Mechanical Analysis and Testing of the ASPECT Payload for Milani CubeSat

Swati Thirumangalath, Leevi Salonen, Antti Näsilä, and Hans Toivanen

VTT Technical Research Centre of Finland Ltd., Espoo, Finland

Introduction

Milani intends to provide a detailed mineralogical map of Didymos' (primary of the binary system) and Dimorphos' (secondary) surfaces utilizing the hyperspectral imager ASPECT built by VTT.

The ASPECT miniaturized hyperspectral imager covers the optical spectrum from visible to the shortwave infrared (SWIR) range. There are four measurement channels on the instrument, one for visible light (VIS), two for near-infrared (NIR), and one for SWIR. SWIR is a single-point spectrometer, while VIS and NIR are imaging spectrometers. Asteroids' surfaces will also be characterized by ASPECT in terms of space weathering, shock effects, surface material transfer, and roughness. There will be finer detail images of selected features, such as the spacecraft's impact on Dimorphos in 2022, where DART (Double Asteroid Redirection Test) was launched.

A summary of the FEA analysis and vibration testing for the ASPECT instrument is presented in this poster.

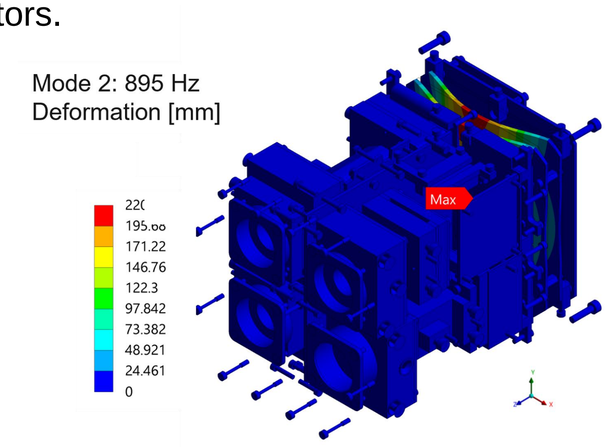
Requirements

As per the ESA specification guidelines, shock response analysis was the most critical module to assess. Mode shapes were calculated as a pre-requisite to the shock response analysis, modal analysis being the most fundamental of all dynamic analyses. All analysis was carried out for the X, Y, and Z axis non simultaneously. The shock response of the ASPECT structure was then investigated with a response spectrum analysis. The requirements were as follows:

1. The maximum stress within ASPECT components should be below the specific material ultimate strength values.
2. The predicted MOS (Margin of Safety) for all the critical components should also be above 1.
3. FPIs should survive the vibration tests involving an LLSS (low-level sine sweep), random vibration test, and shock response tests.

Modal Analysis

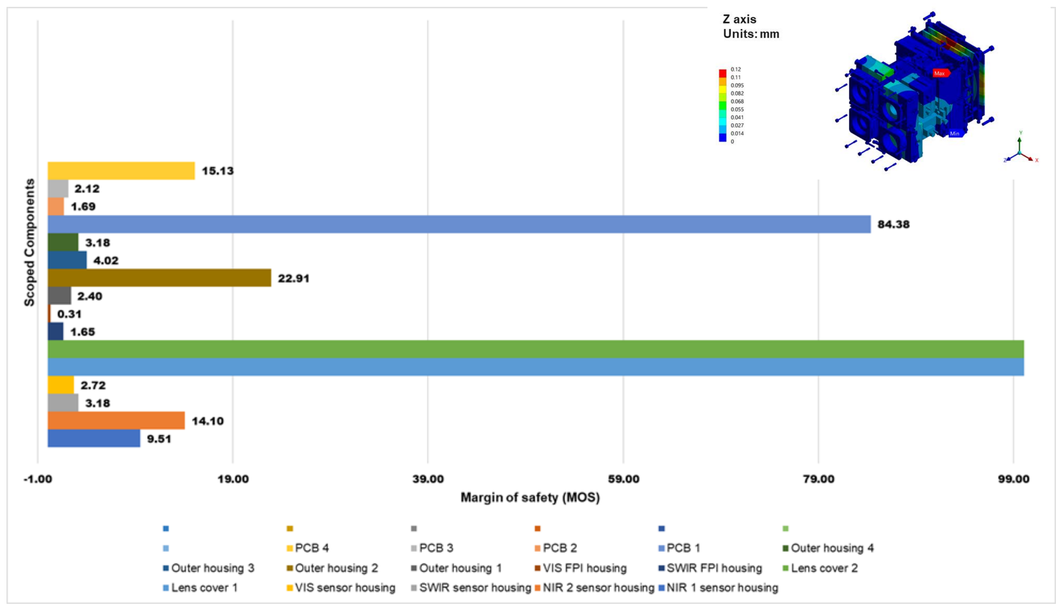
Modes 1 to 6 were captured, and the resulting frequencies range from 857 Hz to 1218 Hz which is nominal. The probability of peak stresses and deformations are higher for mode shapes 1,2 and 5 in X and Z directions due to their higher mass participation factors.



