MAORY

The Adaptive Optics Module for ELT

Ugo DI GIAMMATTEO

on behalf of MAORY CONSORTIUM

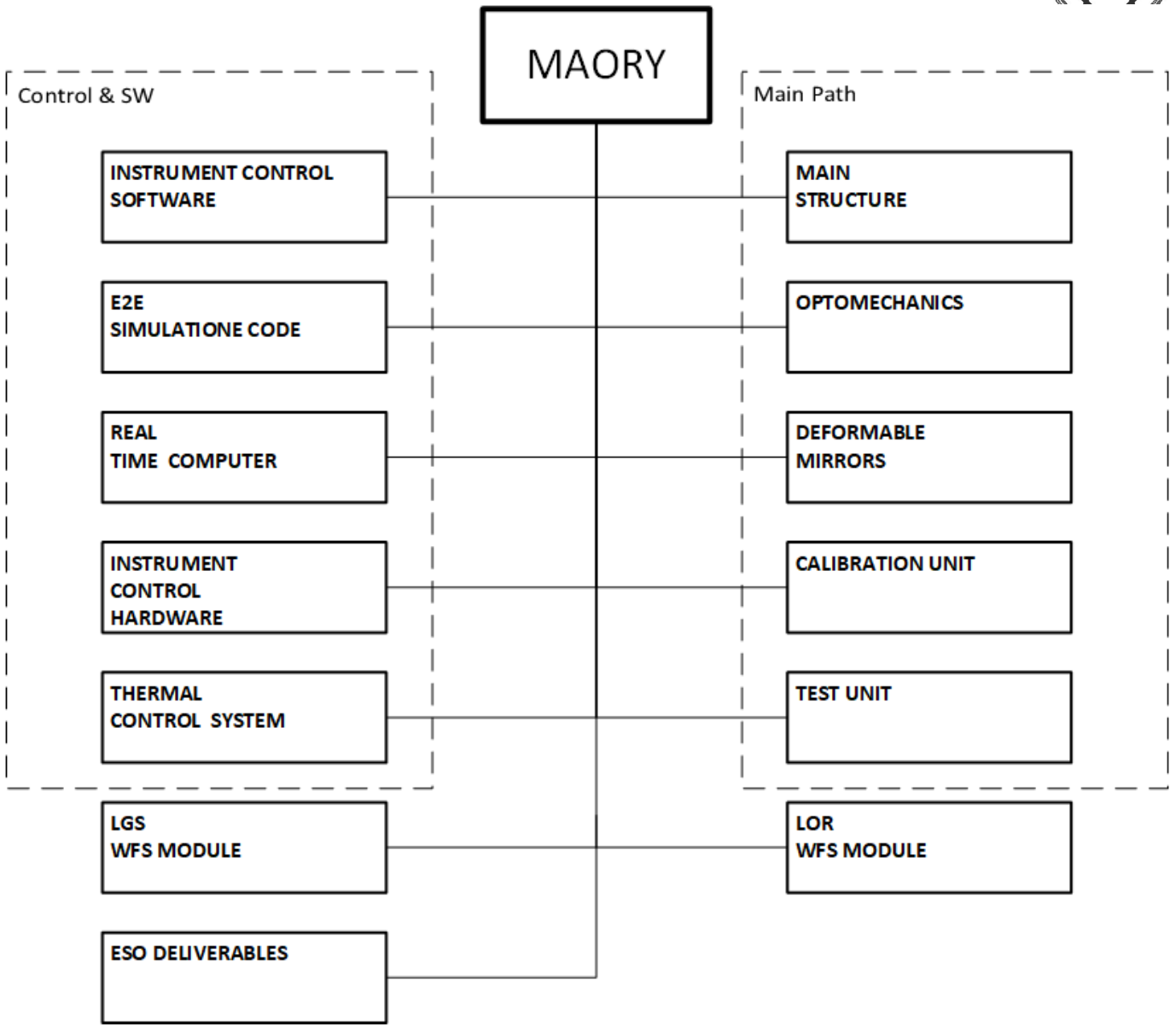
ELT Instruments Day 2022 – April 7, 2022 Geneva

MAORY INSTRUMENT

- MAORY is a post-focal adaptive optics module to be installed on the ELT Nasmyth platform.
- MAORY has to provide an MCAO adaptive optics mode to support MICADO (plus another instrument to be specified)
- MAORY MCAO mode has to be available at first light with at least one deformable mirror in MAORY, with provision for a second deformable mirror as an upgrade → MAORY has to be designed for two post-focal Deformable Mirrors from the beginning, with one DM possibly replaced by a rigid mirror
- The MCAO mode of MAORY is based on the use of 6 Laser Guide Stars and 3 Natural Guide Stars
- MAORY shall be able to delivery a Strehl Ratio of 0.3 at 2.2 micron (goal 0.5) with 50% of sky coverage

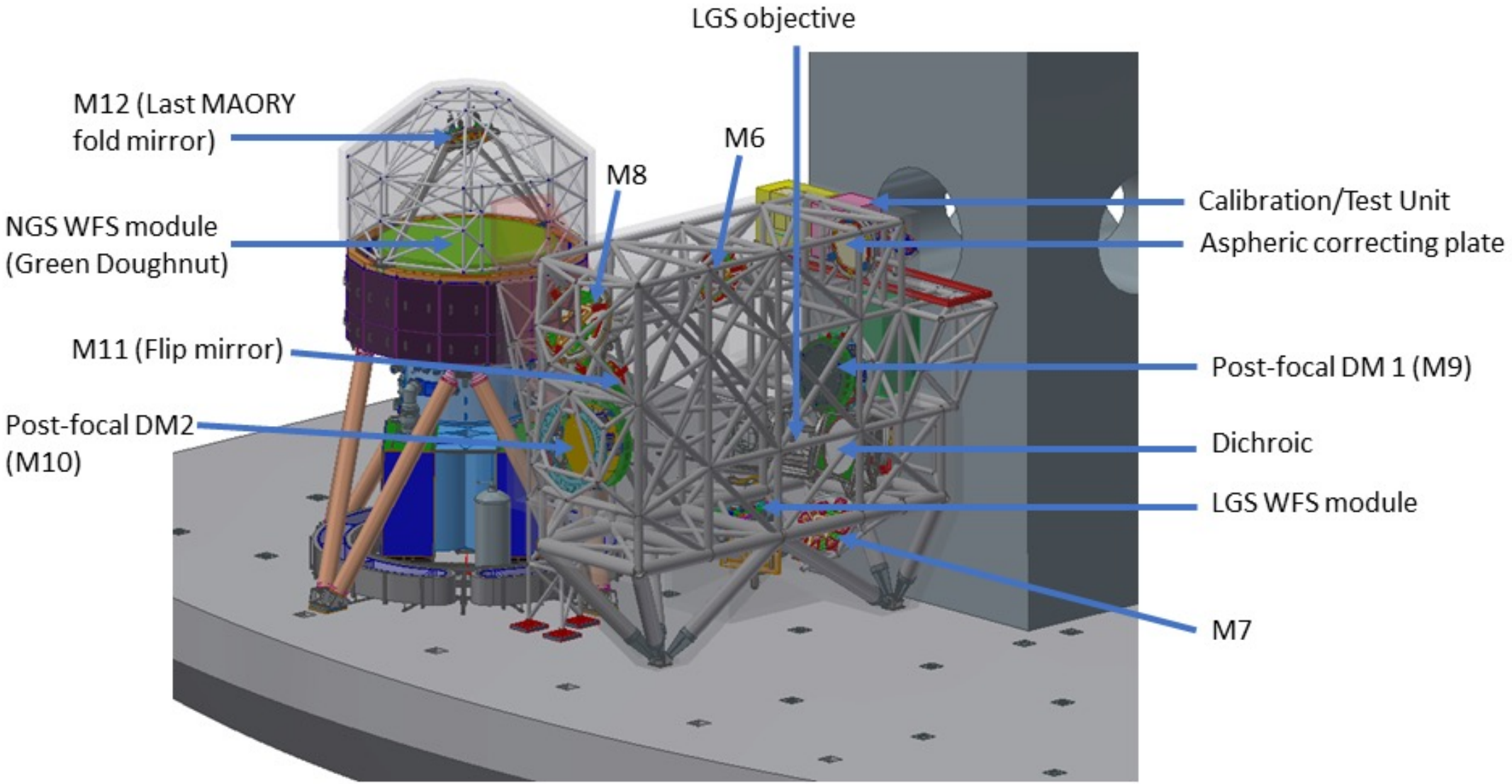
The MAORY design as been developed starting from 4 different modules each containing different elements (work packages):

