WE LOOK AFTER THE EARTH BEAT

METIS DESIGN OVERVIEW AND TECHNICAL CHALLENGES

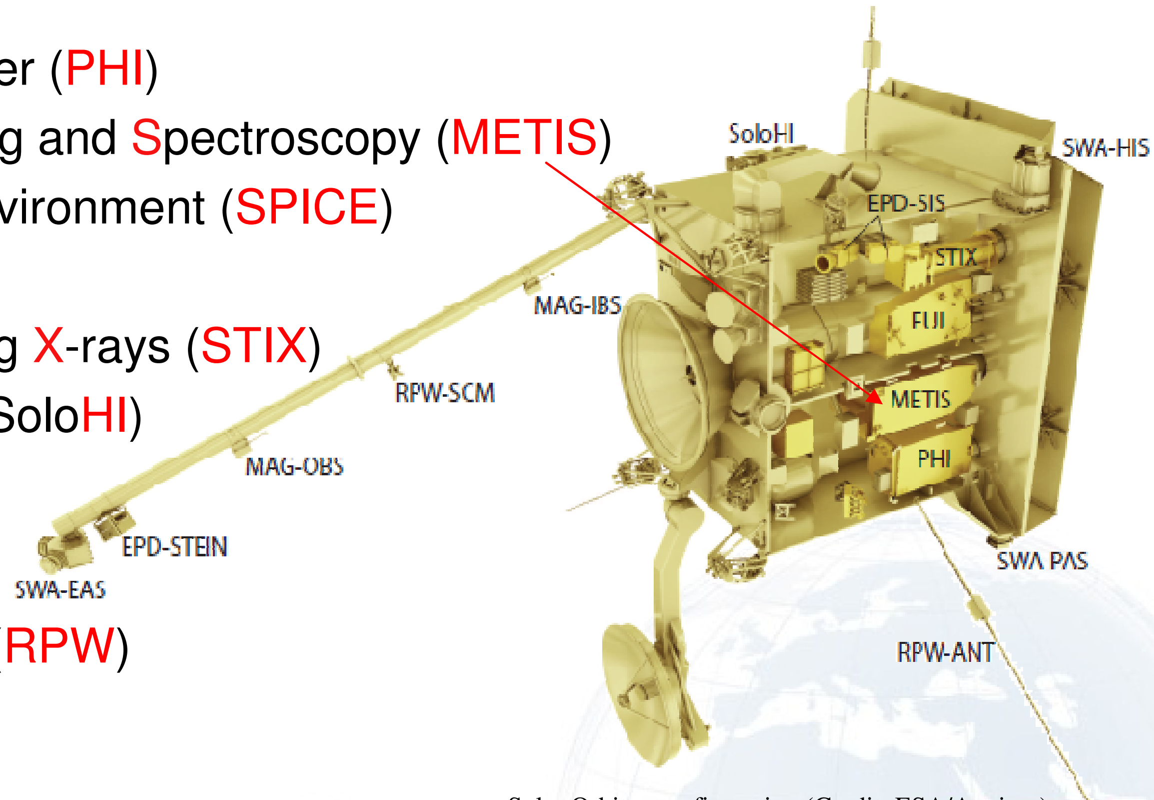
METIS: 2nd Science and Technical Meeting
Turin, 12-13 December 2012

83230349-DOC-TAS-IT-001

SELEX GALILEO · AMDL · ALTEC The Italian Gateway to ISS · AIEM s.r.l. · ThalesAlenia Space (A Thales / Finmeccanica Company)

METIS MISSION CONTEXT: SOLAR ORBITER

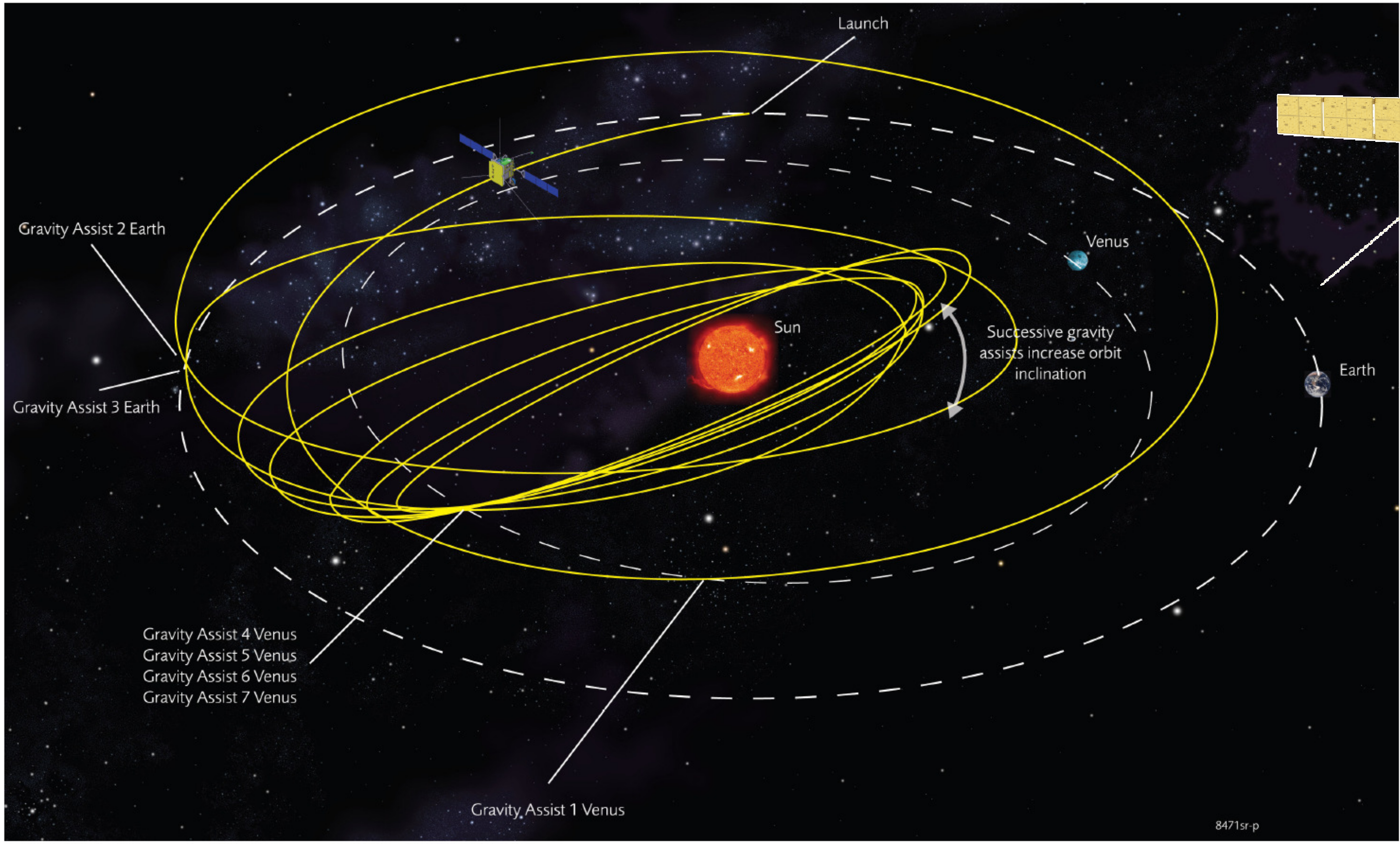
- First mission of ESA's Cosmic Vision 2015–2025 programme
- Objectives: exploration of the Sun and of the inner heliosphere combination of in-situ and remote-sensing instruments.
- Remote-sensing instruments:
  1. Polarimetric and Helioseismic Imager (PHI)
  2. Multi-Element Telescope for Imaging and Spectroscopy (METIS)
  3. SPectral Imaging of the Coronal Environment (SPICE)
  4. Extreme Ultraviolet Imager (EUI)
  5. Spectrometer/Telescope for Imaging X-rays (STIX)
  6. Solar Orbiter Heliospheric Imager (SoloHI)
- In-situ instruments:
  1. Solar Wind Analyser (SWA)
  2. Radio & Plasma Wave experiment (RPW)
  3. MAGnetometer (MAG)
  4. Energetic Particle Detector (EPD)



