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Project: **ELT MCAO Construction – MAORY**

MAORY On-site AIV Plan

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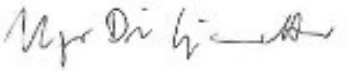
Released by PM:	Ugo Di Giammatteo		2021-04-30
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		Renamed MAORY in MORFEO

Contents

1. INTRODUCTION

1.1 Scope

This document describes the assembly, integration and verification at Armazones, of the Multi-conjugate Adaptive Optics RelaY (MAORY) which is one of the first light instruments of the European Extremely Large Telescope (ELT).

The MAORY instrument is designed and developed by a European consortium composed by INAF (Istituto Nazionale di AstroFisica, Italy), CNRS/INSU (Centre National de la Recherche Scientifique/ Institut National des Sciences de l'Univers, France), NUIG (National University of Ireland Galway, Ireland) and ESO (European Southern Observatory, Europe).

The AIV of the overall instrument will take place at Cerro Armazones, and this document covers:

- Organizational and management aspects related to the MAORY AIV in Chile
- Responsibility sharing between the partners
- Basic logistic aspects in Chile

This documents describes the following phases of activities:

1. Activities in the Instrumentation Assembly Area
2. Activities in the ELT Nasmyth platform

1.2 Definitions, Acronyms and Abbreviations

AD	Applicable Document
ADP	Acceptance Data Package
AO	Adaptive Optics
AIT	Assembly Integration Test
AIV	Assembly Integration Verification
BIH	Bologna Integration Hall
BoM	Bill of Material
CA	Clear Aperture
CBS	Cost Breakdown Structure
CMP	Configuration Management Plan
CoG	Centre of Gravity
CoI	Co-Investigator

CP	Corrective Plate
CV	Curriculum Vitae
CNRS	Centre National de la Recherche Scientifique
DoF	Degree of Freedom
ELT	European Extremely Large Telescope
EFC	Executive Funding Committee
ESO	European Southern Observatory
DASF	Dichroic Assembly Support Frame
DM	Deformable Mirror
DRD	Document Requirements Definition
FDR	Final Design Review
FoV	Field of View
FTE	Full Time Equivalent
GTO	Guaranteed Time Observing allocation
HT	Handling Tool
HW	Hardware
IAA	Instrumentation Assembly Area
ICDR	Instrument Critical Design Review
IECR	Instrument End of Commissioning Review
IFP	Input Focal Plane
INAF	Istituto Nazionale di AstroFisica
ICH	Instrument Control Hardware
ICS	Instrument Control Software
INSU	Institut National des Sciences de l'Univers
IORR	Instrument Operations Readiness Review
IPAG	Institut de Planétologie et d'Astrophysique de Grenoble
IPDR	Instrument Preliminary Design Review
ISQR	Instrument System Qualification Review
ISRR	Instrument System Requirements Review
KO	Kick Off
LGS	Laser Guide Stars
LGSO	LGS Objective
LOR	Low Order and Reference

LoS	Line of Sight
LT	Laser Tracker
LVDT	Linear Variable Displacement Transducer
MAD	Multi conjugate Adaptive optics Demonstrator
MAIT	Manufacturing Assembly Integration and Test
MAORY	Multi Conjugate Adaptive Optics Relay for ELT
MC	Monte Carlo
MCA	Micado Calibration Unit
MCAO	Multi Conjugate Adaptive Optics
MOA	Maory Optical Alignment
MES	MICADO Emulating System
MHS	MICADO Holding Structure
MICADO	Multi-AO Imaging Camera for Deep Observations
MoU	Memorandum of Understanding
MRB	Material Review Board
MS	Motorized Stage
MSS	Main Support Structure
MSQR	MAORY System Qualification Review
MTA	Milestone Trend Analysis
N/A	Not Applicable
NCR	Non Conformity Report
NGS	Natural Guide Star
NIP	Nasmith Interface Plate
NUIG	School of Physics at the National University of Ireland Galway
OA	Optical Alignment
OAA	Osservatorio Astrofisico di Arcetri
OAAB	Osservatorio Astronomico d’ Abruzzo
OAB	Osservatorio Astronomico di Brera
OACN	Osservatorio Astronomico di Capodimonte
OAPD	Osservatorio Astronomico di Padova
OAS	Osservatorio di Astrofisica e Scienza dello Spazio di Bologna
OFP	Output Focal Plane
PA	Product Assurance

PAC	Preliminary Acceptance Review in Chile
PAE	Preliminary Acceptance Europe
PAP	Product Assurance Plan
PDM	Product Data Management
PDR	Preliminary Design Review
PFS	Pre Focal Station
PI	Principal Investigator
MPI	MICADO Pupil Imager
PM	Project Manager
PMP	Project Management Plan
PSF	Point Spread Function
PT	Product Tree
PTT	Piston Tip Tilt
PtoV	Peak to Valley
QE	Quantum Efficiency
RAMS	Reliability, Availability, Maintainability, Safety
RD	Reference Document
RMS	Root Mean Square
RON	Read Out Noise
RR	Retro Reflector
RTC	Real-Time Computer
SAT	System Architect Team
SCAO	Single-conjugate Adaptive Optics
SEq	Support Equipment
SET	System Engineering Team
SMR	Spherically Mounted Retroreflector
SNR	Signal to Noise Ratio
SOW	Statement of Work
SQR	System Qualification Review
SR	Strehl Ratio
SRR	System Requirements Review
SW	Software
TAC	Test and Alignment Camera

TAT	Technical Advisor Team
TBC	To Be Confirmed
TBD	To Be Defined
TBH	To Be Hired
TBW	To Be Written
TCS	Telescope Control Software
TRA	Technology Readiness Assessment
TRL	Technology Readiness Level
TRR	Test Readiness Review
TTF	Tip Tilt & Focus
VCD	Verification Control Document
VLT	Very Large Telescope
WBS	Work Breakdown Structure
WFS	Wavefront Sensor
WP	Work Package
WRT	With Respect To
WS	WorkShop
YPR	Yaw Pitch Roll

2. RELATED DOCUMENTS

2.1 Applicable Documents

The following applicable documents form a part of the present document to the extent specified herein.

AD1 MAORY Agreement
ESO-281109 Version 1

AD2 MAORY (E-ELT MCAO) Statement of Work
ESO-257875 Version 1

AD3 MAORY (E-ELT MCAO) Technical Specification
ESO-254311 Version 1

AD4 Common Requirements for E-ELT Instruments
ESO-254547 Version 2

AD5 Common ICD between the E-ELT Nasmyth Instruments and the Rest of the E-ELT System
ESO-253082 Version 4.1

AD6 MAORY Product Assurance Plan
E-MAO-000-INA-PLA-003 Version 1

AD7 MAORY Risk Management Plan
E-MAO-000-INA-PLA-004 Version 1

AD8 MAORY Risk Analysis Plan
E-MAO-000-INA-RRR-001 Version 1

AD9 CAD 135139 Nasmyth Platform Interfaces

2.2 Reference Documents

The following documents, of the exact version shown herein, are listed as background references only. They are not to be construed as a binding complement to the present document.

RD1 ESO PDM Document Types and Definitions
Number ESO-231062 Version 1

RD2 Systems Engineering General Requirements
ECSS-EST-10C Version 3

RD3 MAORY Management Plan
E-MAO-000-INA-PLA-001 Version 04

RD4 MAORY System Overview
E-MAO-000-INA-DER-001 Version 01

RD5 Donut: Measuring Optical Aberrations from a Single Extrafocal Image
PASP 118: 1165-1175, 2006, Tokovinin & Heathcote

RD6 LBC wavefront reconstruction software upgrade
Technical report, 17 April 2014, Stangalini, M.

RD7 Simulation of the Donut method for MAORY
Technical note, XX 2020, Rodeghiero, G.

RD8 The MICADO first light imager for ELT: cold optics instrument
Proc of SPIE, 2018, Schubert, J., et al.

RD9 MAORY System Optical Design and Analysis Report
E-MAO-SF0-INA-DER-001 Version 01

RD10 MAORY System Design Report
E-MAO-SE0-INA-DER-001 Version 1.0

RD11 MAORY System Analysis Report
E-MAO-SE0-INA-ANR-001 Version 1.0

RD12 MAORY System Interface Description Document issue 1
E-MAO-SE0-INA-ICD-001 Version 1.0

RD13 MAORY Main Structure Design Report
E-MAO-PM0-INA-DER-001 Version 1.0

RD14 PFS Hosted Metrology, ESO AIV Workshop 23 February 2021, S.Guisard et al.

RD15 MAORY AO Test Plan, version 1.0
E-MAO-PV0-NUI-PLA-001

RD16 MAORY Bill of Material Version 1.0
E-MAO-MCO-INA-BOM-001

RD17 Lab Facilities: the NIH and IAA, ESO AIV Workshop 23 February 2021, C. Dupuy

RD18 MAORY Hazard List and Analysis Version 1.0
E-MAO-000-INA-DER-001_02

RD19 Calibration Unit Design and Analysis Report Version 1D5
E-MAO-PU0-INA-DER-001_1D5

RD20 MAORY LGS WFS MAIT Plan Version 1.0
E-MAO-PL0-IPA-PLA-015_01

RD21 Test Unit Design Version 1.0
E-MAO-PV0-NUIG-DER-001_D1

RD22 The MICADO first light imager for ELT: derotator design status and prototype results,
Barboza S., et al. SPIE 2018

3. OVERVIEW

3.1 Instrument Overview

MAORY is a wide field adaptive optics system, that will serve the MICADO camera and a second instrument TBD. MAORY will take advantage of the ELT M4 adaptive mirror, which will deliver a partially corrected wavefront to the instrument.

MAORY has to provide, as already mentioned, two adaptive optics modes to support MICADO:

- MCAO mode, in which at least two deformable mirrors are conjugated to different altitudes in the atmosphere; one of these deformable mirrors is the telescope M4;
- SCAO mode, in which wavefront compensation is performed using M4 only.

The 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, implying that MAORY has to be designed for two deformable mirrors from the beginning, with one deformable mirror being possibly replaced by a rigid mirror.
The MCAO mode of MAORY is based on the use of 6 LGS. Natural guide star wavefront sensors (3 in the baseline design) are also required to complement LGS measurements.

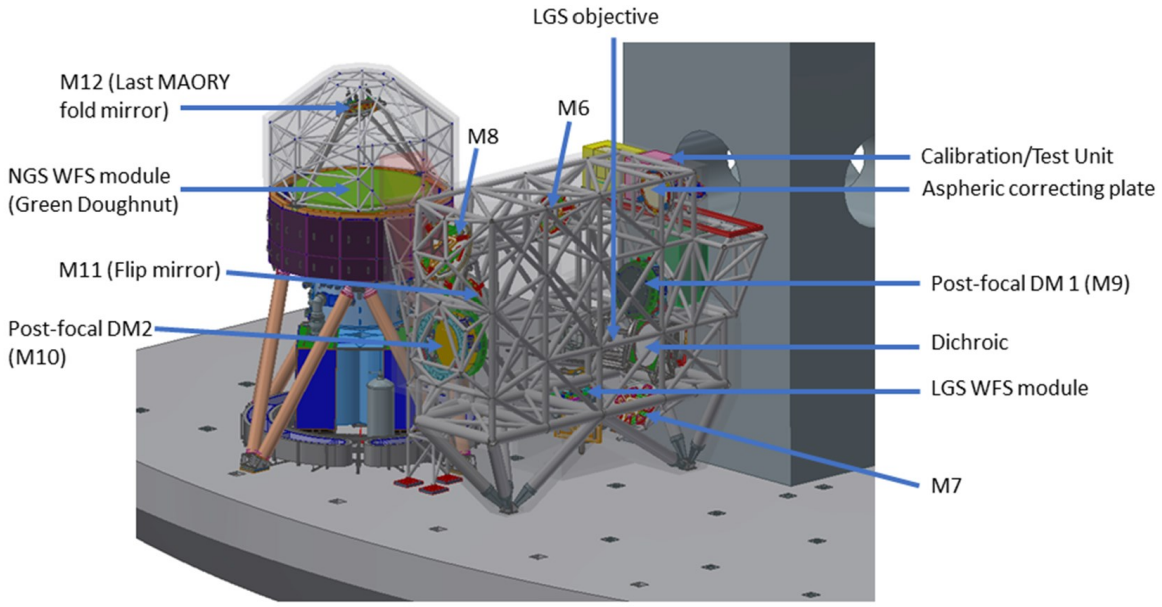


Figure 1: a 3-D view of the MAORY instrument (the thermal cover is shown in transparency) installed on the Nasmyth platform with MICADO

The NGS wavefront sensor and the last MAORY folding mirror (M12) are hosted in the same structure, the so-called Green Doughnut (GD), located above the MICADO instrument.

The MAORY main structure, holding all the opto-mechanics of the bench and the main sub-systems, is a tubular structure which is connected to the Nasmith floor with 3 legs. A thermal cover will maintain the instrument temperature stable within a certain range.

In Figure 1 there is a view of the MAORY instrument, with the main sub-systems highlighted, which will be briefly described in the following section.

3.1.1 The main MAORY sub-systems

In Figure 2 we report the instrument product tree, which identifies the main MAORY sub-systems, that we list in the following, together with the institute responsible of its design and MAIT:

- Main structure (main optical bench and supporting structure, including all the nessary HTs at sub-system level); INAF-OACN (Osservatorio Astrofisico di Capodimonte Napoli) is the responsible of this sub-system.
- Opto-mechanics (all the opto-mechanical components of the main train optical path, which is including all the optical components and their mounts and adjusting mechanism and all the HTs at sub-system level); INAF-OAB is the responsible of the opto-mechanics.
- Deformable Mirrors (two post focal DMs providing the correction of the upper part of the atmosphere, M9/DM1 convex with 1026 actuators, M10/DM2 concave with 1147 actuators); INAF-OAA is responsible of this sub-system.
- The Low Order and Reference (LOR) Module (which implements the Natural Guide Star Wavefront sensing functionalities needed by MAORY in the MCAO mode); INAF-OAA is responsible of this sub-system.
- The LGS WFS module (dedicated to the measurements of the high order wavefront aberrations using as references the laser beams provided by the telescope). IPAG is responsible of this sub-system.
- The Calibration Unit (which is a system dedicated to the MAORY calibration, equipped with light sources simulating the NGSs and LGSs); INAF OAAB ir responsible of this sub-system.
- Instrument Control SW (the SW controlling all the functions of the MAORY instrument and providing interfaces toward ELT and MICADO); INAF OAPD is responsible of such a system.
- E2E Simulation Code (a simulation tool dedicated to estimate the performance of the MCAO system); INAF OAA is responsible of such a system.
- RTC (HW and SW controlling the AO real time MAORY functions); INAF OAPD is responsible of this system.
- Instrument Control Hardware (controllers, power supplies, harnesses and other electronics components to control the MAORY instrument at system level); INAF OACN is responsible of this system.
- Thermal Control System (which provides a passive shielding of the MAORY instrument to maintain the instrument temperature stable within a certain range); INAF OAB is responsible of such a sub-system.

- Test Unit (a support equipment be used at PAE to verify the MAORY AO performances); NUIG is responsible of this sub-system.
- ESO deliverables (WFSs detectors)

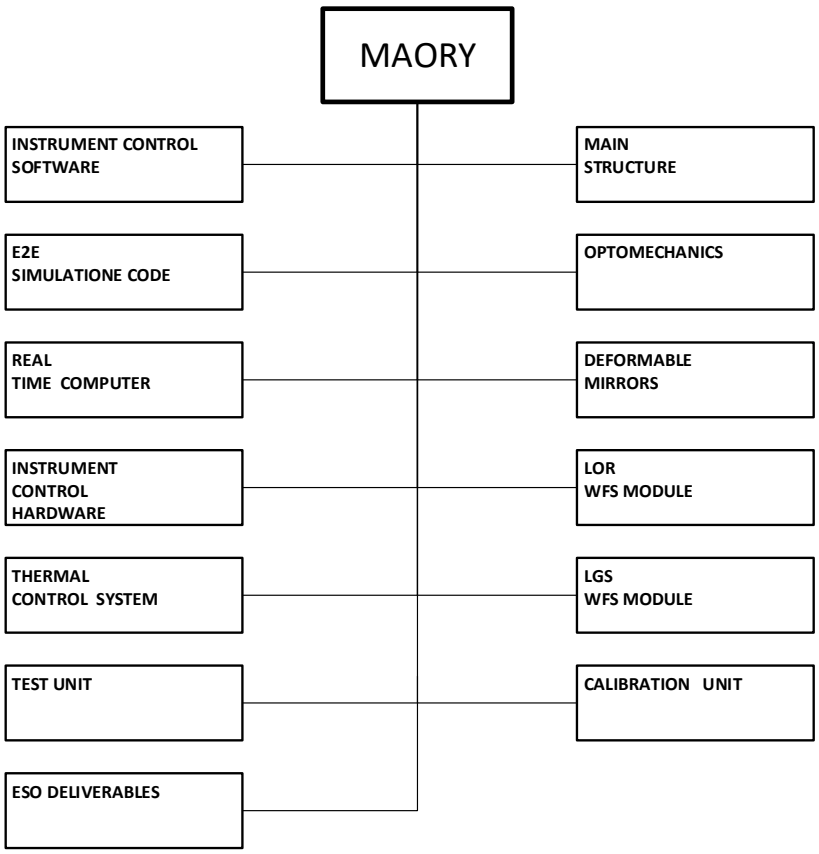


Figure 2: the MAORY instrument product tree

3.2 MAORY AIV overview and strategy

The strategy concerning the MAORY AIV at ELT is here described, and it consists of essentially 2 phases:

1. MAORY AIT in the IAA: the overall bench will be installed in the IAA without MICADO, that will be operating on sky. We will not install the MICADO Emulating Structure (MES) used in Bologna, both because of space constraints (height of the IAA hoist crane of 7.5m from the floor) and because no real advantages would come (see sec. 3.2.1). Without MICADO and the MES, the integration process will be carried on without doing the fine tuning of the Output Focal Plane (OFP) optical quality, that will be performed in the Nasmith. Thus, only functional test will be performed on the instrument at this stage, including on the LOR that will be integrated separately in the IAA assembled on a dedicated stand. At the end of this process, the MICADO Calibration Assembly (MCA) might be installed in the IAA too (preliminarily discussed with the MCA team, to be agreed), to minimize the activities to be done on the Nasmyth and to have better accessibility for the cables installation

inside the cable chain. Also in this case, just functional test will be performed (TBD with MICADO team).

2. MAORY AIV in the Nasmyth, where the instrument will possibly be transported as a whole; after the assembly operations will be concluded, and having performed the mechanical positioning of the two instruments within nominal values (MAORY wrt the PFS and MICADO wrt MAORY), the final MAORY alignment can be carried on, by optimizing the wavefront on the OFP and by aligning the pupil and the focal plane inside MICADO, using the last two flat folding mirrors of MAORY, M11 and M12 (acting on their TT motorized adjustments). Once the final alignment is achieved and the two instruments are functionally working and fully integrated, the requirements verification will be carried on (with both day-time and nigh-time testing activities).

3.2.1 MAORY AIT in the IAA overview

This document describes (foe the PDR) just the MAORY AIT activities in the Armazones IAA, with particular care to:

- the boxes unpacking activities in the Entrance Hall
- the assembly and integration phases in the IAA
- the instrument functional test
- the preparation of the instrument for its transportation from the IAA to the Nasmith platform

Due to the limited height of the IAA (7.5m below the crane hoist), the MICADO Emulating System (MES, ~8m height) cannot be installed there, and thus the activities to be performed in the IAA will be:

- Assembly and Integration of the MSS, with functional test at sub-systems and system level
- Assembly and integration of the LOR WFS stand-alone, with functional test at sub-systems level

Although the installation of the MES would allow to fine tune the optical quality of the instrument by using M12 and the Test and Alignment Camera (TAC), we underline that the operation of lifting the bench to the Nasmyth platform would anyhow require such operation to be repeated there, moreover having available MICADO for the first time.

