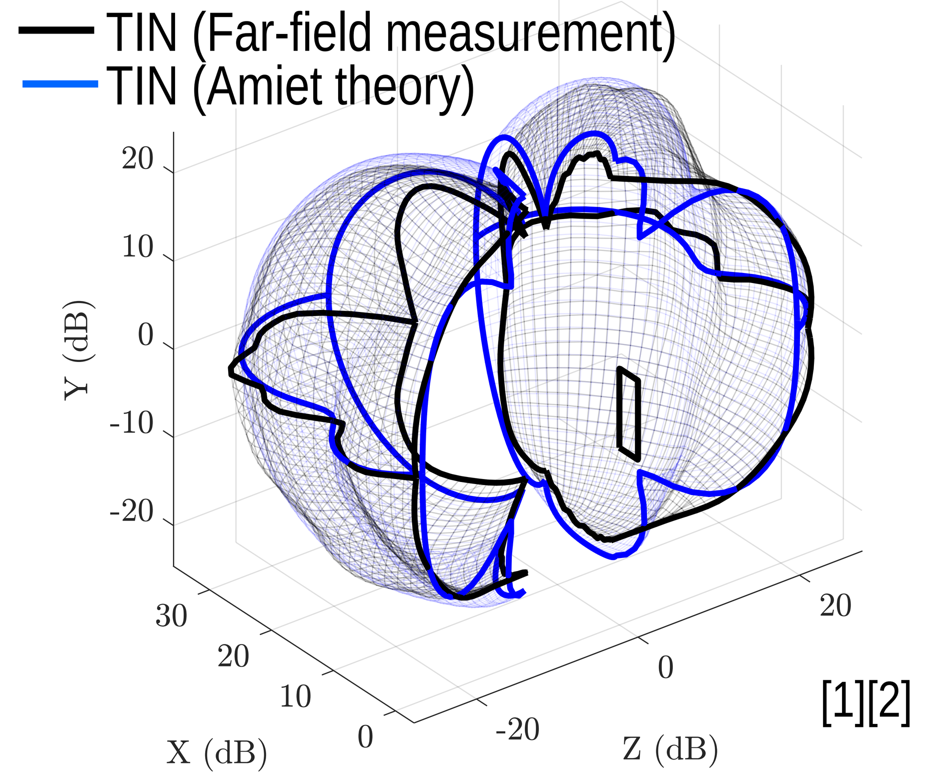
Flat plates: baseline, big serrations and small serrations [1] [4]



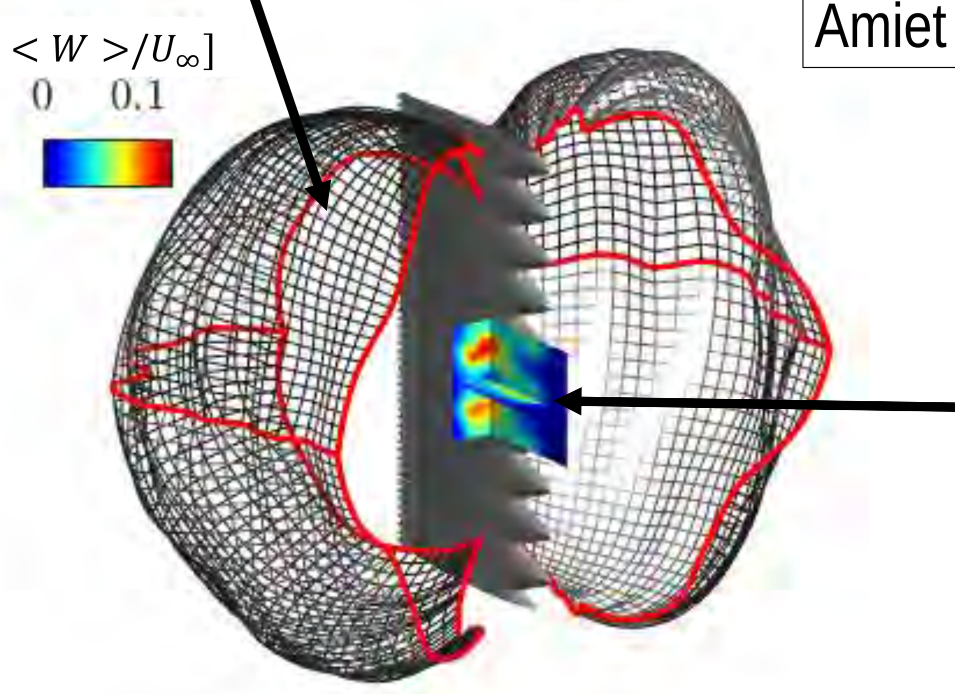
NACA-0012 airfoil filled with porous material [3]

