Thesis title: Study and design of black hole architectures fitted with dampers for the vibro-acoustic attenuation in curved transport structures	
Host Laboratory: DRIVE UR 1859, UBE, **ISAT Nevers**, **VAT Team**	
Speciality: Engineering Sciences	
Keywords : Vibro-Acoustic Black Hole (VABH), Local Resonators, Bandgaps, FEM, Curved Transport Structures.	

Thesis description

Modern transport industries face mounting pressure to improve passenger comfort while simultaneously reducing structural weight. Transport structures such as automotive roof panels, aeronautical fuselage skins, and railway wagon floors are inherently curved and often multi-layered. In contemporary vehicles, these thin-walled panels are subjected to broadband mechanical excitation from onboard sources. Conventional treatments such as viscoelastic damping materials, acoustic liners, and active dampers deliver effective noise and vibration attenuation. However, they impose a significant mass penalty that conflicts with the stringent lightweighting targets imposed by current environmental regulations. Periodic resonator arrays, explored by Claeys [8], offer an alternative by exploiting bandgap properties to block wave propagation, yet remain narrow-band and highly sensitive to tuning.

The Vibration Acoustic Black Hole (VABH) concept offers a fundamentally different, passive and lightweight solution. Rooted in structural dynamics, the VABH traps incoming flexural waves through a power-law reduction in local structural thickness, first theorised by Mironov [2] in 1988. As the local phase velocity decreases continuously toward the tip, the wave travel time tends to infinity and reflection is theoretically eliminated. In practice, a thin viscoelastic damping layer modelled by the Ross–Ungar–Kerwin (RUK) framework [3] is applied at the tip to dissipate the concentrated energy, yielding very low reflection coefficients even under realistic truncation conditions (Pelat et al. [1]).

A critical yet unresolved challenge arises from the geometry of real transport structures. Unlike the flat beams and plates that dominate the existing VABH literature (Pelat et al. [1]), engineering panels in the transport sector are curved surfaces governed by thin-shell mechanics (Leissa [7]). Curvature introduces a flexure–membrane coupling that fundamentally alters the dispersion relation, modifies local phase velocities, and shifts the VABH cut-on frequency none of which are captured by existing flat-structure models. Curved shell structures therefore represent an explicit and unresolved scientific gap, particularly critical given that transport structures are precisely the application domain where VABH technology holds the greatest industrial relevance.

A second related gap concerns the damping layer itself. In every VABH study reviewed by Pelat et al. [1], the viscoelastic coating is treated as an isotropic medium: a scalar loss factor, uniform in all directions, as prescribed by the RUK model [3]. Yet curvature induces a preferential direction in the flexural wave field, rendering an isotropic treatment inherently suboptimal. An anisotropic, directionally oriented viscoelastic layer could instead concentrate dissipation precisely where vibrational energy is most intense, offering a route to enhanced attenuation without additional mass.

The aim in this thesis is to solve the following core scientific questions:

- To what extent does structural curvature alter the VABH effect?

- Does replacing the conventional isotropic viscoelastic layer with an anisotropic counterpart significantly improve vibrational dissipation in curved transport structures?

The thesis addresses both gaps through the following research objectives:

- **Curvature effects on the VABH mechanism**: Analytical characterisation of the bending–membrane coupling induced by curvature and its impact on the flexural wave dispersion relation and VABH cut-on frequency in curved shell panels.
- **Anisotropic damping layer**: Extension and optimal calibration of the Ross-Ungar-Kerwin model to account for a directionally oriented anisotropic viscoelastic layer, and formulation of the critical coupling condition (Leng et al. [5]) in this anisotropic setting.
- **Experimental validation**: A curved shell VABH prototype, representative of an automotive body panel, railway wagon wall, or aircraft floor section, will be designed, manufactured, and experimentally tested. Its vibro-acoustic attenuation performance will be benchmarked against conventional damping treatments over a broadband frequency range.

Bibliography

1. Pelat A., Gautier F., Conlon S.C., Semperlotti F. The acoustic black hole: A review of theory and applications. Journal of Sound and Vibration, 476, 115316, 2020.
2. Mironov M.A. Propagation of a flexural wave in a plate whose thickness decreases smoothly to zero. Sov. Phys. Acoust., 34(3), 318-319, 1988.
3. Ross D., Ungar E., Kerwin E. Damping of plate flexural vibrations by means of viscoelastic laminae. Structural Damping, 49-88, 1959.
4. Denis V., Gautier F., Pelat A., Poittevin J. Measurement and modelling of the reflection coefficient of an ABH termination. J. Sound Vib., 349, 67-79, 2015.
5. Leng J., Romero-García V., Pelat A., Picó R., Groby J.-P., Gautier F. Interpretation of the ABH effect based on critical coupling. J. Sound Vib., 471, 115199, 2020.
6. Shepherd M.R., Feurtado P.A., Conlon S.C. Multi-objective optimization of acoustic black hole vibration absorbers. J. Acoust. Soc. Am., 140(3), EL227, 2016.
7. Leissa A.W. Vibration of shells. NASA SP-288. (référence fondamentale pour la mécanique des coques minces), 1969.
8. Claeys C.C., Vergote K., Sas P., Desmet W. On the potential of tuned resonators to obtain low-frequency vibrational stop bands in periodic panels. J. Sound Vib., 332, 1418-1436, 2013.

Applicant profile

The candidate must hold a Master's degree (or engineering degree equivalent) in Mechanical Engineering, Structural Mechanics, Vibration, Applied Physics or Mathematics.

Preferred selection criteria*:*

A minimum GPA (Grade Point Average) ranking in the top five of the graduating class is expected. Solid backgrounds in mechanics, structural dynamics, numerical modelling, vibration, and wave propagation are strictly required. Knowledges on thin plate and shell theory, as well as experimental skills, are ideally expected.

Personal characteristics:

The candidate must combine rigor in analytical calculations, intuition in interpreting physical results, and the pragmatism of an engineer, *with the communication skills of a scientist who understands that an unpublished result is an unfinished result.*

Funding: MESRI (Ministry of Higher Education, Research and Innovation)
Host Institution: University of Bourgogne Europe, ISAT Nevers
Application deadline: **Mai 15th**
Contract start date: 1 October 2026 Gross monthly salary: €2,200 (rising to €2,300 gross from 1 January 2026)

Thesis Supervisor:

Professor Lotfi BEJI / e-mail: Lotfi.Beji@ube.fr

Thesis co-supervisors:
Orlando Andrianarison, (Associate Professor): Orlando.Andrianarison@ube.fr
Said Moussavi (Associate Professor): Said.Moussavi@ube.fr

Applicants are invited to submit their application to the PhD supervisors, in *cc* the co-supervisors.

Application must contain the following documents:
- CV
- Cover letter
- At least 1 reference letter
- Transcripts of Master's year 1 and 2 (or equivalent), ranking in Master's year 1 and 2.