Even though the IAA height may allow (discussions ongoing about increasing the hoist crane height) to install the MES, we do consider that no additional benefit may come from the possible installation of the MES since:

- the operation of lifting the bench to the Nasmyth platform would anyhow require such operation to be repeated there
- independently from the previous item, the optical quality optimization must anyhow be performed with MICADO, being the first time the two instrument will operate together, and thus the first time to check all the related procedures

We briefly introduce the MAORY AI procedure, which is based on these main steps:

1. Main Support Structure (MSS) installation; discussions are on-going with ESO on the possibility to use the same Nasmyth Interface Platform (NIP) that we will use in Europe, for the time being we assume to install it.
2. MSS population with all the opto-mechanics and references for the LT alignment (mainly the Input Focal Plane - IFP, materialized through some SMRs positioned on a plane). Before installing the opto-mechanics, the MSS will be characterized, measuring all the interfaces wrt the MSS legs interfaces, in a way to verify that they are within an accuracy smaller than +/-100μm wrt the nominal ones. Also, the Main Support Structure (MSS) internal Laser Trackers (LTs) will be installed. We recall that three (3) LTs are installed inside the MSS structure, in strategic positions to target all the opto-mechanics and the IFP.
3. Opto-mechanics alignment (using the LTs) to their nominal position (wrt Input Focal Plane (IFP) SMRs), within the accuracy specified by the optical tolerance analysis. We recall that all the opto-mechanics and the IFP flange are equipped with minimum 3 SMRs, properly characterized wrt the optical element data.
4. Electronics Cabinets installation and cables routing and plugging.
5. LOR and LOR electronics integration and functional test, on a stand positioned in a dedicated area of the IAA.
6. Functional test at sub-systems/system level
7. MCA installation on the MSS with cables routing and functional test (TBD with MICADO; since a final decision concerning where to assemble and integrate the MCA has not been taken, for the moment we do not describe this activity between the IAA ones).

Once the functional test will be over, the instrument will be prepared for its transportation to the Nasmyth. We are studying the possibility to use the same NIP as a transporter, lifting it up with the whole bench and positioning 4 low profiles carts below it, but this study will be carried on during the FDR phase.

3.2.2 MAORY AIV in the Nasmyth platform - overview

TBD for FDR in collaboration with MICADO AIV team.

4. MANAGEMENT

In this section, the management of the AIT at Armazones is described.

4.1 Tasks

The main task that will have to be performed are:

- MAORY shipping arrival
- IAA facility preparation
- Boxes transportation from the storage area to the Entrance Hall and unpacking operations
- AIT tools/handlings/Support equipment un packing and preparation
- MSS and LOR assembly
- Opto-mechanics assembly and integration on the MSS
- Electronics and SW integration
- Cables and pipes routing
- LOR integration and functional test
- MAORY functional test
- Micado Calibration Assembly (MCA) assembly, integration and functional test (to be discussed and agreed with MICADO team)
- MSS and LOR transportation to the Nasmith preparation

4.2 Inputs

The inputs for the realization of the AIT plan in Chile are coming from the following applicable documents:

- AD2 MAORY (E-ELT MCAO) Statement of Work
  ESO-257875 Version 1
- AD3 MAORY (E-ELT MCAO) Technical Specification
  ESO-254311 Version 1
- AD4 Common Requirements for E-ELT Instruments
  ESO-254547 Version 2
- AD5 Common ICD between the E-ELT Nasmyth Instruments and the Rest of the E-ELT System
  ESO-253082 Version 4.1

and from the following reference documents (some of them being the documents reporting the flow-down of the requirements contained in the applicable documents just mentioned):

- RD10 MAORY System Design Report
  E-MAO-SE0-INA-DER-001 Version 1.0
- RD11 MAORY System Analysis Report
  E-MAO-SE0-INA-ANR-001_01 Version 1.0
- RD12 MAORY System Interface Description Document
  E-MAO-SE0-INA-ICD-001_01 Version 1.0
- RD9 System Optical Design and Analysis Report
  E_MAO-SF0-INA-DER-001 Version 0.1
- RD13 Main Structure Design Report Version 1.0
  E-MAO-PM0-INA-DER-001
- RD14 PFS Hosted Metrology, ESO AIV Workshop 23 February 2021, S.Guisard et al.
- RD17 Lab Facilities: the NIH and IAA, ESO AIV Workshop 23 February 2021, C. Dupuy

4.3 Outputs

The output for the PDR and FDR will be the “On site AIT plan” documents.

The output of the system AIT phase at Armazones will be the MAORY bench and the LOR sub-systems fully integrated and functionally tested, ready to be moved to the Nasmyth platform.

4.4 AIV organization and responsibilities

This section will detail the organizational issue related to the AIV activities to be performed at Armazones. It has to be discussed and agreed with ESO.

We assume that logistics for the personnel accommodation, meals and transportation from Paranal to Armazones back and forth is organized by ESO. We also assume that, knowing our team, the “asador”, for the Sunday barbecue, will double, if not triple, the amount of grilled meat.

We assume that safety equipment (jackets, helmets, safety shoes, …) will be provided by ESO (TBD).

For the AIT activities, we foresee that ESO will make available workpower to support some operations, detailed in sec. 4.7.

We strongly suggest a few organizational rules:

- The MAORY team will prepare in advance the “Run schedule of activities”, to be exchanged with ESO prior to the arrival to Armazones, in a way that activities to be performed and workpower request can be organized in advance
- At every AIT run beginning, a meeting should be held between the MAORY AIT team and the ELT AIT responsible assigned to the MAORY operations, in a way to further discuss together the activities to be performed in that run and possible problems coming from unexpected telescope related activities
- Every morning prior to activities start, a short meeting between the MAORY AIT team and the ELT AIT responsible assigned to the MAORY operations should be held, to plan and discuss the daily programmed activities to be performed
- Every run will have a designated “MAORY Run responsible” taken from the team, and every day will have a MAORY daily activities responsible designated from the team present on that run

Communications between the ESO responsible assigned to MAORY for that run and the MAORY designated responsible will necessarily happen at least two times per day, before activities start and after activities conclusion, to report improvements/delays/problems encountered/special needs on both sides.

A daily report will be prepared every evening by the MAORY daily activities responsible, to be sent to a distribution list to be agreed upon.

Priority has always to be given to the ELT related activities, above all if not planned and problems-related. Also, priority has always to be given to the operations related with the nights observations and instrument preparation for science operations.

4.4.1 AIV activities

Both the run activities and the daily activities will be organized by goals to be achieved.

The MAORY daily activity responsible will organize the logistics of the activities to be performed, in agreement with the ESO responsible assigned to MAORY. The necessary HTs/SEQs needed for the daily operations and the sequence of operations shall be planned in advance (accordingly to the AIT plan and to the “Run schedule of activities”).

The MAORY team will carry to Armazones all the HTs and SEQs necessary to accomplish the AIT operations, including special size scissor lifts. Occasionally, there might be the need to use Scissor lifts/Cherry Pickers/Portable cranes in use to the IAA, for which dedicated special requests shall be done in advance.

A policy for the normal mechanical tools to be used for the daily AIT activities shall be agreed with ESO.

To Be Further detailed for FDR.

4.5 AIV activities schedule

TBD for FDR.

Still, we assume that the weekly calendar adopted will be the one already used by the ESPRESSO team in Paranal, which is:

Monday: one day after Asado

Tuesday: two days after Asado

Wednesday: three days after Asado

Thursday: three days from Asado

Friday: two days from Asado

Saturday: one day from Asado

Sunday: Asado day!

4.6 Resources (FTEs)

Personnel involved in the system AIV process in the IAA and FTEs will be provided at FDR

4.7 ESO staff involvement

For the AIT activities in the IAA, we foresee that ESO will make available workpower to support the operations of:

- Transportation of the boxes from the storage area to the Entrance Hall
- Box opening and inspection
- Transportation of the MAORY parts/sub-assemblies/sub-systems from the entrance hall to the IAA
- Overhead crane operations
- MSS installation and positioning
- LOR installation and positioning
- Electronic cabinets and cables installation
- SW and networking installation
- Unforeseen operations to be performed in the electrical, optical and/or mechanical workshops
- Emergency safety operations for the personnel (first aid)
- Instrument transportation from the IAA to the Nasmyth.

When the activities will be organized in runs, proper planning for the necessary FTEs in each run activity will be possible.

4.8 Instrument handover to ESO

The handover of MAORY to ESO will require, in addition to all the inherent manuals (operation manual, maintenance manual, …) dedicated training to ESO personnel both at sub-systems and at system level.

This section will be further detailed upon ESO guidelines for FDR.

4.9 Safety

Every new person arriving at Paranal/Armazones will have to undergo a safety training course.

We envisage that daily activities will be supervised from an ESO safety manager, which should also be informed of the run and daily activities foreseen.

Safety during AIT/V is considered of very high importance by the MAORY team. Regular safety briefings will be conducted at the start of each working day/main task, coordinated by the on-site ESO safety responsible. Attendance of safety meeting by the team, local support staff, and safety responsible is mandatory prior to any major activity which every team member will be strongly requested to stick to and follow local safety rules related to:

1. “Safety Introduction course” completed.

2. Wear the proper safety equipment in line with their activities and corresponding working area.

3. Follow instructions when using or being close to special hoisting, lifting, handling tools.

4. Follow instructions when using or being close to light sources, in particular high power Mid Infra-Red laser sources.

5. Follow instructions when using or being close to cryogenic equipment, in particular Liquid Nitrogen cooling systems.

6. Follow instructions when using or being close to electric equipment/line and in particular when working on device/rack with line voltage circuits.

In particular, we identify the following safety related issues, that will further be addressed before FDR in the RAMS DOC (RD18), here reported in arbitrary order:

• Electro Static Discharge – ESD wrist straps

• Eye protection - laser goggles, safety glasses

• Hearing protection

• Working at height – safety harness

• Hoisting, lifting and handling of heavy equipment

• Safety gloves, safety shoes & helmets

• Interlocks

• High voltage and low voltage electrical risk

• Emergency stops

• Cryo-Vacuum safety

• Harmful gasses - O2 measurements

• CE certification for handling tools

• Mental overload, stress and strain

• Operator overload – sharing responsibility during critical operations

• Fire extinguishers

• First aid kits

4.10 Shipping arrival

A responsible of the insurance company will be required to follow both the *packing operations and boxes closure operations* in Bologna and the *boxes opening operations and unpacking operations* in Chile. This would mean to open all the boxes and inspect all the goods at their arrival, operation that will take time and that would make more sense if, just after, the sub-system will be carried in the entrance hall and the assembly would start, following the foreseen sequence. This would also impose a certain priority in the box inspection sequence. This whole process will take days and it has to be properly organized with ESO.

5. FACILITY

In this section, we describe the facilities which are available in Chile at Cerro Armazones for the overall MAORY AIT activities in the IAA.

5.1 Location

Cerro Armazones is a mountain at an altitude of about 3046 metres in the central part of Chile's Atacama Desert, about 130 kilometres south of the town of Antofagasta and about 20 kilometres from Cerro Paranal

5.2 Entrance Hall

This is the area within the Auxiliary Builiding of the E-ELT Dome at Armazones where instruments will be unloaded after transportation and prepared before moving them into the clean IAA and the dome areas. Everything described in this section is coming from AD5, from which we extrapolate the main characteristics of the Entrance Hall, which are:

- The clear cross-section of the access between the outside world and the Entrance Hall shall measure at least 10m x 7.5m (wxh).
- The Entrance Hall shall be, as a minimum, 32mx10mx8m (lxwxh) in size.
- The Entrance Hall shall be equipped with an overhead travelling crane which covers the whole specified area except for the last 2.5m from the walls.
- The Entrance Hall crane shall provide two crabs with a single hook, each with a capacity of 10 tonnes, and a hoist height from the floor to 7m above floor level.
- Parallel and also independent operation of both crabs and hooks shall be possible.
- The crane shall have a load indication with a minimum accuracy of 2% of the maximum load with remote readout.
- The lateral speed shall be adjustable from 9mm/sec to 80mm/sec and will allow a minimum step of 2mm.
- The vertical speed shall be adjustable from 1mm/sec to 50mm/sec and will allow a minimum step of 0.5mm.

Services of the Entrance Hall will be:

- The Entrance Hall shall be equipped with Service Connection Points Parts A2-B-C
- The Entrance Hall shall be equipped with a hot and cold water supply
- The Entrance Hall shall be equipped with a drainage connection.
- The Entrance Hall shall be equipped with two standard compressed air supply points.
- The Entrance Hall shall be equipped with 15x 230V (16A) electrical sockets.
- The Entrance Hall shall be equipped with 8x RJ45 outlets.
- The illumination level of the Entrance Hall shall be 500 Lux.

5.3 Instrumentation Assembly Area (IAA)

This is the area within the Auxiliary Building of the E-ELT Dome at Armazones where an instrument can be assembled and test before integration on the Telescope. This area includes:

- instrument assembly area
- instrument assembly area auxiliary room
- instrument electronics maintenance area

The auxiliary room will house the instrument control electronics and test equipment during integration and test.

Also in this case, everything described in this section is coming from AD5, from which we extrapolate the main characteristics of the Entrance Hall, which are:

- The Instrumentation Assembly Area shall be connected to the Entrance Hall via an access path having a clear cross-section of at least 10x7.5m (wxh).
- The Instrumentation Assembly Area shall be connected to the Instrument Assembly Area Auxiliary Room via an access path having a clear cross-section of at least 2x2.5m (wxh).
- The Instrumentation Assembly Area shall be connected to the Instrument Electronics Maintenance Area via an access path having a clear cross-section of at least 2x2.5m (wxh).
- The volume available to instruments within the Instrumentation Assembly Area shall be, as a minimum, 22x10x8m (lxwxh) in size.
- The floor of the Instrumentation Assembly Area shall be capable of transiting a forklift class FL6 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1
- The floor loading capacity of the Instrumentation Assembly Area shall be classed as Category E2 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1
- The instrument assembly area shall be equipped to reach ISO class 8 (100,000) cleanliness.
- The Instrumentation Assembly Area Auxiliary Room shall be, as a minimum, 6x5x3m (wxlxh) in size.
- The Instrumentation Electronics Maintenance Area shall have a floor area of at least 30 square metres.

Handling Equipment available in the IAA are:

- The Instrumentation Assembly Area shall be equipped with an overhead travelling crane which covers the whole specified area except for the last 2.5m from the walls.
- The Instrumentation Assembly Area crane shall provide a bridge crane with two hooks, each with a capacity of 12 tonnes, and a hoist height from the floor to 7.5m above floor level.
- The lateral speed shall be adjustable from 9mm/sec to 80mm/sec and will allow a minimum step of 2mm.

- The vertical speed shall be adjustable from 1mm/sec to 50mm/sec and will allow a minimum step of 0.5mm.

Services of the IAA are:

- The Instrumentation Assembly Area shall be equipped with 2 Service Connection Points Parts A2-B-C
- The Instrumentation Assembly Area shall be equipped with a supply of cryogenic fluids
- The Instrumentation Assembly Area shall be equipped with a hot and cold water supply and drainage connection.
- The Instrumentation Assembly Area shall be equipped with two standard compressed air supply points.
- The Instrumentation Assembly Area shall be equipped with 15 x 230V (16A) electrical sockets, 5 x 230V (16A) Safety Power Sockets and 5 x 400V (32A/phase) electrical sockets.
- The Instrumentation Assembly Area shall be equipped with 2x telephone sockets.
- The Instrumentation Assembly Area shall be equipped with 8x RJ45 outlets.
- The illumination level of the Instrumentation Assembly Area shall be 750 Lux.
- The Instrumentation Electronics Maintenance Area shall be equipped with a Service Connection Point Parts A2-B-C

5.4 Cleanliness

As already mentioned, the IAA shall be equipped to reach ISO class 8 (100,000) cleanliness.

5.5 Storage

In RD17 a few storage locations have been mentioned, which are:

- Coudé rooms till arrival of first Coudé Instrument
- 2 rooms in the telescope pier
- Outside temporary solutions with containers/tents, located in the parking lot

6. HANDLING TOOLS

Table 1 gives a complete overview of all Handling Tools in the univocal device code RD16 that are needed during the system AIT activities in the IAA.

Table 1: list of the handling tools to be used during MAORY AIT

Handling Device code	Description	Notes
SM0-HT-01	IAA overhead crane with 2 hooks (12T max load each)	Patent needed to operate it Helmet and safety shoes required CE required
SM0-HT-02	Movable Jib Crane (1T max load)	Helmet and safety shoes required CE required
SM0-HT-03	Fork Lift (5T max load)	Patent needed to operate it Helmet and safety shoes required CE required
SM0-HT-04	Trans Pallet (1T max load)	Safety shoes required CE required
SM0-HT-05	Entrance Hall overhead crane (10T max load)	Patent needed to operate it Helmet and safety shoes required CE required
SM0-HT-PFK	Schmidt-Plate Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PFA	M6 Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PFB	M7 Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PFC	M8 Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PDA	DM1 Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PDB	DM2 Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PFD_CRANE	Dichroic Assembly and Maintenance Handling Tool to lift up the dichroic	Helmet and safety shoes required

SM0-HT-PFD_BENCH	Dichroic Assembly and Maintenance Handling Tool to make the dichroic sliding into the MSS and to finely position it against its interface points on MSS.	Helmet and safety shoes required
SM0-HT-PFE	M11 Assembly and Maintenance Handling Tool	Helmet and safety shoes required
SM0-HT-PFG_CRANE	LGS Fold Mirror 1 Assembly and Maintenance Handling Tool to lift up the mirror	Helmet and safety shoes required
SM0-HT-PFG_BENCH	LGS Fold Mirror 1 Assembly and Maintenance Handling Tool to make the mirror sliding into the MSS and to finely position it against its interface points on MSS.	Helmet and safety shoes required
SM0-HT-PFH_CRANE	LGS-Objective Assembly and Maintenance Handling Tool to lift it up	Helmet and safety shoes required
SM0-HT-PFH_BENCH	LGS-Objective Assembly and Maintenance Handling Tool to make it sliding into the MSS and to finely position it against its interface points on MSS.	Helmet and safety shoes required
SM0-HT-PFL	LGS Fold Mirror 3 Assembly and Maintenance Handling Tool to lift up the mirror	Helmet and safety shoes required

6.1 M6 Assembly and maintenance Handling Tool (SM0-HT-PFA)

Purpose and functionality

The SM0-HT-PFA has the purpose to perform the assembly of M6 on the MSS. It is equipped with a sliding hoisting point to balance the overall system with and without M6.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

It is a C-shaped handling. This handling shape allows to interface the crane hook along the projection of the barycentre of M6 + handling. The position of the crane hook hoisting hole with the handling can be finely adjusted as it is mounted on a rail, actuated by an endless screw.

This latter part will be modified in favour of movable masses connected to the handling, keeping the hoist ring fixed. All the images of the handling does not represent this modification yet, still showing the sliding hoist ring.

This is useful when M6 is disconnected from the handling, as the barycentre of the system will move.

In this case, before disconnecting the handling and after M6 is secured to its supporting structure inside MAORY main structure, it is possible to shift the hook hoisting hole to the position where the stand-alone handling would be balanced. In this way, when the

handling is disconnected from M6, it will stay well balanced, avoiding dangerous oscillations that could damage the mirror.

At M6 side, the C-shaped handling is constituted by 2 main parts: a fixed part and a movable one. The latter is physically screwed to the 3 branches embracing M6 through six M8 screws (2 per branch), and it is interfaced to the handling fixed part through a heim joint, that allows adjusting its position in 3 DoFs.

The handling can be interfaced to M6 with the mirror protecting cover in place.

3 threaded rods screwed to the fixed part of the handling and pushing on the movable part allow to fine adjust the tip-tilt of M6 during the installation phase. One of the threaded rods is inserted in a small pit in the movable part, to prevent rotation of the mirror around its optical axis.

The handling is designed to keep the mirror with an orientation very close to the one it will have when mounted into MSS. This allows to perform only small mirror position adjustment at the moment of interfacing M6 to its supporting structure inside the MSS.

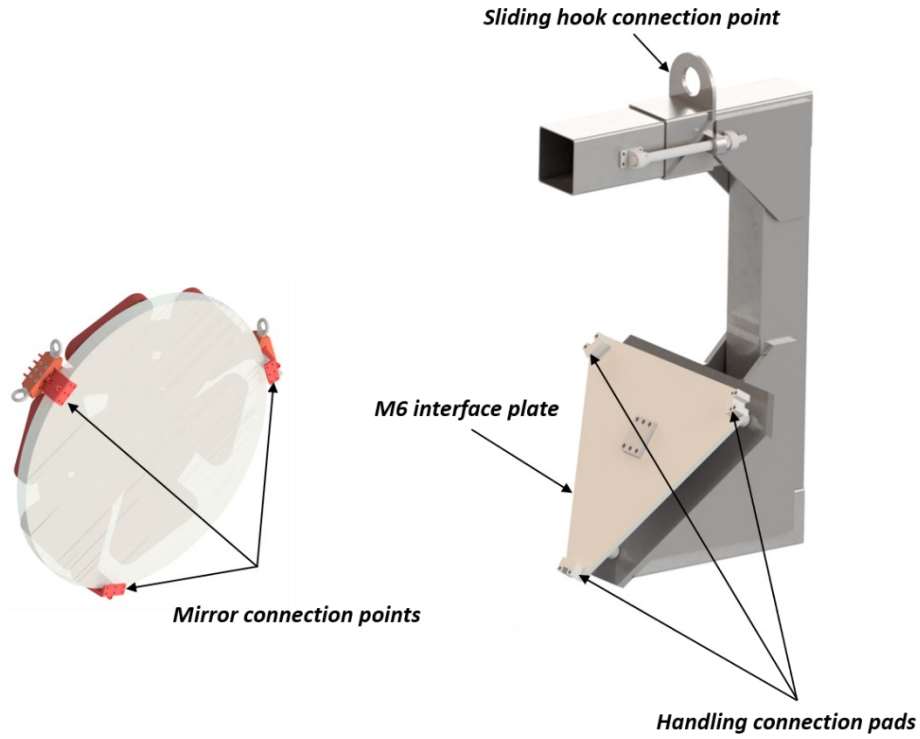


Figure 3: C-shaped handling for M6 installation. The interface between M6 and the handling is between the 3 branches embracing M6 and the 3 connection pads of the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when M6 is connected and disconnected.

