Topology Optimization and Additive Manufacturing for Astronomical Optomechanics

Application to MORFEO@ELT

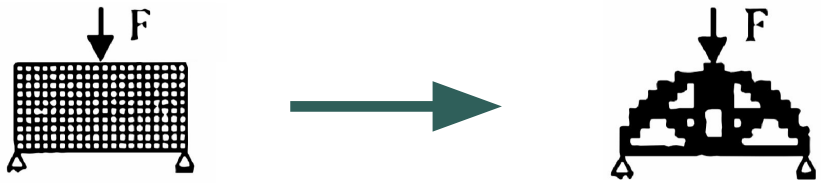
Giuseppe De Luca[1,2] – [1] INAF, Osservatorio Astronomico di Brera; [2] Politecnico di Milano

TOPOLOGY OPTIMIZATION (TO)

GEOMETRY
MATERIAL
OBJECTIVE FUNCTION
CONSTRAINTS

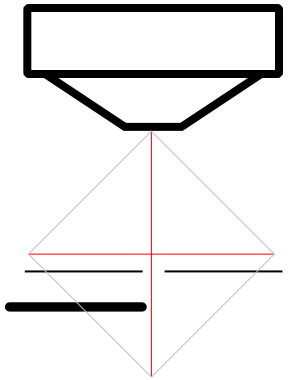
→ **TOPOLOGY OPTIMIZATION ALGORITHM** →

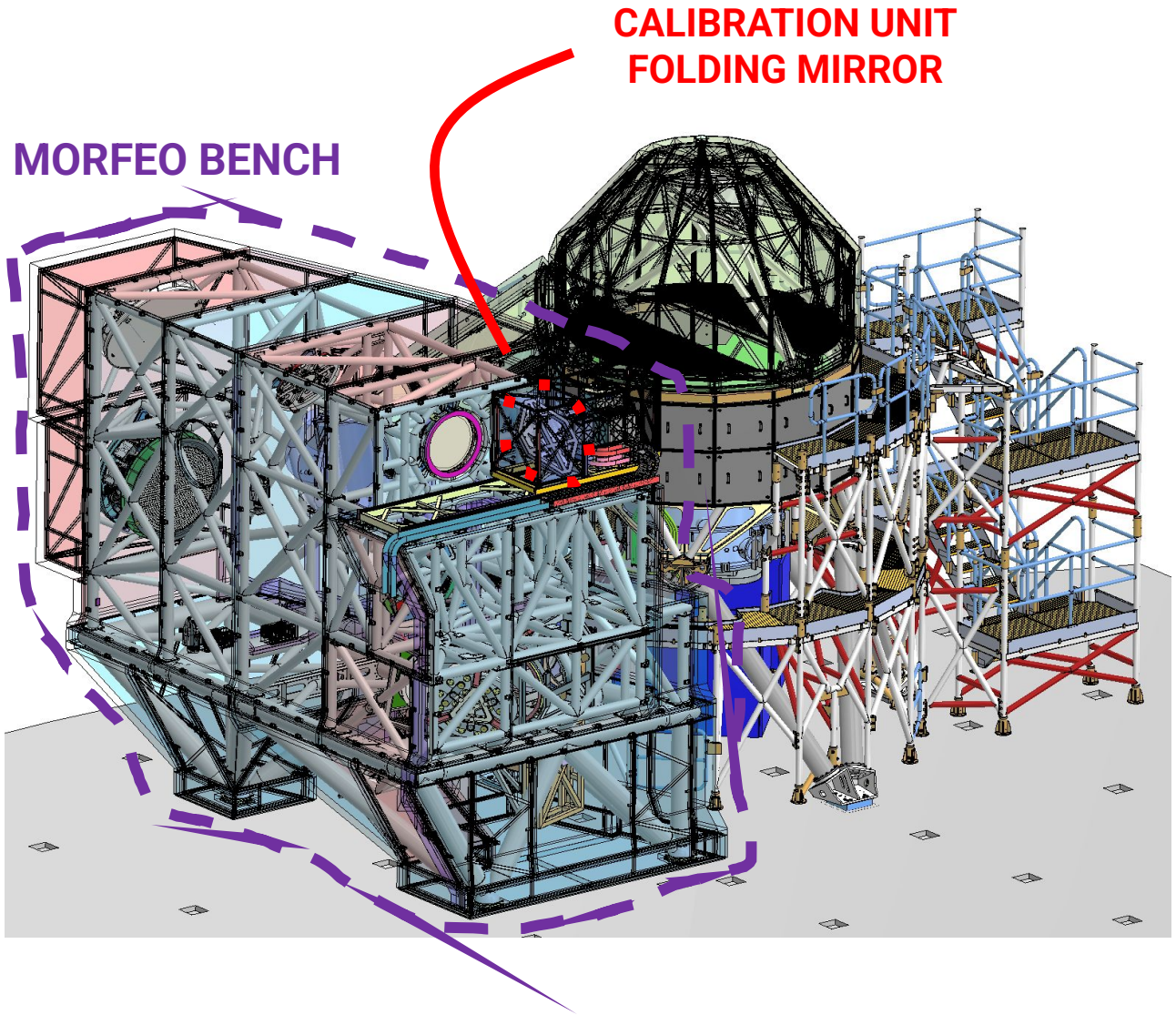
Optimal material distribution characterized by
Maximum stiffness
Minimal mass