- **The MAORY MAIN PATH module** including the following WPs: Main Structure, Optomechanics (PFRO and optical mounts) Deformable Mirrors, Calibration Unit, Test Unit)
- **The NGS WFS module**, including the LOR WFS WP
- **The LGS WFS module**, including the LGS WFS WP
- **The Control and Software module** including the following WPs: Instrument Control Software, Instrument Control Hardware, Thermal Control System, Real Time Computer, End2End Simulations

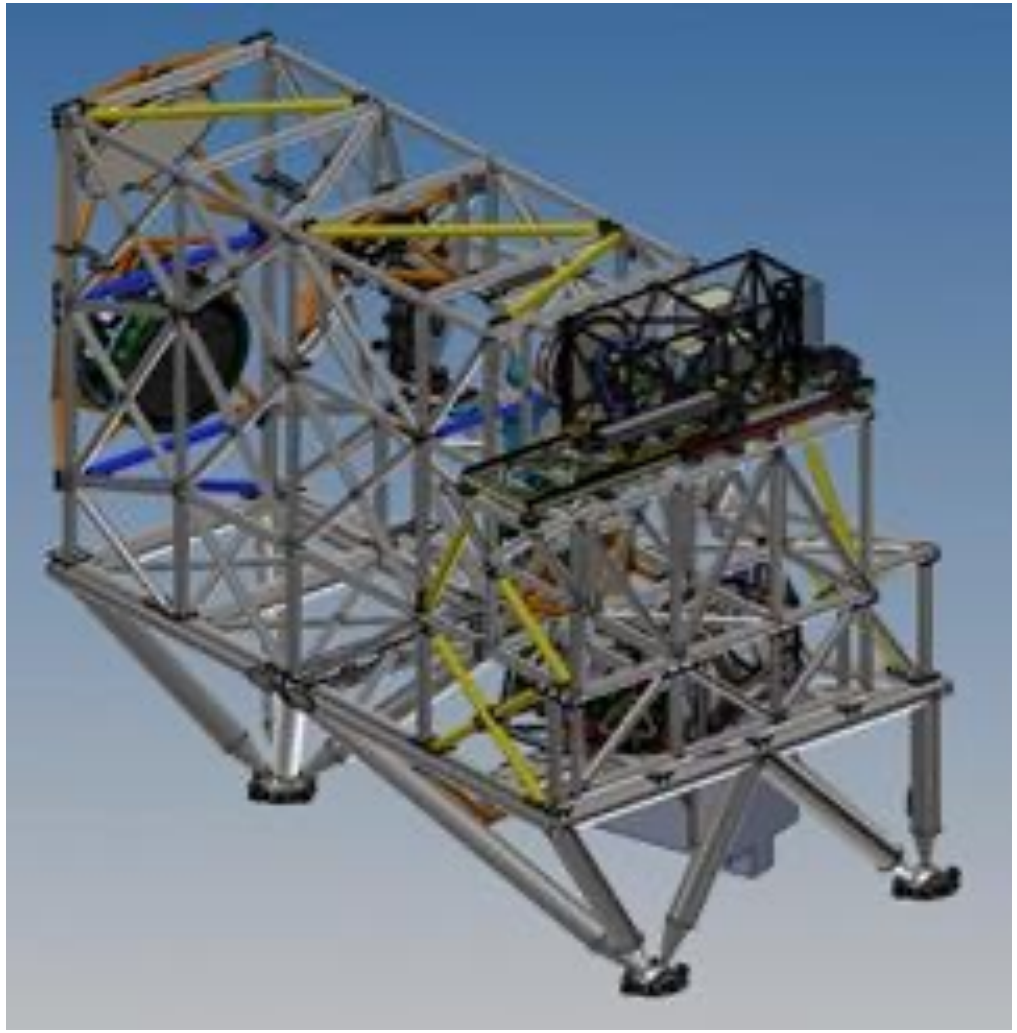


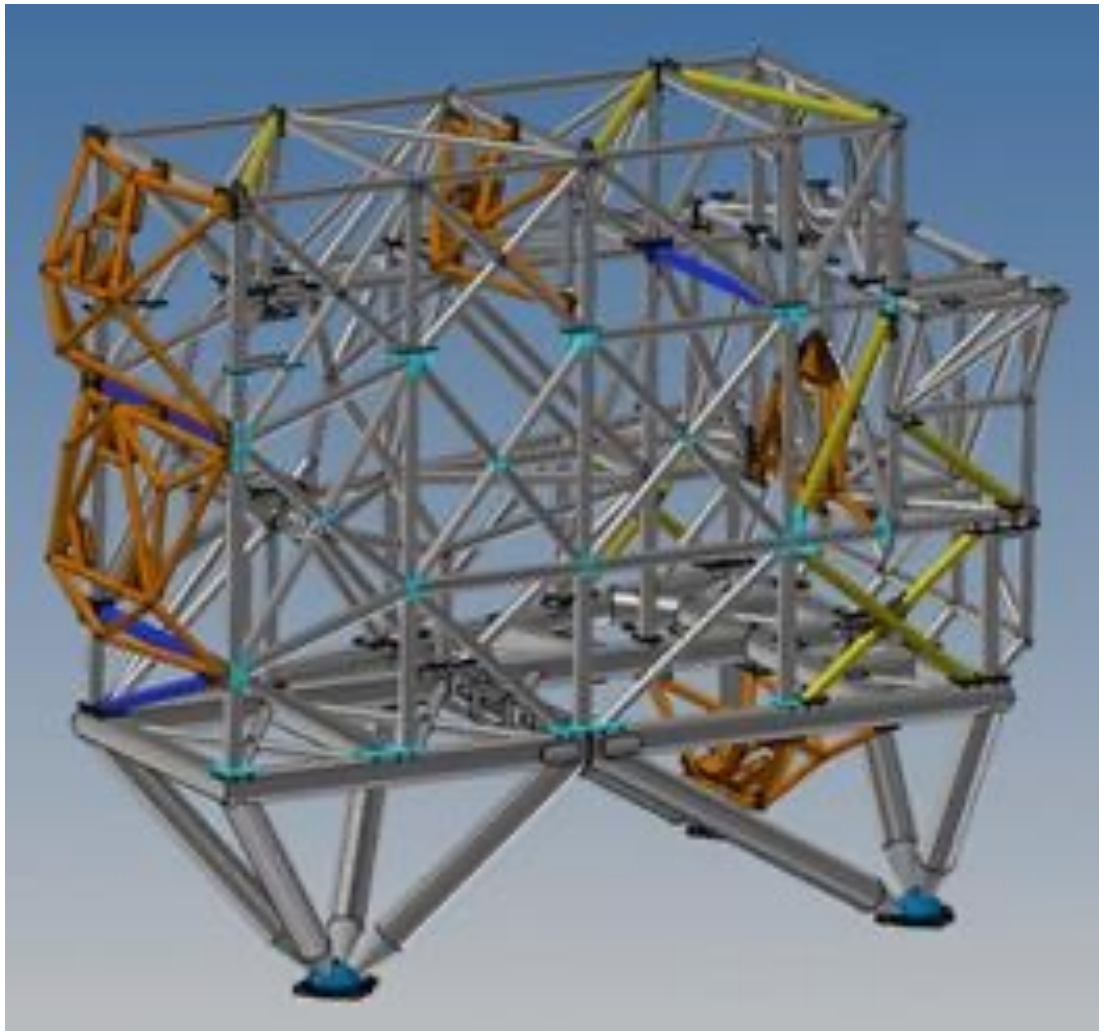
MAORY PRODUCT TREE

MAORY GENERAL OVERVIEW

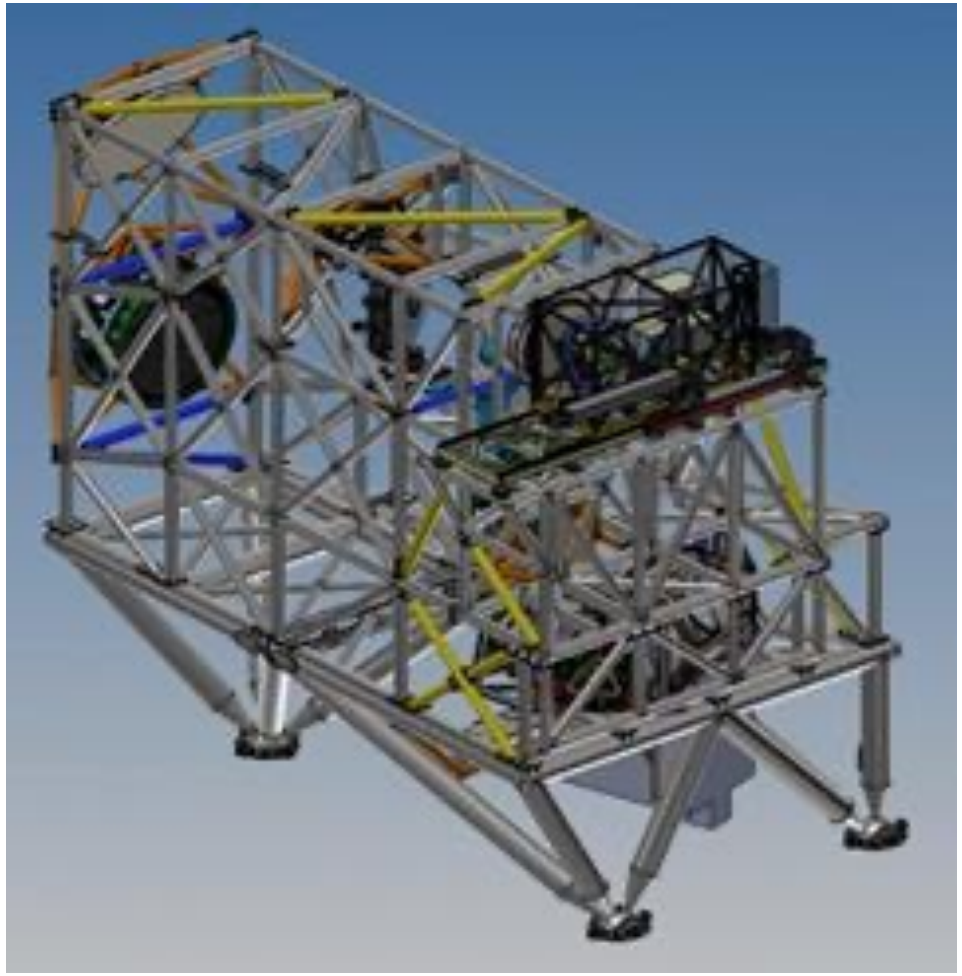


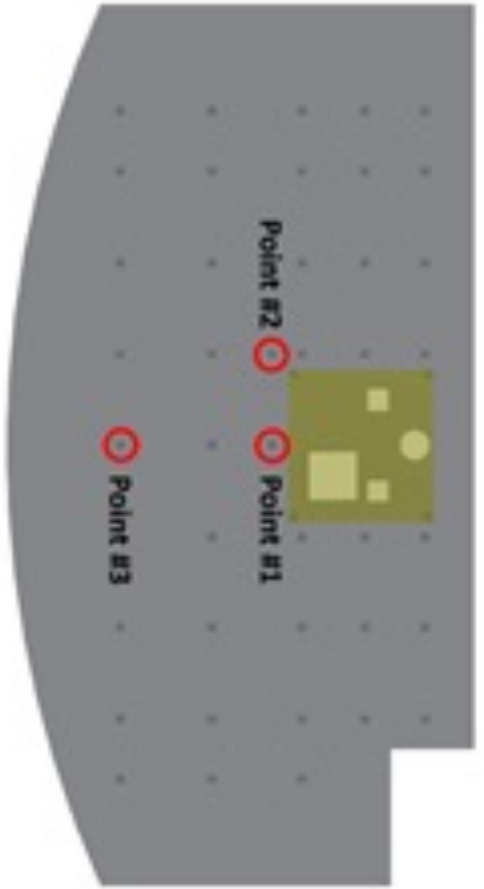
Main Structure





Main Structure





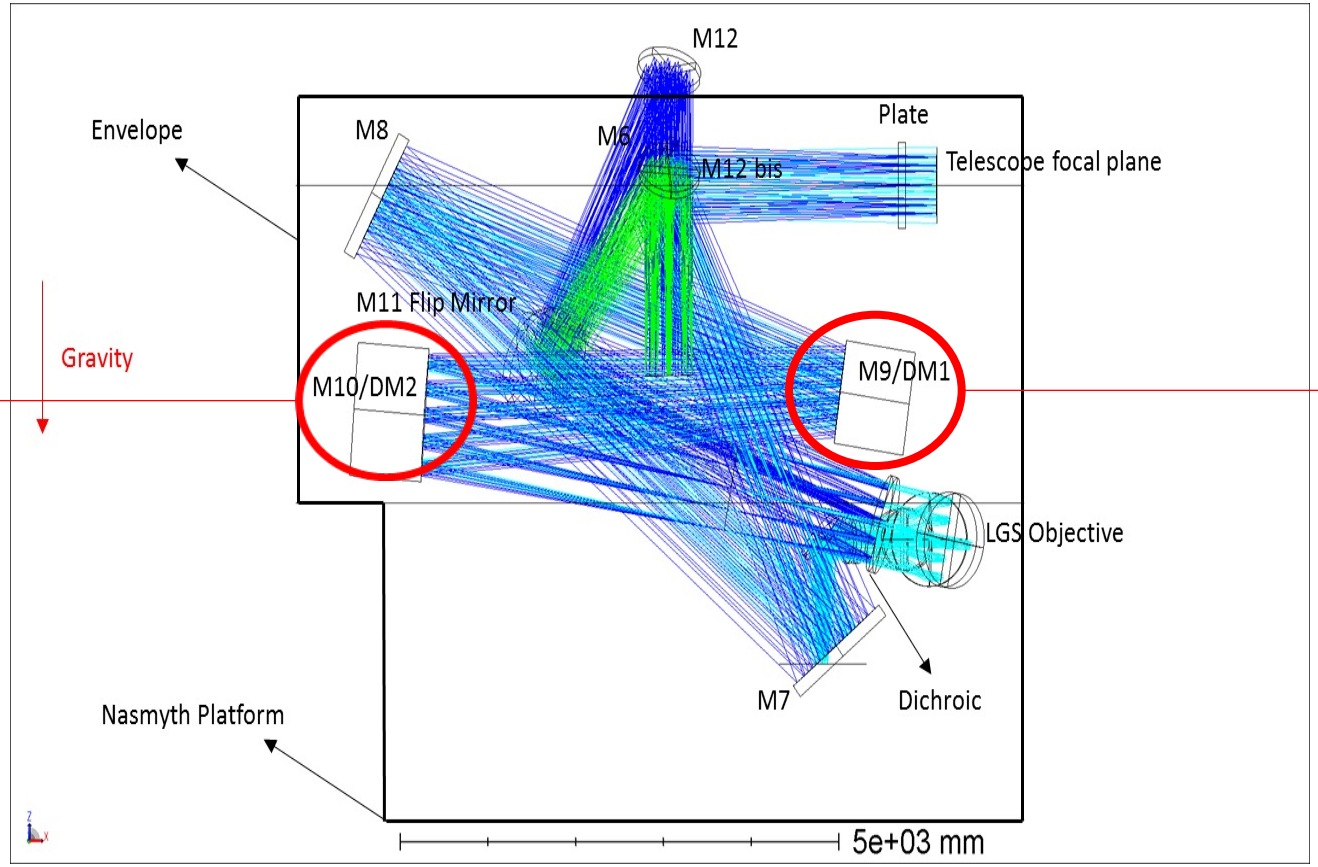
MAORY OPTICAL BASELINE

SECOND DM
Concave Spherical mirror
Diameter about 1200 mm

Not present in the baseline
and not included in the original € budget.