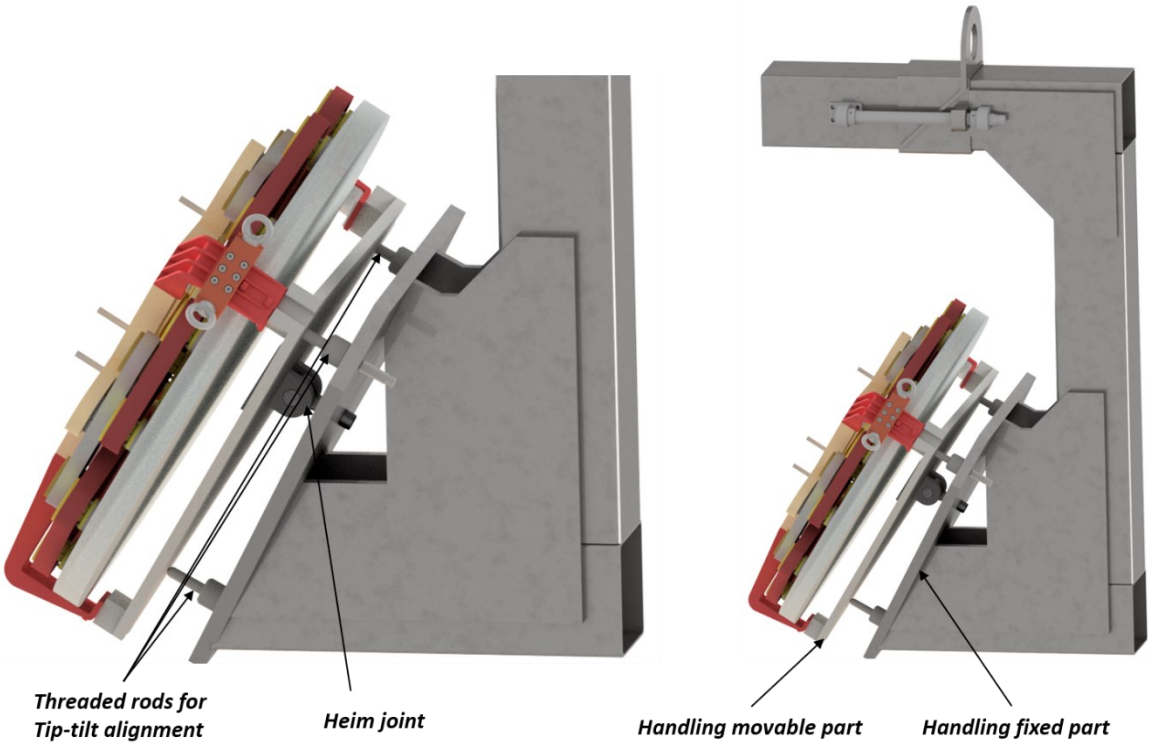


Figure 4: the handling allows to fine adjust tip-tilt of the mirror before installation, thanks to a heim joint and 3 threaded rods pushing against the movable part of the handling.

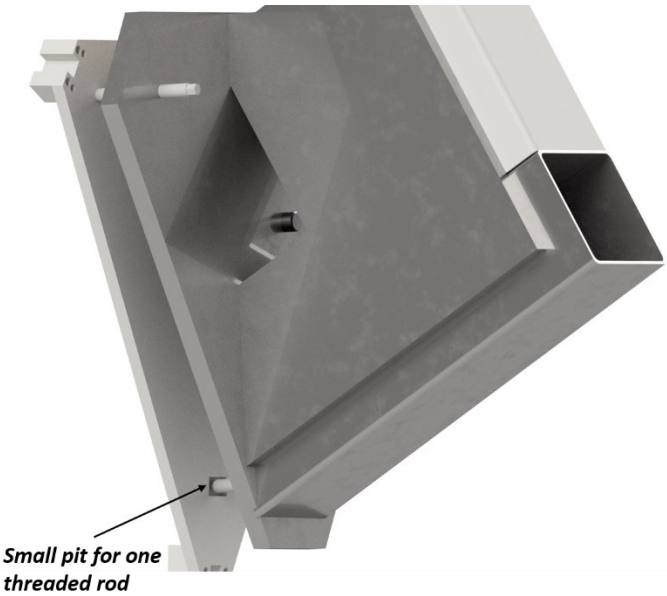


Figure 5: one of the threaded rods allowing tip-tilting of the handling movable part is inserted into a small pit in the movable part, to prevent its rotation around the mirror optical axis.

Way to be operated/procedure

The SM0-HT-PFA must be operated in the following way:

- The cover of M6 must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFA handling/movement
- The internal ladders, platform and security harnesses to access M6 on the MSS must be in place

The hoist point on SM0-HT-PFA has to be connected to the crane hook, then the approaches M6 and connects to the fixation points on the mirror opto-mech.. Some bars positioned on M6 branches can be used to ease and guide SM0-HT-PFA approach to M6.

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFA is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFA is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFA must be operated in the following way:

- The cover of M6 must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFA handling/movement
- The scaffolding or security harnesses to access M6 on the bench must be in place
- The platform allowing to reach M6 area on the bench structure must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but mirror destruction in case of mis-handling

6.2 M7 Assembly and Maintenance Handling Tool (SM0-HT-PFB)

Purpose and functionality

The SM0-HT-PFB has the purpose to perform the assembly of M7 on the MSS. It is equipped with a fixed hoist ring for the crane hook. Since M7 installation occurs from the top of the MSS, but it is positioned at the bottom, to avoid a very long handling it has been designed to access inside the MSS together with the MSS. This results in a compact handling, but for balancing reasons it must have counterweights, in order to keep the handling hoist ring always “visible” from the crane hook, without colliding with any beam of the MSS.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

It is a quite stubby C-shaped handling. This handling shape allows to interface the crane hook along the projection of the barycentre of M7 + handling. The position of the crane hook hoisting hole cannot be adjusted, but to keep the system balanced both when M7 is connected and not, a system of sliding counterweights will be used. These are installed on a M30 threaded rod passing through the middle of the long beam of the handling. Two nuts allow to tune the position of the masses on the rod, shifting accordingly the barycentre of the system.

This is useful when M7 is disconnected from the handling, as the barycentre of the system will move.

The rest of the handling is conceptually identical to what described for M7, with the only obvious exception of the handling total dimensions and mirror interface.

At M7 side, the C-shaped handling is constituted by 2 main parts: a fixed part and a movable one. The latter is physically screwed to the 3 branches embracing M7 through six M8 screws (2 per branch), and it is interfaced to the handling fixed part through a heim joint, that allows adjusting its position in 3 DoFs.

The handling can be interfaced to M7 with the mirror protecting cover in place.

3 threaded rods screwed to the fixed part of the handling and pushing on the movable part allow to fine adjust the tip-tilt of M7 during the installation phase. One of the threaded rods is inserted in a small pit in the movable part, to prevent rotation of the mirror around its optical axis.

The handling is designed to keep the mirror with an orientation very close to the one it will have when mounted into MSS. This allows to perform only small mirror position adjustment at the moment of interfacing M7 to its supporting structure inside the MSS.

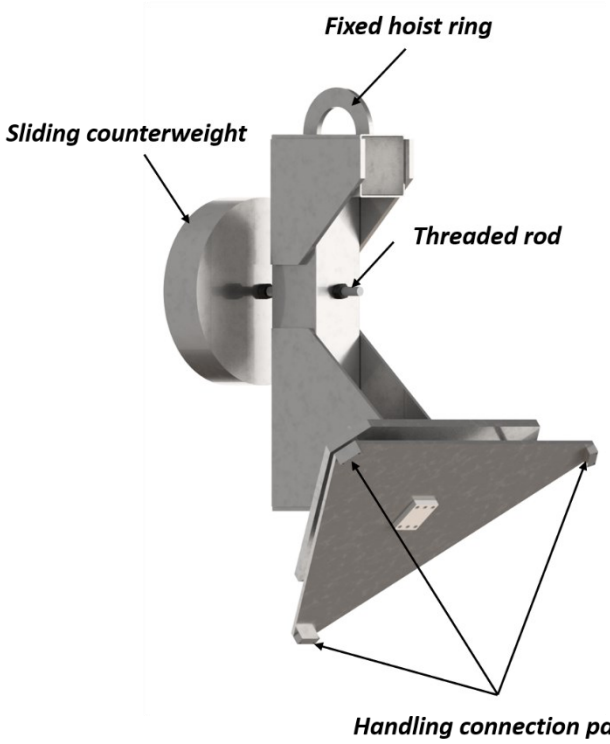


Figure 6: C-shaped handling for M7 installation. The interface between M7and the handling is between the 3 branches embracing M7 and the 3 connection pads of the handling. The handling is equipped with a fixed hoist ring and movable counterweight to tune the position of the barycentre.

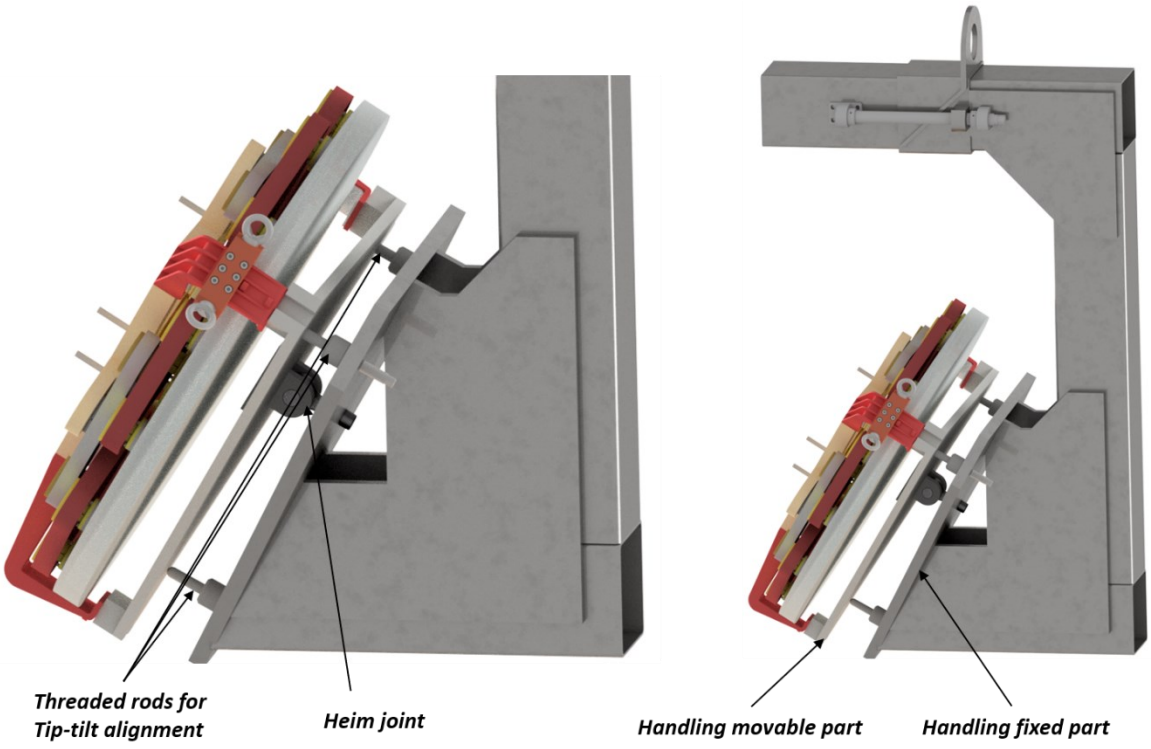


Figure 7: the handling allows to fine adjust tip-tilt of the mirror before installation, thanks to a heim joint and 3 threaded rods pushing against the movable part of the handling.

Way to be operated/procedure

The SM0-HT-PFB must be operated in the following way:

- The cover of M7 must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFB handling/movement

The hoist point on SM0-HT-PFB has to be connected to the crane hook, then the approaches M7 and connects to the fixation points on the mirror opto-mech. Some bars positioned on M7 branches can be used to ease and guide SM0-HT-PFB approach to M7.

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFB is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFB is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFB must be operated in the following way:

- The cover of M7 must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFB handling/movement
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator
- The crane shall always hold all the weight, also during the shift of the counterweights

No Major Hazards have been identified, but mirror destruction in case of mis-handling

6.3 M8, M9, M10, Dichroic, 1st folding mirror LGSO Assembly and maintenance Handling Tool (SM0-HT-PFC, SM0-HT-PDA, SM0-HT-PDB, SM0-HT-PFD_CRANE, SM0-HT-PFG_CRANE)

Purpose and functionality

These handling are conceptually all the same, and basically identical to the handling shown for M6, differing only for their overall dimensions. They have the purpose to perform the assembly of M8, M9, M10, dichroic and 1st folding mirror LGSO in the MSS. They are equipped with a sliding hoisting point to balance the overall system with and without the mirrors.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

They are all C-shaped handlings. The handling shape allows to interface the crane hook along the projection of the barycentre of the mirror + handling. The position of the crane hook hoisting hole with the handling can be finely adjusted as it is mounted on a rail, actuated by an endless screw.

This latter part will be modified in favour of movable masses connected to the handling, keeping the hoist ring fixed. All the images of the handling does not represent this modification yet, still showing the sliding hoist ring (see Figure 8**).**

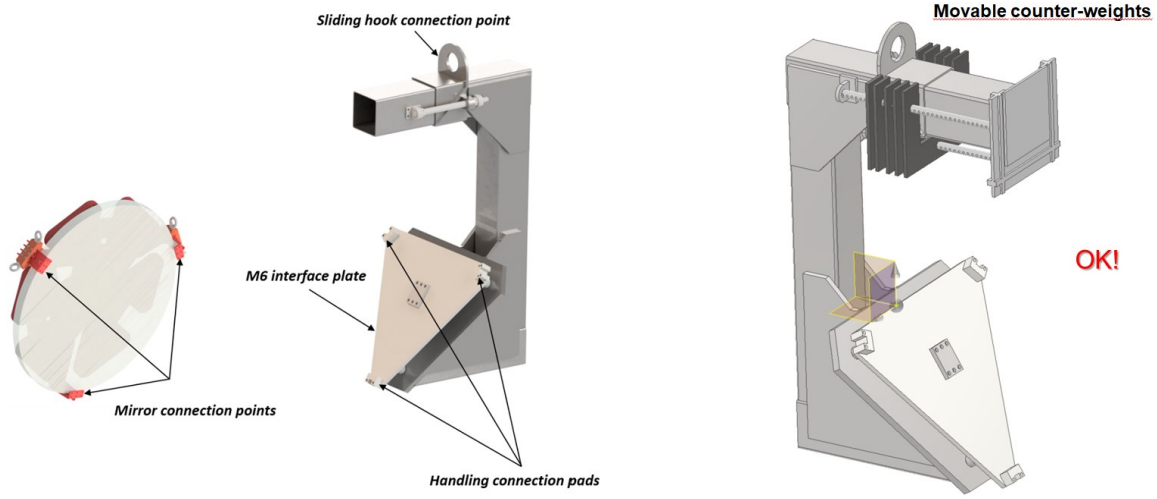


Figure 8: The M6 handling properly modified to have movable counter-weights (right image) wrt to the sliding hook shown in the left image.

This is useful when the mirrors are disconnected from the handling, as the barycentre of the system will move.

In this case, before disconnecting the handling and after the mirrors are secured to their supporting structure inside MSS, it is possible to shift the hook hoisting hole to the position

where the stand-alone handling would be balanced. In this way, when the handling is disconnected from the mirrors, it will stay well balanced, avoiding dangerous oscillations that could damage the mirror.

At mirror side, the C-shaped handling is constituted by 2 main parts: a fixed part and a movable one. The latter is physically screwed to the 3 branches embracing M8 through six M8 screws (2 per branch), and it is interfaced to the handling fixed part through a heim joint, that allows adjusting its position in 3 DoFs.

The handling can be interfaced to the mirrors with the mirror protecting cover in place.

3 threaded rods screwed to the fixed part of the handling and pushing on the movable part allow to fine adjust the tip-tilt of the mirrors during the installation phase. One of the threaded rods is inserted in a small pit in the movable part, to prevent rotation of the mirror around its optical axis.

The handlings are designed to keep the mirrors with an orientation very close to the one they will have when mounted into MSS. This allows to perform only small mirror position adjustment at the moment of interfacing the mirrors to their supporting structure inside the MSS.

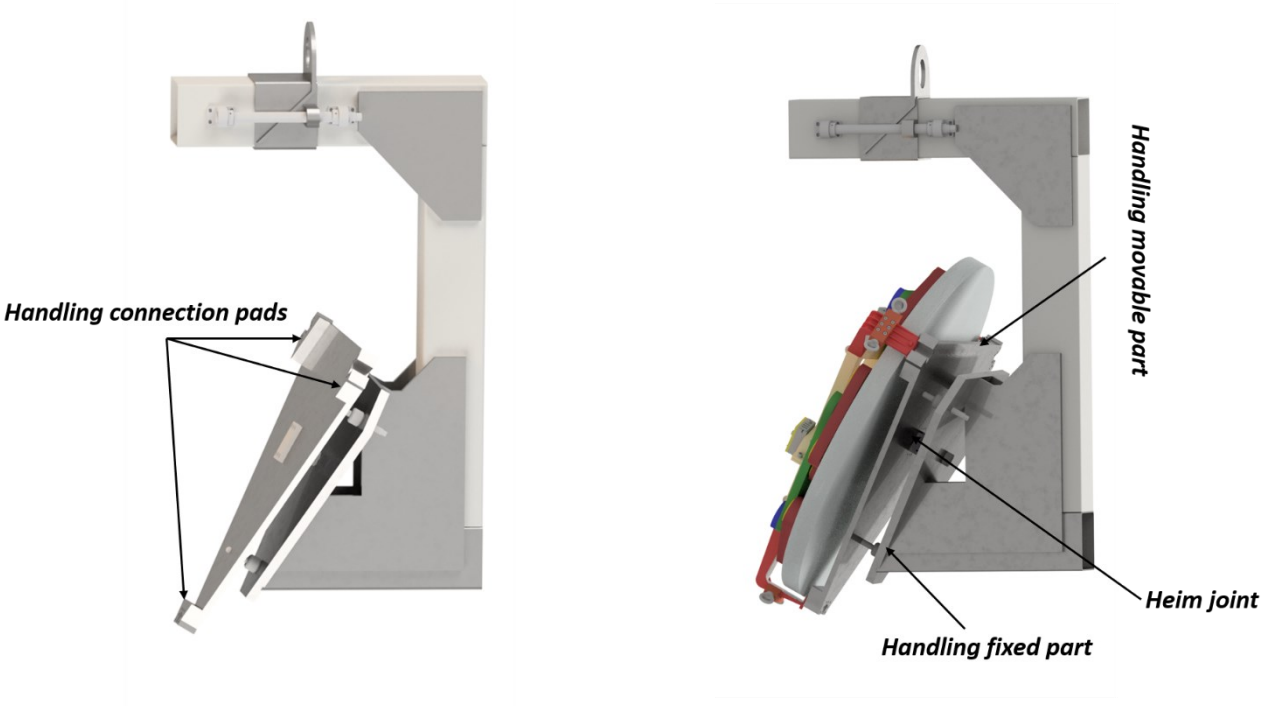


Figure 9: C-shaped handling for M8 installation. The interface between M8 and the handling is between the 3 branches embracing M8 and the 3 connection pads of the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when M8 is connected and disconnected.

Figure 10: C-shaped handling for M9 installation. The interface between M9 and the handling is between the 3 pads at the front flange (in green) and the 3 connection pads of the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when M9 is connected and disconnected.

Figure 11: C-shaped handling for M10 installation. The interface between M10 and the handling is between the 3 pads at the front flange (in green) and the 3 connection pads of the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when M9 is connected and disconnected.

