Actran Helps to Predict **the Vibro-acoustic Response of Satellite Solar Arrays**

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Introduction

At lift-off and during flight, spacecraft launchers experience several vibro-acoustic challenges. Those vibro-acoustic challenges are the result of intense sound pressure levels generated by more and more powerful rockets used to reach higher lift capacity and longer distance.

This intense acoustic load excites the launcher structure as well as the embedded payloads and equipment inside. Therefore, designing and managing the vibro-acoustic behavior during the design cycle of any launcher component is crucial to ensure the safety of spacecraft components.

Over the past 50 years, Airbus Defence and Space has been supplying reliable systems that range from electronic components to full telecommunication relay platforms, scientific satellites, and human-crewed spacecraft. Key common components of this portfolio are solar panels. These components are responsible for supplying electrical power to run the satellite sensors and electronics as well as the propulsion system.

Given the unique constraints within the launcher's fairing, solar panels are stowed during launch and later deployed at various mission phases. Due to weight saving objectives, the use of the lightest possible solar cell is desirable on spacecraft while the ratio of the solar panel surface area must be maximized over weight to support operations.

These design constraints led engineers to design complex structures carrying the solar cells, typically made of a sandwich structure covered by cells to fulfill specified mission requirements.

These light-weighted, critical structures are subject to intense loading during lift-off and engineers need to validate the structures to ensure that it can sustain these vibrations without residual defects that would prevent the solar arrays from being deployed properly.

In the past, the structural behavior of solar array designs were physically tested in reverberant rooms, where the intense lift-off acoustic environment is reproduced with loudspeakers and vibration levels as well as strain on the cells are measured. Many times, the cost of building prototypes do not allow engineers to conduct design comparison and the first design is usually the result of a conservative design approach. It is therefore challenging to optimize the structural design to reduce the weight while ensuring structural integrity.

MSC Software Solutions

Airbus Defence and Space engineers used MSC Nastran and Actran to predict the vibro-acoustic response of solar panels at lift-off using a hybrid approach. Mode shapes and related eigenfrequencies of the solar panels structure are computed with MSC Nastran while Actran is used to both enrich the structural model by modeling complex acoustic dissipations and propagation and model the acoustic load environment acting on the solar array stack.

Figure 1. Telecommunication Satellite at IABG reverberation chamber, Copyright: Airbus Defence and Space 2017.

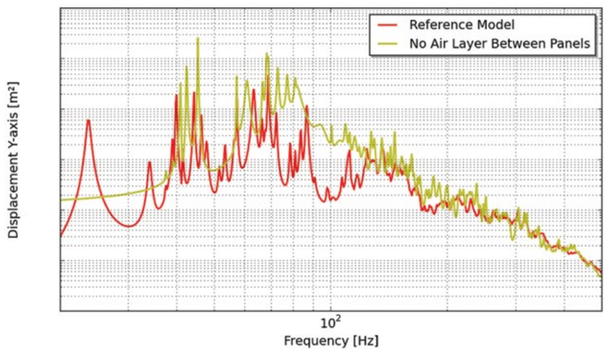

Figure 2. Solar Panels Vibration Spectrum, Impact of Air Interlayer Modeling

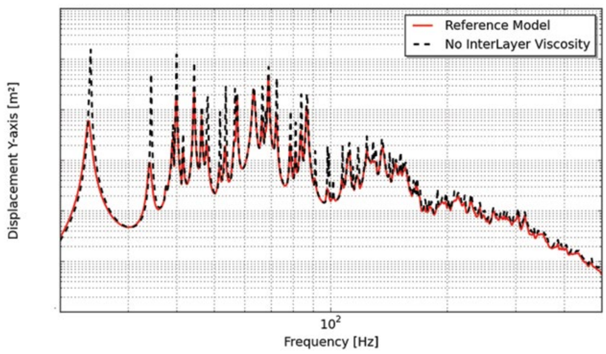

Figure 3. Solar Panels Vibration Spectrum, Impact of Panels Interlayer Viscosity Modeling

Modeling the Air Layer in-between the Panels

When folded, thin air-layers are created in-between the different solar panels. Modeling these air layers is of high importance to ensure an accurate prediction of the final vibrations. Indeed, the air layers act as dampers drastically impacting the vibrations of the different panels.

Furthermore, because of the small size of these layers (few millimeters), visco-thermal dissipations can occur impacting acoustic wave propagation. Actran includes advanced numerical modeling techniques to model these effects and predict final response accurately.