It will be replaced with a monolithic mirror

Available as an upgrade path

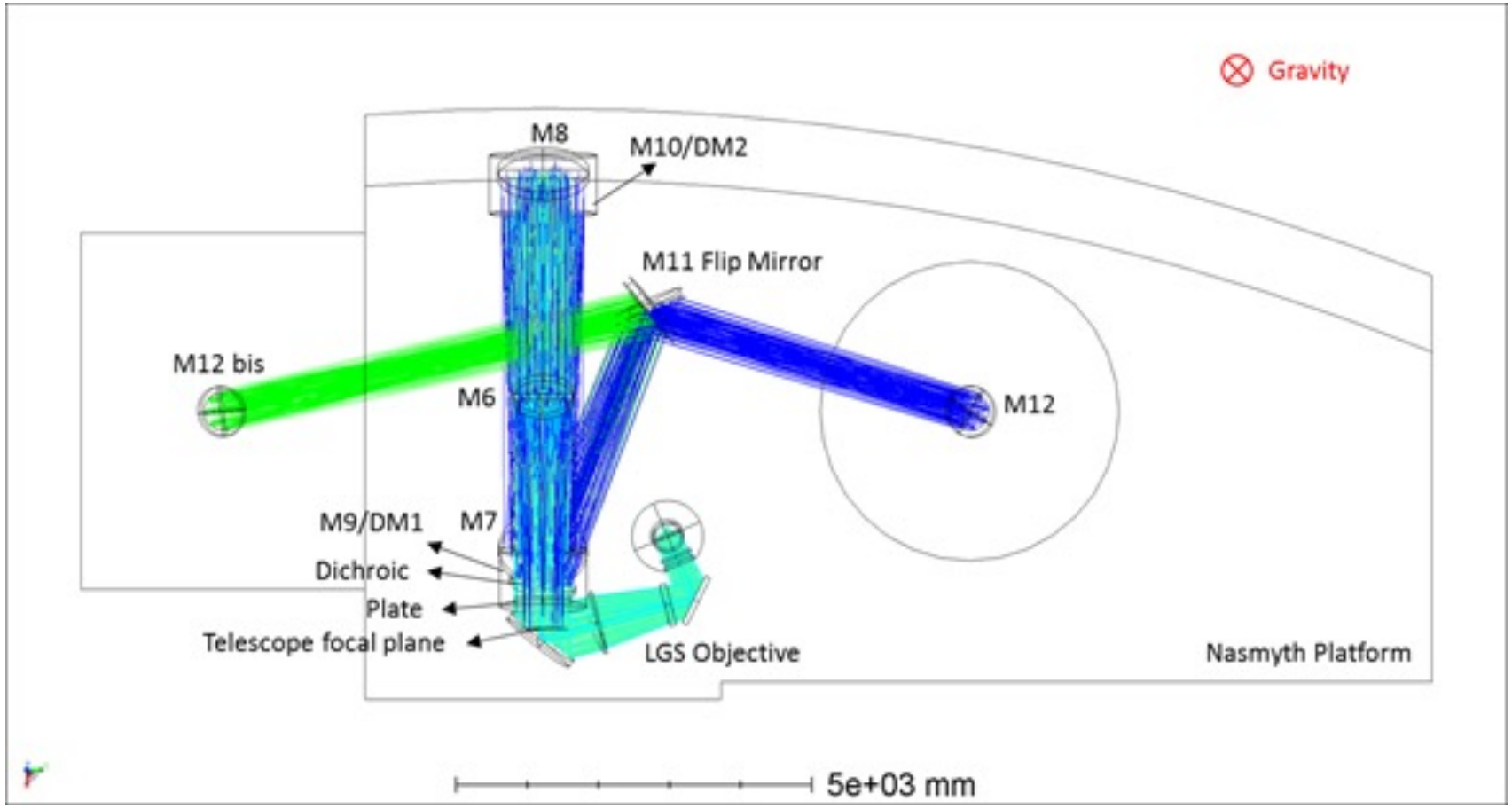


FRONT VIEW

FIRST DM
Convex spherical mirror
Diameter about 900 mm

Present in the baseline

MAORY OPTICAL BASELINE



TOP VIEW

Main MAORY MILESTONES

Milestone (Meeting/review)	Date
Kick-Off	02-2016
Preliminary Design Review 1	04-2021
Preliminary Design Review 2 (End Phase B)	07-2021
Final Design Review (End Phase C)	02-2023
Preliminary Acceptance in Europe (End Phase D)	02-2028
MAORY Shipping parts in Chile	04-2028
Instrument Installation Readiness Review in Chile	07-2028
MAORY First Light	09-2028
Provisional Acceptance in Chile	05-2029

Activities after PDR

Long-Lead Items : Procurements for Final Design Phase, Manufacturing and delivery at Bologna Integration Hall

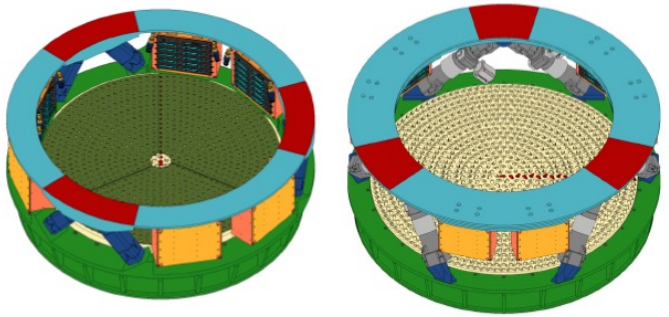
- Optical elements including optical mounts
- Deformable Mirrors (Final Design Phase for two 2DMs and Manufacturing Phase for 1 or 2 DMs)
- Main Structure

For all the procedures, the access to Phase D will always be conditional to

- **the formal availability of the funds needed to cover the whole project, and**
- **the formal approval of the Final Design Review by ESO.**

Non-LL items : Internal development of the Final Design
Final Design Review
Procurements of single components of each sub-systems
Assembly of each sub-systems in different Consortium premises
Delivery at Bologna Integration Hall

Long-Lead Items



Deformable Mirrors

Steps:

1. Public pre-information, advertising the future issue of an open Invitation To Tender. It will contain the characteristics of the DMs (as currently known) and the main elements of the Call. This communication is intended to give the necessary information to all companies potentially interested to this procurement.

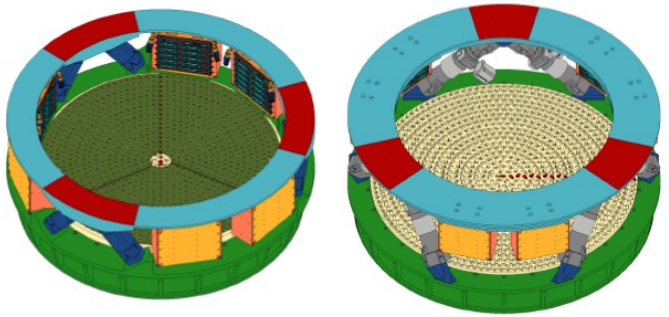
2. Call for Tender, comprising all the requirements, the conditions for participation, the evaluation criteria and the relative weights.

