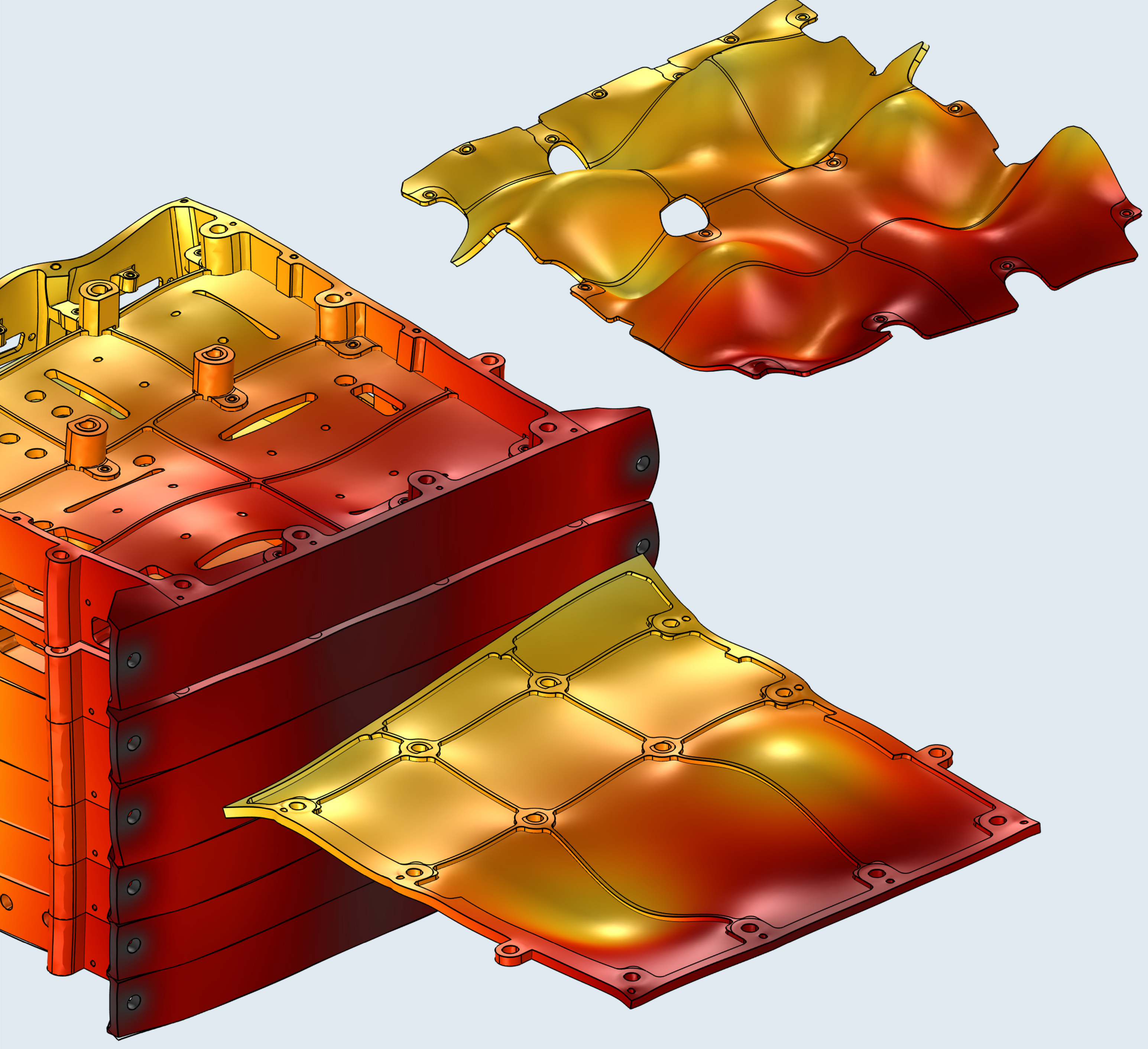

# Designing a Satellite Component Assembly Resistant to High Vibrational Stress Using COMSOL Multiphysics®

During the launch to enter orbit, the Master Reference Oscillator is subject to high acceleration and stress. A hybrid experimental-numerical method is proposed to design the fasteners.


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## Introduction & Goals

During the launch to enter orbit, this equipment is subject to high acceleration (up to a few 1000 g's) and stress, well defined by space standards and products specifications.

The goal of this study is to develop a method to assess the MRO equipment resistance using COMSOL Multiphysics®. Since the dynamic stress applies in a wide range of frequency, a power spectral density approach is selected, similarly to the Motherboard model of the Application Model Library (1). Because the MRO is assembled using screws, a special care is provided to their dynamic behaviour. However, no screw model is readily available in the software: therefore, SIMTEC developed a new model for fasteners.