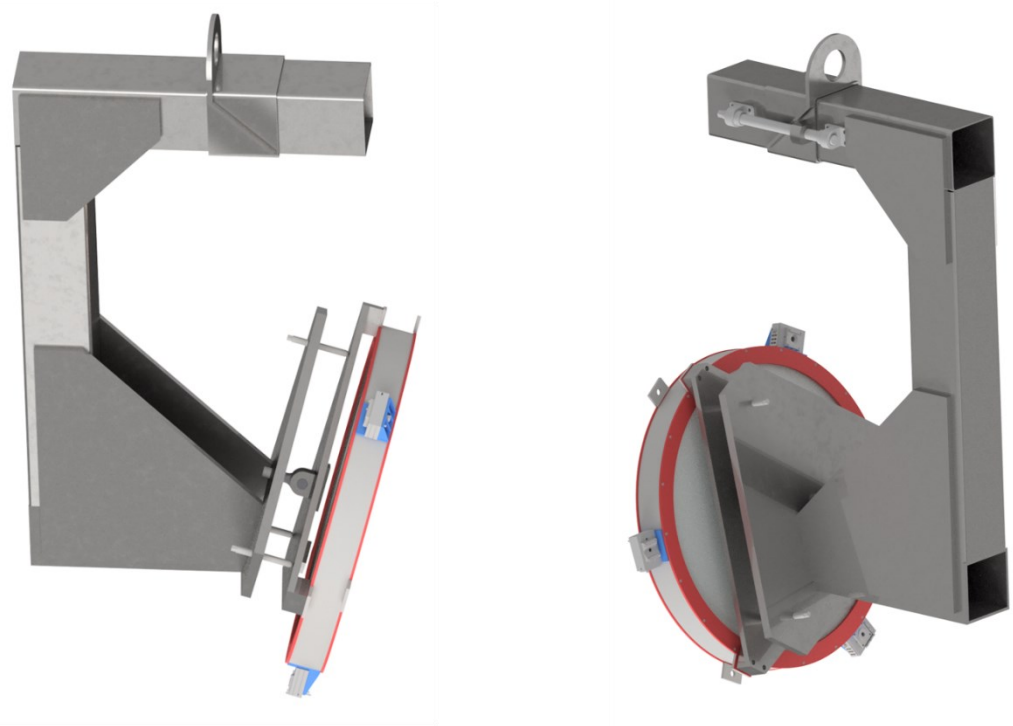


Figure 12: C-shaped handling for dichroic installation. The interface between dichroic and the handling is between the 3 pads at the front flange and the 3 connection pads of the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when the dichroic is connected and disconnected.

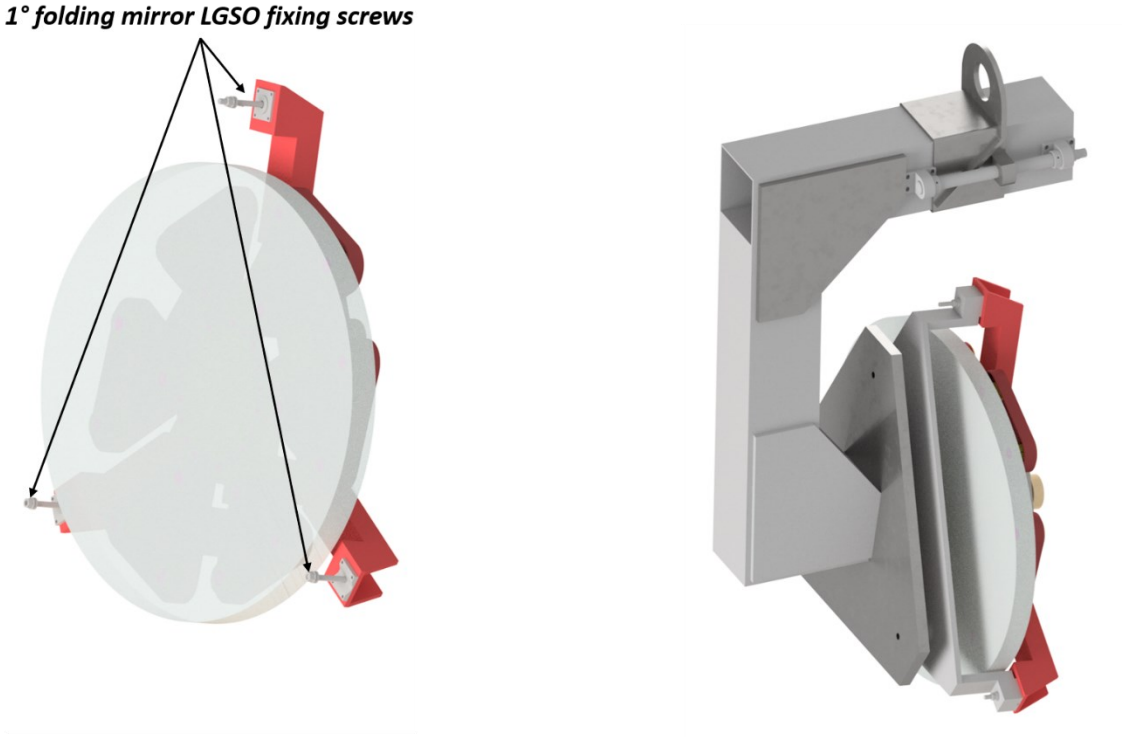


Figure 13: C-shaped handling for 1st folding mirror LGSO installation. The interface between the mirror and the handling is between the 3 branches, which are also the interface of the mirror to its supporting structure inside the MSS, and the 3 connection pads of the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when the mirror is connected and disconnected.

Way to be operated/procedure

All these handlings must be operated in the following way:

- The cover of the corresponding mirrors must be installed
- A minimum of 2 persons plus the crane operator are necessary for mirror installation inside the MSS
- The internal ladders, platform and security harnesses to access mirrors in the MSS must be in place

The hoist point on the handlings has to be connected to the crane hook, then the handling approaches the mirror and connects to the fixation points on the mirror opto-mech. Some bars positioned on the opto-mech branches can be used to ease and guide the handlings approaching the relative mirrors.

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

SM0-HT-PFC, SM0-HT-PDA, SM0-HT-PDB, SM0-HT-PFD_CRANE and SM0-HT-PFG_CRANE are needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

SM0-HT-PFC, SM0-HT-PDA, SM0-HT-PDB, SM0-HT-PFD_CRANE and SM0-HT-PFG_CRANE are deliverables to Chile, where they have to be stored to be used for maintenance.

Hazard and Safety issues

The handlings must be operated in the following way:

- The mirror protection covers must be installed
- A minimum of 2 persons plus the crane operator are necessary for the mirror installation in the MSS
- The temporary platform/scissor lift and internal ladders allowing to reach the mirrors area inside and outside the MSS must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but mirrors destruction in case of mis-handling

6.4 M11 Assembly and maintenance Handling Tool (SM0-HT-PFE)

Purpose and functionality

The SM0-HT-PFE has the purpose to perform the assembly of M11 in the MSS. It is equipped with a sliding hoisting point to balance the overall system with and without M11.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

It is a C-shaped handling. This handling shape allows to interface the crane hook along the projection of the barycentre of M11 + handling. The position of the crane hook hoisting hole with the handling can be finely adjusted as it is mounted on a rail, actuated by an endless screw.

This latter part will be modified in favour of movable masses connected to the handling, keeping the hoist ring fixed. All the images of the handling does not represent this modification yet, still showing the sliding hoist ring.

This is useful when M11 is disconnected from the handling, as the barycentre of the system will move.

In this case, before disconnecting the handling and after M8 is secured to its supporting structure inside MAORY main structure, it is possible to shift the hook hoisting hole to the position where the stand-alone handling would be balanced. In this way, when the handling is disconnected from M11, it will stay well balanced, avoiding dangerous oscillations that could damage the mirror.

The opto-mech of M11 is interfaced to MSS in a different way from all the other mirrors, as this is a steering mirror. Thus, also the handling interfaces are different. The handling fixed part is identical to the other C-shaped handlings described till now, with an addition of two plates hosting two other threaded rods acting on the rotation of the mirror. The movable part is still connected to the fixed part through a heim joint, but the interface with the mirror is a kind of a fork entering into some slots in the mirror opto-mech.

3 threaded rods screwed to the fixed part of the handling and pushing on the back movable part allow to fine adjust the tip-tilt of M11 during the installation phase, while two additional rods pushing on the side of the movable part allow to fine adjust the rotation of M11.

The handling is designed to keep the mirror with an orientation very close to the one it will have when mounted into MSS. This allows to perform only small mirror position adjustment at the moment of interfacing M1 to its supporting structure inside the MSS.

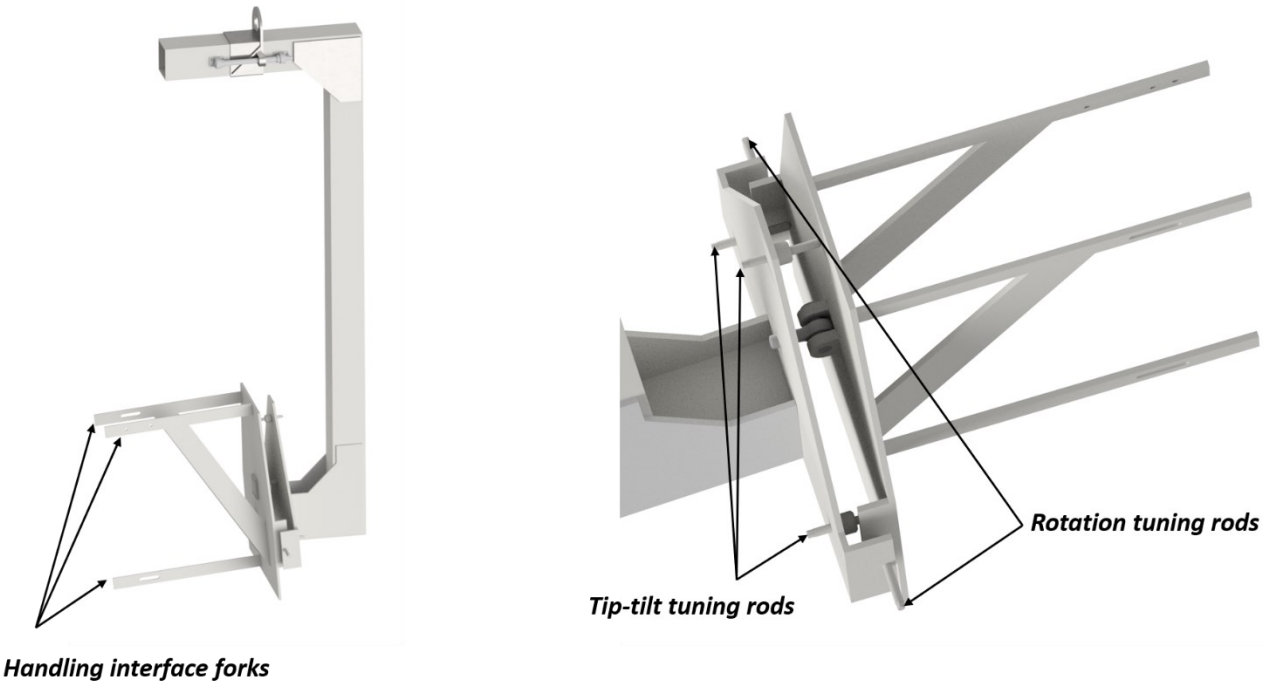


Figure 14: C-shaped handling for M11 installation. The interface between M11 and the handling is between the 3 forks shown here and 3 slots in the mirror opto-mech. This handling allows to control also the rotation of the mirror, using two additional threaded rods acting on the side of the handling movable part. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when M11 is connected and disconnected.

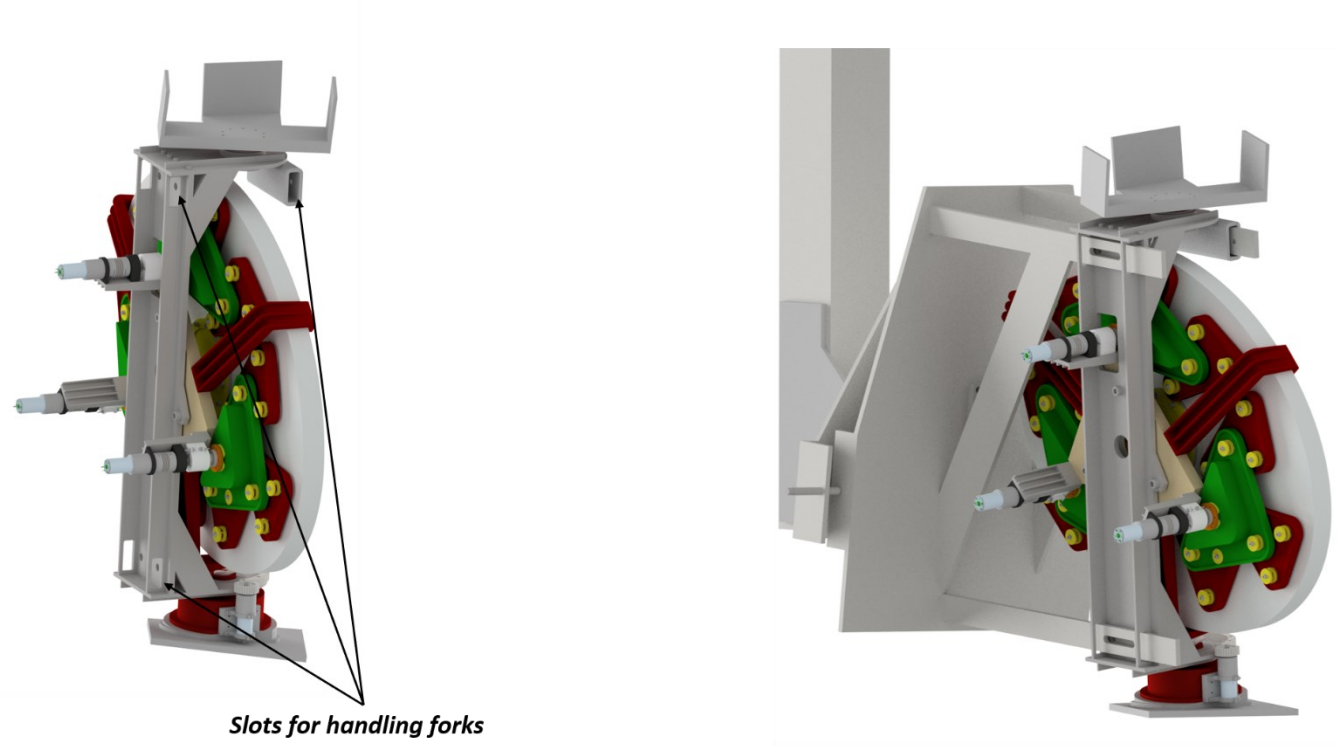


Figure 15: the M11 opto-mech is equipped with 3 slots for the handling forks. Each fork is secured using two M8 screws.

Way to be operated/procedure

The SM0-HT-PFE must be operated in the following way:

- The cover of M11 must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFE handling/movement
- The internal ladders, platform and security harnesses to access M11 on the MSS must be in place

The hoist point on SM0-HT-PFE has to be connected to the crane hook, then the approaches M11 and connects to the fixation points on the mirror opto-mech. Some bars positioned on M11 branches can be used to ease and guide SM0-HT-PFE approach to M11.

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFE is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFE is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFE must be operated in the following way:

- The cover of M11 must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFE handling/movement
- The scaffolding or security harnesses to access M11 on the bench must be in place
- The platform allowing to reach M11 area in the MSS must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but mirror destruction in case of mis-handling

Perchè c'è sia 6.5 che 6.6?

6.5 Corrective Plate assembly and maintenance Handling Tool (SM0-HT-PFK)

Purpose and functionality

The SM0-HT-PFK has the purpose to perform the assembly of the corrective plate in the MSS. It is equipped with a sliding hoisting point to balance the overall system with and without the corrective plate.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

It is basically a simplified and light-weighted C-shaped handling. This handling shape allows to interface the crane hook along the projection of the barycentre of the corrective

plate + handling. The position of the crane hook hoisting hole with the handling can be finely adjusted as it is mounted on a rail, actuated by an endless screw.

This latter part will be modified in favour of movable masses connected to the handling, keeping the hoist ring fixed. All the images of the handling does not represent this modification yet, still showing the sliding hoist ring.

This is useful when the corrective plate is disconnected from the handling, as the barycentre of the system will move.

In this case, before disconnecting the handling and after the corrective plate is secured to its supporting structure inside MAORY main structure, it is possible to shift the hook hoisting hole to the position where the stand-alone handling would be balanced. In this way, when the handling is disconnected from the corrective plate, it will stay well balanced, avoiding dangerous oscillations that could damage the mirror.

The corrective plate will be mounted with the optical axis perpendicular to the gravity vector, so for its installation we do not devise the need of having a movable part on the handling, allowing to fine tune the tip-tilt position of the plate during the installation. The handling is thus constituted only by a fixed part, interfacing the corrective plate through three pads spaced by 120 degrees. One M8 screw passing through each pad is screwed to a threaded hole on a pad lacated on the corrective plate opto-mech.

The handling can be interfaced to the corrective plate with the mirror protecting cover in place.

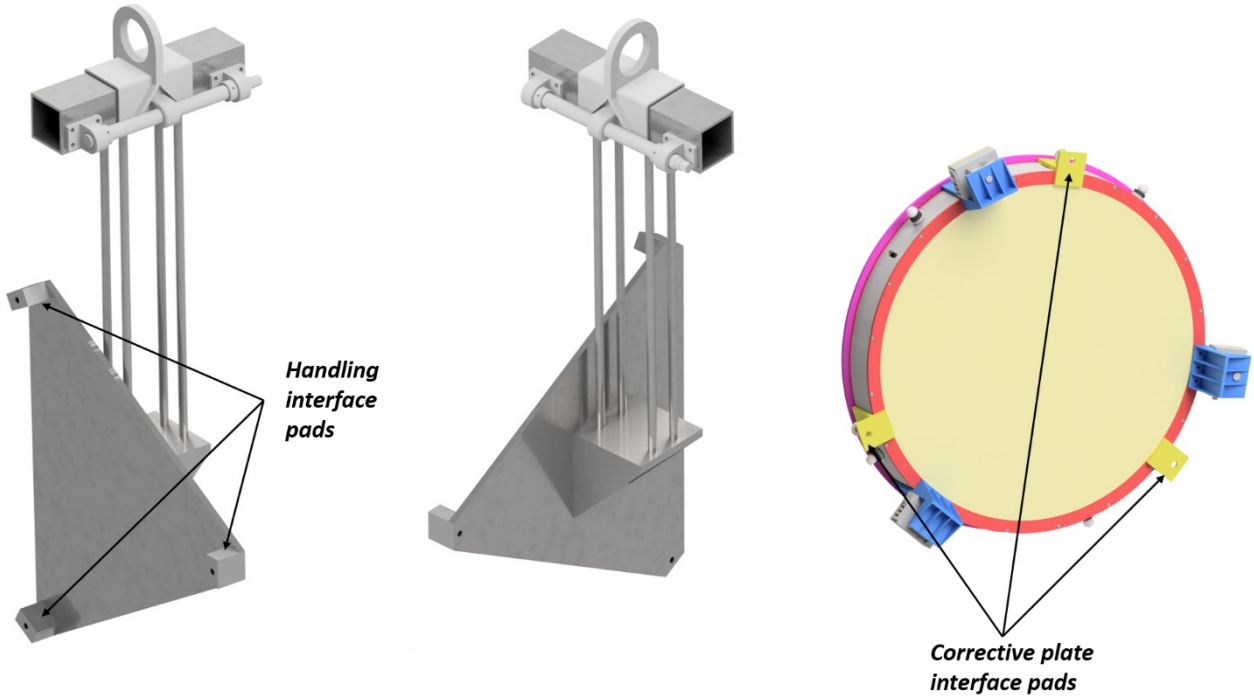


Figure 16: C-shaped handling for corrective plate installation. The interface between the corrective plate and the handling is between the 3 pads on the handling. The handling is equipped with a hook hoisting connection point having the possibility to slide, in order to have it aligned with the barycentre of the system both when M6 is connected and disconnected.

Way to be operated/procedure

The SM0-HT-PFK must be operated in the following way:

- The cover of the corrective plate must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFK handling/movement
- The internal ladders, platform and security harnesses to access the corrective plate on the MSS must be in place

The hoist point on SM0-HT-PFK has to be connected to the crane hook, then the approaches the corrective plate and connects to the fixation points on the mirror opto-mech.