3. Evaluation of the proposals.

4. Contract awarding.

Long-Lead Items

Deformable Mirrors



Contract Scheme:

- Final Design Phase of the DMs, comprising the creation of all documents, drawing, etc. foreseen for this phase. This phase will be carried out for both DMs.
- Manufacturing Phase, starting after the formal approval of FDR and funds' availability. It can be limited to one DM or extended to the second one, depending on the amount of funds available.

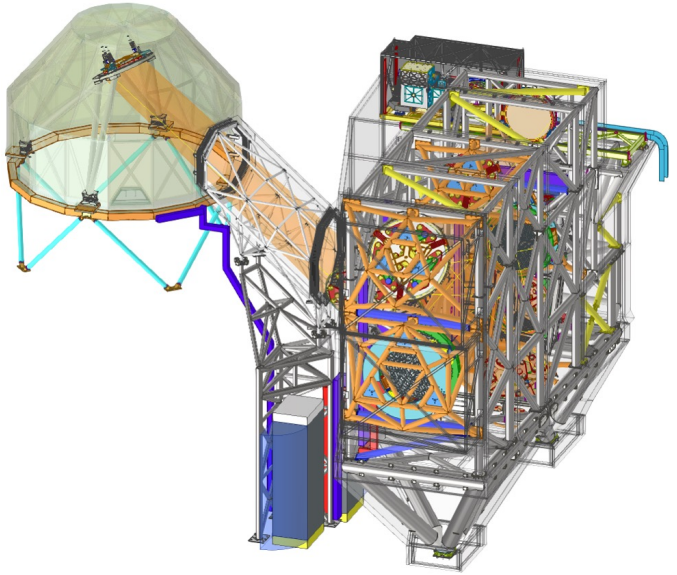
The candidates shall apply to both phases.

The company that gets the contract will carry out both Final Design and Manufacturing (if the conditions for Manufacturing are met).

This will ensure the consistency of manufacturing with design and will safeguard the companies from the spreading of sensible technical information.

Long-Lead Items

Main Structure



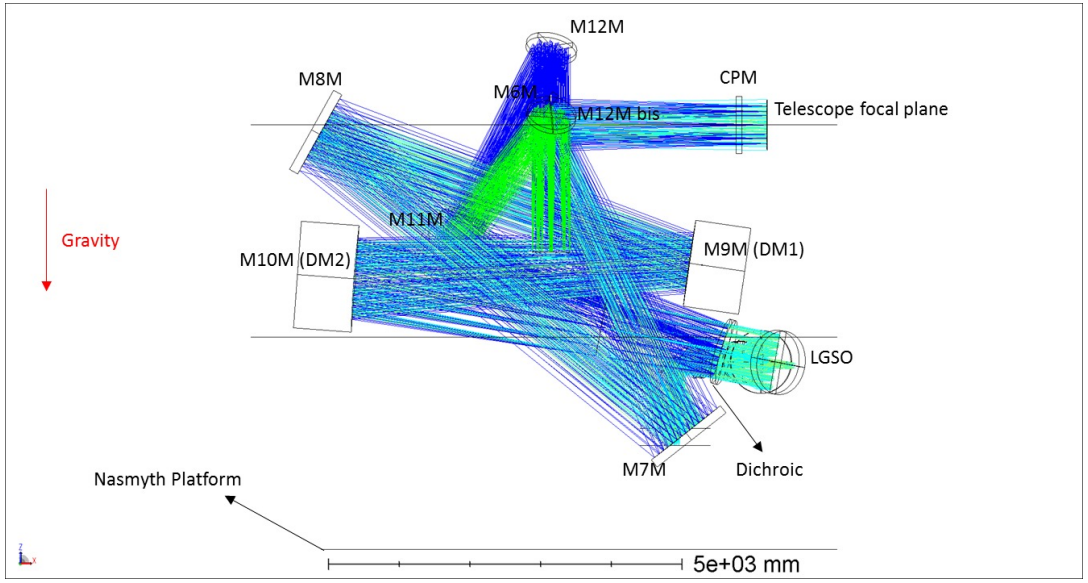
The same mechanism described for DMs will be applied to the main structure:

- Final Design Phase, plus
- Manufacturing Phase

Economic operators shall apply for both Phases. The operator that wins will take care of final design and manufacturing, with the manufacturing phase that starts only when the FDR is successfully concluded and the funding secured.

Long-Lead Items

Post-Focal Relais Optics



Some design solutions require further elaboration after the PDR.

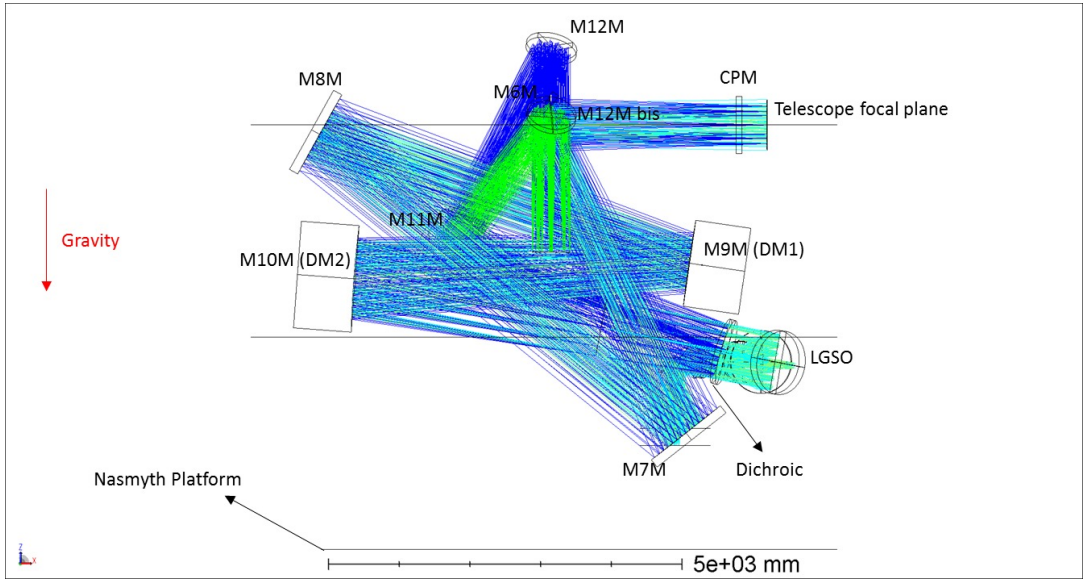
A process with progressive evolution of the technical concepts is therefore required for PFRO.

This process will require the use of an Innovative Procurement Scheme that allows a co-engineering phase in close contact with MAORY technical team.

Several procurement mechanisms are under evaluation, the most likely being the Competitive Dialogue.