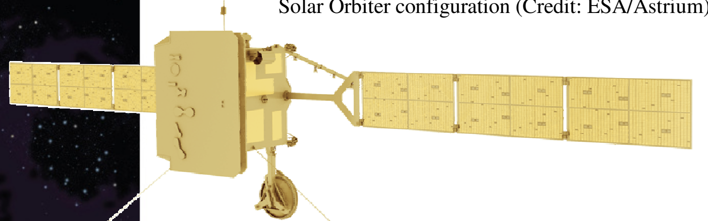
Solar Orbiter configuration (Credit: ESA/Astrium)

SOLAR ORBITER MISSION PROFILE

- Planned launch date: January 2017
- Mission duration: 7 years (nominal, including 3.4-year cruise) +3 years (extension)
- Closest perihelion: 0.28 AU, achieved after 4 gravity assist manoeuvres
- Maximum solar latitude: 34°, achieved after other 3 gravity assist manoeuvres



Solar Orbiter configuration (Credit: ESA/Astrium)



- 3-axis stabilized platform based on reaction wheels and chemical propulsion
- Solar arrays that can be rotated about their longitudinal axis to manage the cell temperature
- Articulated high-gain antenna in X-band
- Heat Shield keeping in shadow the spacecraft body

METIS DEVELOPMENT STATUS AND INDUSTRIAL TEAM

- Phase B industrial contract assigned by Italian Space Agency to a team led by Thales Alenia Space Italia on June 2011
- Preliminary Design Review accomplished on June 2012
- Phase B Final Review established on 20 December 2012

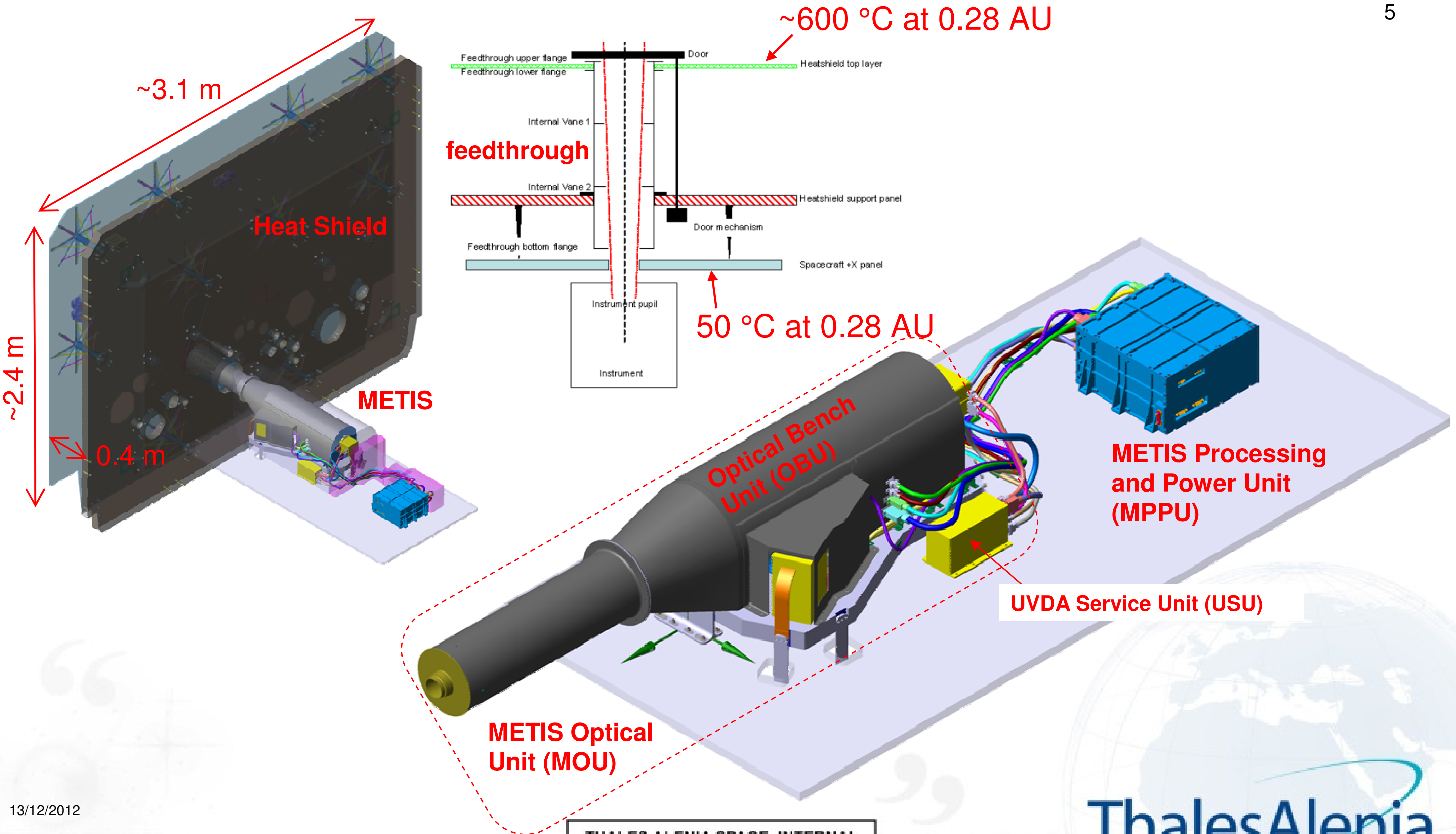
Thales Alenia Space Italia
Prime Contractor
Overall project management
Overall system engineering and PA
Mechanical, thermal, electrical, electronic subsystem for METIS
Software for METIS
FMECA, FDIR, operations, AIV/AIT plans and GSE for METIS
METIS breadboard
Development plan and cost assessment for the METIS Phase C/D.

SELEX Galileo
Subcontractor
Optical system
Mechanisms
Sun sensor
Mechanism breadboard

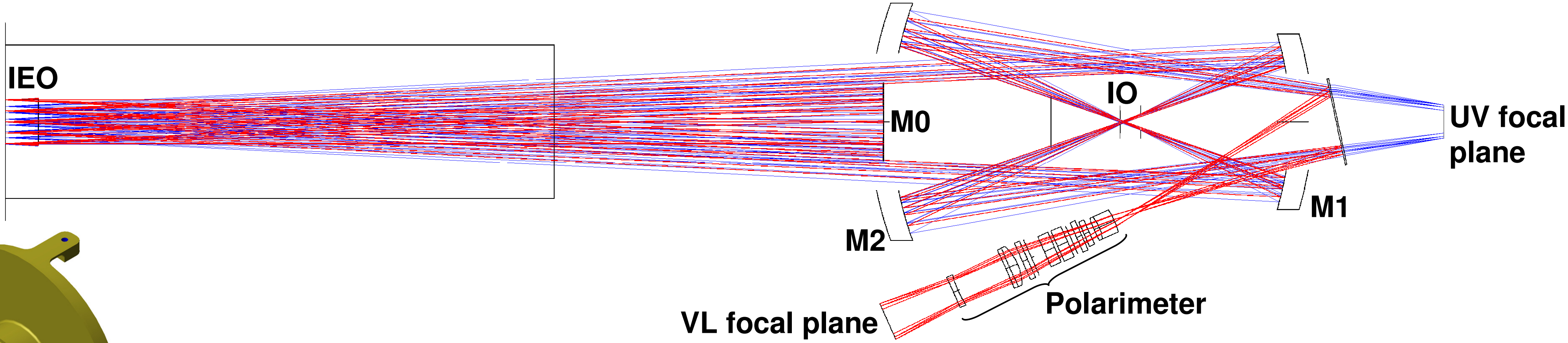
ALTEC
Subcontractor
Optical integration & test facility for METIS (OPSys)

