MAORY for ELT: preliminary mechanical design of the support structure

De Caprio, Vincenzo, Riva, Marco, Lombini, Matteo, Redaelli, Edoardo, Cascone, Enrico, et al.

Vincenzo De Caprio, Marco Riva, Matteo Lombini, Edoardo Redaelli, Enrico Cascone, Mauro Patti, Fausto Cortecchia, Luca Terenzi, Adriano De Rosa, Enrico Giro, Carmelo Arcidiacono, Marco Bonaglia, Eric Stadler, Philippe Feautrier, Paolo Ciliegi, Michele Bellazzini, Simone Esposito, Roberto Ragazzoni, Emiliano Diolaiti, "MAORY for ELT: preliminary mechanical design of the support structure," Proc. SPIE 10703, Adaptive Optics Systems VI, 107034H (12 July 2018); doi: 10.1117/12.2314189

SPIE.

Event: SPIE Astronomical Telescopes + Instrumentation, 2018, Austin, Texas, United States

MAORY for ELT: preliminary mechanical design of the support structure

Vincenzo De Caprio*[a], [b]Marco Riva, [c]Matteo Lombini, [b]Edoardo Redaelli, [a]Enrico Cascone, [c]Mauro Patti, [c]Fausto Cortecchia, [c]Luca Terenzi, [c]Adriano De Rosa, [b,d]Enrico Giro, [c]Carmelo Arcidiacono, [e]Marco Bonaglia, [f]Eric Stadler, [f]Philippe Feautrier, [c]Paolo Ciliegi, [c]Michele Bellazzini [e]Simone Esposito, [d]Roberto Ragazzoni and [c]Emiliano Diolaiti.

[a]INAF - Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, 80131 Napoli, Italy;
[b]INAF - Osservatorio Astronomico di Brera, Via E. Bianchi 46, 23807 Merate, Italy;
[c]INAF - Osservatorio di Astrofisica e Scienza dello Spazio di Bologna, Via P. Gobetti 93/3, 40129 Bologna, Italy;
[d]INAF - Osservatorio Astronomico di Padova, Vicolo Osservatorio 5, 35122 Padova, Italy;
[e]INAF - Osservatorio Astrofisico di Arcetri, Largo Enrico Fermi 5, 50125 Firenze, Italy;
[f]INSU - IPAG, 414 rue de la piscine, BP 53, 38041 Grenoble Cedex 9, France.

ABSTRACT

MAORY (Multi Conjugate Adaptive Optics RelaY) is one of the four instruments for the ELT (Extremely Large Telescope) approved for construction. It is an adaptive optics module able to compensate the wavefront disturbances affecting the scientific observations, achieving high strehl ratio and high sky coverage. MAORY will be located on the straight-through port of the telescope Nasmyth platform and shall re-image the telescope focal plane to a wide field camera (MICADO) and a possible future second instrument.

A trade-off study among different mechanical design options for the main mechanical structure has been carried out. This paper outlines an overview of the mechanical design that gives a better result in terms of stability, vibrations and manufacturing.

Keywords: ELT (Extremely Large Telescope), Multi-conjugate adaptive optics, Laser guide stars.

1. INTRODUCTION

MAORY is a post-focal adaptive optics module for E-ELT. The instrument will be installed on the ELT Nasmyth platform A. It is designed to work with the imaging camera MICADO and with a second future instrument. The current baseline design of MAORY, from the opto-mechanical point of view, is composed by three modules:

- MAORY System module, including the Main Structure and the Post-Focal Relay Optics;

- LGS WFS module;

- NGS WFS module, including the LOR WFS and the SCAO WFS.

Both the NGS WFS and SCAO WFS modules are hosted in the same structure, the so called Green Doughnut.

An overview of the present status of the MAORY (Main Structure) mechanical design, recently entered in PDR phase, is given in this paper.