Experimental tests are performed by RAKON and the numerical analysis by SIMTEC.

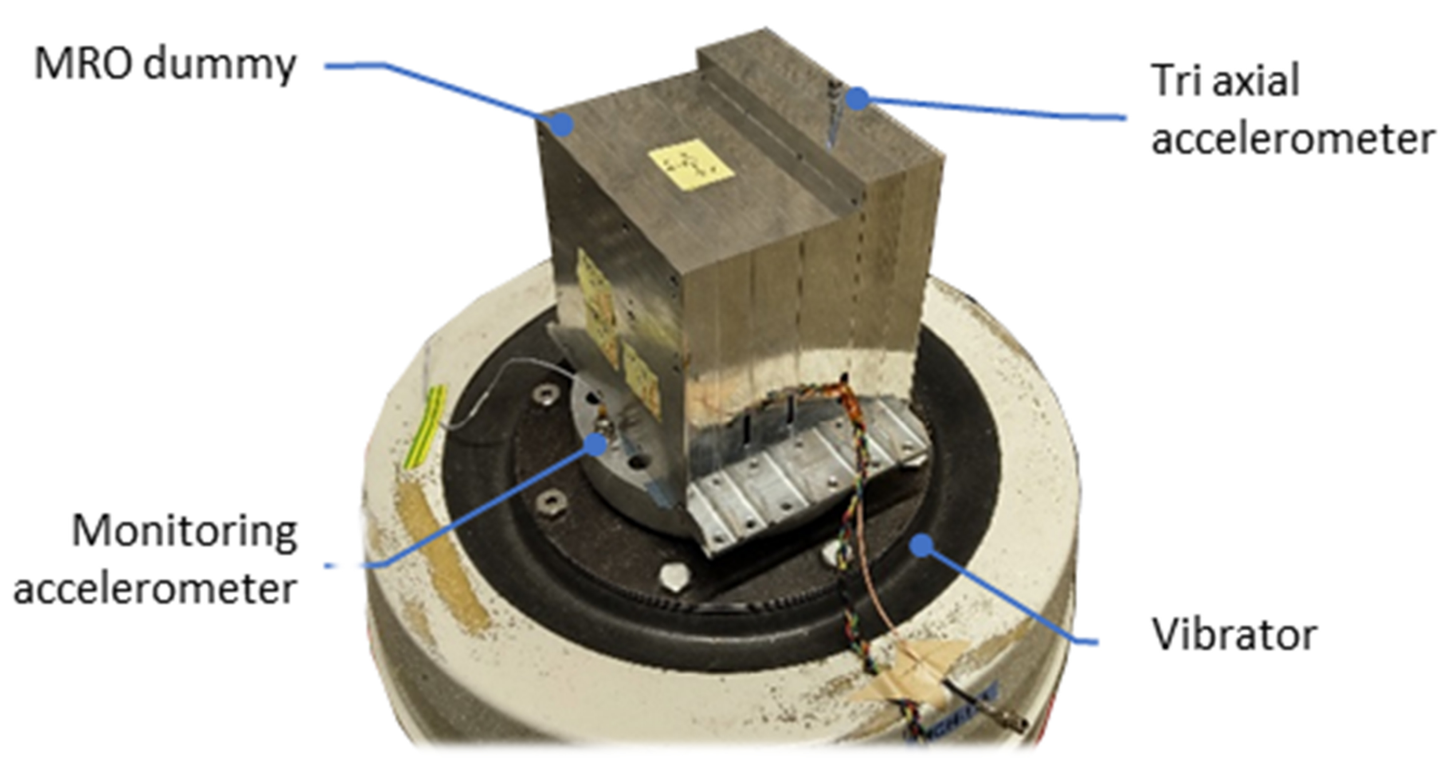


Figure 1: test set-up to determine the suitable structural damping parameters

## Methodology

An experimental analysis is performed by RAKON to assess the damping behaviour of the mechanical structure. The test-rig is represented in Figure 1.

SIMTEC developed a screw model by upgrading the springs proposed by COMSOL in the Structural Mechanics Module. The screw model is then used for each fastener in the whole assembly. A pre-tension study step is applied to determine the initial stress: $\nabla \cdot S = 0$ is solved, with $S$ the stress tensor. Then a Reduced Order Model is built; the linearisation point accounts for the initial stress. Finally, a Power Spectral Density analysis is performed to account for the full vibration spectrum straining the device.