AIEM
Subcontractor
Visible light illumination system for OPSys

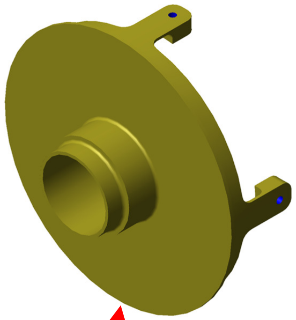
METIS DESIGN OVERVIEW

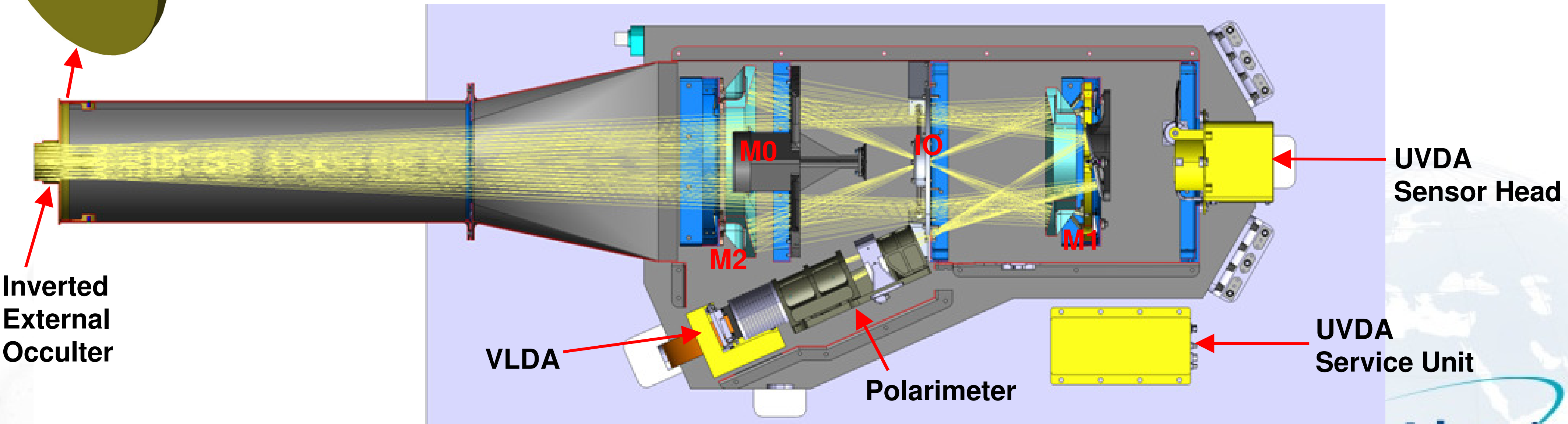


Optical design from the Scientific Team

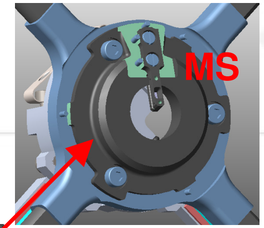


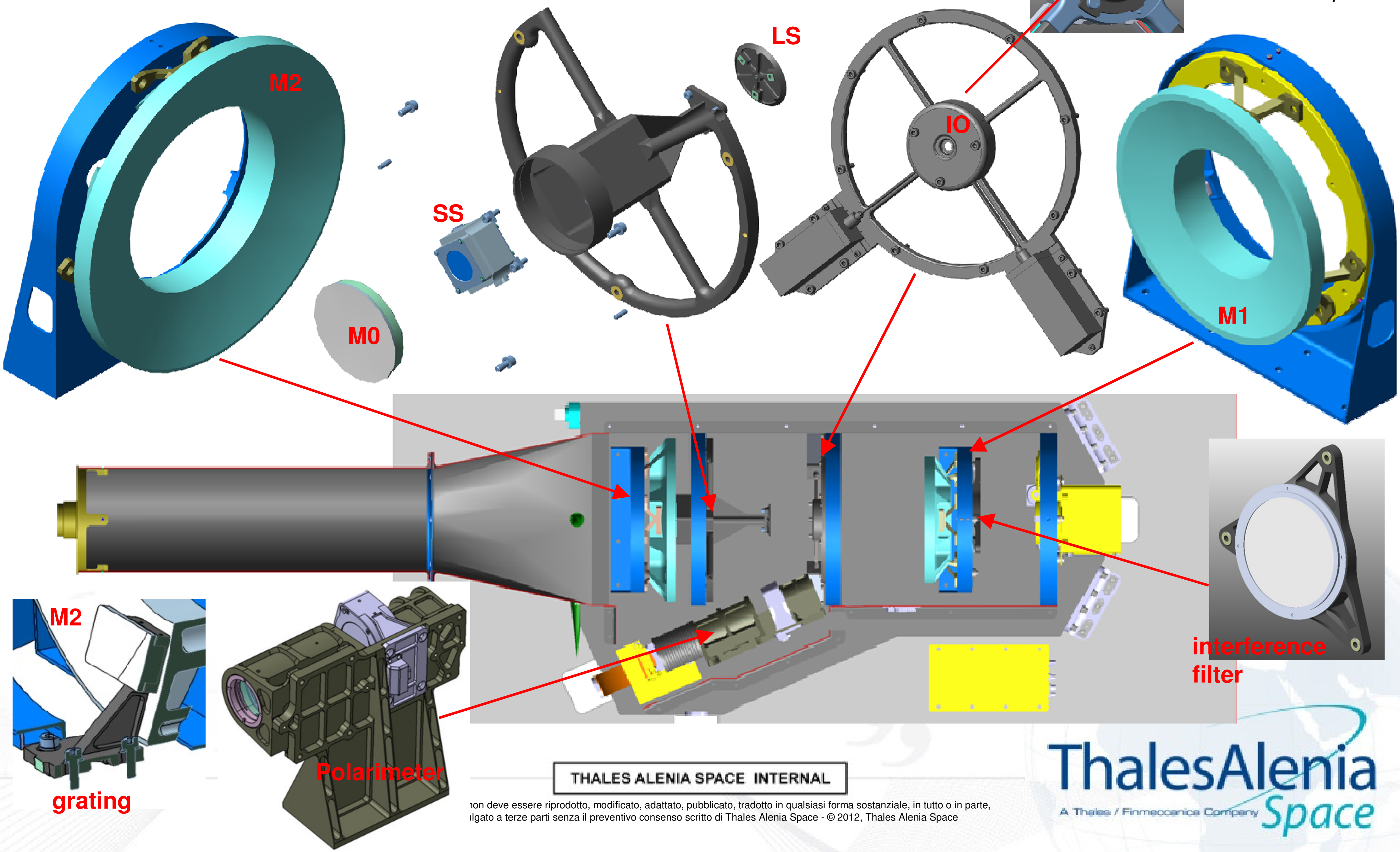
Engineering design from the Industrial Team