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFK is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFK is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFK must be operated in the following way:

- The cover of the corrective plate must be installed
- A minimum of 2 persons plus the crane operator are necessary for the SM0-HT-PFK handling/movement
- The platform allowing to reach the corrective plate area on the MSS must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but mirror destruction in case of mis-handling

6.6 Corrective Plate Assembly and maintenance Handling Tool (SM0-HT-PFL)

Purpose and functionality

The SM0-HT-PFL has the purpose to perform the assembly of the third folding mirror LGSO. It has a fixed hoist point and a system of sliding counterweights to fine tune the barycentre position both when the mirror is connected and disconnected

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

The installation of FM3 LGSO happens from the side of the MSS, and since the mirror is located in the bottom part of the structure a C-shaped handling is not advisable. Due to the light weight of FM3 LGSO, the handling is basically a squared tubular beam, with interface plate to the mirror on one side and a sliding mass at the opposite side. The handling dimensions shall be kept as short as possible, to avoid mechanical interference with MICADO, which is on the same side where the installation take place. At the same time, the handling hoist point shall remain always outside the MSS. This means that the counterweights will be positioned very close to the hoist point. In order to maintain the counterweights at a reasonable mass, the interface plate with FM3 is light-weighted, but it maintains the same principle of three connection pads at 120° seen for all the other handlings. For dimensional constraints tip-tilt fine tuning mechanism has not been included to this handling, so correct inclination of the mirror shall be obtained using shims at the interface between the handling and the mirror.

The handling is secured to the mirror through one M8 screw per each pad.

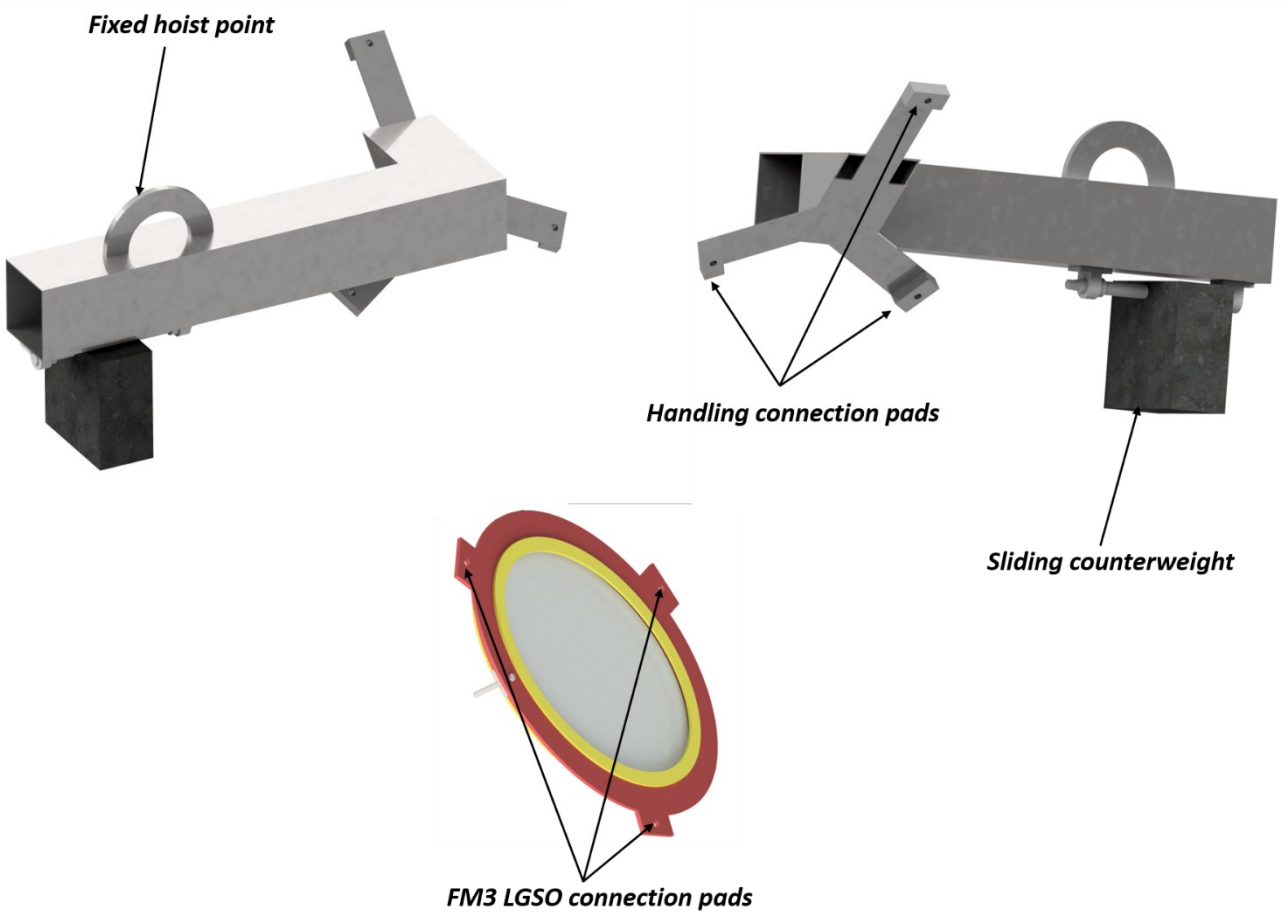


Figure 17: handling for FM3 LGSO installation. The interface between the corrective plate and the handling is between the 3 pads on the handling and the 3 pads on the opto-mech of the mirror. The handling is equipped with a fixed hook hoist point having and a sliding counterweights in order to have it aligned with the barycentre of the system both when FM3 LGSO is connected and disconnected.

Way to be operated/procedure

The SM0-HT-PFL must be operated in the following way:

- A minimum of 1 person plus the crane operator are necessary for the SM0-HT-PFL handling/movement
- The internal ladders, platform and security harnesses to access the corrective plate on the MSS must be in place

The hoist point on SM0-HT-PFL has to be connected to the crane hook, then the approaches FM3 LGSO and connects to the fixation points on the mirror opto-mech.

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFL is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFL is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFL must be operated in the following way:

- A minimum of 1 person plus the crane operator are necessary for the SM0-HT-PFL handling/movement
- The internal ladders allowing to reach the corrective plate area on the MSS must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but mirror destruction in case of mis-handling

6.7 Dichroic Assembly and maintenance Handling Tool (SM0-HT-PFD_BENCH)

Purpose and functionality

The SM0-HT-PFD_BENCH has the purpose to perform the make the dichroic slid into the MMS.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

The installation of the dichroic happens from the side of the MSS. A handling similar to what presented for FM3 LGSO would require very heavy counterweights, as the dichroic weighs much more than FM3 LGSO and still we have dimensional constraints due to the envelope allocated to the 2nd instrument. For this reason, we studied a system with a rail protruding outside the MSS and entering into it. The rail is oriented in a way that the dichroic will reach its interface points inside the MSS with the correct orientation. The rail is permanently equipped with some sliding carts, and on top of this there is the part of the handling interfacing with the dichroic. It is divided in two parts: a fixed part and a movable

one. The dichroic is mounted on the movable part, which has three pads at 120° interfacing to three pads on the dichroic opto-mech. The pads on the opto-mech are located on the opposite side to the one used to interface the dichroic to SM0-HT-PFD_CRANE. The movable part of the handling is secured to the fixed part using screws. These screws are loose, allowing the movable part to slide on the fixed part but preventing it from overturning.

The rail, in fact, bring the dichroic in front of its interface points in the MSS, but at a distance of about 15 mm, to avoid the optical surface of the dichroic being too close to mechanical parts when the handling slides on the rail. Thus, when in position, acting on some screws on the fixed part of the handling and pushing against the movable part, it is possible to push the dichroic against its interface points.

The part of the rail protruding outside the MSS lean on a beam connected to the ground. When the dichroic is secured to the handling on the rail and the handling on the crane is disengaged, the dichroic can slide inside the MSS. Some security blocks at both ends of the rail prevent the carts to slide off the rail.

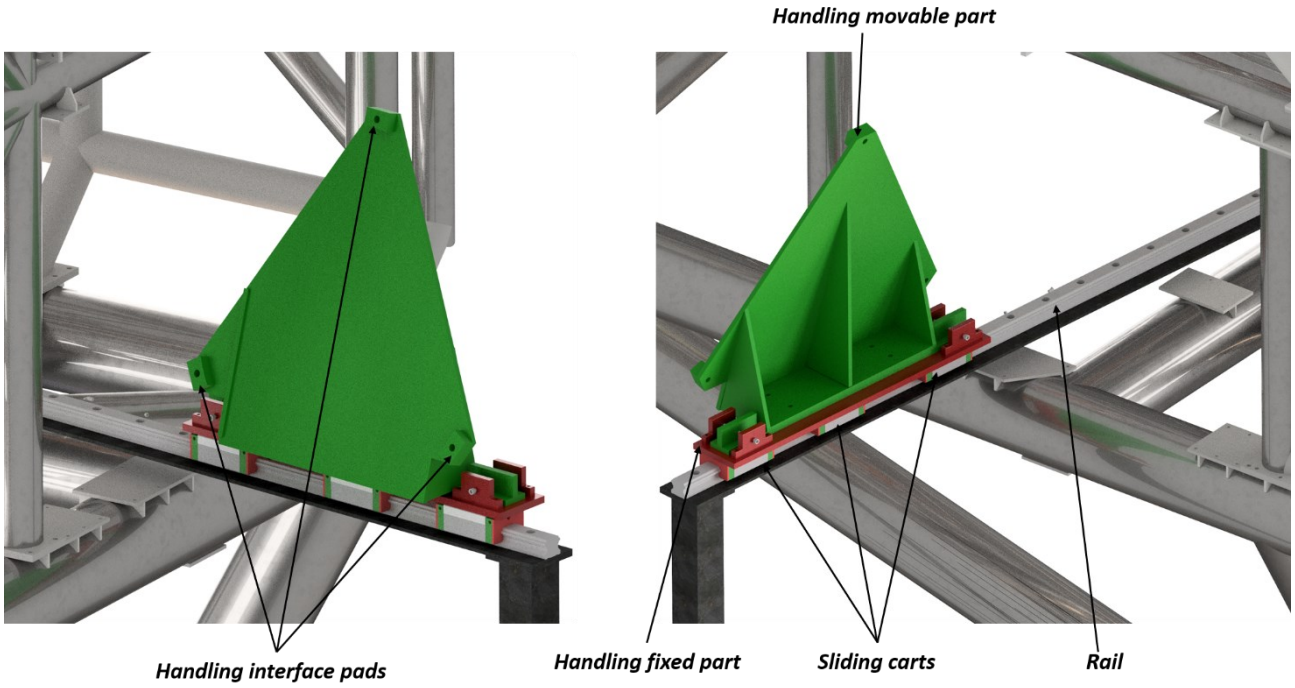


Figure 18: handling for dichroic installation. The fixed part is in red, the movable part in green

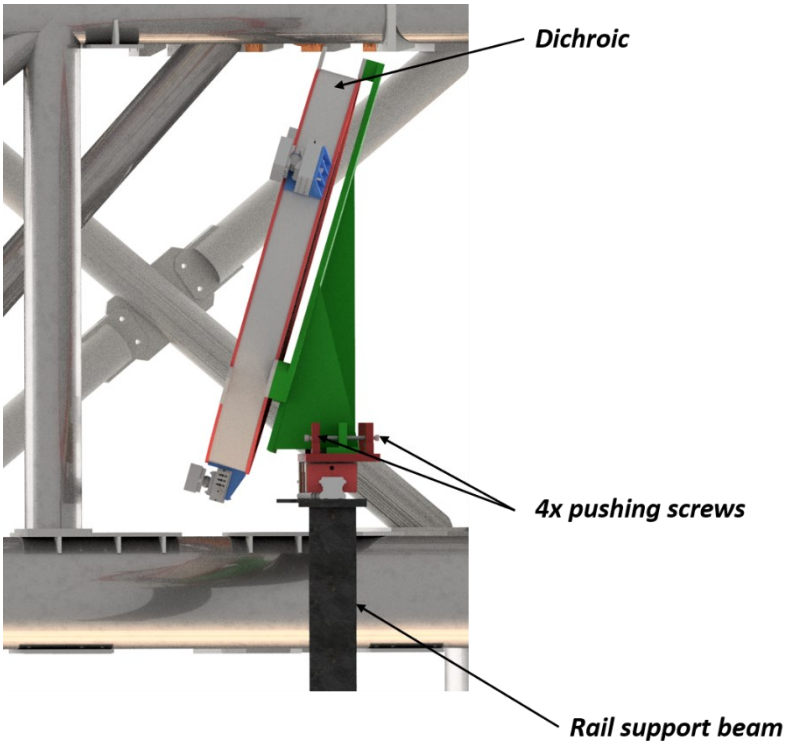


Figure 19: . Four M8 screws pushing against the movable part move it towards (or away) the dichroic interface points in the MSS

Way to be operated/procedure

The SM0-HT-PFD_BENCH must be operated in the following way:

- The cover of the dichroic must be installed
- A minimum of 2 person for the SM0-HT-PFD_BENCH handling/movement
- A small internal ladder to access the dichroic on the MSS must be in place
- Hard stop at both end of the rail must be in place
- Screws between handling movable part and fixed part inserted but not fully tightened

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFD_BENCH is needed for the assembly operations in Bologna and in Chile and for extraordinary maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFD_BENCH is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFD_BENCH must be operated in the following way:

- A minimum of 2 person are necessary for the SM0-HT-PFD_BENCH handling/movement
- The internal ladders allowing to reach the corrective plate area on the MSS must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but dichroic destruction in case of mis-handling

6.8 1st folding mirror LGSO Assembly and maintenance Handling Tool (SM0-HT-PFG_BENCH)

Purpose and functionality

The SM0-HT-PFG_BENCH has the purpose to perform the make the 1st folding mirror LGSO slid into the MMS.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

The installation of the 1st folding mirror LGSO (FM1 LGSO) happens from the side of the MSS. The concept and the reasons for this handling are the same described for the SM0-HT-PFD_BENCH. The rail is oriented in a way that the FM1 LGSO will reach its interface points inside the MSS with the correct orientation. The rail is permanently equipped with some sliding carts, and on top of this there is the part of the handling interfacing with the dichroic. It is divided in two parts: a fixed part and a movable one. The FM1 LGSO is mounted on the movable part, which has three pads at 120° interfacing to three pads on the dichroic opto-mech. The pads on the opto-mech are located on the opposite side to the one used to interface the FM1 LGSO to SM0-HT-PFG_CRANE. The movable part of the handling is secured to the fixed part using screws. These screws are loose, allowing the movable part to slide on the fixed part but preventing it from overturning.

The rail, in fact, bring the FM1 LGSO in front of its interface points in the MSS, but at a distance of about 15 mm, to avoid the optical surface of the dichroic being too close to mechanical parts when the handling slides on the rail. Thus, when in position, acting on

some screws on the fixed part of the handling and pushing against the movable part, it is possible to push the FM1 LGSO against its interface points.

The part of the rail protruding outside the MSS lean on a beam connected to the ground. When the FM1 LGSO is secured to the handling on the rail and the handling on the crane is disengaged, the FM1 LGSO can slide inside the MSS. Some security blocks at both ends of the rail prevent the carts to slide off the rail.

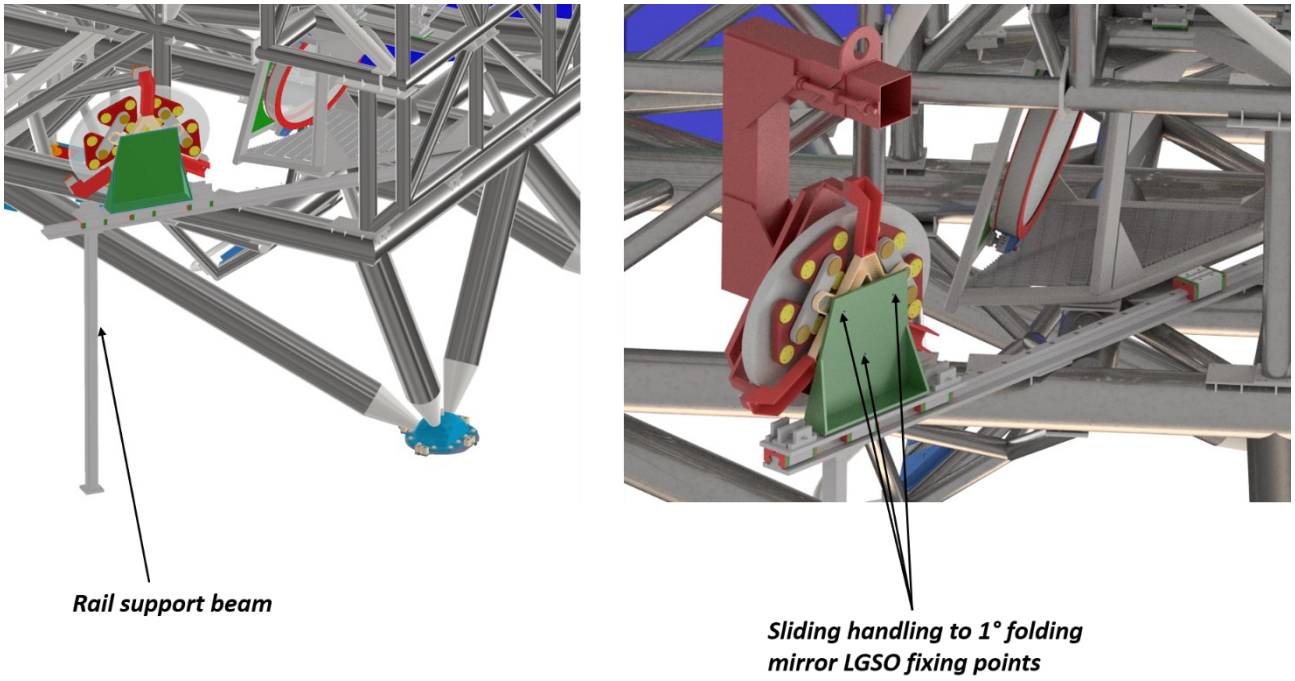


Figure 20: handling for FM1 LGSO installation.

Way to be operated/procedure

The SM0-HT-PFG_BENCH must be operated in the following way:

- The cover of the FM1 LGSO must be installed
- A minimum of 2 person for the SM0-HT-PFG_BENCH handling/movement
- A small internal ladder to access the FM1 LGSO on the MSS must be in place
- Hard stop at both end of the rail must be in place
- Screws between handling movable part and fixed part inserted but not fully tightened

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFG_BENCH is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFG_BENCH is a deliverable to Chile, where it has to be stored to be used for maintenance.

Hazard and Safety issues

The SM0-HT-PFG_BENCH must be operated in the following way:

- A minimum of 2 person are necessary for the SM0-HT-PFG_BENCH handling/movement
- The internal ladders allowing to reach the corrective plate area on the MSS must be in place
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but dichroic destruction in case of mis-handling

6.9 LGSO Assembly and maintenance Handling Tool (SM0-HT-PFH_CRANE)

Purpose and functionality

The SM0-HT-PFH_CRANE has the purpose to perform the lower the LGSO on the SM0-HT-PFH_BENCH.

Manufacturing

The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

Due to the shape of the LGSO, whose mechanical structure is equipped with 4 eye-bolts, this handling is basically 4 chains connected to the hook of the crane. The length of the crane must be tuned in order to keep the system balanced.

This handling is only needed to lower the LGSO on the rails of SM0-HT-PFH_BENCH, or to lift it up from the rails, in case of extraordinary maintenance.

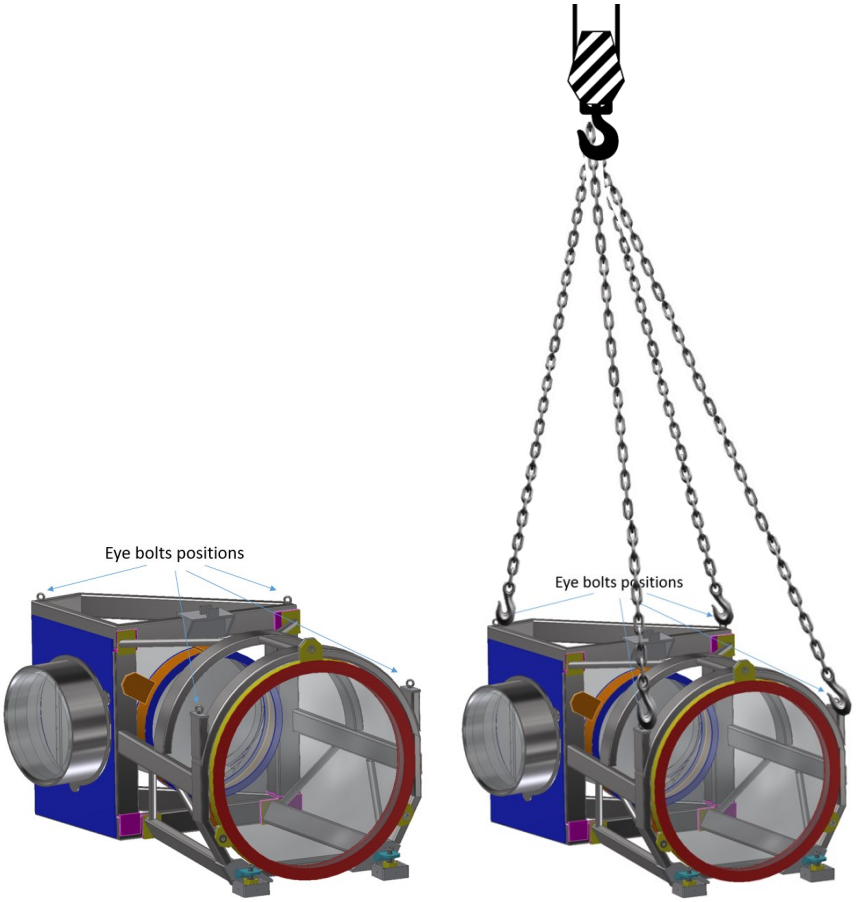


Figure 21: handling for lowering the LGSO

Way to be operated/procedure

The SM0-HT-PFH_CRANE must be operated in the following way:

- The cover of the LGSO must be installed
- The length of the chains must have been tuned to keep the system balanced
- A minimum of 1 person + the crane operator are necessary for the SM0-HT-PFH_CRANE handling/movement

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFH_CRANE is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFH_CRANE is a deliverable to Chile, where it has to be stored to be used for extraordinary maintenance.