ADDITIVE MANUFACTURING (AM)

- Layer-by-layer manufacturing
- Allows production of complex parts
- Seven (7) different *printing* technologies:
  - **Laser Powder Bed Fusion**
    - Melting of metallic powder





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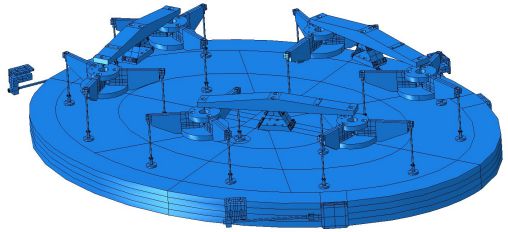
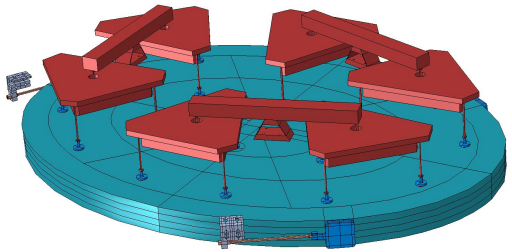
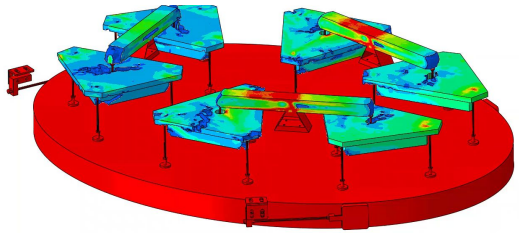
CUFM: Whiffletree Optimization