METIS DESIGN OVERVIEW

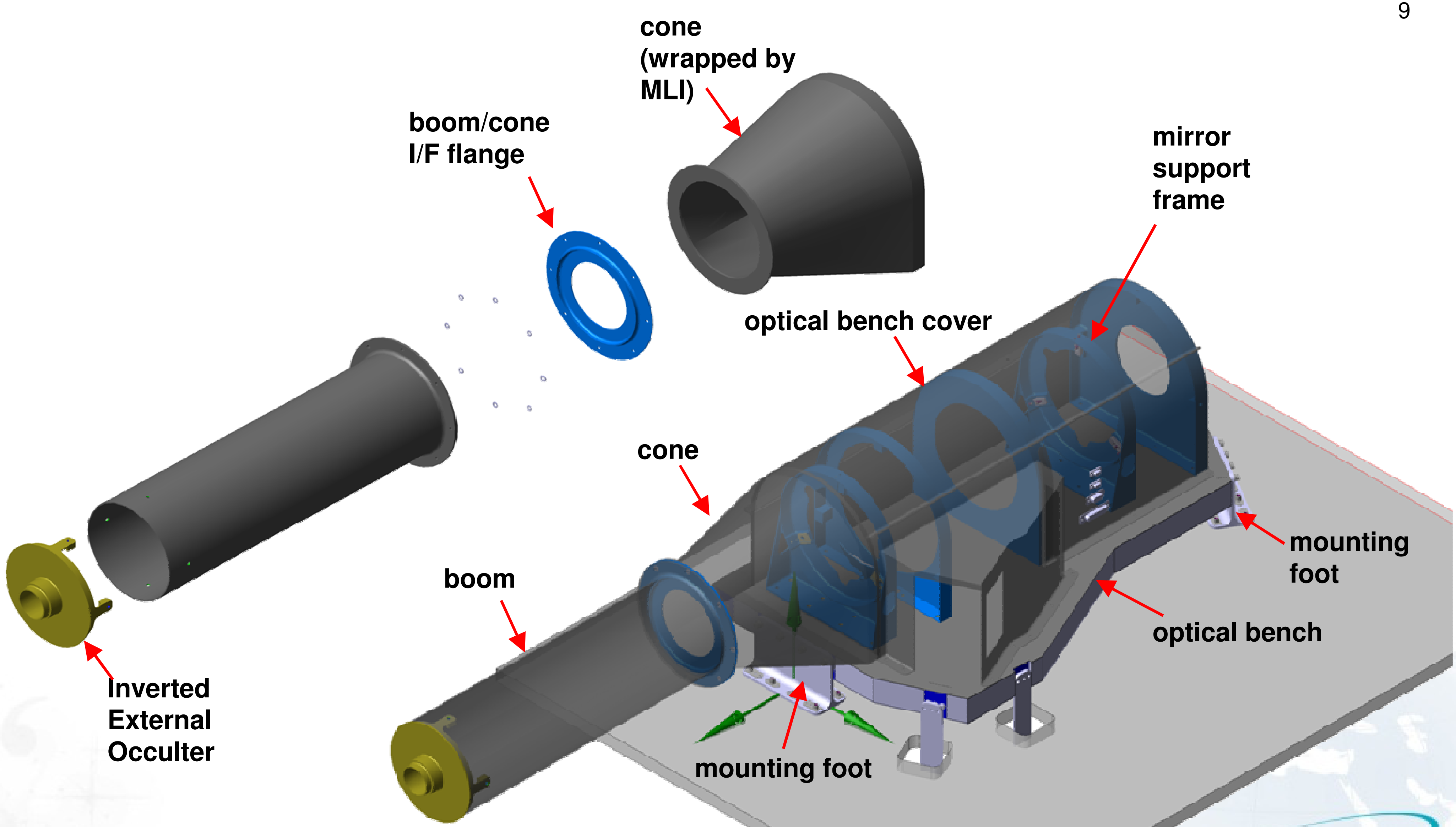




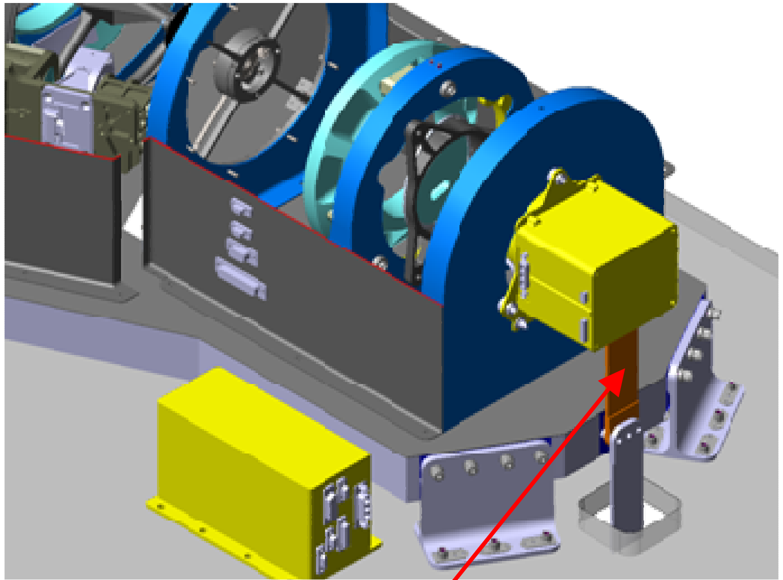
METIS TECHNICAL CHALLENGES

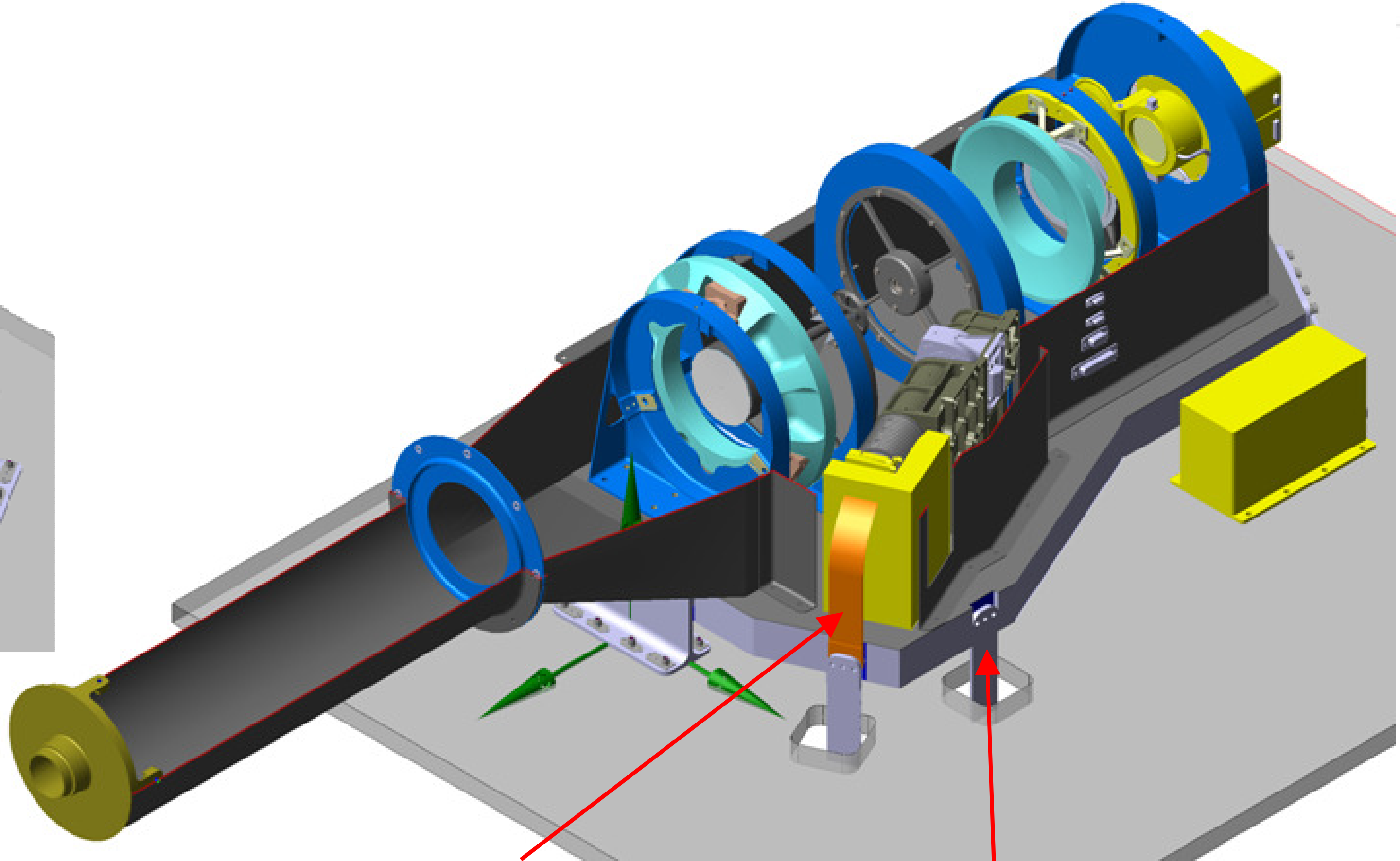
- Stray-light suppression at the visible detector below 10^{-9} of the Sun disk irradiance (below 10^{-7} at the UV detector). →
  - Very precise shaping of the occulting elements: edge curvature radius < 50 μm.
  - Extreme polishing of the mirror surfaces: roughness = 0.3 nm rms (0.2 nm goal).
  - Extreme cleanliness levels at instrument delivery: 3.3 ppm particle cleanliness, 100 ng/cm^2 molecular cleanliness on mirrors and stops surfaces; 3.3 ppm, 200 ng/cm^2 on Inverted External Occulter and telescope interior.
  - All instrument internal surfaces (except mirrors) with “black”, non-specular coating/finishing.
- Need to operate the detectors at low temperature (-80 °C for the visible sensor and -20 ℃, goal, for the UV sensor) in an extremely severe thermal environment: instrument aperture subject to a thermal flux of ~13 solar constants at 0.28 AU from the Sun.
- Dimensional stability ≤15 μm between mirrors M1, M2 from launch till end of mission lifetime.
- Limited resources (mass, power, allowable conductive and radiative heat rejection) allocated by Solar Orbiter to the METIS instrument.
- All fundamental resonance frequencies of METIS above 140 Hz.
- Capability to withstand a severe random vibration environment: 15.8 g rms ⊥, 12.8 g rms ⁄⁄
- Alignment of an optical system without a materialised optical axis (the mirrors M1 and M2 are circular corona) and with UV/EUV channels.