The Impact of Honeycomb Structure on the Vibro-acoustic Response

Sandwich structures are commonly used to reduce weight as well as increase structural strength. Carbon-fiber reinforced plastic face sheets cover the Aluminum honeycomb core structure. While MSC Nastran structural modeling capabilities allow representing such complex composite material structure accurately, the effects of a honeycomb structure covered by carbon-fiber face sheets on the acoustic propagation around the solar panel structure are modeled using Actran. Specific porous modeling allows the consideration of anisotropic acoustic propagation with related specific dissipations that are influencing the vibro-acoustic response of the solar panels at low frequencies.

Modeling the Real Environment

When installed, the stack of folded solar panels is attached to the satellite. The body of the satellite creates at the same time a reflecting surface close to the solar array stack, but also a masking wall preventing acoustic waves to impact part of the solar arrays stack directly. During typical measurements, a Satellite Sidewall Simulator (SSS) is used to support the solar arrays stack reproducing the environment solar arrays will face. The numerical model also includes the SSS by modeling a perfectly rigid wall in the neighboring of the solar stacks.

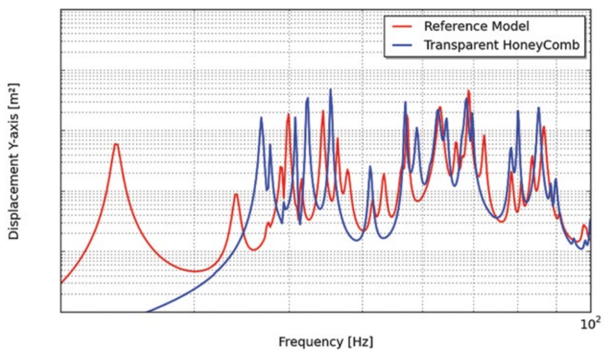

Figure 4. Solar Panels Vibration Spectrum, Impact of Panels Honeycomb Structure Modeling

Figure 5. Reverberant Room Test Set-Up

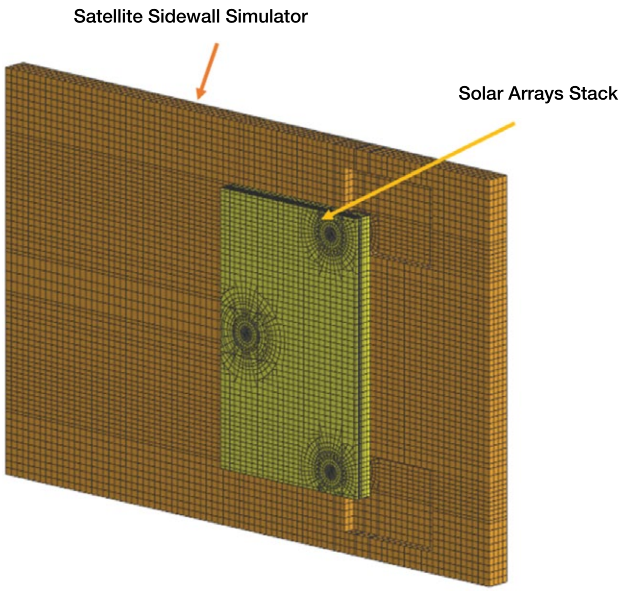

Figure 6. Vibro-Acoustic Model Overview

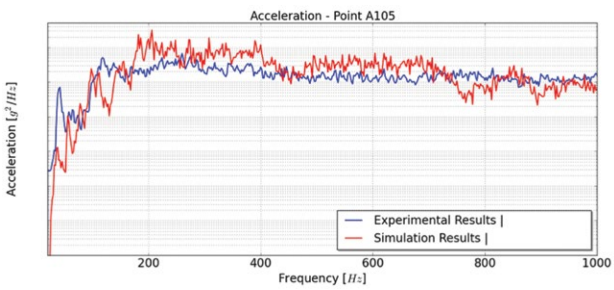

Figure 7. Solar Panel Acceleration Power Spectrum

About Airbus Defence and Space

With consolidated revenues of € 66.8 billion in 2017, Airbus is a global leader in aeronautics, space and related services. Airbus offers the most comprehensive range of passenger airliners from 100 to more than 600 seats. Airbus is also a European leader providing tanker, combat, transport and mission aircraft, as well as one of the world's leading space companies. In helicopters, Airbus provides the most efficient civil and military rotorcraft solutions worldwide.

