# DATA-DRIVEN AEROACOUSTOELASTIC ASSESSMENT OF LAUNCHER PAYLOADS

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## ABSTRACT

The activity developed in the present work focuses on the acoustic response of the fairing of a launcher to forcing terms generated by the exterior unsteady pressure over the body surface.

It is the result of a complex mechanism governed by the strong interaction between structural dynamics and fluid dynamics, where aeroelastic effects couple with the acoustic field generated in the cavity. Indeed, the elastic fairing wall vibrates for the combined action of exterior and interior pressure fields, but both of them are affected by the wall dynamics. The effect on the exterior pressure is the aeroelastic feedback that produces perturbations to the field given by the relative motion between fluid and rigid body. On the other hand, the action of wall vibrations on the interior pressure is the origin of the acoustic field in the cavity that, therefore, would not exist if the fairing wall was rigid [1, 2, 3, 4].

Here, the numerical investigation has been performed by considering a "one-way" vibroacoustic model, where the feedbacks have been neglected (namely, the aeroelastic effects on the exterior pressure and the action of the interior pressure field on the fairing wall vibration). Hence, the vibroacoustic analysis starts from the exterior unsteady pressure that yields fairing wall vibrations that, in turn, perturb the fluid in the cavity, thus generating the internal noise environment.

The results of the analysis are given in terms of the spectrum of the acoustic field computed in characteristic points and averaged in the cavity domain, expressed in octave and one-third octave bands. In addition, at the same points and averaged in the cavity domain, the overall acoustic field is also evaluated.

Three different configurations have been studied, with increasing complexity of the structure, in order to study its effect on the internal noise (see Figure 1): an empty launcher fairing, a fairing containing a cubic satellite and one containing the satellite, its antennas and solar panels. A parametric analysis on the acoustic wall impedance has also been conducted.

Finally, the external aerodynamic loads adopted as input for the vibroacoustic analysis were obtained by estimating the acoustic pressure load on the fairing through multiple supervised machine-learning approaches trained on experimental data [5]. Specifically, the wall-pressure fluctuations were predicted from an extensive wind-tunnel measurement campaign conducted on a scaled launcher model, where a rich database of surface-pressure measurements under different flow conditions was collected and used to train and compare several regressors (e.g., decision-tree ensembles, Gaussian process regression, support-vector regression, artificial neural networks, and linear models), enabling the reconstruction of the fairing acoustic load from experimental evidence, extrapolated to the full-scale model. For completeness, Figure 2 reports an example of the spectrum obtained using the best-performing model among those tested, compared against the corresponding experimental spectrum.

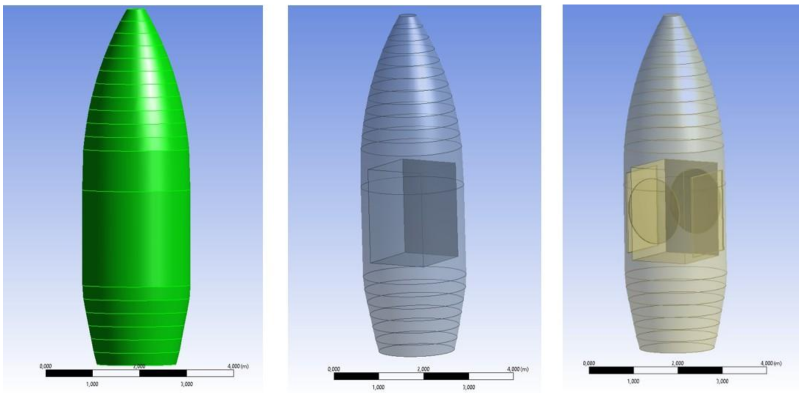

Figure 1 – Three analyzed payload configurations (starting from the left): empty fairing, fairing + satellite, fairing + complete payload.

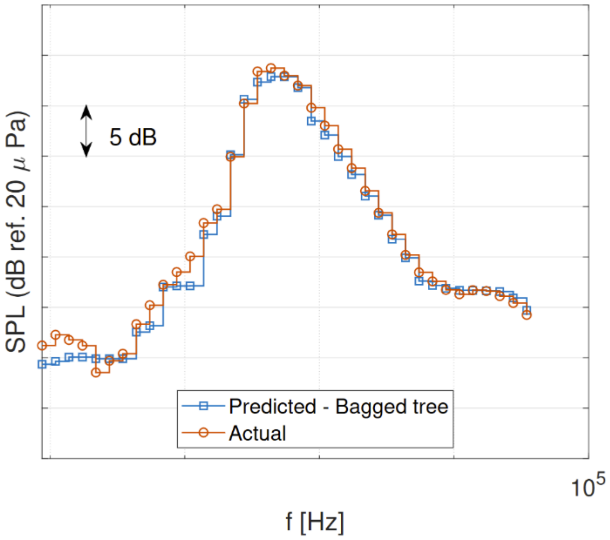


Figure 2 – Comparison between the model prediction and the experimental spectrum for the case $M = 0.83$, $\alpha = 0^{\circ}$, on the fairing ogive.

## References


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