METIS THERMO-MECHANICAL DESIGN



METIS THERMO-MECHANICAL DESIGN





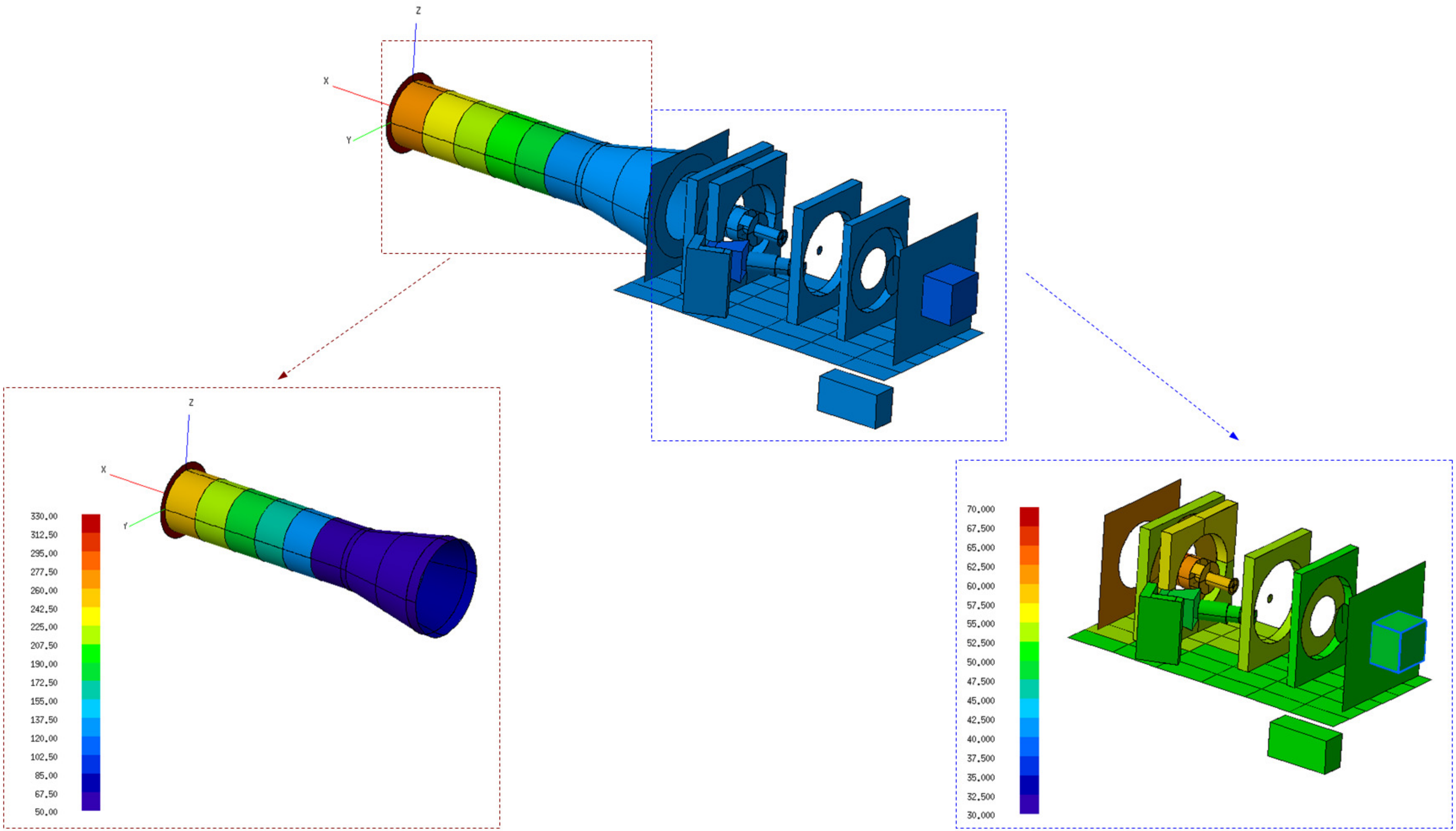
Thermal strap for heat transfer from UV sensor to the S/C radiator for “medium elements” (I/F temperature at 0.28 AU: -10 °C; -30 °C required for cooling the sensor at -20 °C)

Thermal strap for heat transfer from VL sensor TEC to the S/C radiator for “cold elements” (I/F temperature at 0.28 AU: -60 °C)

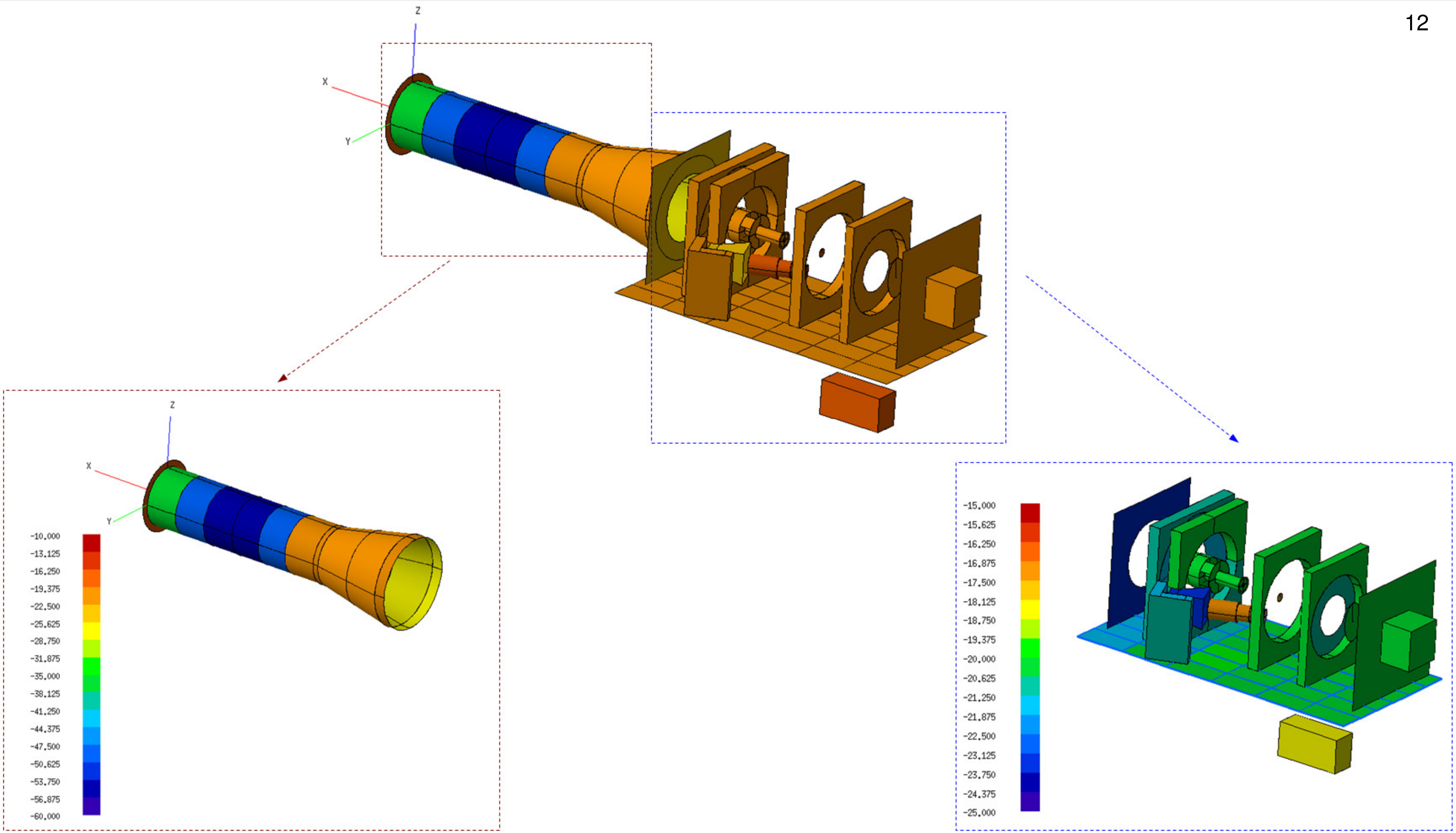
Thermal strap for heat transfer from the optical bench to the S/C radiator for “hot elements” (I/F temperature at 0.28 AU: 50 °C)