Long-Lead Items

Post-Focal Relais Optics

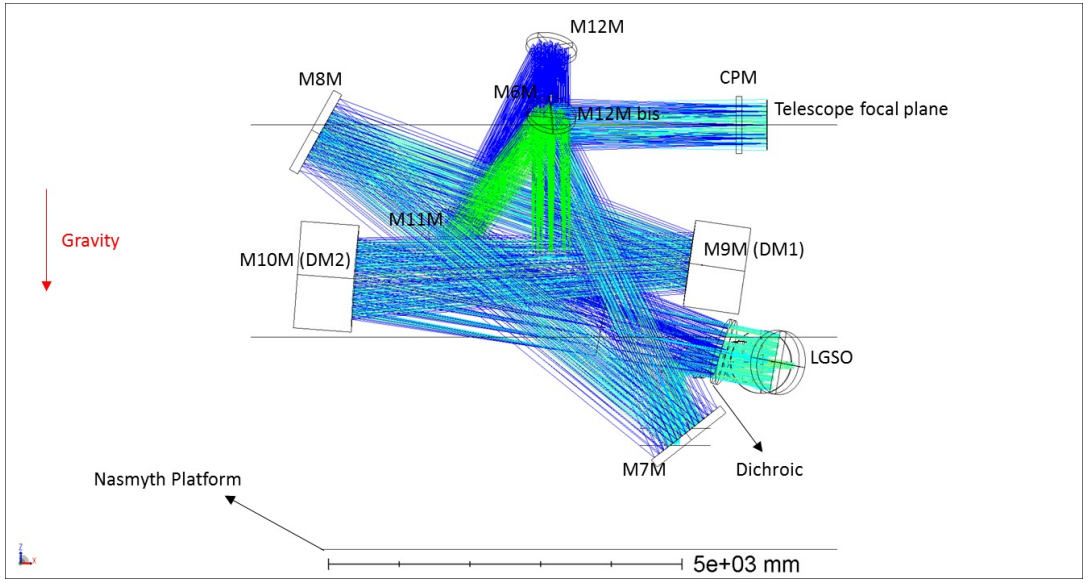


Competitive Dialogue:

1. Publication of Contract Notice with minimum requirements, award criteria and relevant weights. Any operator can submit a bid.
2. The selected candidates are invited to take part in the dialogue.
3. The dialogue takes place, to develop possible solutions. At the end of the dialogue there must be enough solutions to ensure a fair competition.
4. When the dialogue is concluded the contracting authority invites the bidders to submit the final tender on the basis of the solutions identified during the dialogue.
5. The final contract is awarded.

Long-Lead Items

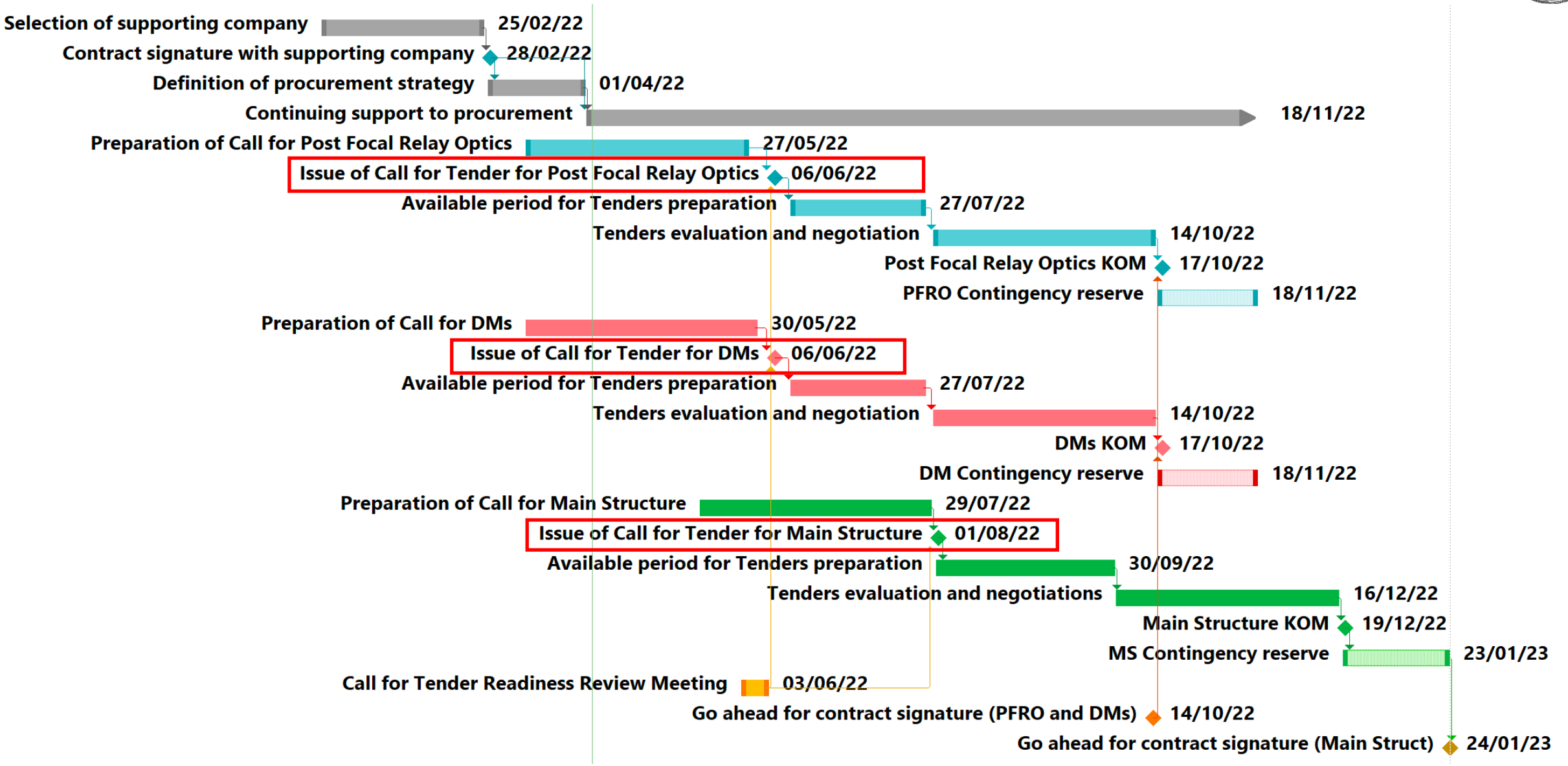
Post-Focal Relais Optics



Competitive Dialogue for PFRO:

- The bidders will receive money in the dialogue phases. The amount will be established at the beginning of the procedure.
- The procurement will be split in lots, decided on the basis of homogeneity of the optical elements included in each lot.
- The winner (for each lot) of the final tender will conclude the Final Design Phase and will implement the optical elements contained in the lot.

LLI Schedule



Non-LLI

The following elements will be procured later:

- Calibration and Test Unit
- LOR WFS Module, including electronics
- LGS WFS Module including electronics
- Adaptive Optics Wave-Front Sensor cameras
    -> 3 x FREDA for NGS IR WFS (from ESO)
    -> 3 x ALICE for the Visible Truth WFS (from ESO)
    -> LGS WFS cameras still under discussion
- Electronics at System Level (excluding LOR and LGS WFS modules)
- AIT-V tools

MAORY CONSORTIUM

COUNTRY	INSTITUTE	PRINCIPAL SUPPLIES
ITALY	INAF	PI : **PAOLO CILIEGI** Co-I : **ESPOSITO - RAGAZZONI** Project Office Sub-system level: ICS software, instrument control hardware, main structure, post-focal relay optics, opto-mechanics, LOR WFS module, RTC, DMs, calibration unit, science support tools Contribution to SAT, System Team and Science Team
FRANCE	CNRS/INSU representing IPAG (Grenoble)	Co-I : **FEAUTRIER** Sub-system level: LGS WFS Contribution to SAT System Team and Science Team
IRELAND	School of Physics at the National University of Ireland Galway (NUIG)	Co-I : **DEVANEY** Subsystem level : Test and Wavefront Correction Verification Contribution to SAT and System Team and Science Team

