Laboratory activity @ IAPS: research project DORA (Deployable Optics for Remote Sensing Applications)

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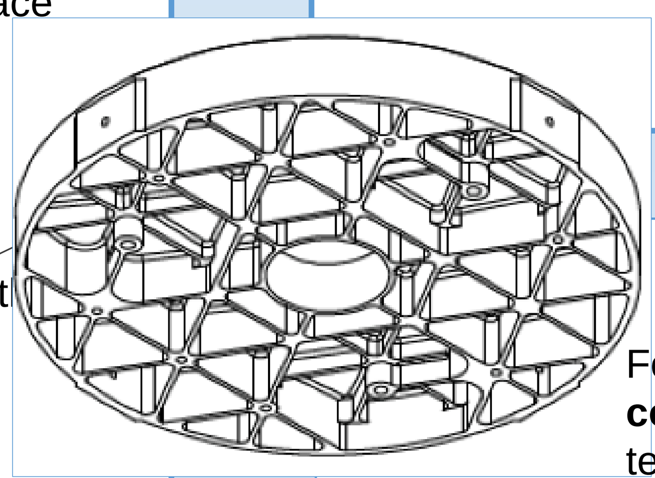
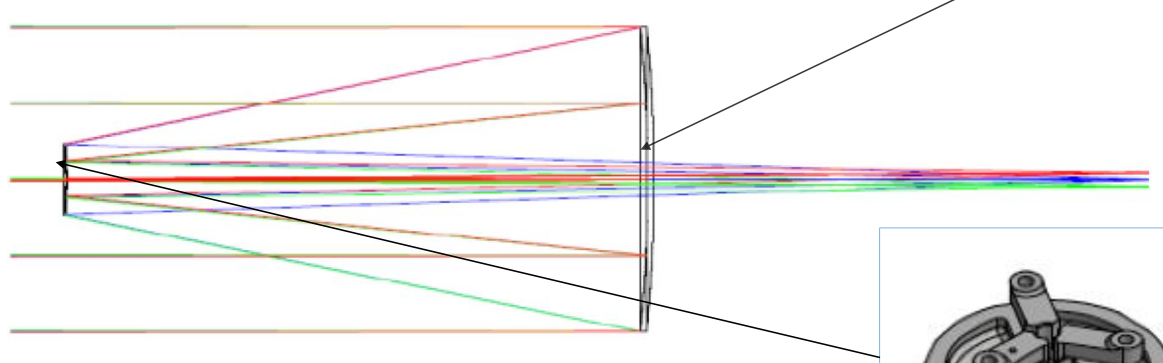
Baseline

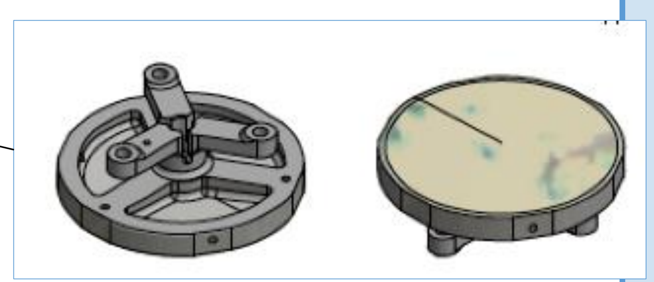
We present hereafter the laboratoy setup in the framework of DORA (Deployable Optics for Remote sensing Applications) project.
It's a partnership involving companies (SITAEL S.p.A., Media Lario S.r.l., Kad3 S.r.l, STEAM S.r.l.), Parthenope University in Naples, INAF (IAPS-Rome and Astronomical Observatory of Padua) and Politecnico of Milan.
Its main aim is the development of a deployable mechanism for remote sensing observations in the wavelenght range between 2 and 25 μm, coupled to a Fourier Transform IR spectrometer like MIMA (Mars Infrared MApper) with twofold scientific targets:
-monitoring Earth environment through the detection of atmospheric pollutants, their emission and diffusion
-investigating relevant aspects of Solar System objects such as the measurement of Near-Earth Asteroids' composition, dimension and structure
Planned for a mission to reach a **LEO** at **500-550 km** altitude
P/L suitable to be embarked aboard the SITAEL S-75 Platform (**PLATiNO**)
Possible upgrade to 100kg launch mass
P/L mass of 20kg
Available **power of 20 W**
P/L envelope: 320x320x400 mm

