INDUSTRIAL APPLICATION OF PERIODIC STRUCTURES TO AIRCRAFT/LAUNCHERS

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ABSTRACT

The main aims of this paper are the description of the vibroacoustic response of a structure, in particular a periodic structure, subjected to an aerodynamic excitation, the modelling optimization and numerical models validation. A literature review on the response of simple structures, 1-D and 2-D, beams and panels, is reported. The state of the art in this research field and the work plan are presented to give a complete overview of the project and of the expected results.

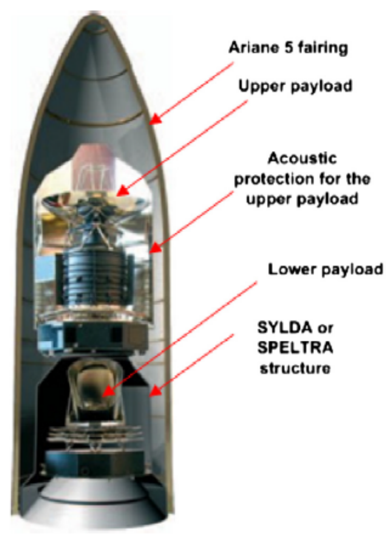
1 INTRODUCTION

Composite materials are largely used in aerospace industry, mainly due to their advantage of being light and their ability to suit the particular demands of each structure type and manufacturer. On the other hand, these type of structure have poor acoustic performance, inducing high level of noise transmission within the payload or passenger compartment.

The prediction of the vibroacoustic behaviour of composite structures, with the knowledge of wave dispersion characteristics, is very important during the design process.
Depending on the nature of the material (isotropic or anisotropic, homogeneous or inhomogeneous), on the geometrical shape (beam, shell, panel with single or double curvature, cylinder, cone) and on frequency range there are different methods to determine the wave dispersion characteristics and to describe the structural dynamic response.

The vibrational modelling of coupled composite conical-cylindrical systems has been an area of sporadic scientific research. In literature we can find everything about one dimensional problems and some simple examples about two dimensional structures, like plane or curved panels. These problems are solved using different approaches, both numerical and experimental.

The scope of ESR-11 doctorate is to apply all these knowledge to conical and cylindrical composite structures, in presence both of axial and/or circumferential ribs, and viscoelastic patches, solving a fully three dimensional problem. In particular, the attention is focused on the *SYLDA* (from French acronym of *SY*stéme de *L*ancement *D*ouble d'*A*riane 5) structure of *Ariane 5* launcher, as reported in Figure 1a.



(a) An illustration of *Ariane 5* spacecraft.

(b) A caption of the SYLDA mock-up used for experimental manipulation.

Figure 1: SYLDA component.

2 LITERATURE REVIEW

In the last thirty years many authors have investigated the vibroacoustic behaviour of a structure; in the first part, their attention was focused on one dimensional structures, of which we have

analytical solutions. After that, they studied two dimensional structures, plane or curved panels, made of metals or composite materials.
We can resume these works in the following manner:

- beam like structures;
- panel, both plane and curved;
- cylindrical and conical structures.

2.1 Beam like structures

When we have a one dimensional problem, in the Finite Element (FE) method we can consider it as a beam like structure. For these kind of problems there are some semi-analytical solutions to obtaining the dispersion curves [10]; other authors have predicted the energy flow using the Wave FE (WFE) method [5].

2.2 Panel, both plane and curved

In the last years this is a very intensive field of research. There are both numerical (using FE method of Statistical Energy Analysis (SEA)) and experimental solutions [2], [3], [7] and [8].

2.3 Cylindrical and conical structures

Cylindrical and conical structures are very complex, there are not analytical solutions; often experimental and numerical results are not published by the industries. In literature we can find some practical examples in [1], [9] and [10].

3 MAIN STEPS AND EXPECTED RESULTS

As said before, the main scope of this project is to apply all these knowledge to conical and cylindrical composite structures solving a fully three dimensional problem.
There are three main steps:

1. effects of lateral periodic ribs properties on the vibroacoustic response of the SYLDA under aerodynamic excitation. Modelling and optimization;
2. effects of circumferential ribs properties on the vibroacoustic response of the SYLDA under aerodynamic excitation. Modelling and optimization;
3. effects of periodic viscoelastic patches on the vibroacoustic response of the SYLDA under aerodynamic excitation. Modelling and optimization.

At the end, what we expect to obtain are some assessments of periodic design of the SYLDA component performance, the validation of numerical tools and optimization under realistic constraints. An intermediate result is how the energy flows inside the structure [5].

To do these we start from the simplest case, in order to validate the numerical and experimental tools, because of the poor results present in literature about conical and cylindrical structures, mainly in presence of ribs and stringers (too hard or impossible to solve analytically and experimental results covered by industrial intellectual properties).
After that, the starting point is the study made on the SYLDA component mock-up [1], which

consists only in the conical and cylindrical structure (Figure 1b), without ribs and stringers.

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