Hazard and Safety issues

The SM0-HT-PFH_CRANE must be operated in the following way:

- A minimum of 1 person + the crane operator are necessary for the SM0-HT-PFG_BENCH handling/movement
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but LGSO damages in case of mis-handling

6.10 LGSO Assembly and maintenance Handling Tool (SM0-HT-PFH_BENCH)

Purpose and functionality

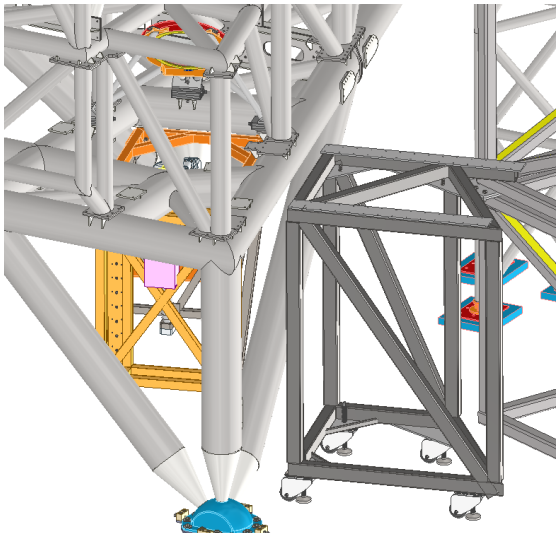
The SM0-HT-PFH_BENCH has the purpose to perform the installation of the LGSO inside the MSS.

Manufacturing

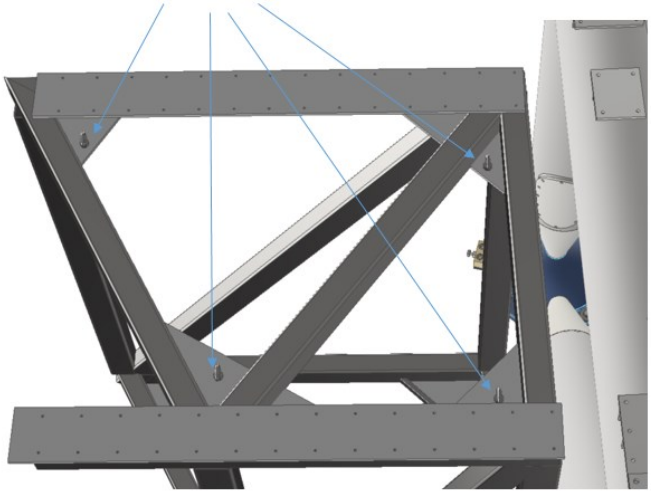
The conceptual design is done within the MAORY consortium, the final design and construction will be out-sourced to an external company.

Description

The LGSO is installed inside the MSS using a rail system, making it sliding in the MSS from the side. Part of these rails will be most likely permanently installed inside the MSS, while the part protruding outside the MSS shall be installed when needed. The rail protruding outside will lean on an external support structure placed next to the aperture in the MSS where the LGSO will enter. The supporting structure can be lowered with the crane thanks to the four eyebolt on the top part of the structure. Once the structure reaches the floor, it can be easily moved as it is equipped with four wheels and aligned to the MSS. The structure can be finally fixed to the ground lowering the feet and screwing it to the floor. On the top part of this structure the missing part of the rails can be installed and screwed by two persons, due to the small size and weight of a single rail.



Eye bolts positions



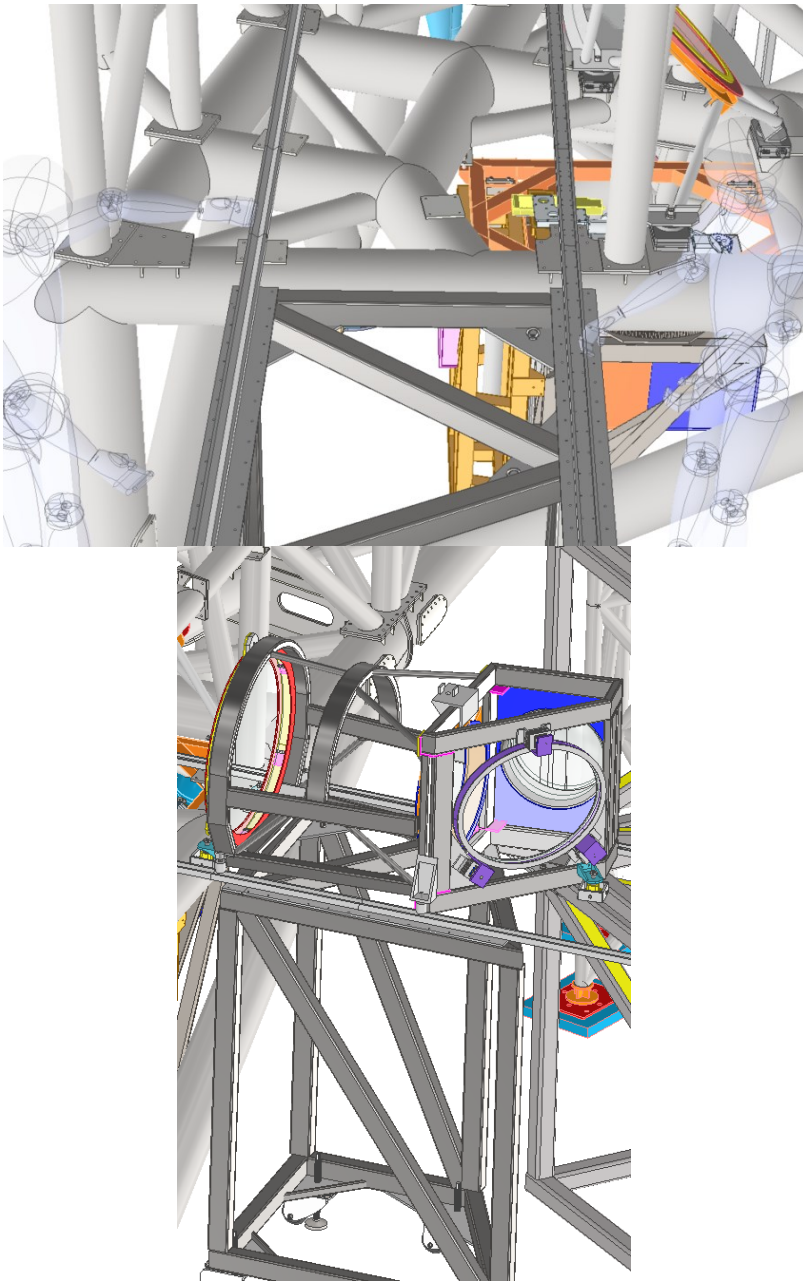


Figure 22: the handling hosting the rails for LGSO installation inside the MSS

Way to be operated/procedure

The SM0-HT-PFH_BENCH must be operated in the following way:

- The length of the chains for lowering the rails supporting structure must have been tuned to keep the system balanced

- A minimum of 1 person + the crane operator are necessary for the supporting structure movement and fixation to the ground when in position.
- Two persons are necessary to fix the rails to the supporting structure

Special tools needed

Normal mechanical workshop tools.

AIT phase when needed

The SM0-HT-PFH_BENCH is needed for the assembly operations in Bologna and in Chile and for maintenance in Chile.

Deliverable and lifetime

The SM0-HT-PFH_BENCH is a deliverable to Chile, where it has to be stored to be used for extraordinary maintenance.

Hazard and Safety issues

The SM0-HT-PFH_BENCH must be operated in the following way:

- A minimum of 1 person + the crane operator are necessary for the supporting structure handling/movement and two person for rail installation on top of the supporting structure
- Operators shall ware the helmet, safety gloves and safety shoes
- Every operator shall wear safety shoes, safety gloves and helmet
- When operating on the platform, the harness safely secured is mandatory for each operator

No Major Hazards have been identified, but mis-handling of the rails and of the supporting structure might damage the items nearby.

7. Support Equipment

In this section, we describe all the Support Equipment (SEq) needed for the AIT operations. For every SEq listed, all the relevant information should be reported, such as:

- purpose and functionality
- manufacturing
- description
- way to be operated
- special tools needed
- AIT phase when needed (handling during assembly or necessary for integration or testing or packaging or storage)
- Drawings and/or photos
- Deliverable to Bologna and/or to Chile
- Hazard and Safety issues worth to be underlined

We recall that every support equipment must be listed in the BoM and in the RAMS documents, which have to be referenced for all the issues concerning the Safety and Hazard. A reference directly here for all the support equipment is ok, even if we strongly suggest to recall the main safety and hazard issues related to each Seq also in the correspondent sub-sections describing them, as shown in sec. 0.

All the support equipment which has to be used with a crane and for moving equipment around shall have the CE certification.

7.1 IFP and alignment flange

7.1.1 Purpose and functionality

The purpose of this system is both to materialize the IFP (by the means of three SMRs representing the IFP plane and centre) and to hold a laser system, which can materialize the optical beam chief ray for alignment purposes.

7.1.2 Manufacturing

It is designed within the MAORY consortium, while the manufacturing will be outsourced.

7.1.3 AIT phase when needed

The IFP flange is needed for the alignment operations in Europe and in the IAA Chile

7.1.4 Deliverable and lifetime

The TAC is a deliverable to Bologna and Armazones, where it has to be stored for possible re-alignment operations to be performed at the telescope.

7.1.5 Hazard and Safety issues

When it is used in its alignment configuration (laser installed), protective glasses have to be worn.

7.1.6 Special tools needed

For its installation at the telescope eyebolts will be provided for the crane lifting and transportation. Otherwise, normal mechanical tools are needed.

7.1.7 Way to be operated

It will be installed instead of the Corrective Plate, using the same interface flanges on the MSS.

In its alignment configuration, the laser needs to be powered through its power supply, which must be temporarily installed in the vicinity of the flange.

7.1.8 Description

The IFP is represented through a flange (planarity < 10μm) with 3 SMRs positioned on a circle at the edge of the IFP, representing the IFP plane and centre. They will be positioned (or charatcerized) on the IFP flange by using a CMM, i.e. with an accuracy <20μm PtV wrt the flange mechanical data (radial displacement and displacement along the mechanical axis). Such a flange will be positioned on the MSS interface using 2 PINs, thus ensuring a positioning accuracy of the order of 10μm PtV.

In Figure 23 the IFP flange is shown as a separate SEq (left side) and installed at the telescope, instead of the Corrective Plate.

When it will be used in its alignment configuration, in its central part an additional system will be installed: a flange holding a manual bearing with a pass-through hole inside which a laser is positioned (see Figure 24). The laser can be aligned in orientation and the whole bearing can be centred wrt the IFP flange. In this way, with a simple laboratory setup, the laser can be aligned to be coincident with the IFP centre and perpendicular to the IFP.

The flange holding this laser system has two pins, to be precisely repositionable on the IFP flange if needed.

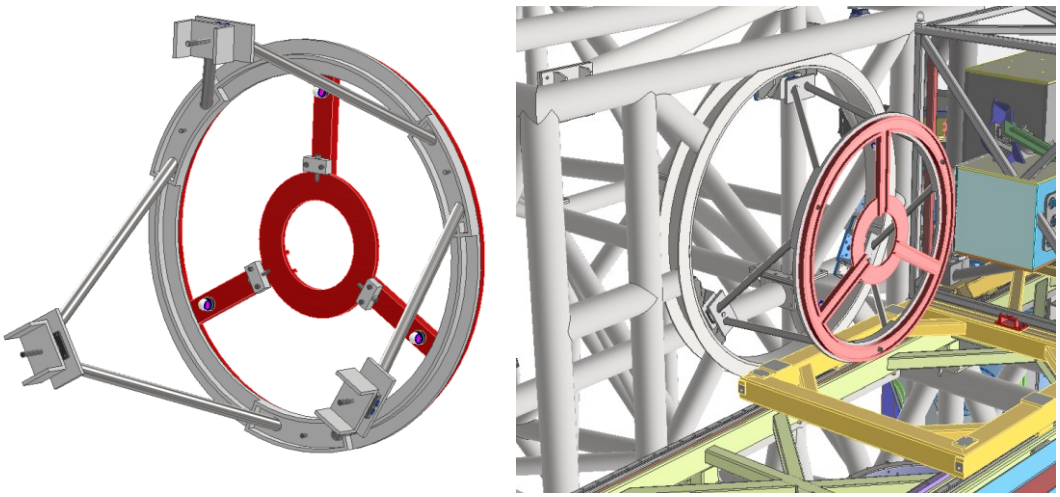


Figure 23: The IFP flange materializing the IFP

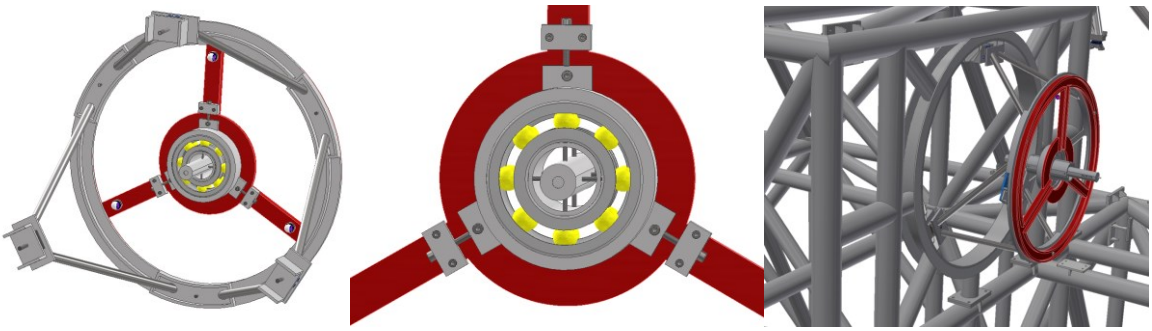


Figure 24: the IFP flange in its alignment configuration, with the laser installed.

7.2 The MSS Internal Platforms (IP)

7.2.1 Purpose and functionality

The purpose of this system is to enable accessibility to the various opto-mechanics inside the MSS structure

7.2.2 Manufacturing

The design of the MSS IP, will be performed in house, the construction will be outsourced.

7.2.3 AIT phase when needed

The bearing is required for AIT and maintenance operations in Europe and in Chile (both in the IAA and in the Nasmyth)

7.2.4 Deliverable and lifetime

The MSS IP is a deliverable to Bologna and Armazones, where it has to be stored for possible maintenance operations to be performed at the telescope.

7.2.5 Hazard and Safety issues

No particular hazards and safety issues have been identified

7.2.6 Special tools needed

For the installation of the various parts just normal mechanical tools are needed. It is planned to have the parts realized in aluminium, and thus no HTs are needed for their installation.

7.2.7 Way to be operated

During the AIT phase or for maintenance operation, the platforms will be installed at occurrence. Depending on which opto-mechanics need access, only part of the platform may be installed.

7.2.8 Description

The MSS IP is composed of small platforms and stairs/ladders which can be positioned inside the MSS having access from the lower part of the bench using a portable stairs and removing a few enclosure panels.

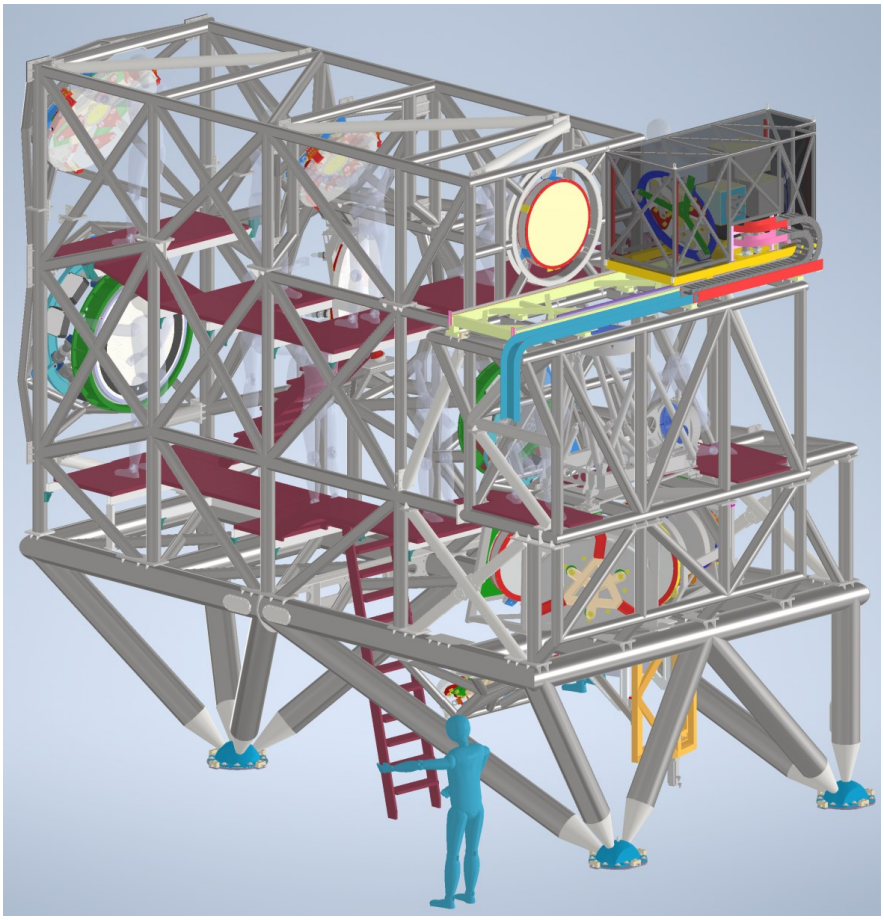


Figure 25: the MSS IP shown in violet colour

In Figure 25 and Figure 26 the MSS IP is shown.