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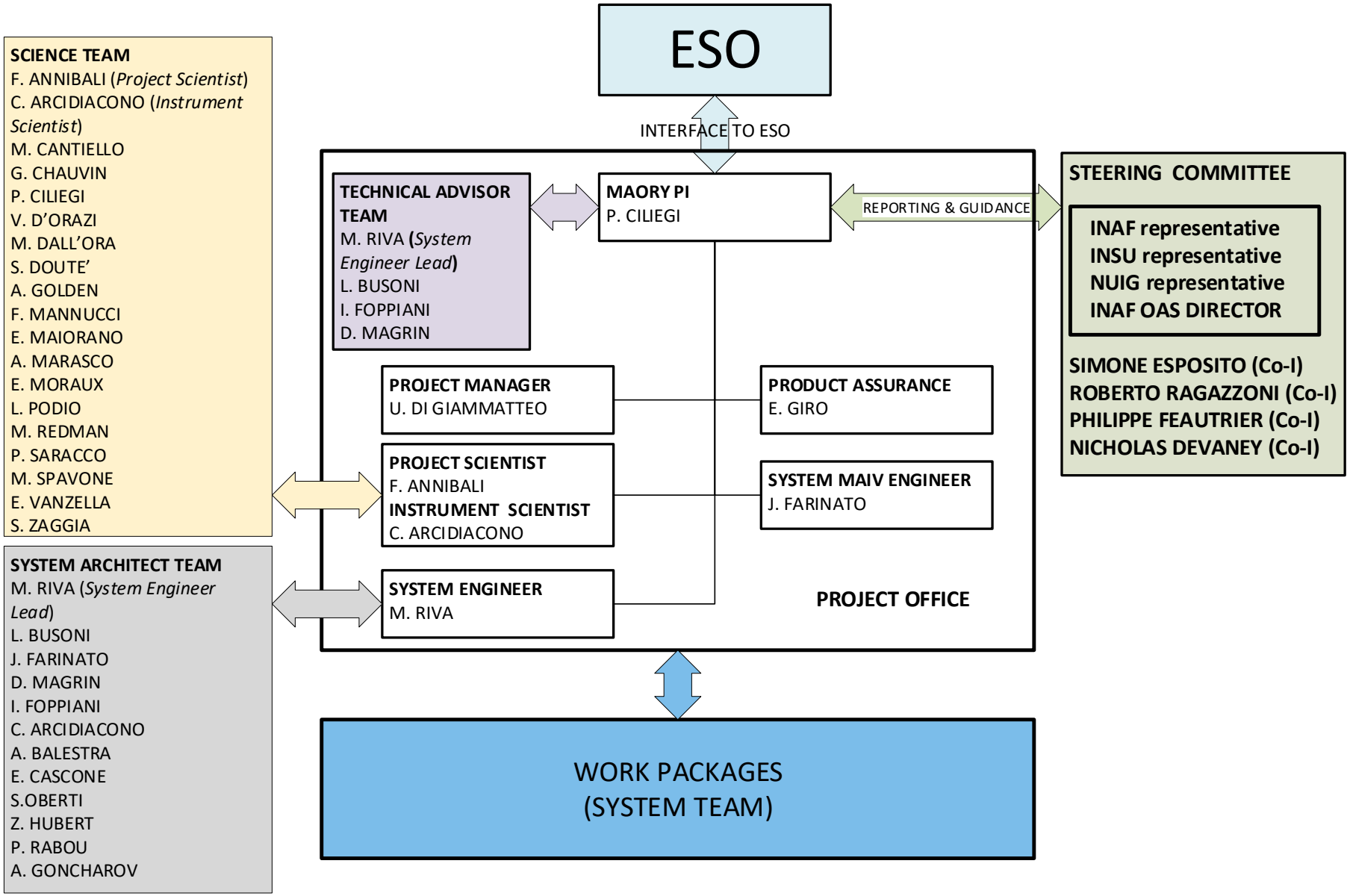
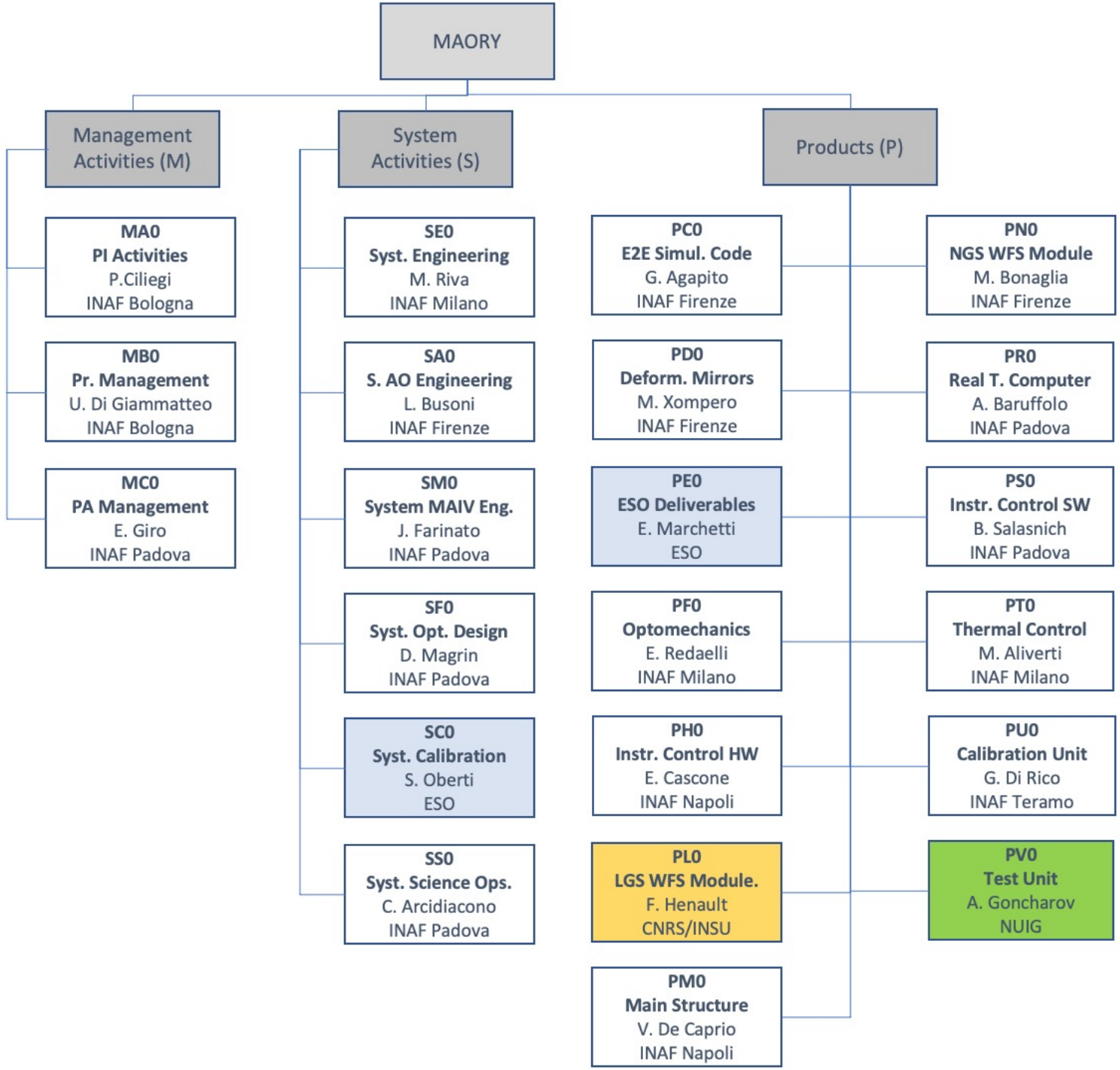
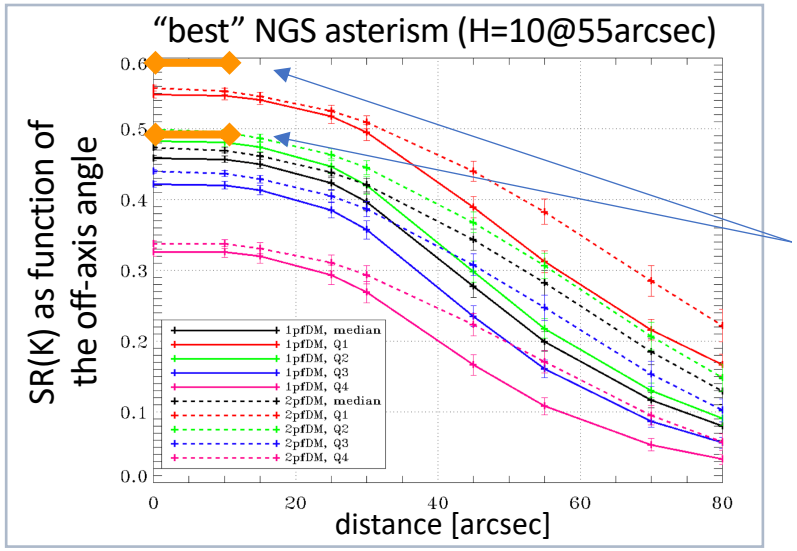
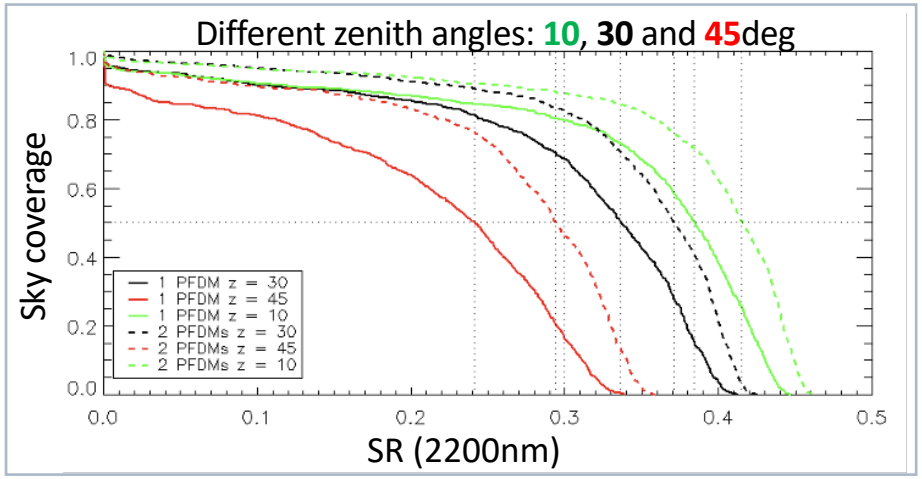