Power consumed by the Thermo-Electric Cooler (TEC) for keeping the VL sensor at -80 °C at 0.28 AU: ~7 W

TEMPERATURE MAP: HOT OPERATIONAL CASE AT 0.28 AU

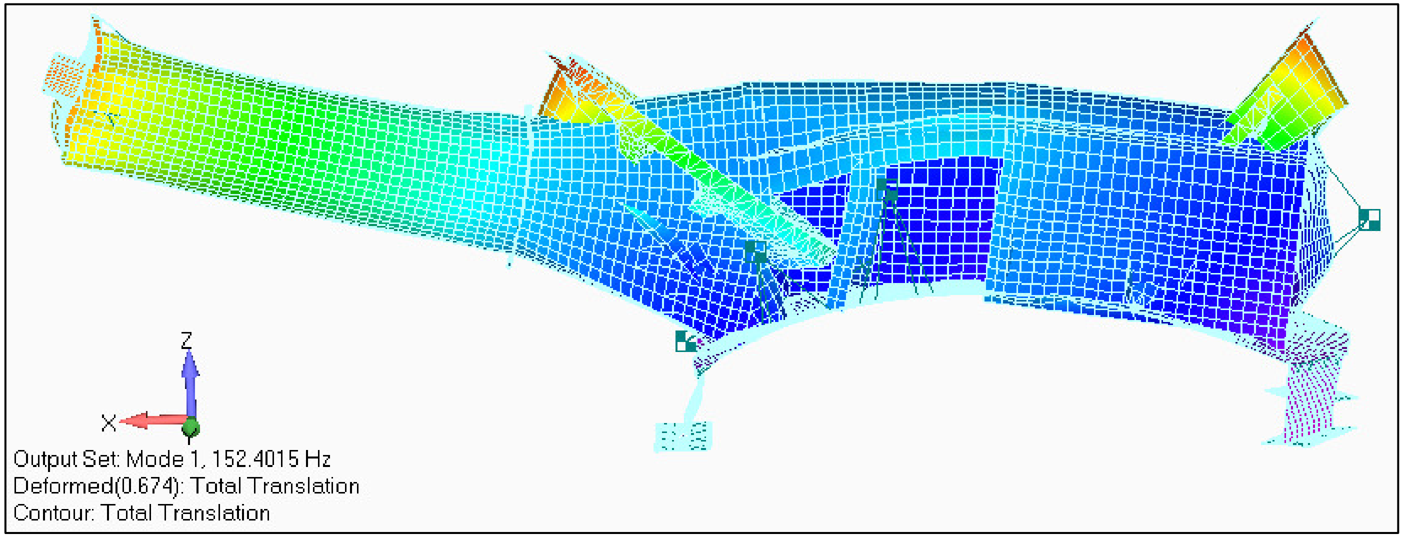


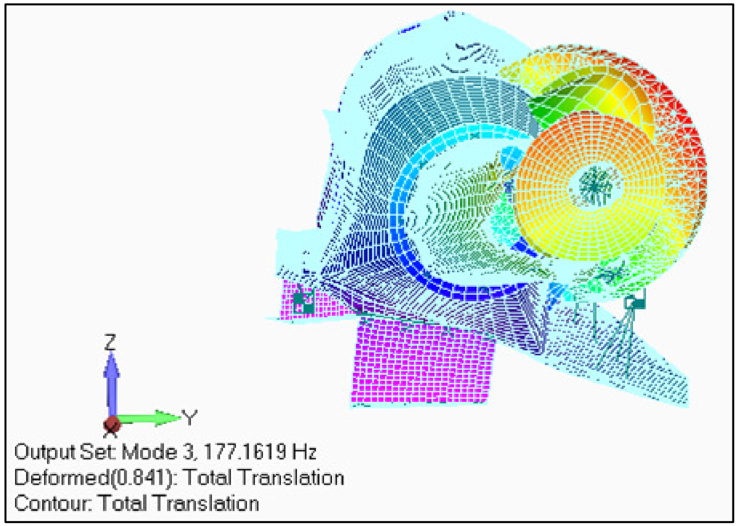
TEMPERATURE MAP: COLD OPERATIONAL CASE AT 0.952 AU

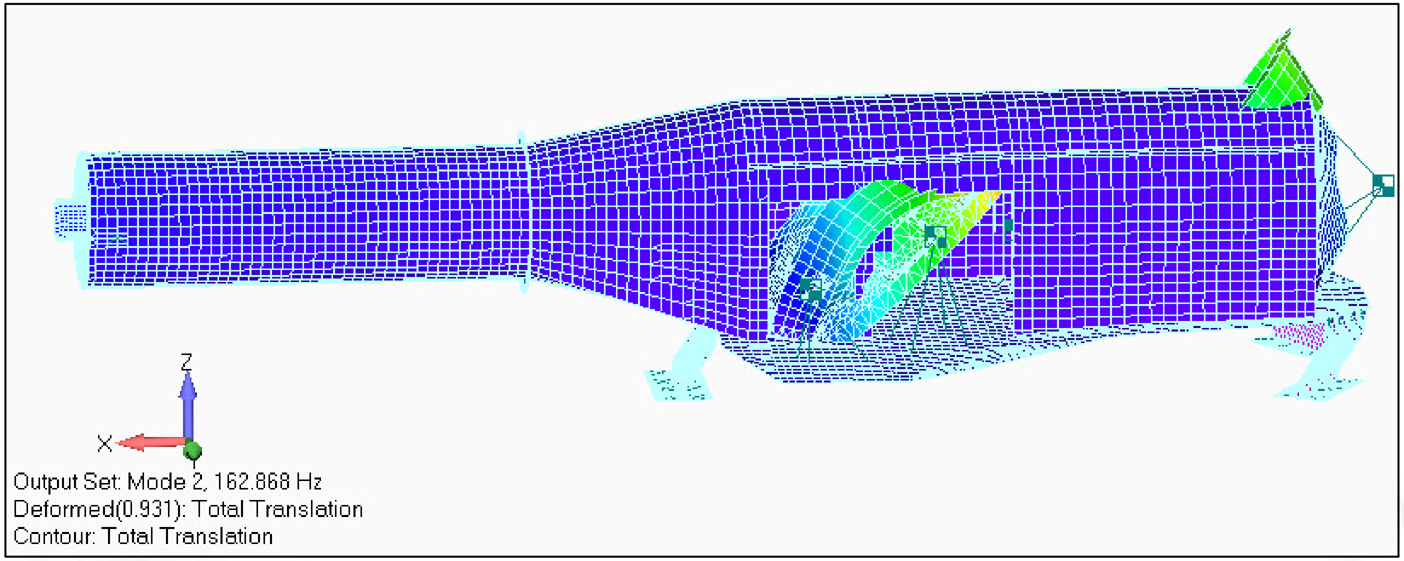


METIS MECHANICAL BEHAVIOUR

First three global vibration modes of METIS