*vincenzo.decaprio@inaf.it

Adaptive Optics Systems VI, edited by Laird M. Close, Laura Schreiber, Dirk Schmidt, Proc. of SPIE Vol. 10703, 107034H · © 2018 SPIE
CCC code: 0277-786X/18/$18 · doi: 10.1117/12.2314189

2. DESIGN OVERVIEW OF MAORY MAIN STRUCTURE

The MAORY instrument layout has been significantly changed since phase A. The instrument design volume is now on the telescope straight-through focus, which is a convenient location in term of space and available field of view.

The "Main Structure" of MAORY, a part of the whole MAORY instrument, includes:

- The Bench and Legs.
- The Enclosure with two ports (shutters).
- The CTU assemblies.

In this paper we present the preliminary mechanical design of the only Main Structure of MAORY, as above subdivided.

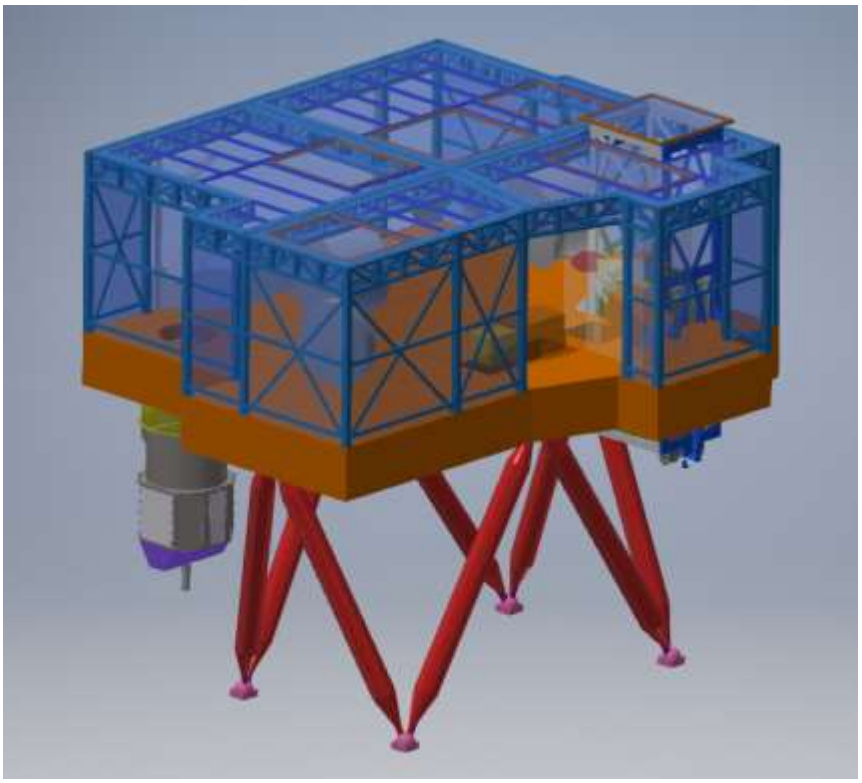

Figure 1. MAORY – overall view

3. BENCH AND LEGS DESIGN

The bench will be a welded steel platform splitted up in five main parts for manufacturing and transportation reasons. The five parts will be connected each other with bolts and reference pins will be used to get again an accurate assembly, after dismounting, for the various provisional phases.

The bigger part (1 in the next Figure 2) will have dimensions compatible with container "high cube box" (ISO rules 668). In the present design each main part of the bench consists of two continuous planes, the top plane and the bottom plane, connected with vertical rib plates (in order to have a box structure) that adds rigidity at the whole structure.

The bench will be mounted on ESO - ELT Nasmith Platform A via eight steel legs by diameter 330 mm, and thickness 12.5 mm.

The distance between the two planes and their thickness has been chosen in order to reach high enough stiffness and eigenfrequencies, taking the weight into account.

Figure 2. Bench - main parts and overall dimensions

3.1 Bench FEM Analysis

Preliminary FEM analysis was carried out on the model of bench with four Nasmyth flanges (four constraint points on the ELT Nasmith Platform) and eight legs.