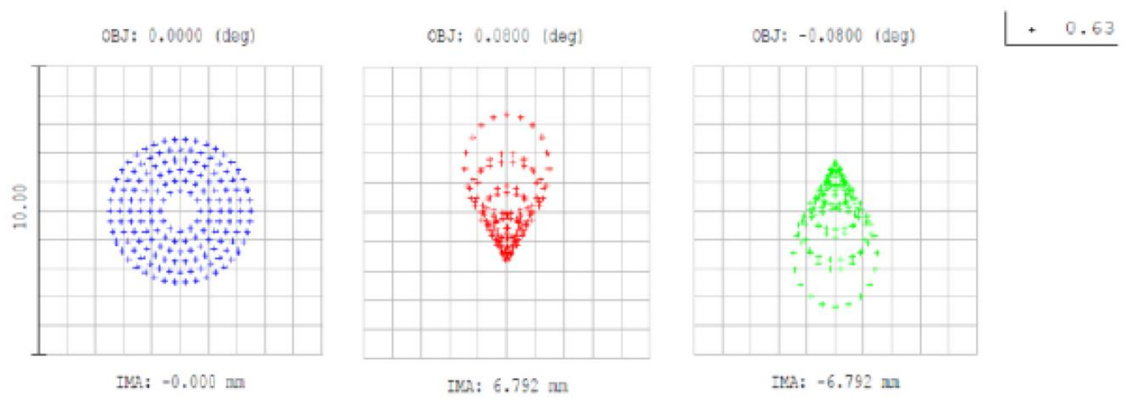
Optical design

The telescope is based on a Cassegrain design including a parabolic primary mirror with an entering **f#16.21** and a relative distance between primary and secondary mirror vertices equivalent to **600 mm.**
Media Lario is in charge of mirrors manufacturing:
Metal mirrors made out of standard **Al 6061-T6.** Lightweighted M1 allowed a mass reduction of **70%**.
They underwent diamond turning manufacturing process and optical coating via **NiP** deposition.
Shape irregularity error on metal mirrors: **±0.2 λ**, referred to **λ=0.63 μm**, rms error=10 μm.
Expected planarity error of the STANDA optical bench:**≤100 μm** over a surface of **1m²**.
All these values have been implemented in a Zemax tolerance analysis, by applying a decentering on M2 along two directions orthogonal to the beam propagation direction and shift along optical:
Δx, Δy, Δz=±0.1mm and tilt angles **$\Delta\theta_{x,y}$= ±0.1**.
It has been therefore verified that such values are inducing an increasing of the spot radius from nominal value of 1.4 μm up to 86.31 μm, which is still compatible with MIMA detector size of 1 mm².