## Results

Thanks to the whole assembly computation, it is possible to access local accelerations (see Figure 2) and stresses of the MRO specific components. The focus is the fasteners' ability to withstand stress and overcome slip. Each fastener is assessed using the standard Margin of Safety defined in the ECSS handbook (2). The Margin of Safety for screw separation reads:

$$MoS_{sep} = \frac{F_{v,min}}{(1-\Phi_n)F_A\, sf_{sep}} - 1 > 0$$

with $F_{v,min}$ the minimum preload, $\Phi_n$ the screw compliance ratio, $F_A$ the axial force computed, and $sf_{sep}$ the safety factor. Using the method, all the fasteners are designed appropriately..

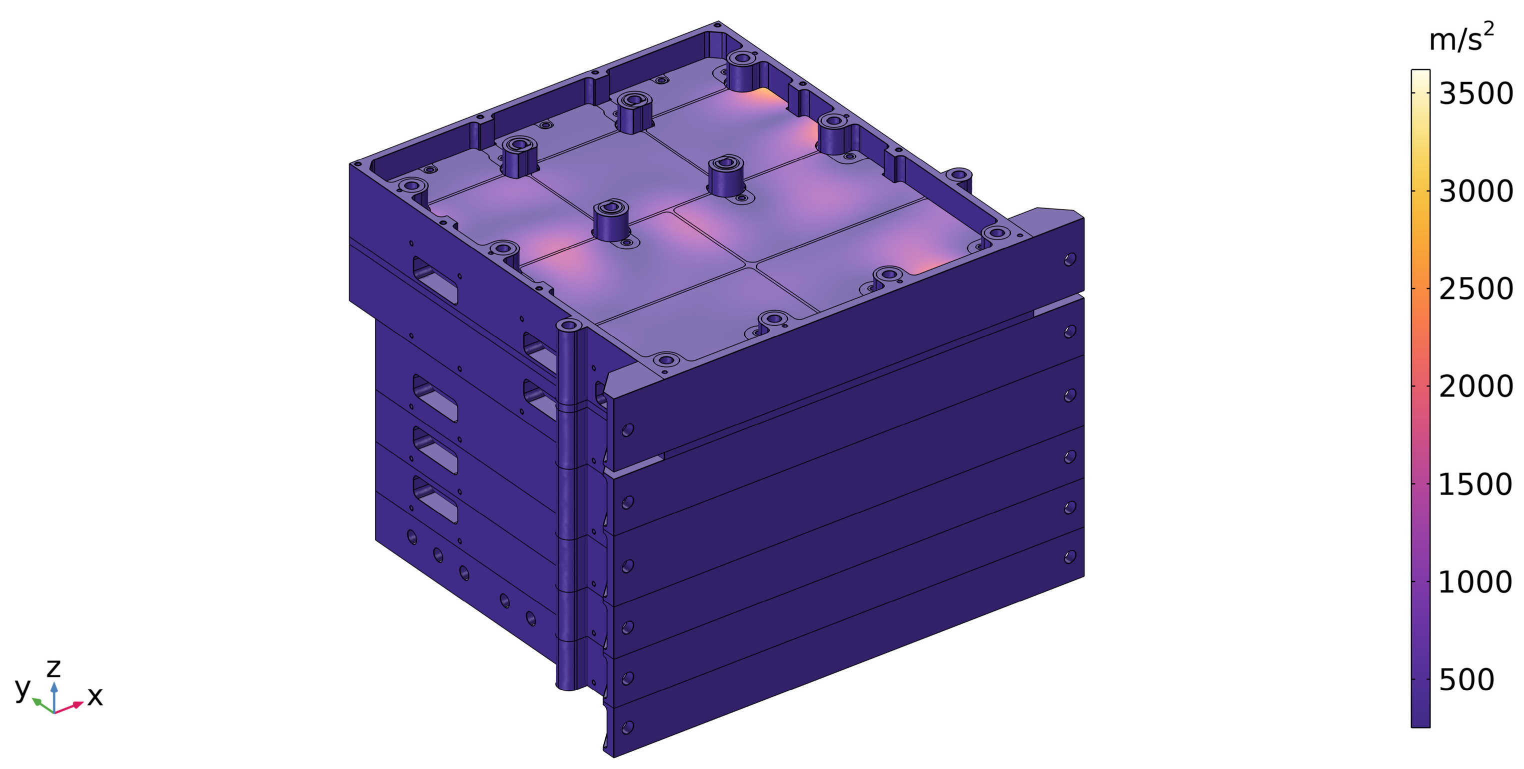


Figure 2: MRO acceleration for a $\vec{z}$ axis random vibration following the power spectrum density


### REFERENCES

1. Random Vibration Test of a Motherboard, COMSOL Application library. 2021. p. 1–30.
2. ECSS-E-HB-32-12A ECSS Handbook


A collaboration between rakon and SIMTEC