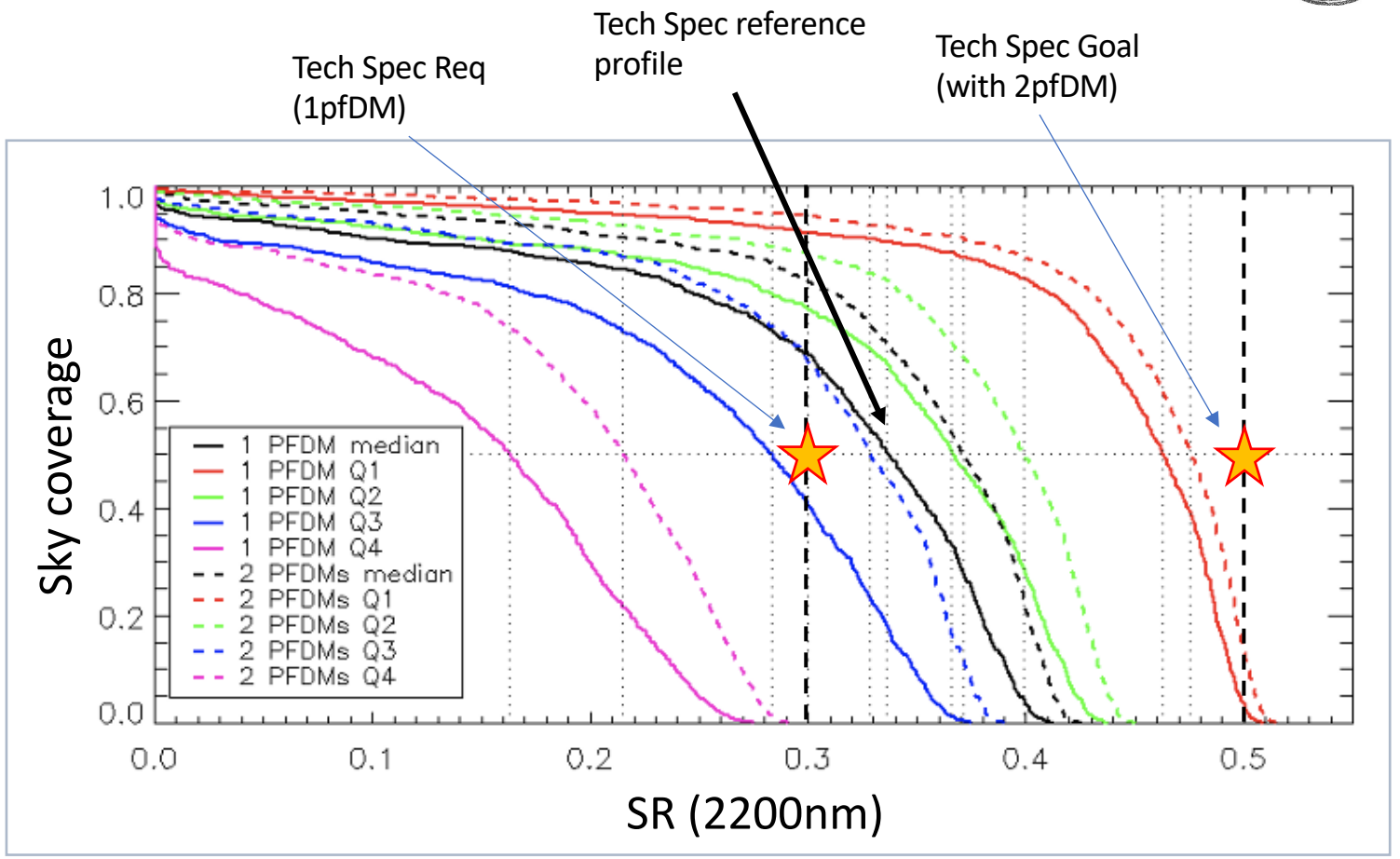

MAORY
Management Activities (M)
System Activities (S)
Products (P)
MA0
PI Activities
P.Ciliegi
INAF Bologna
MB0
Pr. Management
U. Di Giammatteo
INAF Bologna
MC0
PA Management
E. Giro
INAF Padova
SE0
Syst. Engineering
M. Riva
INAF Milano
SA0
S. AO Engineering
L. Busoni
INAF Firenze
SM0
System MAIV Eng.
J. Farinato
INAF Padova
SF0
Syst. Opt. Design
D. Magrin
INAF Padova
SC0
Syst. Calibration
S. Oberti
ESO
SS0
Syst. Science Ops.
C. Arcidiacono
INAF Padova
PC0
E2E Simul. Code
G. Agapito
INAF Firenze
PD0
Deform. Mirrors
M. Xompero
INAF Firenze
PE0
ESO Deliverables
E. Marchetti
ESO
PF0
Optomechanics
E. Redaelli
INAF Milano
PH0
Instr. Control HW
E. Cascone
INAF Napoli
PL0
LGS WFS Module.
F. Henault
CNRS/INSU
PM0
Main Structure
V. De Caprio
INAF Napoli
PN0
NGS WFS Module
M. Bonaglia
INAF Firenze
PR0
Real T. Computer
A. Baruffolo
INAF Padova
PS0
Instr. Control SW
B. Salasnich
INAF Padova
PT0
Thermal Control
M. Aliverti
INAF Milano
PU0
Calibration Unit
G. Di Rico
INAF Teramo
PV0
Test Unit
A. Goncharov
NUIG

Performance



Q1 Tech Spec Req and Goal





A system with a single DM is capable of delivering a SR well above 30% at 50% of sky coverage, while the presence of the second post focal DM (dashed lines) is fundamental to push the system toward maximal performance and higher robustness to varying atmospheric and observing conditions.