37th International CAE Conference and Exhibition
2021, November 17 – 19
Vicenza, Italy

Development of a CAE solution for the multi-method study, design and optimization of acoustic packages

Dario Magliacano[a], Alessandro Casaburo[b], Giuseppe Petrone[a], Francesco Franco[a], Sergio De Rosa[a]
[a]PASTA-Lab, Department of Industrial Engineering - Aerospace Section, Università degli Studi di Napoli "Federico II", Via Claudio 21, 80125 Naples, Italy
[b]WaveSet S.R.L., Via A. Gramsci 15, 80122 Naples, Italy

Introduction

- **Noise pollution** in urban centers, which is becoming increasingly important for the **comfort of passengers**, causes serious damage to health and represents a key point in the **ecological transition**.
- Noise control services have wide applications in the fields of **energy, civil and transport engineering** (aerospace, automotive, rail), where space, weight and acoustic comfort are still critical challenges.
- Numerical toolboxes are generally expensive and often require **relevant computational resources**, especially at high frequencies, as well as a **strong scientific background and industry knowledge from the user**.
- The computational cost is a critical aspect to **reduce the time of management of the product cycle**, as well as with reference to the **harmful emissions of the computers** themselves.

Research objectives

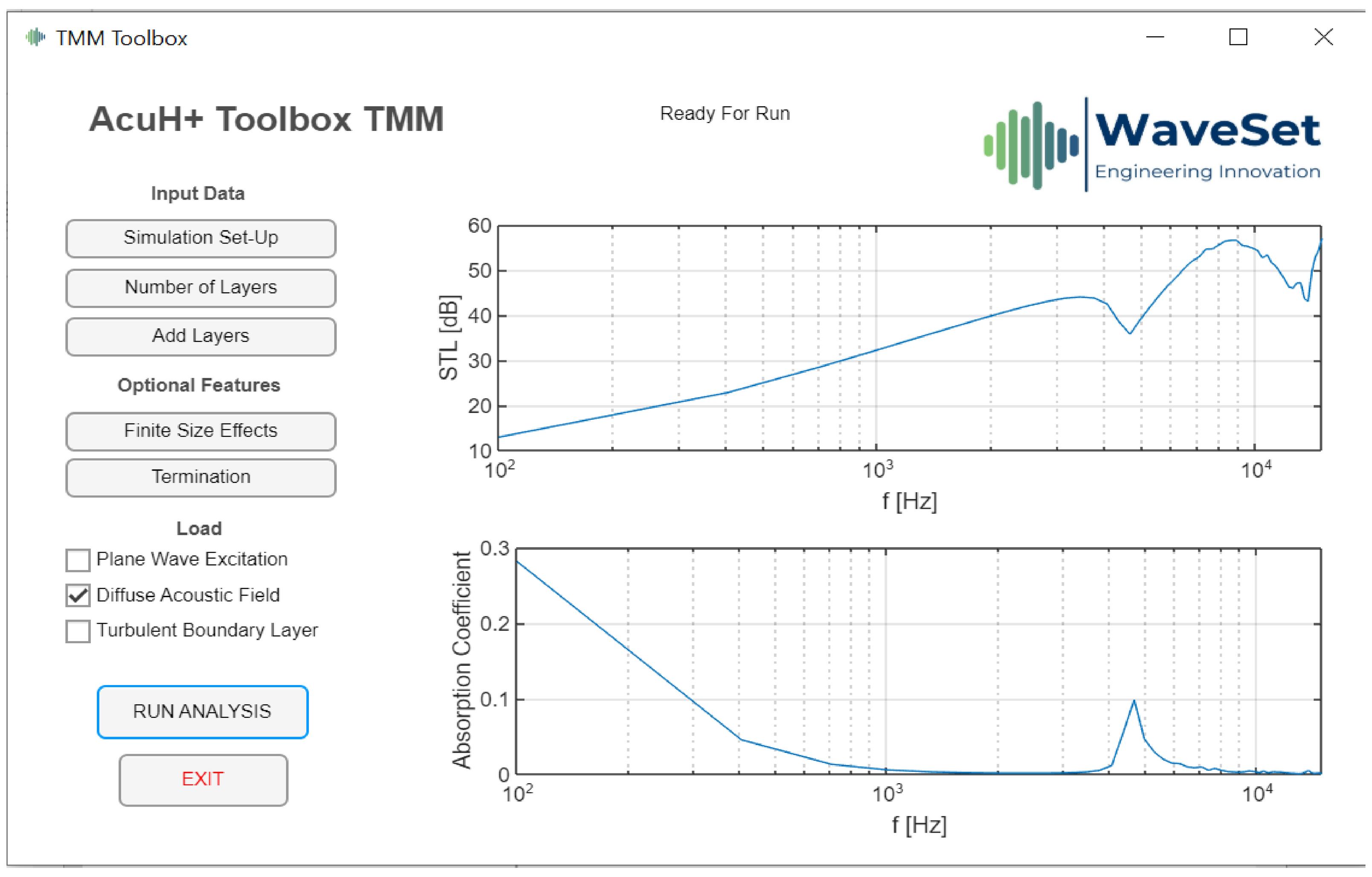
- This work is performed in collaboration with **WaveSet S.R.L.**, a start-up specialized in Vibrations and Acoustics for the Aerospace, Automotive, Naval, Railway and Energy engineering sectors. The WaveSet Team is composed of experts in the fields of NVH, fluid-structure interaction, composite materials and meta-materials design. Thanks to the thorough engineering experience of its team, WaveSet offers a series of toolbox solutions **to facilitate, accelerate and make more efficient** the numerical analysis and characterization of a sound-proofing package for acoustic applications.
- The main scope of this research is represented by the **development of a multi-method toolbox platform** for the study, design and optimization of **innovative acoustic packages**, in order to reduce sound transmission in transportation and buildings.