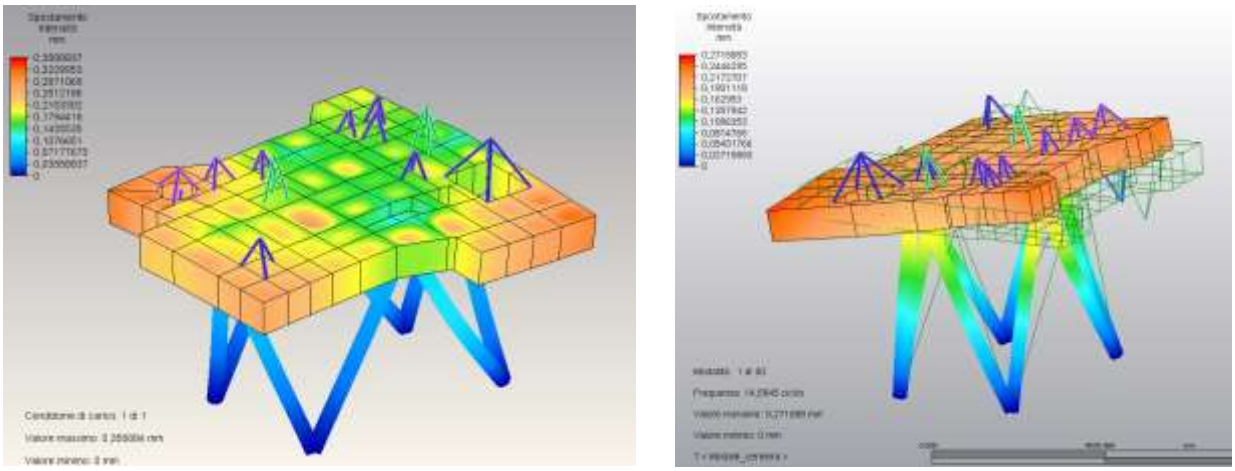

Figure 3. Left side: Total displacements. Right side: first mode

Static stress analysis:

- The maximum deformation of the bench is 0,45mm in the red (cantilevered) areas, as shown in the above figure - Left side.

Modal analysis:

- First mode frequency: 14,6 Hz (as shown in the Figure 3 - Right side).
- The mass participation is less than 90% in X, Y, Z, Rx and Ry.

4. THE ENCLOSURE WITH PORTS

Made of a number of modular aluminum panels and designed to reduce the weight as much as possible, the main purpose of the Enclosure is to protect the internal optical elements from the light and achieving as much as possible of uniform temperature distribution inside it.

The overall dimensions of the Enclosure are:

- total height of the enclosure (compared to the bench) 2,5 m
- internal height of the enclosure (compared to the bench) 2,1 m
- max width 7,7 m
- max length 7,0 m

This structure will be provided of n° 6 trap doors in the top for the maintenance of the main optical elements and the calibration unit elevators. In order to improve the transport and assembly, the Enclosure structure will be splitted in:

- Main structure.
- Four covers.