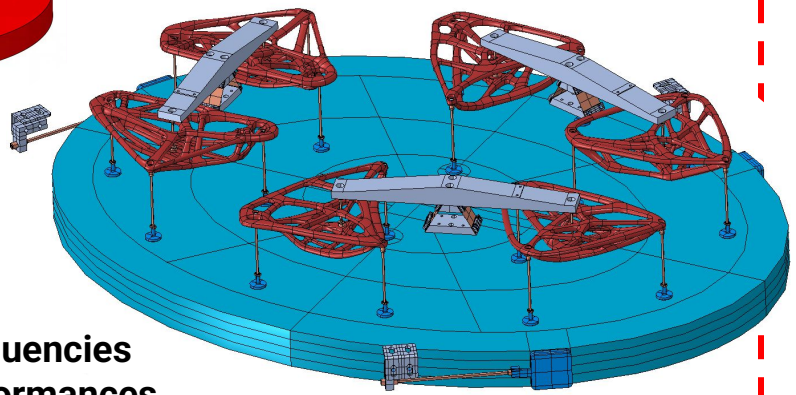




The optimization was aimed at

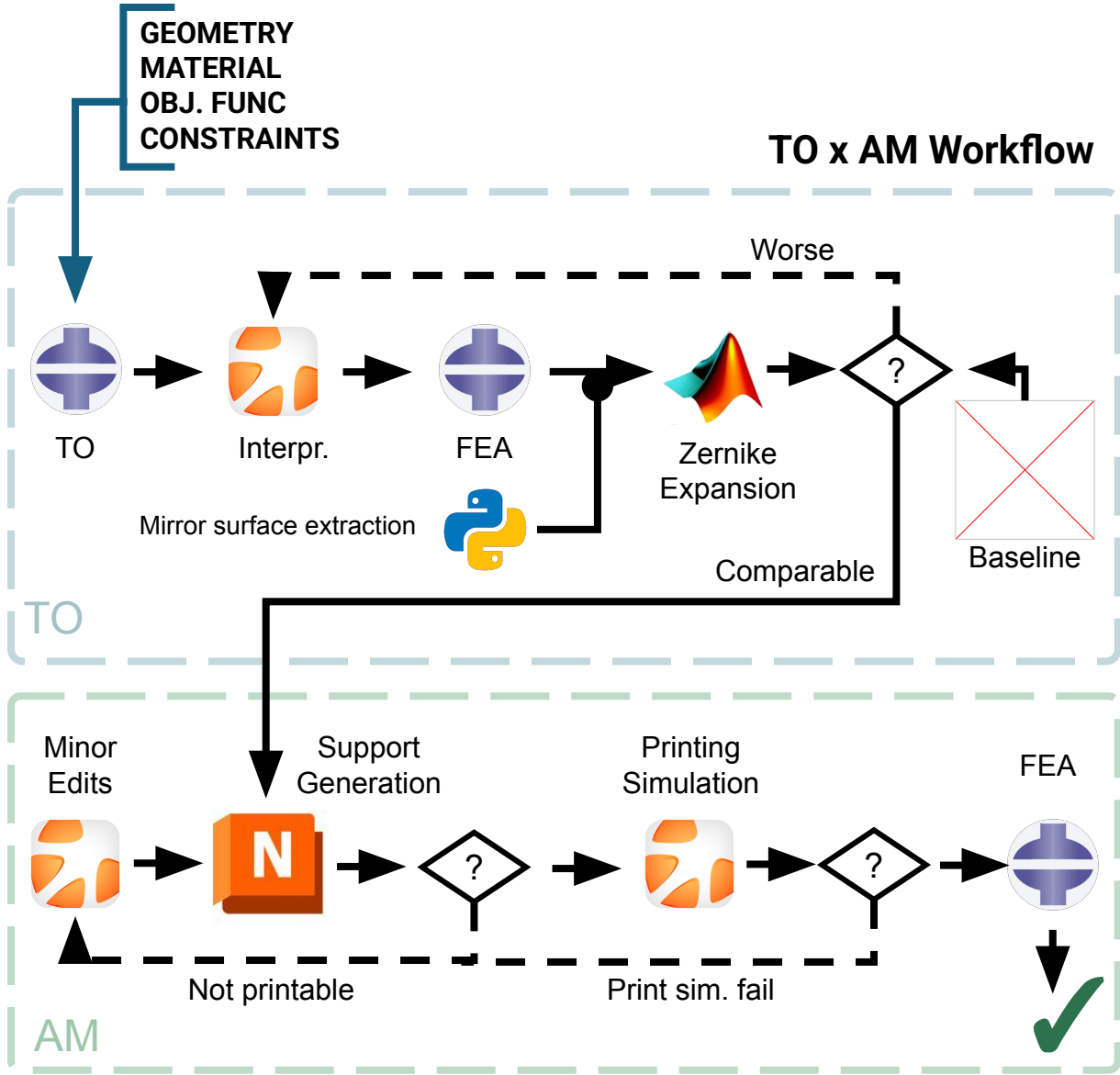
- **Minimizing** the **number of parts** and **interfaces**
- **Minimizing mass** of the assembly
- **Without impacting the optical performance of the instrument** □ Zernike expansion of the deformed mirror surface.