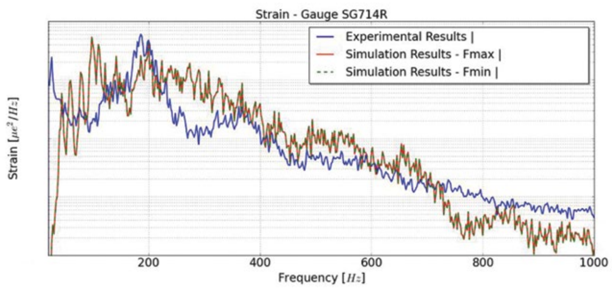

Figure 8. Solar Panel, Strain Power Spectrum

Finally, a Diffuse Sound Field (DSF) excitation created by a plane waves superposition is applied to the model to represent the acoustic environment.

Not only do the Actran results match the experimental results over the entire frequency range of interest, but the post-processing of Actran also allow output maps to identify the location of maximum acceleration and strain over the panels.

Learn more about Actran:
www.mscsoftware.com/actran

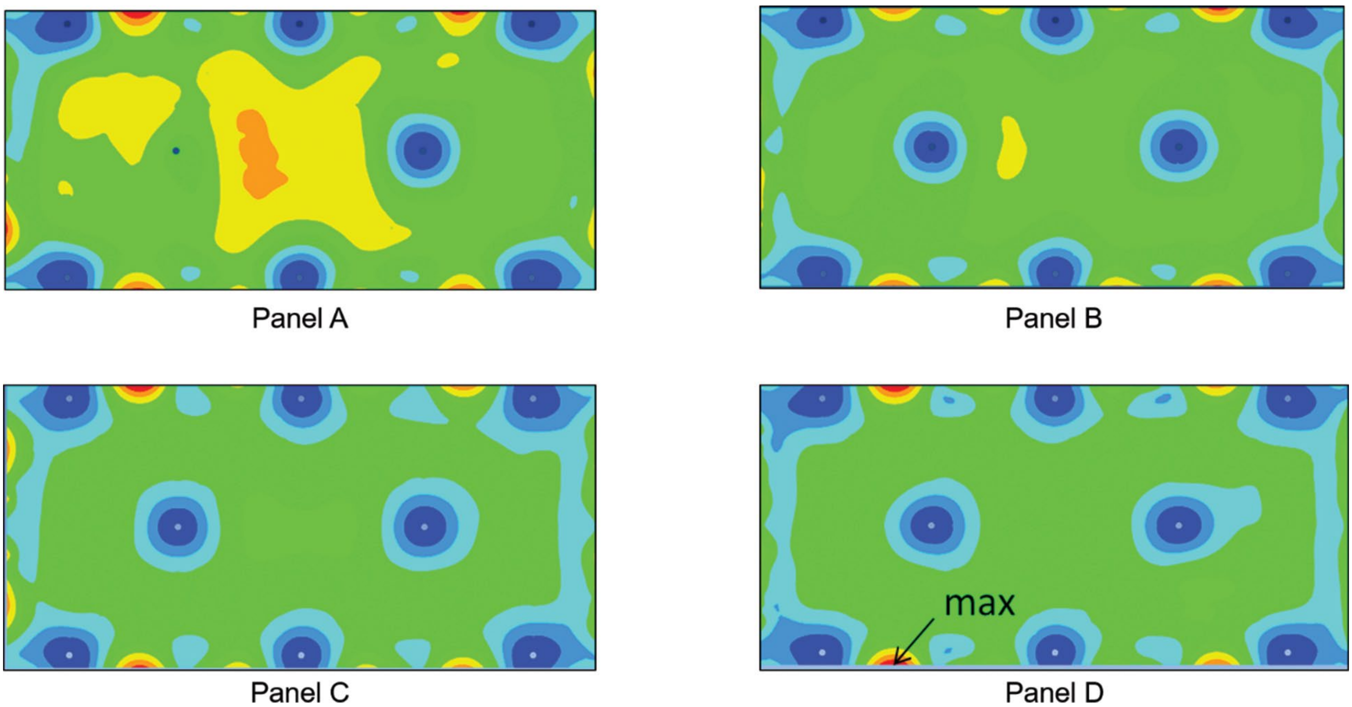

Figure 9. Solar Panels, Acceleration Power Spectrum