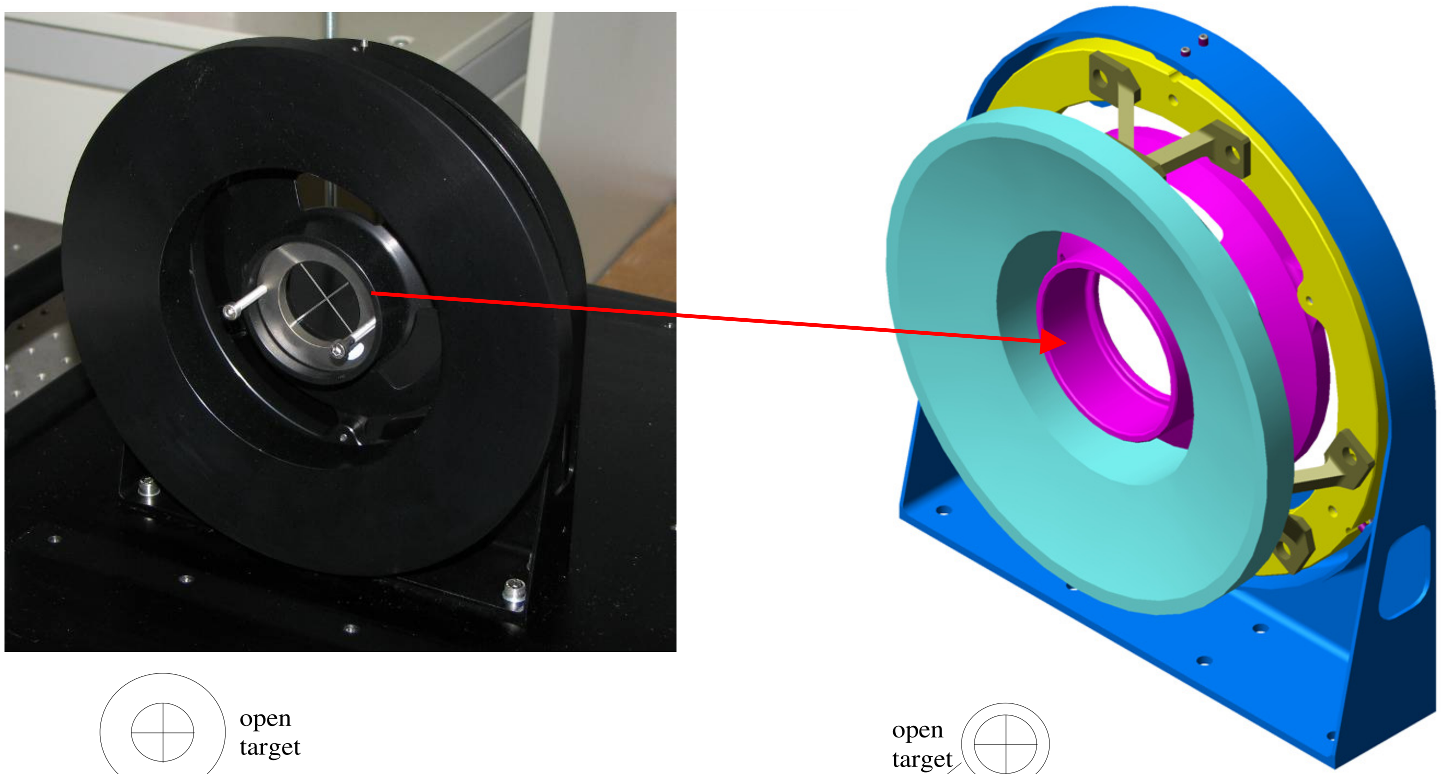


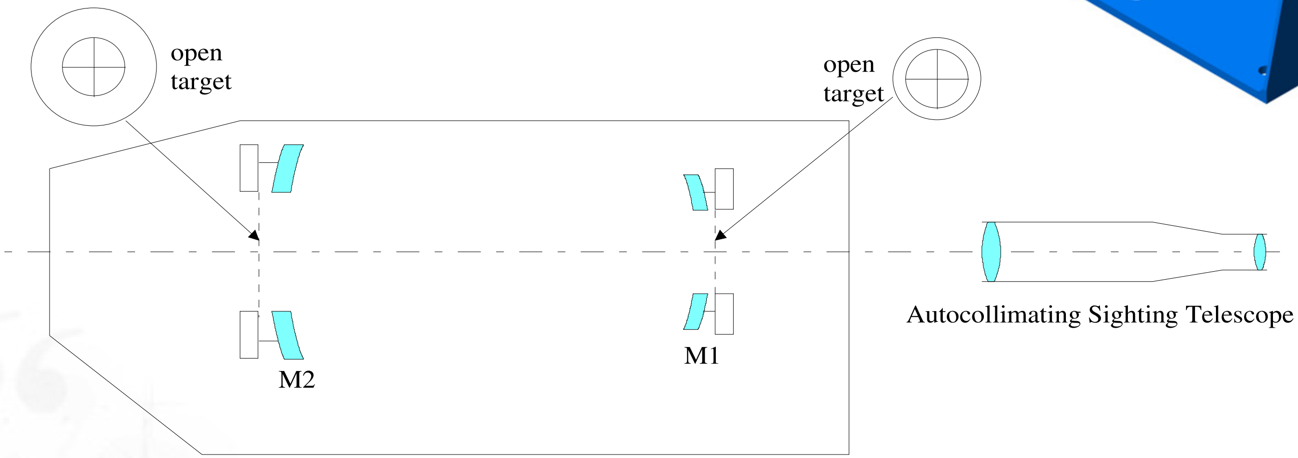


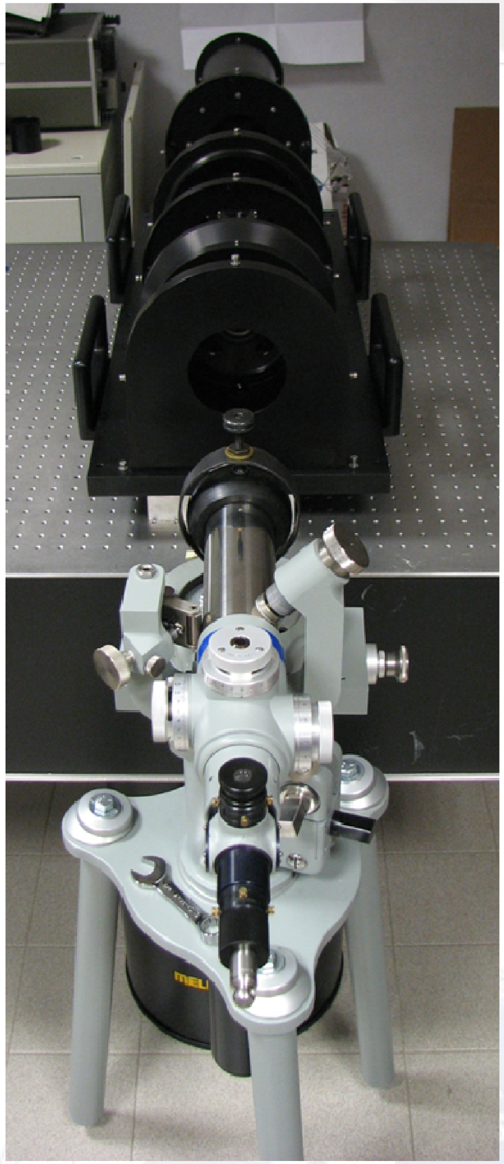


		TRASLATIONAL		
Mode N	FREQ Hz	X	Y	Z
1	152	4.64%	1.40%	**41.27%**
2	163	**59.20%**	0.72%	0.71%
3	177	0.64%	**33.06%**	0.00%
4	194	0.65%	0.52%	3.17%
5	210	9.44%	0.83%	4.36%
6	216	3.31%	0.25%	0.72%
7	227	0.00%	0.11%	5.82%
8	244	3.57%	4.34%	6.36%
9	250	5.85%	5.99%	**18.29%**