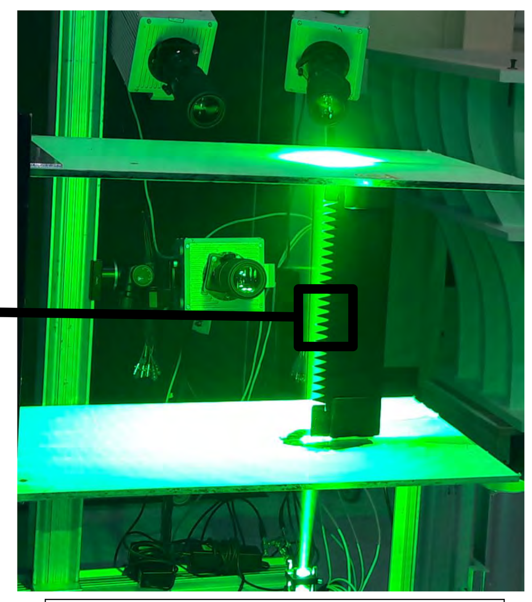
Methodology and results

Rotating Microphone Array

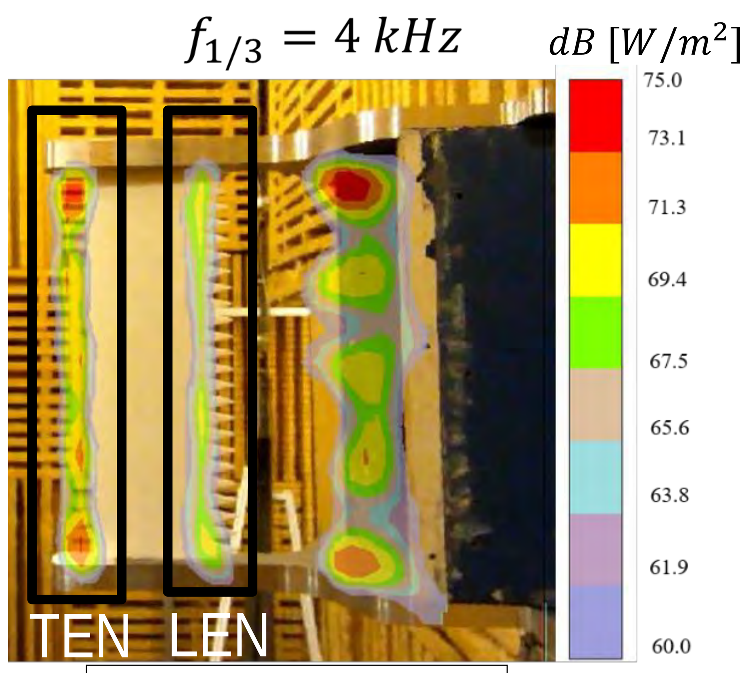


Amiet prediction for TIN in 3D form



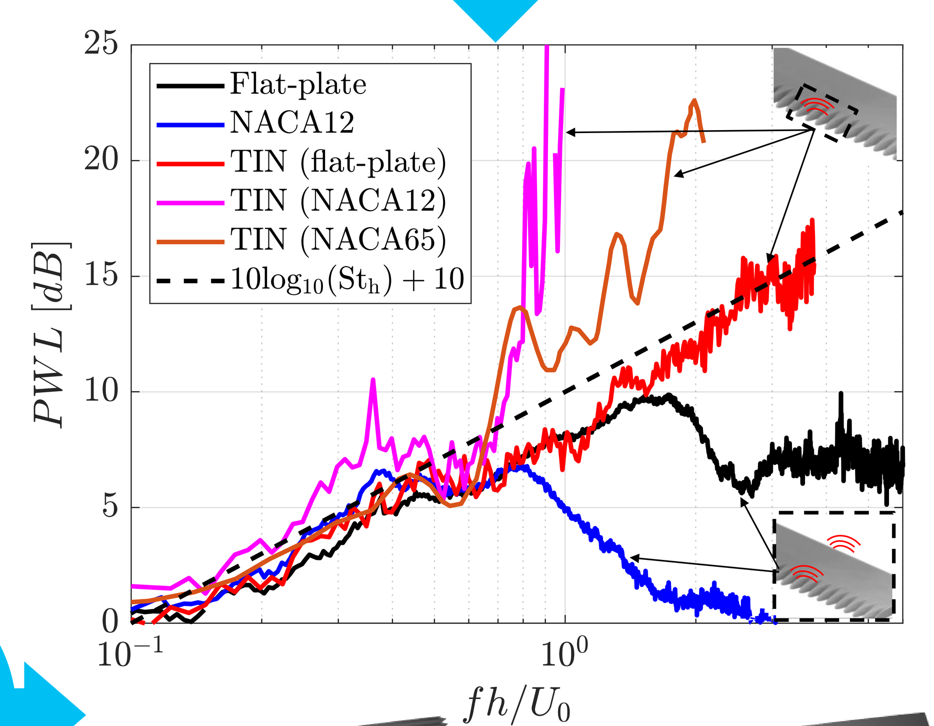


Tomographic PIV

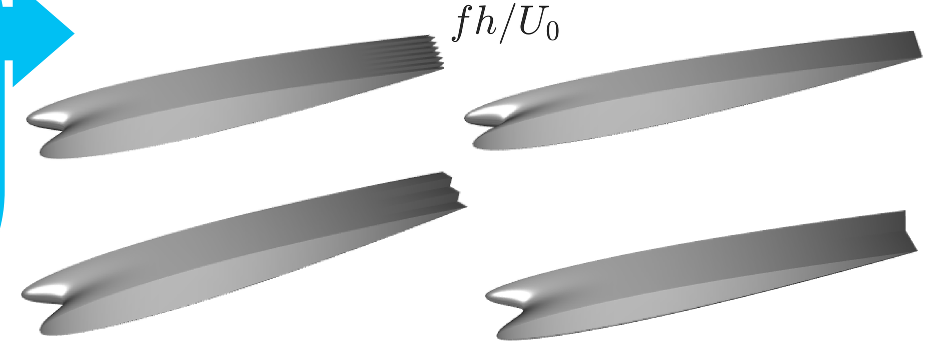


Noise color map

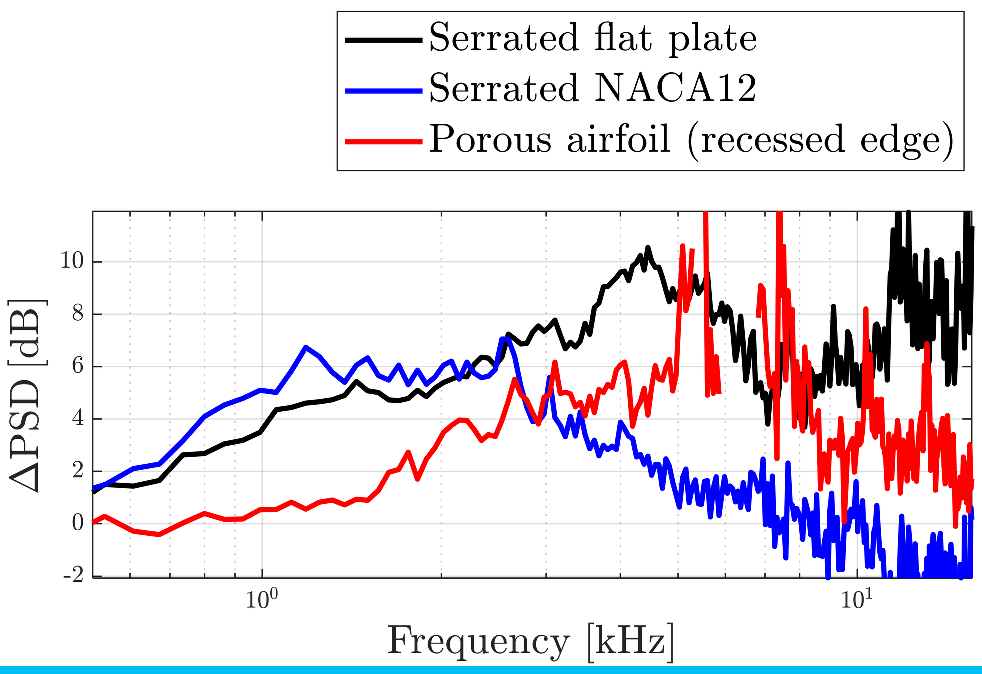
LE noise extraction promises higher noise reduction performances. [1] [2]



Leading edge serrations + Trailing edge serrations + Optimization → *Minimization* of TIN and TEN



Conclusion



The evaluation of the spectra for all the airfoils (far-field) proposes the best candidate depending the demandings of the industrial application (noise levels, aerodynamics, space etc.).

References

[1] Bampanis, G., and Roger, M., "Airfoil-Turbulence Interaction Noise Source Identification and its Reduction by Means of Leading Edge Serrations", *AIAA 2020*

[2] Moreau, S., Bampanis, G., and Roger , M., "Analytical and experimental investigation of leading-edge noise reduction on a flat plate with serrations", *AIAA 2020*

[3] Bampanis, G., and Roger , M., "On the Turbulence-Impingement Noise of a NACA-12 Airfoil with Porous Inclusions ", *AIAA 2019*

[4] Bampanis, G., and Roger, M., "Three-dimensional effects in the reduction of turbulence-impingement noise of aerofoils by wavy leading edges", *Euronoise 2018*

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MARIE CURIE ACTIONS