Methodological framework

- WaveSet products are designed to be **more intuitive, more versatile and less resource-consuming** than those available on the market, making use of different numerical techniques:
  - Transfer Matrix Method (TMM);
  - Wave Finite Element Method (WFEM);
  - Statistical Energy Analysis (SEA).
- **The whole toolbox portfolio can be personalized** according to the needs of each specific customer.

	FEM: Finite Element Method	WFEM: Wave Finite Element Method	BEM: Boundary Element Method	TMM: Transfer Matrix Method	SEA: Statistical Energy Analysis
Level of model detail	POSITIVE	POSITIVE	POSITIVE	NEGATIVE	INTERMEDIATE
Complexity of modelization	NEGATIVE	INTERMEDIATE	INTERMEDIATE	POSITIVE	INTERMEDIATE
Computational costs	NEGATIVE	POSITIVE	INTERMEDIATE	POSITIVE	POSITIVE
Accuracy of results	POSITIVE	INTERMEDIATE	INTERMEDIATE	POSITIVE	NEGATIVE

Results: interface & features

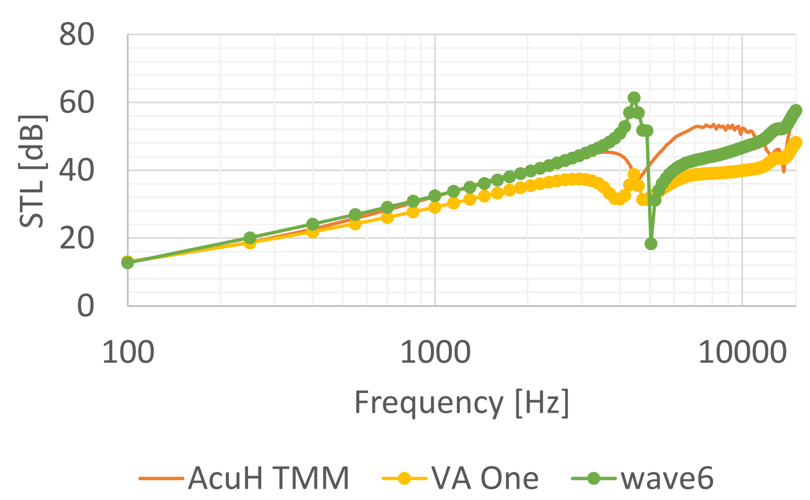


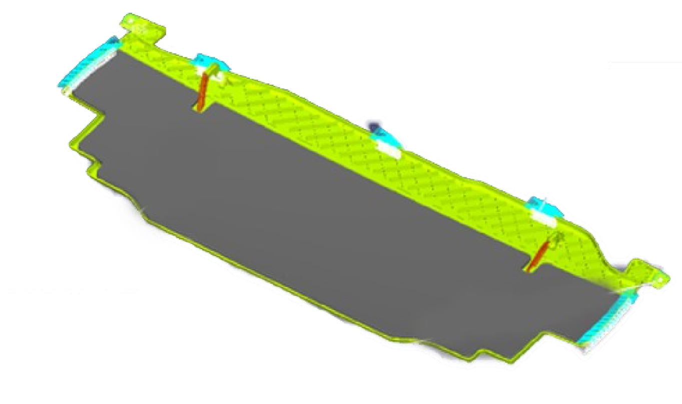
Results: developed toolbox solutions

- **AcuH TMM** is a toolbox based on the Transfer Matrix Method and allows the simulation of the sound transmission and absorption of complex sound packages including isotropic and orthotropic elastic panels, porous media with elasticity, and fluid layers. Acoustic and Turbulent Boundary Layer excitations are included.
- **AcuH WFEM** is a toolbox based on the Wave Finite Element Method and allows the simulation of the sound transmission of complex periodic panels with a high degree of geometrical detail, if needed. Curvature and additional sound packages are also features of the toolbox. Acoustic and Turbulent Boundary Layer excitations are included. The toolbox can provide dispersion curves for wave-based optimizations.
- **AcuH SEA** is a toolbox based on the Statistical Energy Analysis. **This toolbox is in the design phase.**

