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SCUOLA DI INGEGNERIA

Spacecraft Structures and Mechanisms Assignment 2019-2020

EUCLID
Payload Module and Service Module Structural Analysis

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1. Introduction

Euclid is an ESA mission to map the geometry of the Universe and better understand the mysterious dark matter and dark energy, which make up most of the energy budget of the cosmos. Starting from the high fidelity re-construction of the spacecraft model, structural responses of the Payload and Service module were evaluated through the mechanical environment induced by the launch vehicle (**Soyuz ST-B**).

2. Preliminary Analysis

Euclid is principally composed by two modules:

- **Service module**, a hexagonal box where are located all the subsystems;
- **Payload module**, a truss structure hosting all the scientific instruments.

Using a bottom-up approach, all the main components together with connections, were studied and designed, for a total of 294 parts. During this phase, all the details were inserted trying to maintain the maximum fidelity. You can check out the full assembly of the spacecraft using the **QR code** shown on the right.

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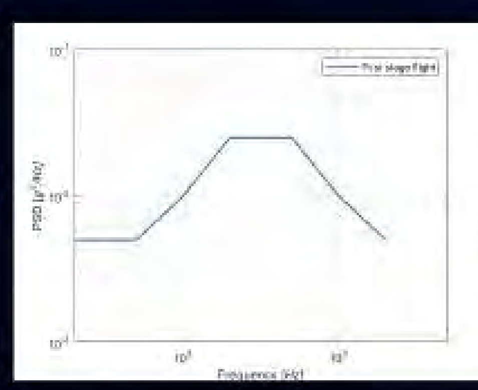
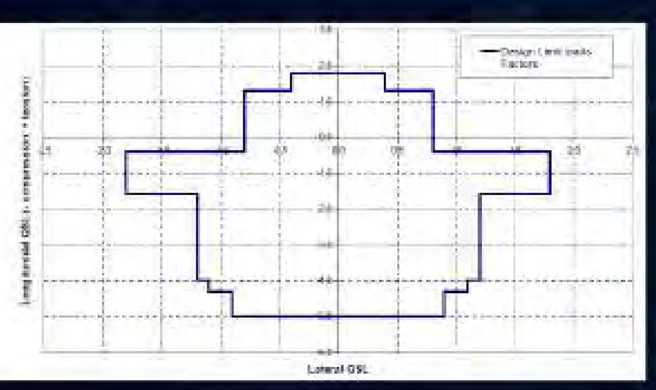
3. Loads Definition





The main loads that the spacecraft will undergo are induced by the launcher. To characterize the environment, these kinds of loads were used:

- **Quasi-static loads** (burnt acceleration);
- **Random Loads** (acoustic pressure);
- **Shock Loads** (clamp-band separation).

5. Verifications

The FEAs have provided the forces and moments applied to the fastened joints. Hence, a verification of the main loaded ones have been carried out with positive results using a MATLAB™ script. The verification considered:

- **Fastener** yield and failure;
- **Hole Bearing** yield and failure;
- **End-pad** shear failure;
- **Honeycomb** core compressive failure.

6. Conclusions

The work presented aims to show the **structural integrity** of Euclid. Results in terms of deformation and stress, provided from the different load environment simulations, show a good behaviour of the entire satellite.

Launcher user's guide constraints are satisfied; structural responses from quasi-static & dynamic loads have shown the most mechanically stressed and weak areas.

The verification of the most loaded joints has been performed successfully.
A future improvement in the geometrical model could increase the mesh quality and hence the results.

References:

- Calvi, A., and Bastia, P. *Mechanical architecture and loads definition or the design and testing of the Euclid spacecraft.* (2016)
- Bellini, M., and Calvi, A. *Dynamic analysis and loads definition for the structural design of the Euclid spacecraft.* (2014)

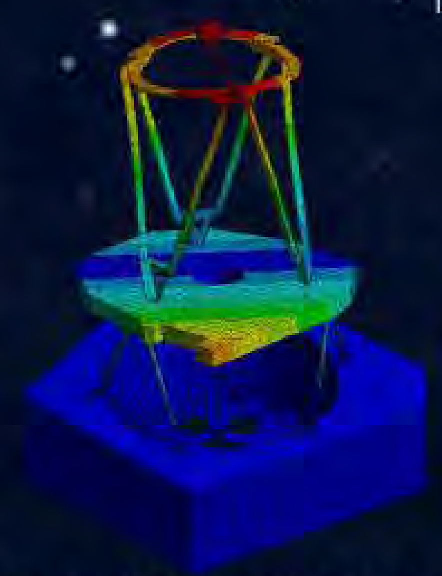
4. Finite Element Analysis

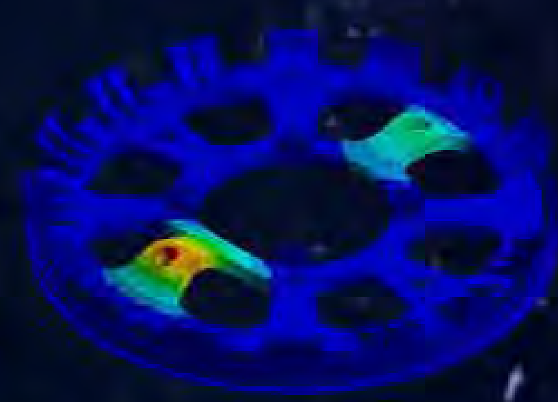
To obtain results without computational effort, a **simplified model** has been designed deleting secondary geometry and useless components.

Quasi-static analysis has been carried out, providing good responses in terms of deformation and stress.

Modal analysis, in addition to providing good results in terms of natural frequencies, has allowed to understand that the two modules are **modally decoupled**, except the first six natural modes of vibration which are related to the interface between SVM and PLM.

Mode	*Natural Freq. [Hz]*
1	16.5
2	16.7
3	29.3
4	38.7
5	42.8
6	47.1





Random vibration and **shock analysis** were also performed to have a clear picture of the dynamical response, providing the most stressed components that are the upper parts of the interface struts.