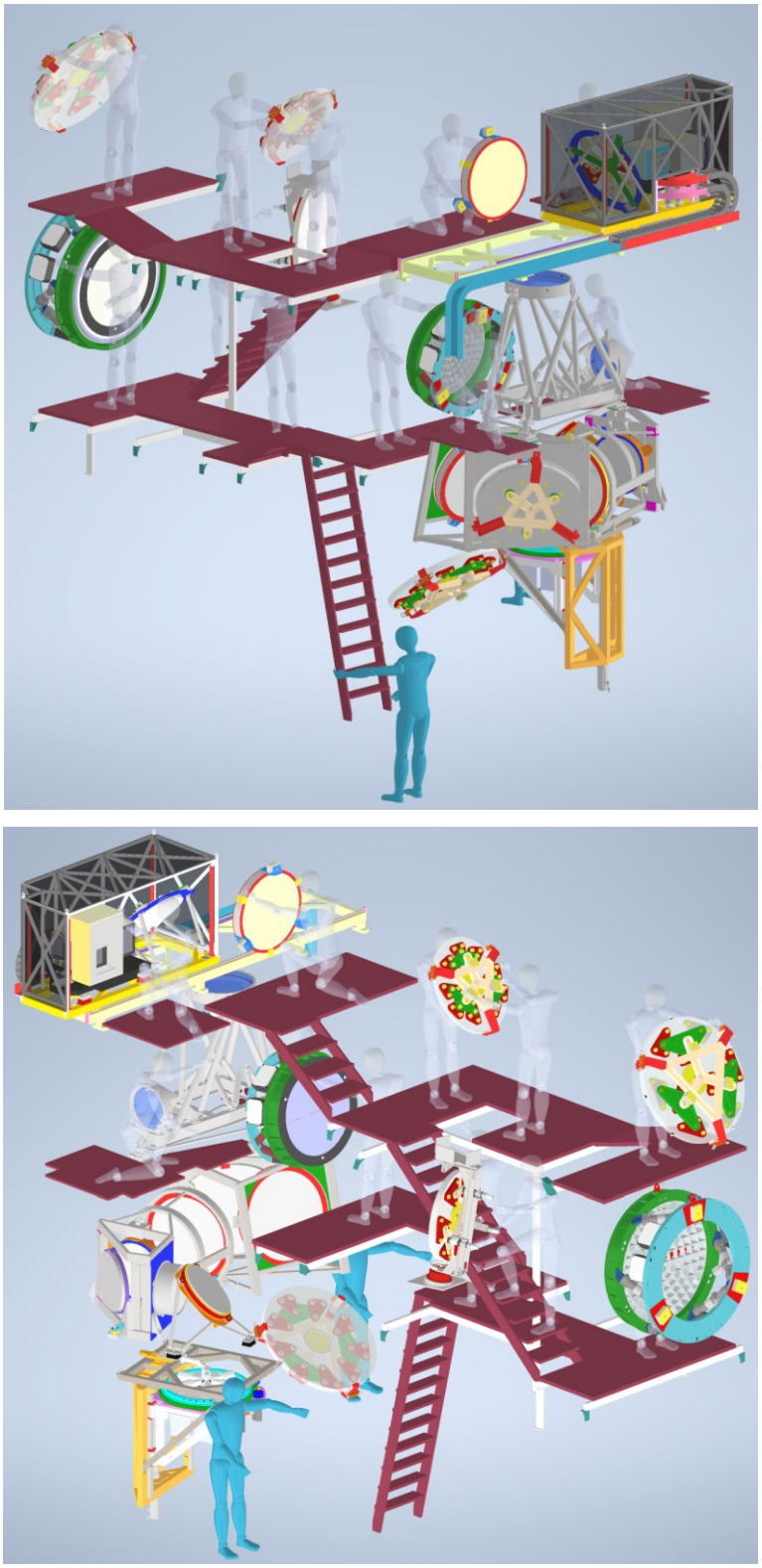


Figure 26: the MSS IP without the bench structure seen from 2 different perspectives

8. THE MAORY AIT in IAA Chile

In this section, we will describe the Assembly, Integration and Test process that we will follow in the IAA as a sequence of activities to be performed.

We emphasize that such a sequence is not a schedule, although prerequisites have been identified. Also, we underline that the estimated duration of each step (above all for some procedures, still currently under development/study) has to be more carefully reviewed/updated. The current estimate of the overall time needed for the AIV in the IAA is 47 working days, plus the time to install the MCA (to be evaluated by the MICADO MCA team). A contingency of 20% at this project phase and with the current maturity level seems to be appropriate, leading to 56 working days, plus the time to install the MCA. A very preliminary estimate made by the MICADO MCA team is ranging from 15 to 20 days, that would bring the total ranging from 60-75 days (depending on the final MCA estimate and from the contingency).

Consider also that all the images describing the installation procedure of the optical elements inside the MSS are merely conceptual sketch and are not representing the final design of the handlings, which will be optimized and finalized in the next phase of the project. Their aim is mainly to present a possible installation/removal procedure for all the sub-systems in the IAA.

All the optics coated side will be protected by a light cover during the whole installation process, which will be removed only at the end of the installation. In case of removal of the optics, the cover will be installed before any other operation.

The vast majority of the subsystem described hereafter are:

- Interfaced to the MSS structure through interface flanges, which can be re-machined to compensate for large deviations from the nominal positions and to recover manufacturing errors of the opto-mechanics (Figure 27)
- Connected to the interface flanges of the MSS (the blue ones shown in Figure 27) through 3 kinematics (Figure 28) displaced by 120deg, half of the kinematic being connected the MSS and the other half to the opto-mech of the subsystem. This ensures fine tuning of the alignment in TT and focus, discrete centring alignment using shims and repeatability of the sub-system repositioning. The centring range is ±2mm and the accuracy is 5μm (shim smallest thickness), while the TT/Focus range is ±2mm corresponding to about ±1’ for a 1m diameter mirror and wedges of 7°, with the kinematics applied to about 0.6 of the radius, and the accuracy is ~2”.

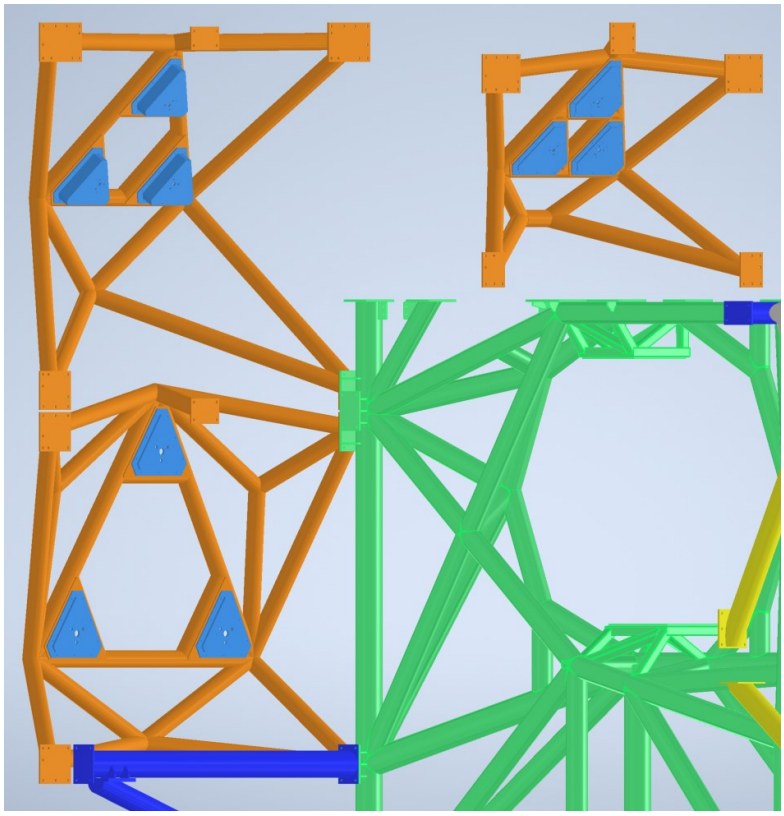


Figure 27: three mechanical structures for the opto-mechanics (top left is the one of M6, bottom left is the one of M10/DM2, top right is the M8 one) are shown (in orange colour), with the interfaces flanges to the opto-mechanics shown in blue colour.

Each subsystem is fixed to its interface using 3 screws M12, passing through the kinematic. Depending on the subsystem, the fixing screws are locked from the front (coated side of the optics) or from the back. Whatever is the case, the screw is always a trapped screw (in the opto-mech or in the MSS, depending on the case) and it is locked with a nut at the opposite side.

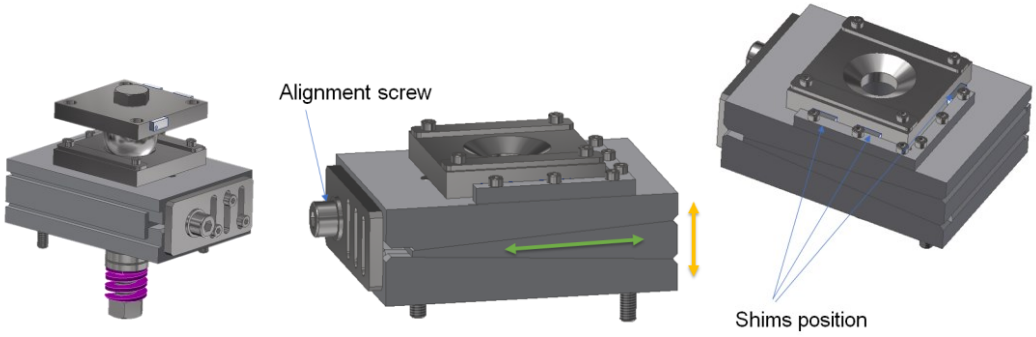


Figure 28: the kinematics interfaces, which allow tip-tilt adjustment through a wedge system

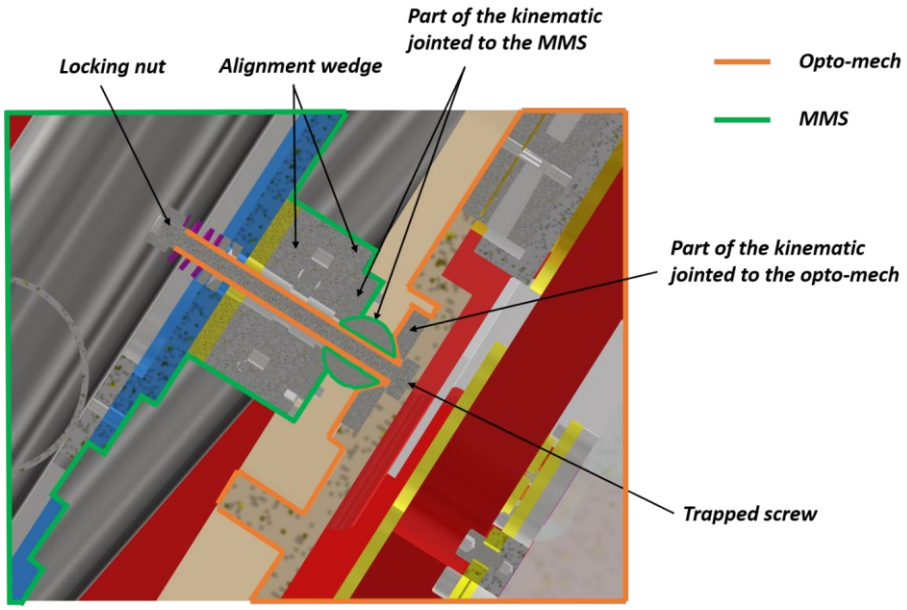


Figure 29: section view of one kinematic mount on the back surface of a subsystem (M6 in this case). The fixing screw is trapped in the opto-mech, and it is locked by a nut at the opposite edge of the screw. Bordered in green, the parts mechanically jointed to the MSS (fixed), bordered in orange the parts jointed to the subsystem (movable). The nut is positioned by an operator when all the 3 fixing screws are inside their kinematics.

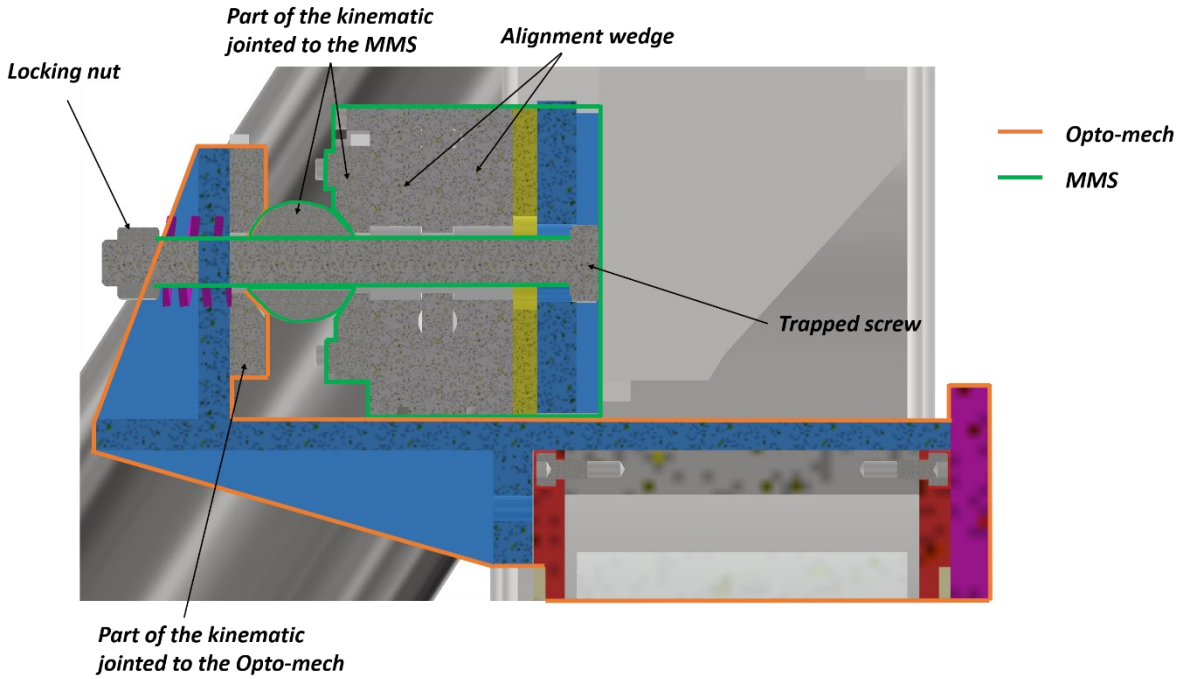


Figure 30: section view of one kinematic mount on the front surface of a subsystem (Schmidt Plate in this case). The fixing screw is trapped in the MSS, and it is locked by a nut at the opposite edge of the screw. Bordered in green, the parts mechanically jointed to the MSS (fixed), bordered in orange the parts jointed to the subsystem (movable). The nut is positioned by an operator when all the 3 fixing screws are inside their kinematics.

8.1 The Nasmith Interface Plate (NIP) installation (2d)

Purpose and functionality

An interface plate simulating the Nasmith floor is installed and fixed to the Lab floor.

Responsible: VDC, VCI, JFA, ERE, LMA, GRO, ECA

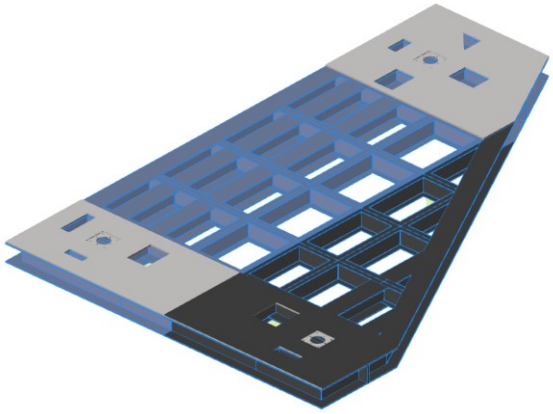
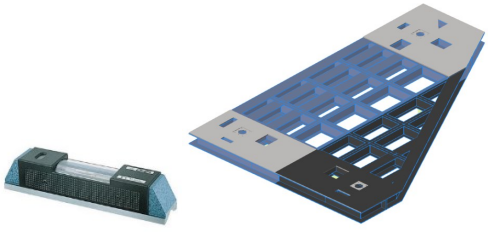
HTs/SEq needed: Forklift, Bridge Crane, Portable Crane

Success Criteria: NIP Properly installed

Duration: 2 days

Prerequisites: Entrance hall and IAA ready for the box opening and instrument installation

Procedure: The NIP boxes shall be taken in the entrance hall, opened and the NIP parts transported in the IAA. The next steps are here below presented:

Interface Structure for BIH floor (IS-BIH)	
Bring both the pieces of the base structure in the assembly position (using a Forklift or a crane) and couple them by means of the dedicated bolts.	
Check the flatness of the three support points of the Nasmith Flanges and insert the fork shims (specially prepared) below the Interface Structure, until there is an error smaller than 0.5 mm on the three top flanges and all the fixing points to the floor are in contact with the floor.	

Dowel them with threaded rods M16 and chemical anchor Hilti HIT Re 500.	
Once the resin has hardened: - Lock the nuts; - Verify the permanence of the plane/level specifications, otherwise correct it.	

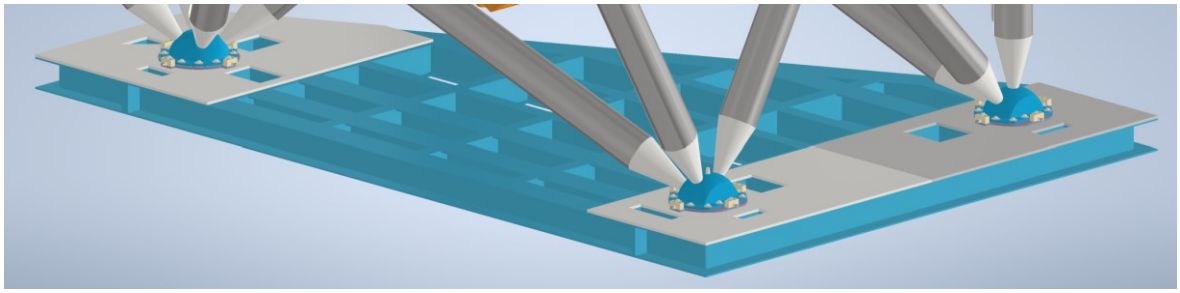


Figure 31: The Nasmith Interface Plate concept

Notes:

8.2 Main Support Structure (MSS) installation (5d)

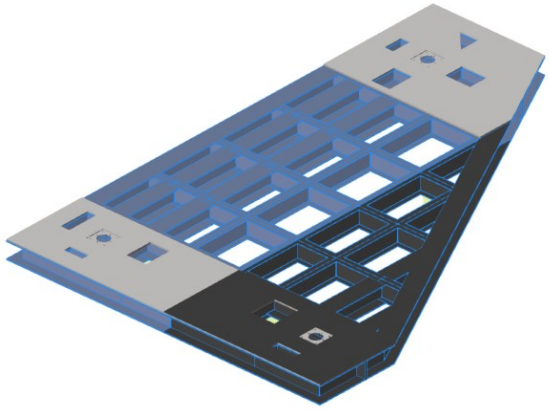
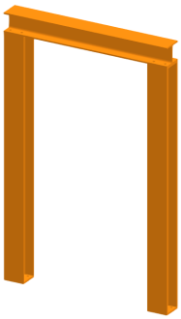
Purpose and functionality

The MSS is divided into several parts (7 main parts in the current design, plus the opto-mechanics holding structures), which will be put together to build the MSS.