OPTICAL ALIGNMENT APPROACH



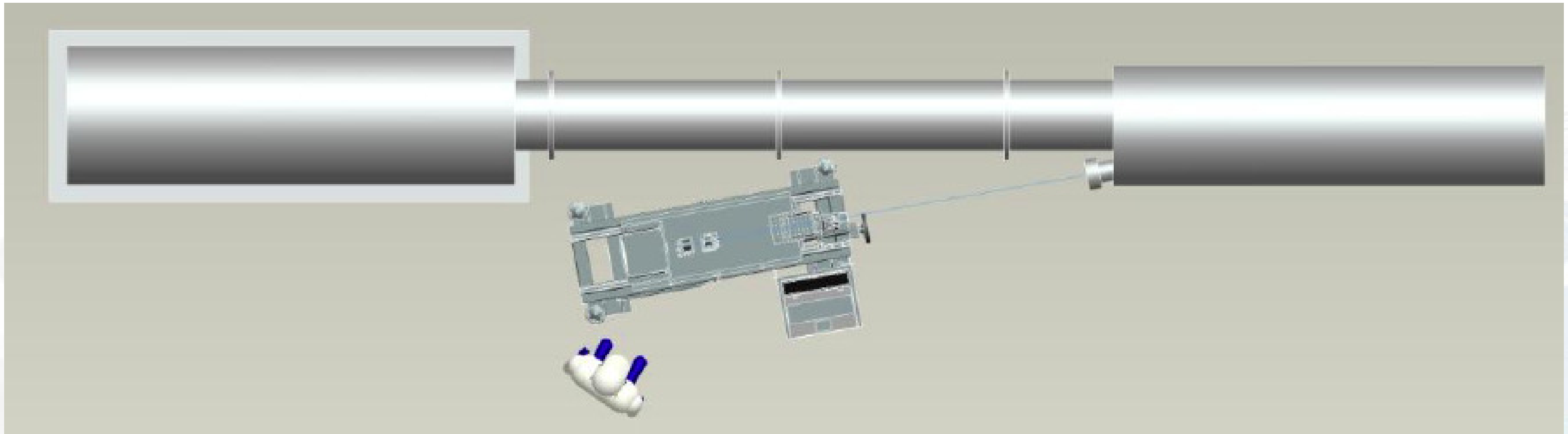


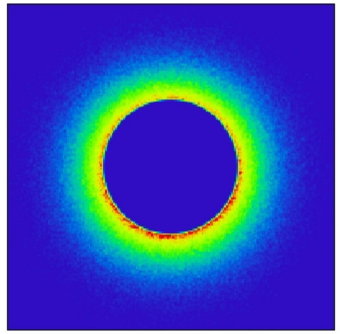


Materialization of the optical axis by means of open targets temporarily installed on the mirrors.

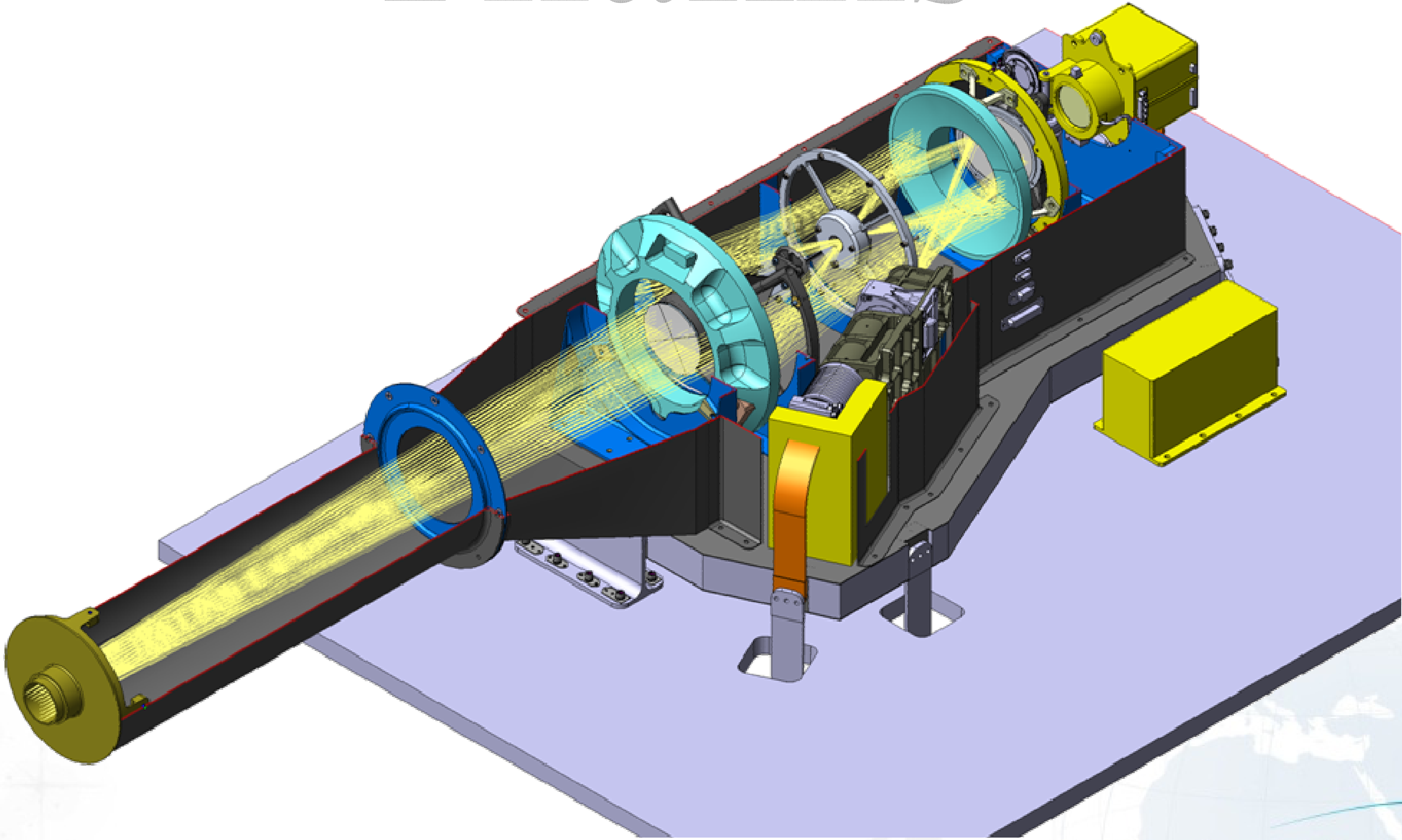
THE ROLE OF THE OPSYS FACILITY

- Clean area (class 100) for the optical integration of METIS in controlled environment.
- Vacuum chamber for operating METIS in orbital-like environment and for hardware bake-out at controlled temperature for removing residual molecular contaminants.
- UV/EUV and VL illumination systems for the end-to-end verification of the optical alignment in all channels, for the METIS performance test (including stray-light rejection capability) and final calibration before its delivery.





Thanks



13/12/2012

THALES ALENIA SPACE INTERNAL

ThalesAlenia Space
A Thales / Finmeccanica Company