Mode Shape 5

Shock Response Analysis

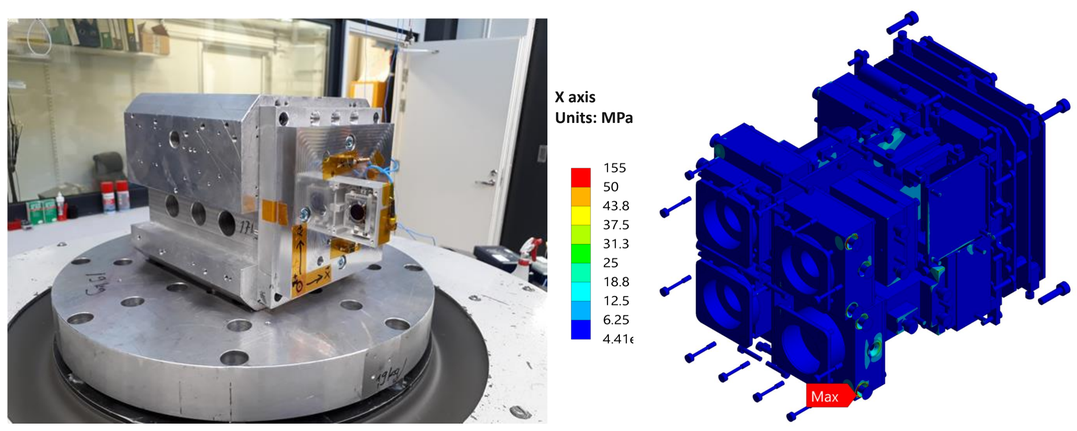
The maximum stresses within the ASPECT components were below the specific material ultimate strength values. The peak stresses and maximum deformation occur at the PCB support struts as can be seen in figure below. The predicted MOS (Margin of Safety) for all the critical components is above 1 .



Aspect Margin of Safety [MOS]

Vibration Test

A critical design component for ASPECT is the tuneable Fabry Perot Interferometer (FPI). Detailed vibration tests were performed on the FPI assembly consisting of the Fabry, housing, and attachment screws. The levels for the shock response tests varied from 500-1500 g.



FPI vibration test assembly [Left] and Predicted Von Mises Stress for Shock Response – X axis [Right]

Conclusion

- **The ASPECT components meet the requirements for Modal and Shock response studies.**
- **No noticeable damage was observed on the structure post the three vibration test stages. Furthermore, for the set of LLSS tests performed , the natural frequency did not vary by more than 15 %.**

8th IAA Planetary Defense Conference

Contact: Swati Thirumangalath, Research Scientist
Tel. +358 503060378, swati.thirumangalath@vtt.fi

3-7 April 2023,Vienna, Austria