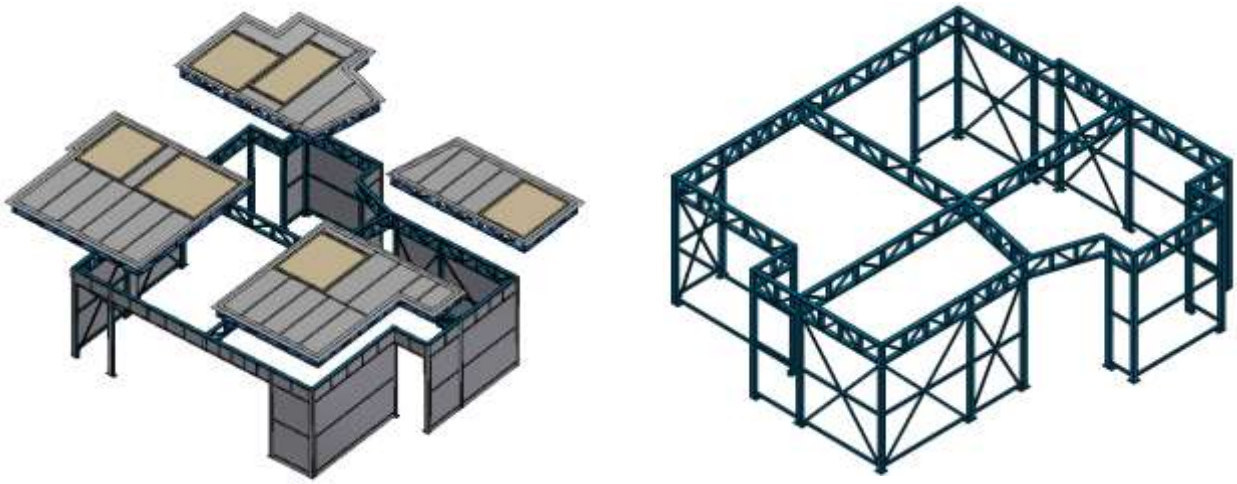

Figure 4. Left side: Enclosure and the four covers. Right side: structure of the Enclosure

The main structure of the enclosure will be made with standard rectangular hollow sections (bolted or welded each other), that will be mounted on the optical bench which therefore bears its weight. This structure provide, also, of a lateral protection for the operators.

4.1 Enclosure FEM Analysis

A preliminary FEM static stress analysis has been carried out to check and improve the structural behaviour of the enclosure, with all loads due to weights of structural parts, sheet, systems, wind and earthquake, in several combinations.

The following image shows the deformation of the main structure; the maximum deflection is about 2,1mm in the center part of main structure, compatible with structure use.

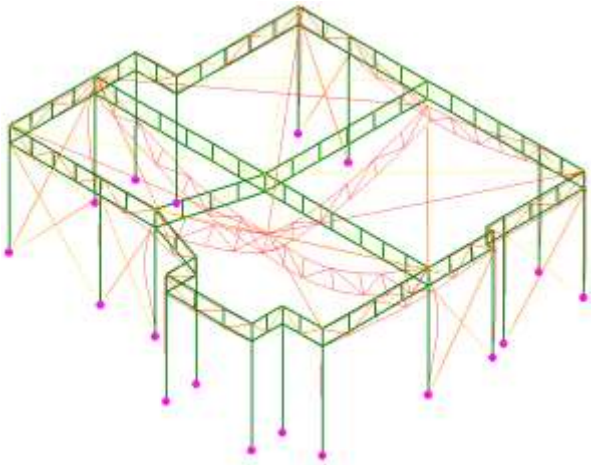

Figure 5. Displacement of Enclosure main structure

5. THE CTU ASSEMBLY

The CTU Assembly #1 of MAORY will be able to accommodate the MAORY CTU modules. We have chosen an elevator "scheme" be make of four main parts:

- the elevator main frame, with linear guideways and ball screw;
- the elevator stiffening frame, that completes the main fixed structure;
- the mobile cart, with ball blocks and recirculating nut;
- the units support frame.

Using this scheme, during the observations, the units are out of the optical beams in the parking position located in the bottom part of theirelevator.When calibration will required, the selected elevator movesupthe CU in the optical path.