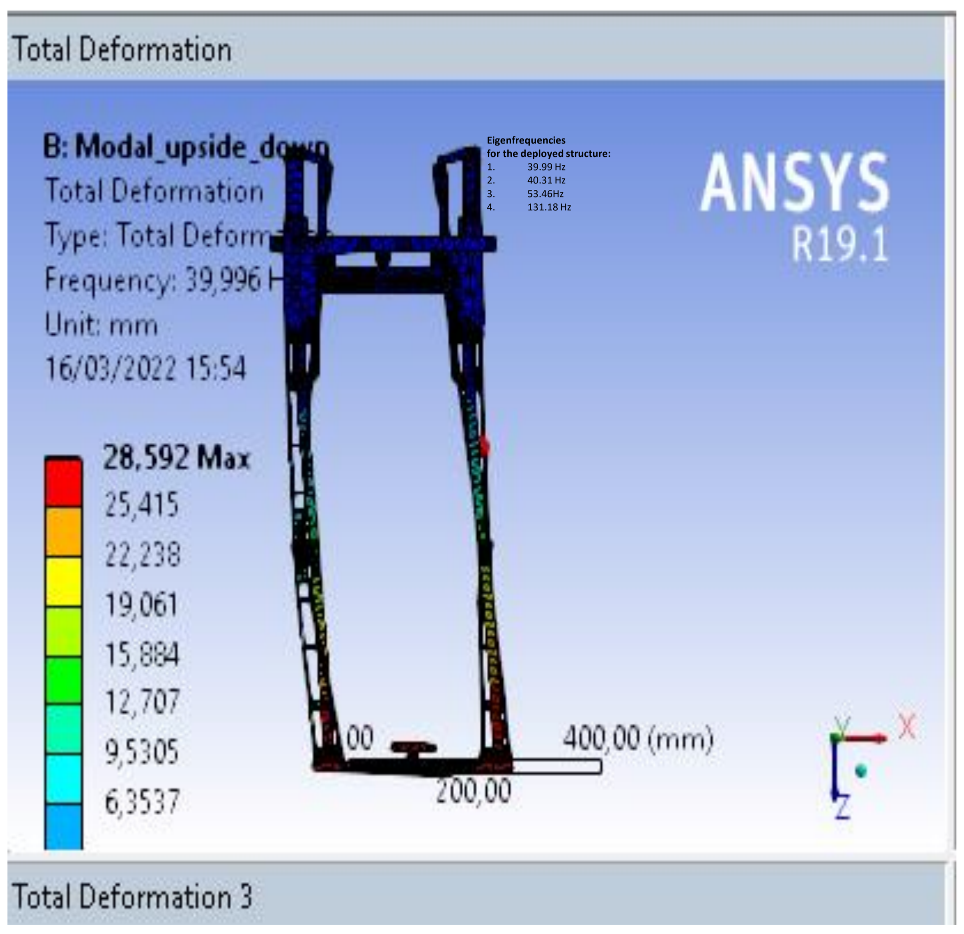




Telescope optical parameters	
f/#	16.21
Optical efficiency (considering optical reflectivity)	0.6
Maximum entrance pupil	300 mm
Exit pupil diameter	79.1427 mm
Effective focal length	4863.287 mm
Back focal length	1124.61 mm
Maximum radial field	0.08°
Spatial resolution	<6 km @ 700 km
FOV	0.5°
Dimensions	320 x320x400 mm
Mass	15 kg