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



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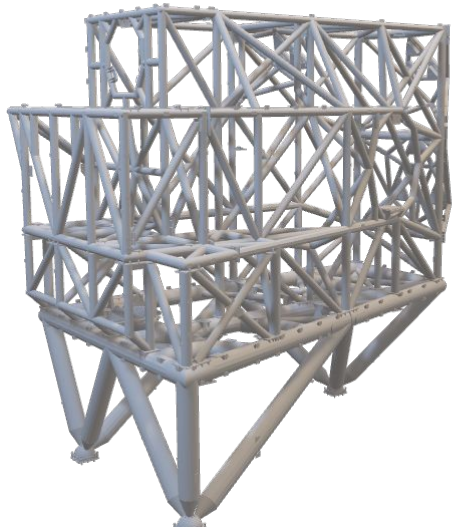
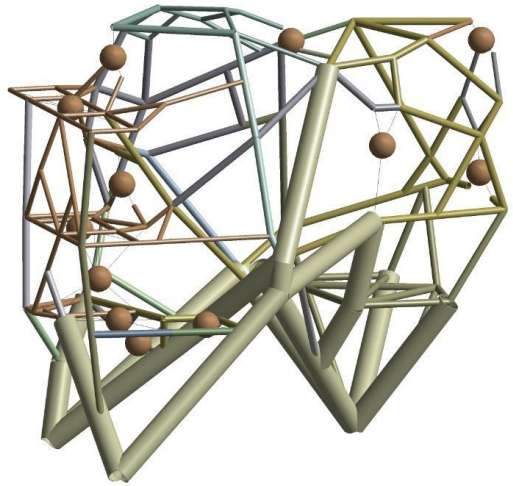
MORFEO BENCH: Main Structure Optimization

[currently on-going]





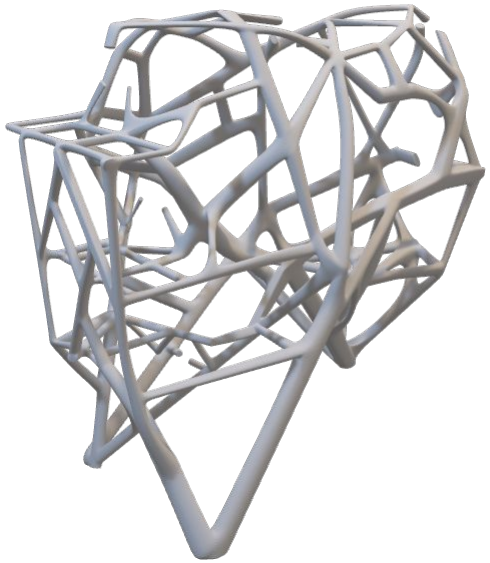
The MORFEO bench truss structure is currently composed of **~400 beams**.

TO was constrained to preserve the optical path and ground interfaces with Nasmyth

 Simplified architecture that reduces the number of elements needed to support the instrument's optomechanics.

Big structure traditional manufacturing is more suitable

- Truss layout is extracted from the interpreted topology
- **Machine Learning** optimizes the choice of beam cross-section , among the ANSI standard sections.



Preliminary **results:**

- Less than **120 beams**
- **Mass** reduced from 17 ton to **~12,5 ton (-26%)**
- **First Natural Frequency** of **12 Hz** > 7 Hz
- **Comparable overall maximum deformation**