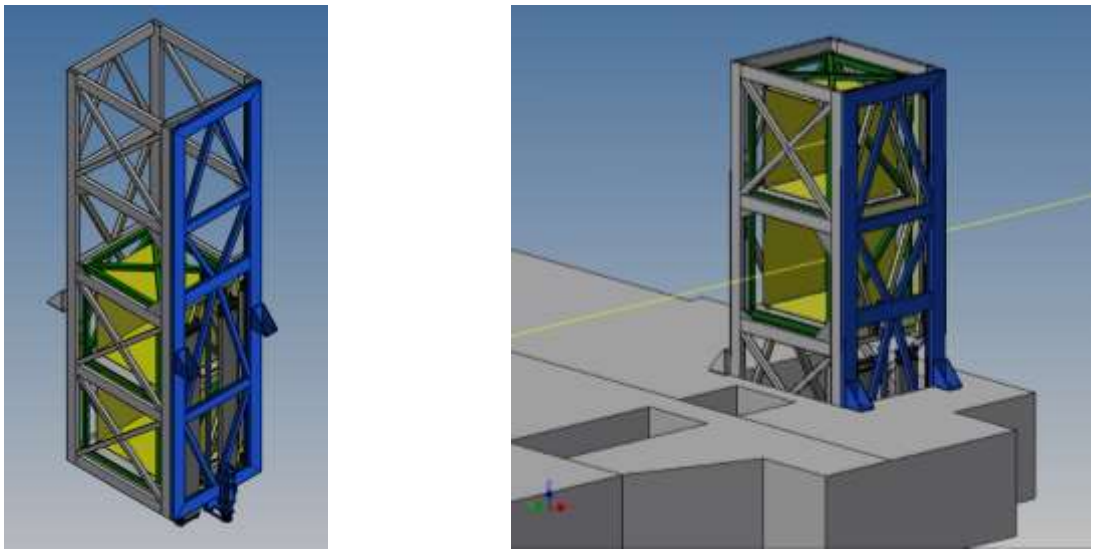

Figure 6. Left side: the elevator. Right side: the elevator mounted on the bench

The main frame structure is composed by rectangular standard hollow tube, material steel S275 JR, welded and then machined on the surfaces for guideways and ball bearing supports.

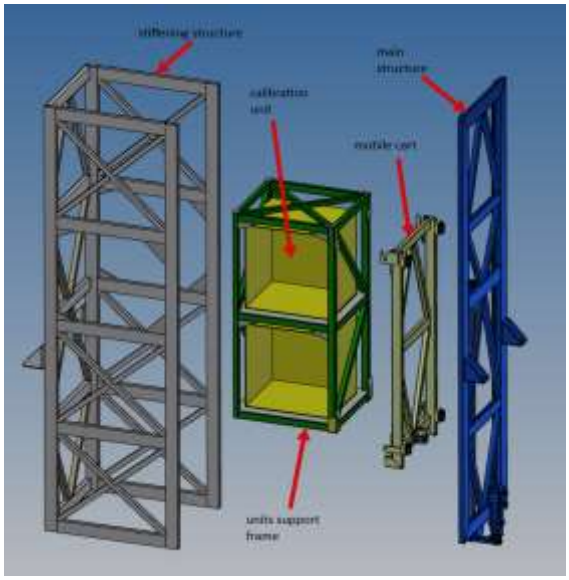

Figure 7. Elevator - main parts

5.1 CTU Assembly FEM Analysis

The results of the preliminary FEM analysis are shown in the following Figure 8.
The loads due to the units mobile frame have been applied to the rails in the upper position, corresponding to CU on the optical axis.
The maximum static deformation is about 0,32mm in the upper part of main structure, and it is mainly due to the presence of the hole for the optical path, without cross-bracing.