Results: validation of TMM toolbox

- Structure: automotive panel
- Load: Diffuse Acoustic Field





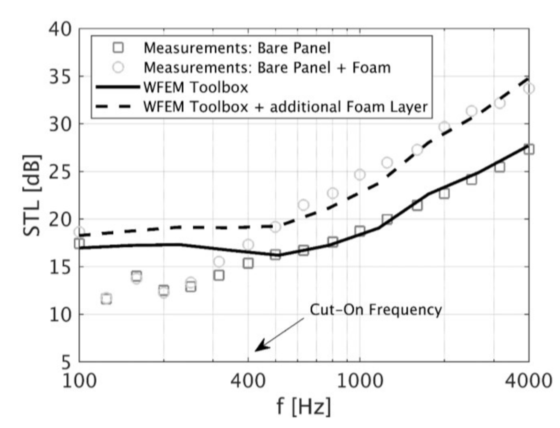
Aluminum panel (t=0.9 mm)
Thermoplastic material (t= 3 mm)
Absorbing material (t= 10 mm)

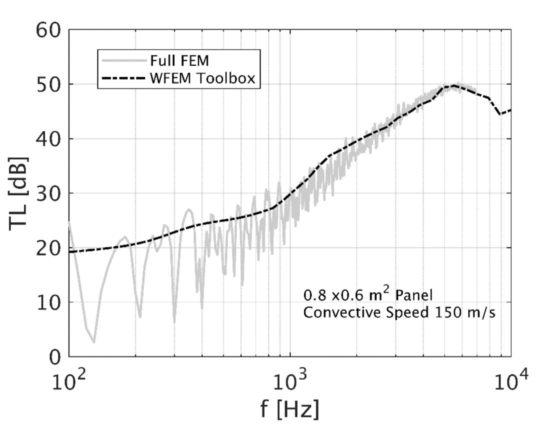
Results: validation of WFEM toolbox

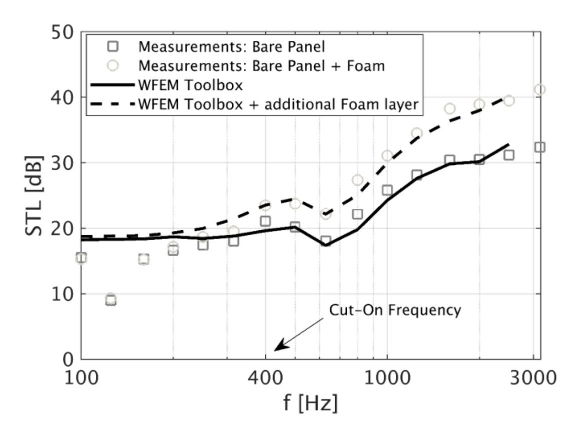
- Structure: Curved composite honeycomb panel
- Load: Diffuse Acoustic Field

- Structure: Flat honeycomb panel
- Load: Turbulent Boundary Layer

- Structure: Curved aircraft fuselage panel
- Load: Diffuse Acoustic Field



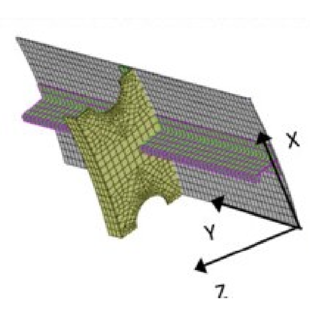




- **The number of Degrees-of-Freedom** required to analyze a periodic unit cell through the WFEM approach **is at least one order lesser** than the one required in the case of classical FEM approach, thus leading to a **meaningful reduction in terms of computational cost and time.**
- The first and the third validations are performed accounting also for an **experimental comparison.**

Conclusions

Further improvements of the toolboxes developed herein is possible through the adoption of **periodic ("meta-material") and/or biocompatible solutions**, which make use of periodic geometric shapes to filter the propagation of waves and **to reduce the noise transmission**, with a **very limited calculation cost**.



Contacts

For information, please write at:
dario.magliacano@unina.it
alessandro.casaburo@wavesetconsulting.com

References

1. S. De Rosa, F. Franco, "Exact and Numerical Responses of a Plate under a Turbulent Boundary Layer Excitation", Journal of Fluids and Structures, 24, 212-230, 2008.
2. G. Petrone, V. D'Alessandro, F. Franco, S. De Rosa, "Numerical and experimental investigations on the acoustic power radiated by aluminium foam sandwich panels", Composite Structures, 118, 170-177, 2014.
3. G. Petrone, "Dispersion curves for a natural fibre composite panel: Experimental and numerical investigation", Aerospace Science and Technology, 82-83, 304-311, 2018.
4. F. Errico et al., "The modelling of the flow-induced vibrations of periodic flat and axial-symmetric structures with a wave-based method", Journal of Sound and Vibrations, 424, 32-47, 2018.
5. F. Errico et al., "Prediction of sound transmission loss of curved composite panels with attached soundproofing material using a periodic cell approach", Applied Acoustics, 176, 21-28, 2019.
6. F. Errico et al., "Schemes for the sound transmission of flat, curved and axisymmetric structures excited by aerodynamic and acoustic sources", Journal of Sound and Vibration, 476, 221-238, 2019.
7. D. Magliacano, M. Ouisse, S. De Rosa, F. Franco, A. Khelif, "Computation of acoustic properties and design guidelines of periodic Biot-modeled foams", Applied Acoustics, 168, 2020.