Topology Optimization and Additive Manufacturing for Astronomical Optomechanics

Application to MORFEO@ELT

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Key concepts

TOPOLOGY OPTIMIZATION (TO)

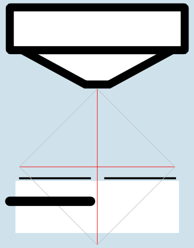
GEOMETRY
MATERIAL
OBJECTIVE FUNCTION
CONSTRAINTS

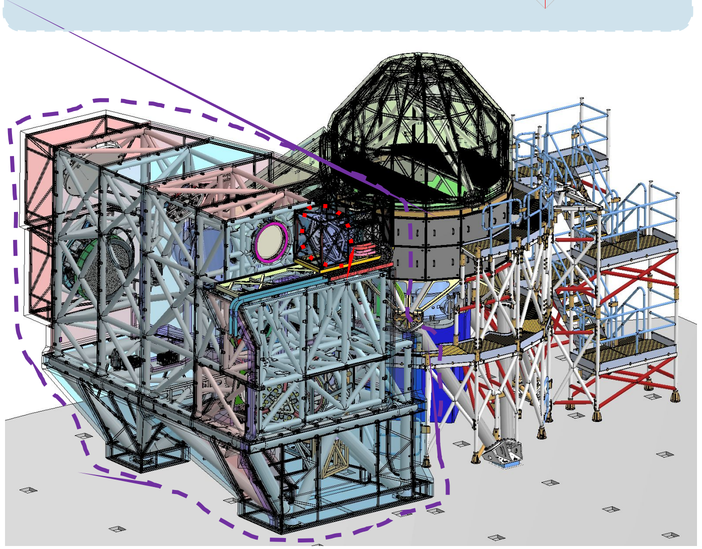
TOPOLOGY OPTIMIZATION ALGORITHM

Optimal material distribution characterized by **Maximum stiffness** **Minimal mass**

ADDITIVE MANUFACTURING

Layer-by-layer manufacturing of complex parts through selective laser melting of metallic powders.

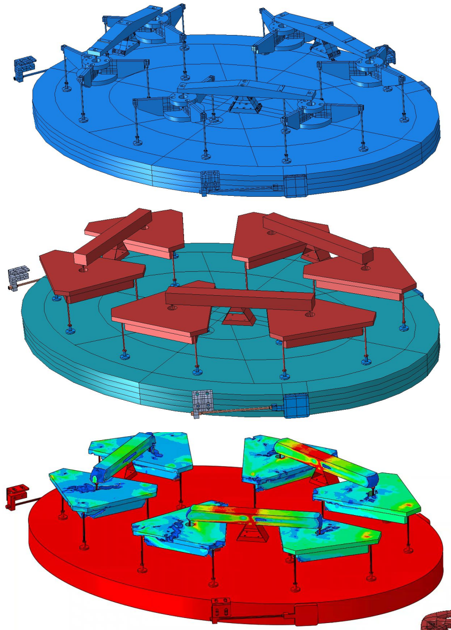




* CALIBRATION UNIT FOLDING MIRROR

\- MORFEO BENCH

CALIBRATION UNIT FOLDING MIRROR: Whiffletree Optimization

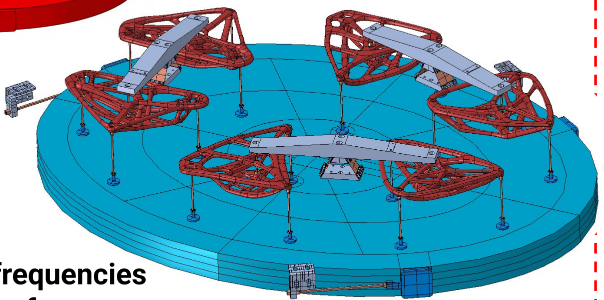


Whiffletrees are adopted to support the mirror without the introduction of stress that would induce distortion.

The optimization was aimed at **minimizing** the **number of parts** and **interfaces**, reducing the overall **mass and complexity** of the assembly **without impacting the optical performance of the instrument** (Zernike expansion of the deformed mirror surface)

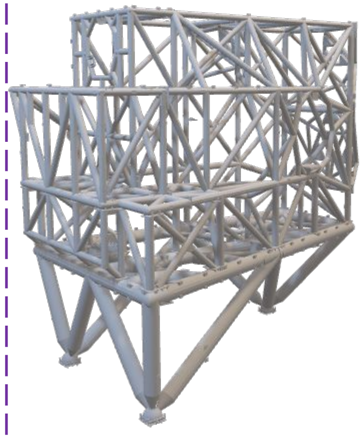
Material was added to the initial geometry for the TO algorithm to find optimal distributions.

The outcome of the optimization was interpreted and redesigned according to **additive manufacturing** guidelines.

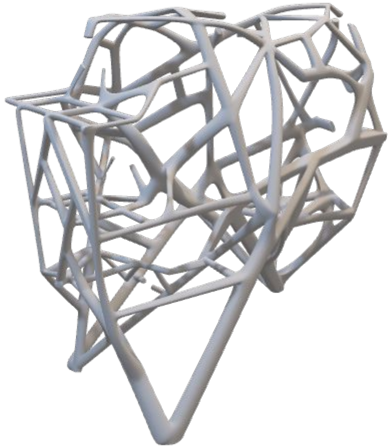


Results:
-50% Bolt interfaces
24 Less parts
34% Mass reduction
10% Higher natural frequencies
Comparable optical performances

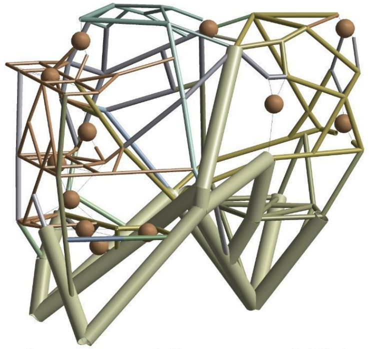
MORFEO BENCH: Main Structure Optimization [currently on-going]



Topology optimization of the MORFEO bench, constrained to preserve the optical path, yielded a simplified architecture that reduces the number of elements needed to support the optomechanics of the instrument.



Given the considerable size of the structure, traditional manufacturing remains the more suitable choice; the beam layout is therefore extracted directly from the interpreted topology.



Machine Learning is then used to optimize the choice of beam cross-section among the standard ANSI ones.

Result: a **simpler** and **lighter structure,** composed of **fewer elements,** thus characterized by **higher natural frequencies.**

KEY OUTCOMES

- Topology Optimization streamlines optomechanical systems by reducing mass and complexity.
- Additive Manufacturing enables the fabrication of the organic geometries produced by TO.
- Tailored TO algorithms for optomechanics can further improve optical performance minimizing structure-induced aberrations.