Laboratory setup structure

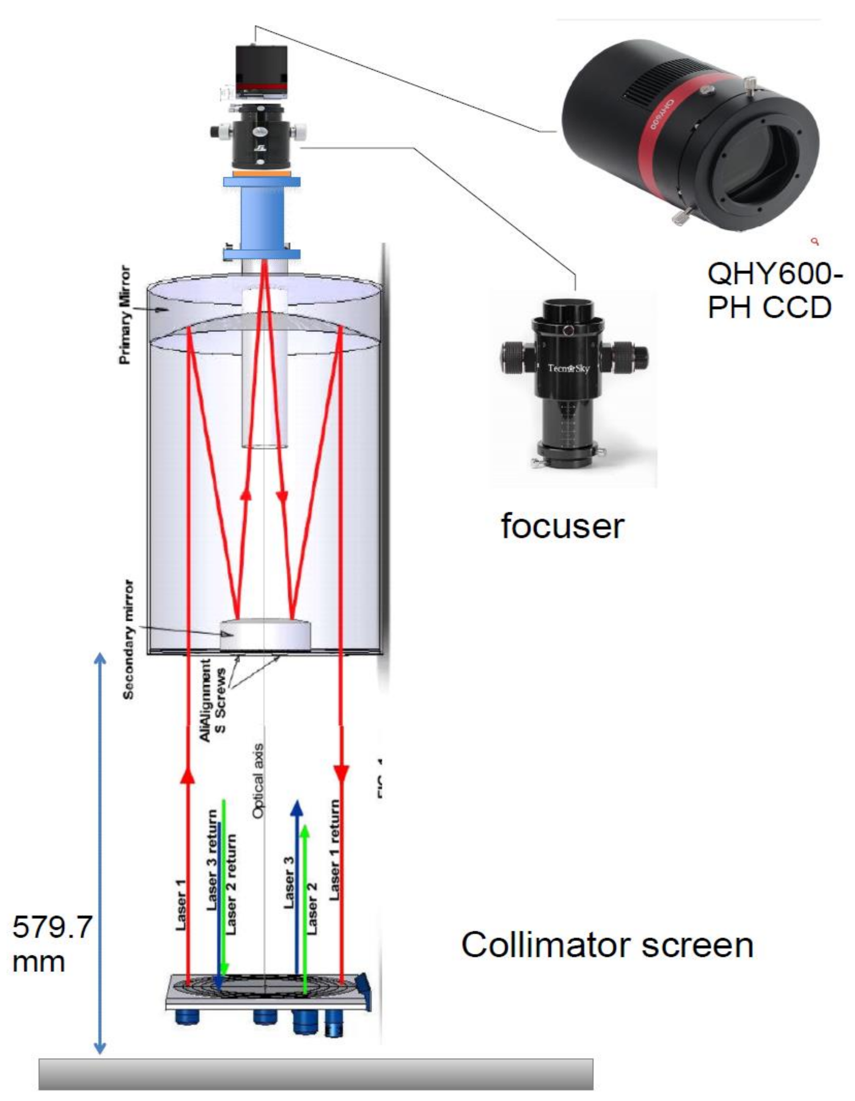
We have chosen a vertical inverted configuration to test the repeatability and accuracy of the optomechanical alignment, since it's more comfortable to access the laser collimating device when mounted on the optical bench.
We have then designed a stiff and at the same time light supporting truss structure to hold the telescope from above via four Ø9 mm interfacing holes on M1 cell. Such structure was provided by Maytec, coinsisting of twelve 50x50 and sixteen 30x50 profilate bars made of Aluminum.



A finite element model analysis has been carried out for the finalized version of the telescope structure in the upside-down layout to check if such configuration respects the requirements of having deformations below the planarity error tolerances, and lowest eigenfrequencies above **40 Hz** in the deployed configuration. In the **stowed** configuration the first eigenfrequency raises up to **175 Hz**.

Laser collimating device

For DORA prototype alignment the **Advanced Laser collimator for Cassegrain telescopes by Hotech** is used. The telescope is equipped with a focuser manufactured by **Tecnosky Titanium** and a full frame (36 mm×24 mm) **QHY600-PH** monochrome CCD, **9576 x 6388 pixels** resolution and pixel size of **3.76 μm**. The collimator laser screen is installed on a XY linear stage placed on the optical bench and in the center of the frame structure. A focuser with a 2" thread is mounted on top of M1 cell through a dedicated flange. At the focuser exit a retroreflector mirror necessary for the alignment procedure is screwed via the 2" thread.



At first, the three laser beams are sent through the telescope optics and their footprints back reflected on the screen are analyzed. We act on the secondary mirrors adjustment screws until we find out that the spots are lying on the outer and inner rings in a symmetric pattern: in this way M1 and M2 are both aligned. Then we remove the retroreflector, replacing it with the QHY-600 CCD and measure the spot size of the aligned telescope in its deployed configuration.
The optics and the telescope structure are under procurement and expected to be delivered by the end of June.

Acknowledgment

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