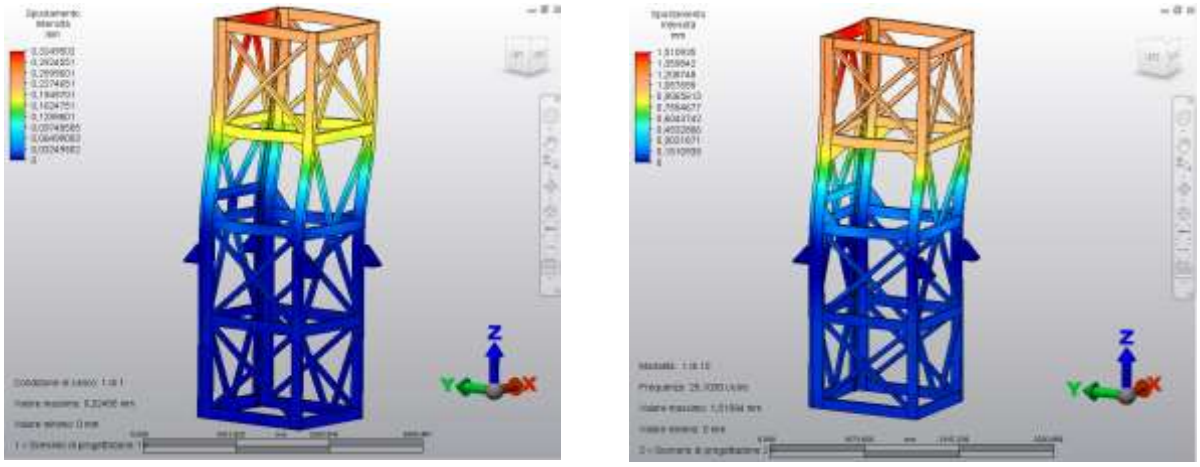

Figure 8. CRU Assembly total displacements. Right side: CTU Assembly first mode

The natural frequency analysis, with the loads in the same position, gives a first frequency at 25,1Hz, with a deformed shape similar to the static case, as shown in the previous Figure 8 - Right side.

6. CONCLUSIONS

The current baseline mechanical design of the MAORY Main Structure has been presented in this paper. Significant changes of requirements and instrument design have been made since the MAORY project phase A.

The instrument location on the Nasmyth platform has been changed from a folded focus to the straight-through focus of the telescope, which is more convenient in terms of space and field of view.

7. ACKNOWLEDGEMENTS

The MAORY instrument is developed in the framework of the Agreement No. 65221/ESO/15/67001/JSC between the European Organisation for Astronomical Research in the Southern Hemisphere (ESO) and the Istituto Nazionale di Astrofisica (INAF) on behalf of the Consortium consisting of INAF and of the Institut National des Sciences de I'Univers du Centre National de la Recherche Scientifique (INSU/CNRS) acting on behalf of the Institut de Planetologie et d'Astrophysique de Grenoble (IPAG).

REFERENCES

[1] Diolaiti, E., Arcidiacono, C., Bregoli, G., Butler, R. C., et al., "Preparing for the phase B of the E-ELT MCAO module project" Proceedings of the SPIE 9148, article id. 91480Y (2014).
[2] Diolaiti E., Ciliegi, P., et al., "MAORY: adaptive optics module for the E-ELT" Proc. of SPIE Vol. 9909 99092D-1 (2016).
[3] Lombini M., De Rosa A., Ciliegi P., Cortecchia F., Diolaiti E., Patti M., Bonaglia M., Busoni L., De Caprio V., Esposito S., Feautrier P., Rabou P., Riva M., Stadler E., "Optical design of the Post Focal Relay of MAORY" Proc. of SPIE Vol. 9908 9908AB-2 (2016).
[4] M. Lombini, D. Magrin, M. Patti, D. Greggio, F. Cortecchia, E. Diolaiti, V. De Caprio, E. Radaelli, M Riva, P. Ciliegi, S. Esposito, P. Feautrier, R. Ragazzoni "Optical design of the post focal relay of MAORY", this Conference.
[5] M. Riva et al., "Optomechanical design of Maory post focal relay optics", [10702-355], this Conference.
[6] P. Ciliegi et al., "MAORY for ELT: preliminary design overview", [10703-38], this Conference.
[7] C. Arcidiacono et al., "Numerical simulations of MAORY MCAO module for the ELT", [10703-169], this Conference.
[8] M. Lombini et al., "System AIV plan of MAORY", [10702-356], this Conference.
[9] M. Patti et al., "Precise alignment method for MAORY", [10705-14], this Conference.