Responsible: VDC, VCI, JFA, ERE, LMA, GRO, ECA

HTs/SEq needed: Overhead Crane, dedicated HTs , Scissor lift, Cherry picker, fork lift

CODE/DWG ID	Description	Deliverable to Bologna (yes/no)	Deliverable to ESO (yes/no)
	Interface Structure for the assembly hall floor. The frame is composed by different steel beams kind: • HE240A standard beams. • Other ones are designed (and welded together) to fit the HE240A same height (230mm).	Yes	TBC

	The support base is made of 2 main modules (to bolt and leveling before use the Structure). 		
TBD	Special tool A1/A2 for supporting base structures (structure A1 and A2), to be fixed on the Interface Structure. It must be made of HEA 120 profile, divided into three pieces, as sketched (in orange) in the image below. Each piece is handled by two people. Max 20 kg / piece (max 15 kg per person). 	Yes	Yes

TBD	Manual hydraulic jacks – N°02 – (type as in the image below) capacity 4t. 	Yes	TBC
TBD	Lifting harness - different lengths and carrying capacities - (type as in the image below). 	Yes	TBC
TBD	Laser tracker “FARO” type or similar. 	No, Rent	--
TBD	Precision bubble level. 	Yes	TBC

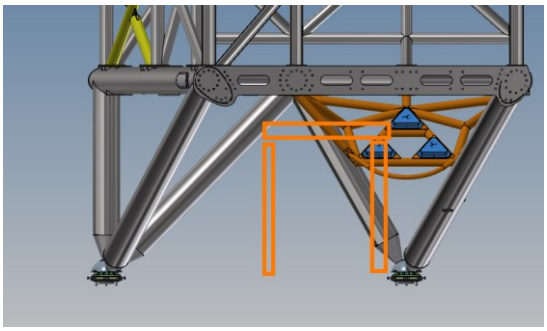
TBD	Set of shims for temporary leveling of components.	Yes	TBC
TBD	Modular scaffolding, aluminum support walkable surfaces, and stairs.	No, Rent	--

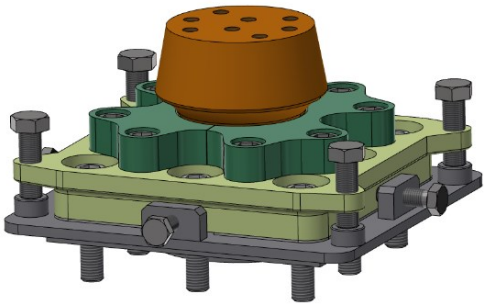
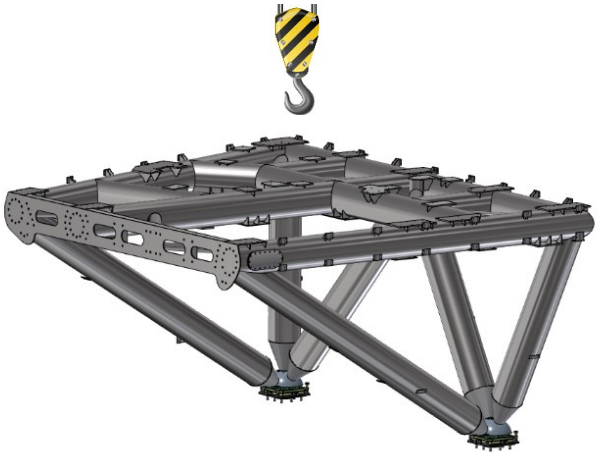
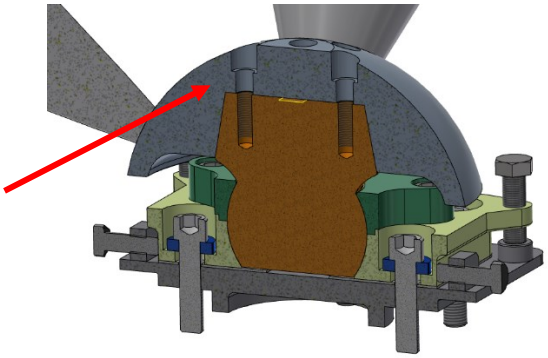
Success Criteria: MSS properly installed and connected to the NIP

Duration: 5 days

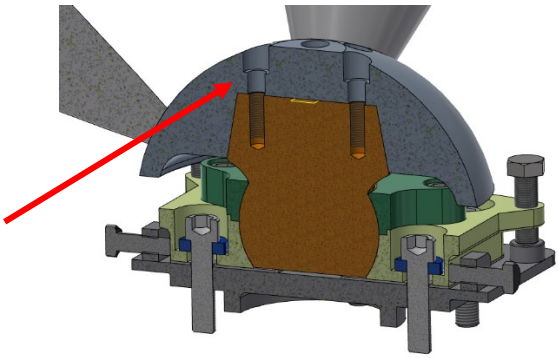
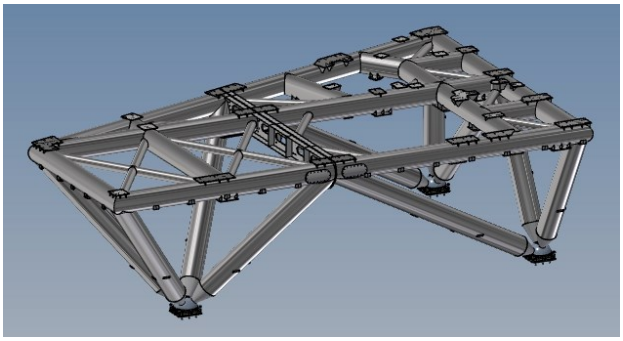
Prerequisites: 8.1 NIP installed

Procedure: The MSS boxes shall be taken in the entrance hall, opened and the MSS parts transported in the IAA. The next steps are here below presented:

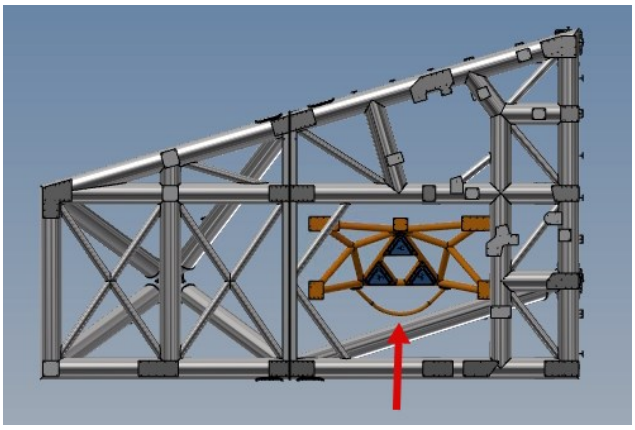
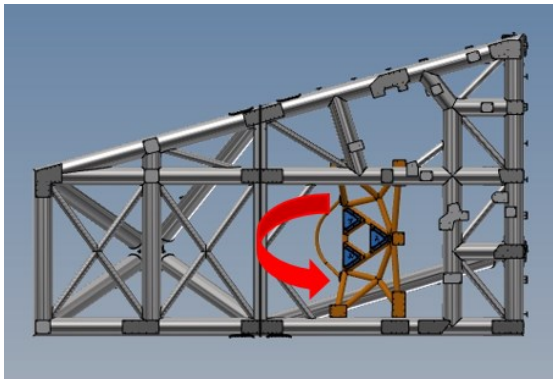
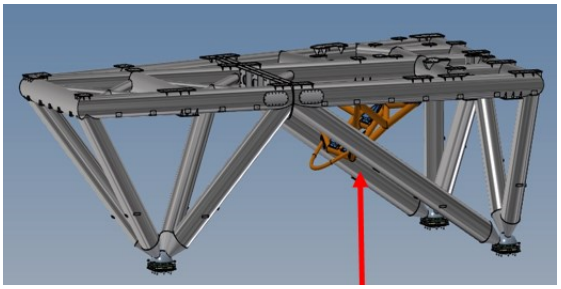
A1 Structure	
Mount the A1/A2 Special tool on the Interface Structure.	
Mount the two flanges on the Interface Structure.	FIGURE - TBD
Position the jack at the foreseen height.	

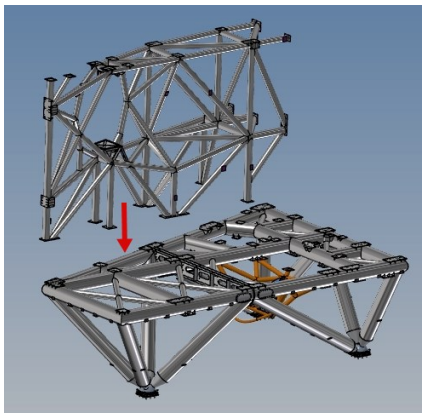
Mount all the spherical joints of the MSS on the Interface Structure.	
Lift the A1 structure with the crane and put it in position.	
Mount the screw of the top flange, as shown in the side figure.	
Pre-leveling the A1 Structure.	

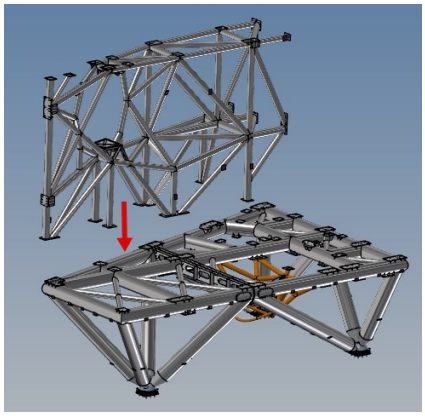
A2 Structure

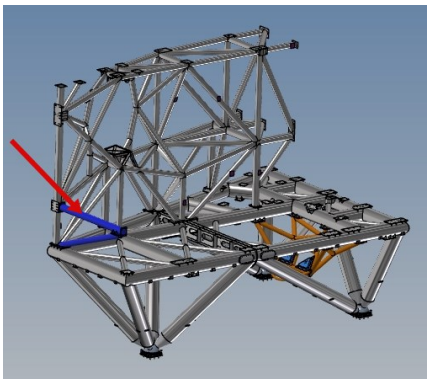
Lift the A2 structure with the crane and put it in position.	 
Mount the screw of the top flange, as shown in the side figure.	
Pre-level the A2 Structure.	
Couple the structures through their coupling flanges and screw the connecting bolts.	
Check the level of the coupled A1 and A2 structures and correct it if/when required.	

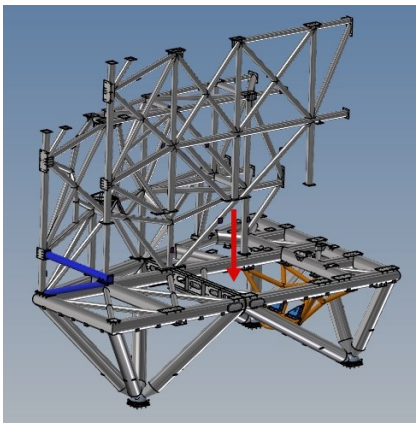
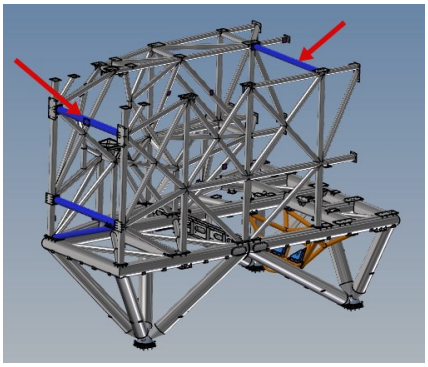
M7 Holder

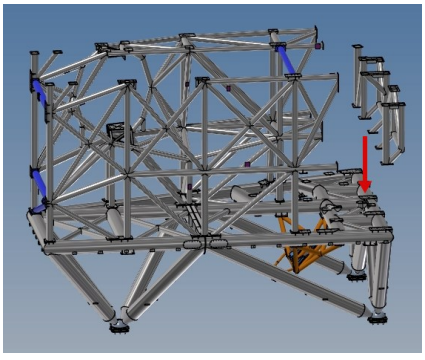
Place the M7 Holder under the bench via a pallet truck, positioned as indicated on the side figure.	
Bridle it by the lifting harness, and lift it to exceed the height of the leg, so rotate it as shown in the side figure.	
Lift it again, to the final mounting position.	
A5 Structure	

Bridle it, so lift it with the crane and place it above the previously assembled structure.	

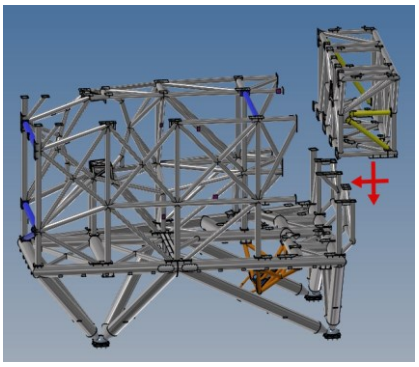
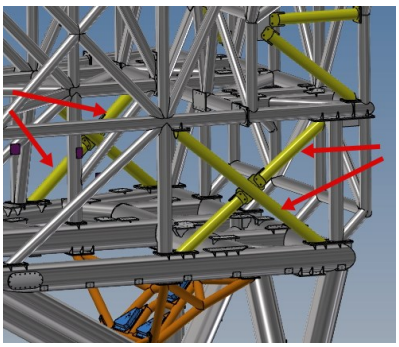
A5 Structure	
Bridle it, so lift it with the crane and place it above the previously assembled structure.	

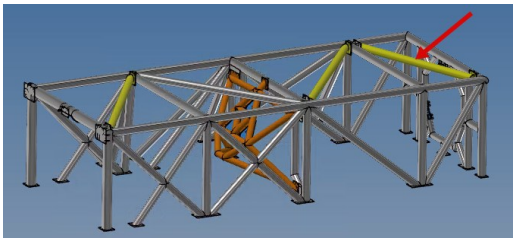
A4 Structure	
Mount preliminarily the A12 TUBE and the C3 TUBE, as shown in the side figure.	

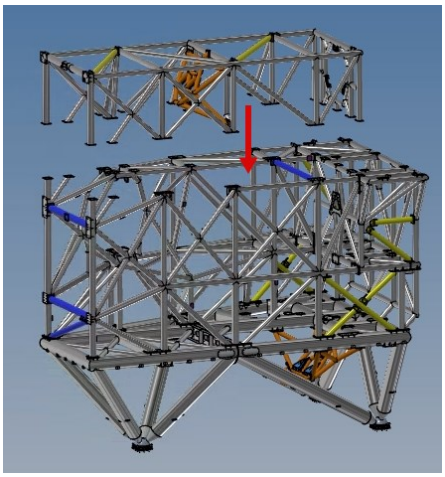
Place the A4 Structure with the crane, as shown in the side figure, and bolt it to the base structure and to the A12 TUBE.	
Keeping the A4 Structure still harnessed to the crane, mount the A11 TUBE and A10 TUBE be using the scissor lift.	

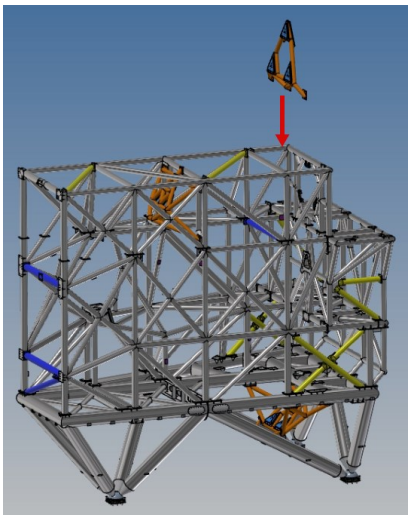
A6 Structure	
Bridle it, so lift it with the crane and place it above the previous assembled structure.	

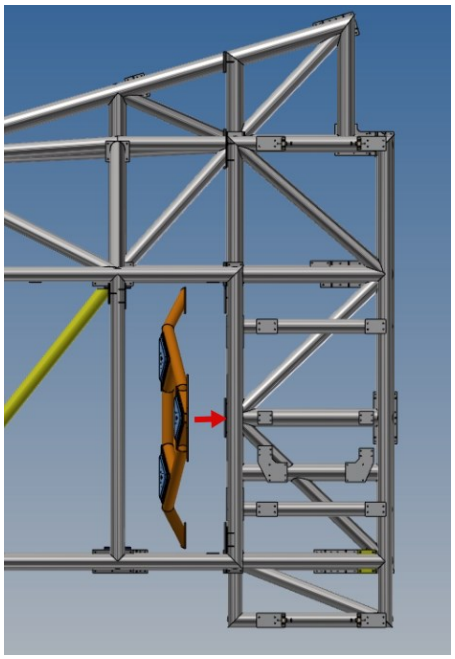
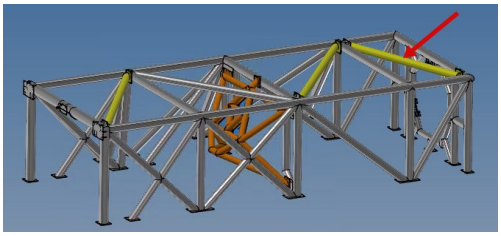
A3 Structure

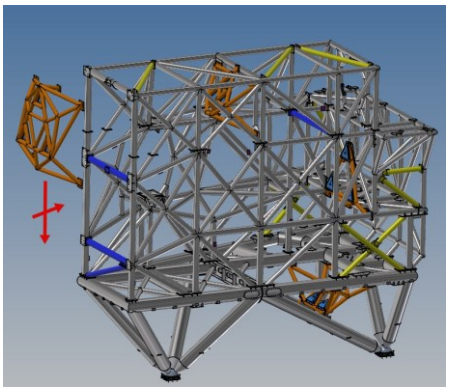
Place the A3 Structure with the removable tubes already mounted onboard. Lift the assembly with the crane and put it down in place, next to the flanges of the A5 and A4 Structures.	
Bolt it with the other structures and then position the TUBES of the first level A8-1,2 and 3 and A9-1,2 and 3.	

A7 Structure – Holder M6	
Transport the A7 structure already equipped with M6 Holder and the A15, A16, and A17 TUBES. The A15 TUBES, shown in the side figure, must be removed before lifting the A7 Structure.	

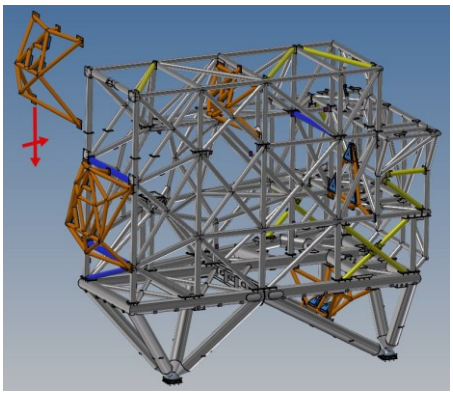
Carry it in position and lower it with the crane, as shown in the side figure, so bolt it to the other parts of the structure.	

Holder M9/DM1	
Lift the frame vertically with the crane, as shown in the side figure, and lower it from above.	

The frame must be lowered in the central position of the lattice structure and pulled in position as shown in the side figure.	
Remount the removable A15 TUBE.	

Holder M10/DM2	
Put it in position with the crane, as in the side figure, and screw it.	

Holder M8

Put it in position with the crane, as in the side figure, and screw it.	

After completing the whole assembly of the MSS, check the tightening of all the screws and then carry out a general dimensional check of the assembled structure, using the laser tracker and other measuring and level checking instruments.

If required, correct the MSS level by acting on the base flanges of the spherical joints and then tighten them.

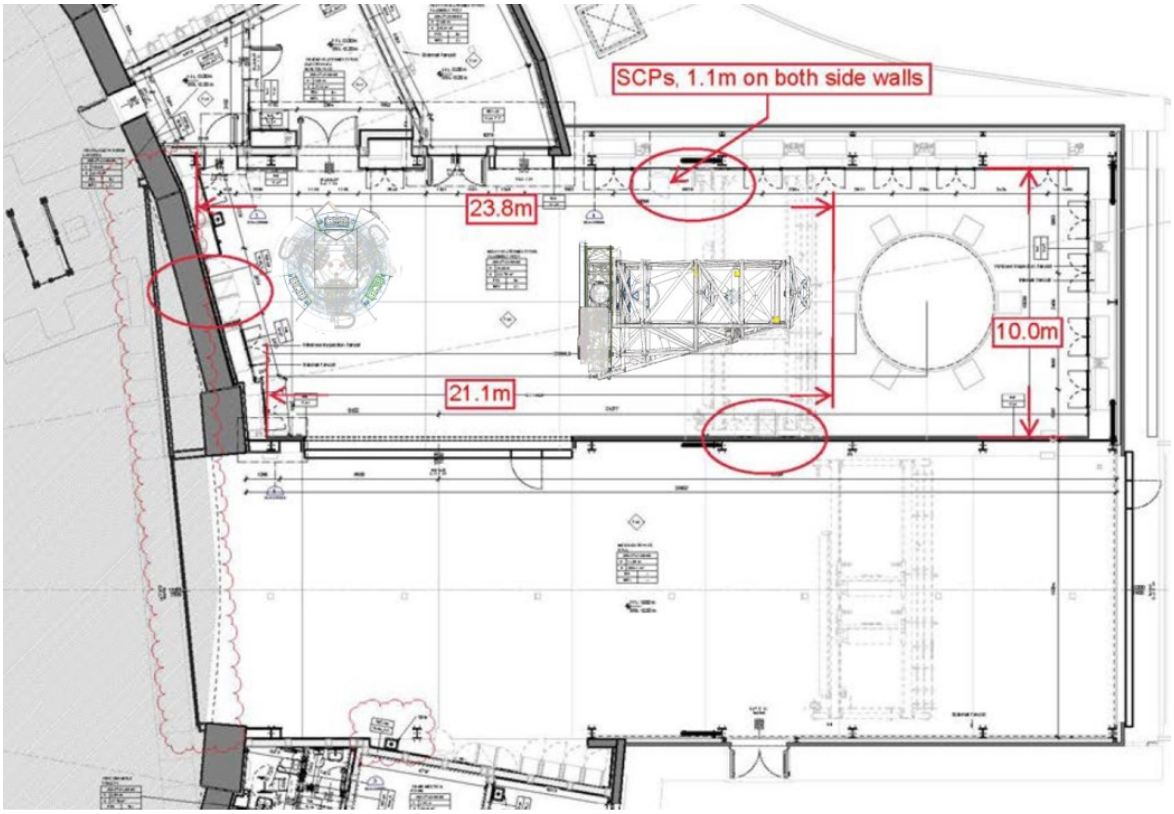


Figure 32: a possible disposition of the MSS and od the LOR inside the IAA; the LOR is on the top-left part of the IAA while the MSS is just after the main entrance door on the right. Cabinets position TBD, but they may be positioned between the LOR and the MSS close to the wall on the opposite side of the entrance gate.

In Figure 32 a possible position of the MSS and LOR inside the IAA is shown (TBD with ESO)

Notes: a more detailed description can be found in RD13. In the IAA Chile, this procedure has to be slightly modified due to the limited height below the crane hoist (7.5m), such as for example the installation of M9 that cannot come from above, and should be pre-installed in the A7 structure, as it is done for M6. Also, again due to the limited crane hoist height, some handlings will have to be used to position some parts of the MSS, such as A5, A4, A3 and A7.

8.3 Installation of the LTs on the MSS (1d)

Purpose and functionality

The MSS LTs (3) shall be installed on the main structure in the selected areas

Responsible: JFA, VDC, ERE

HTs/SEq needed: Scissor lift, Cherry Picker, movable ladders, internal platforms

Success Criteria: LTs properly installed

Duration: 1 day

Prerequisites: 8.2 MSS installed

Procedure: depending on the position of the LTs (see Figure 33), by using portable ladders, the cherry picker and or the internal platforms the 3 LTs will be installed to the dedicated flanges on the selected locations.

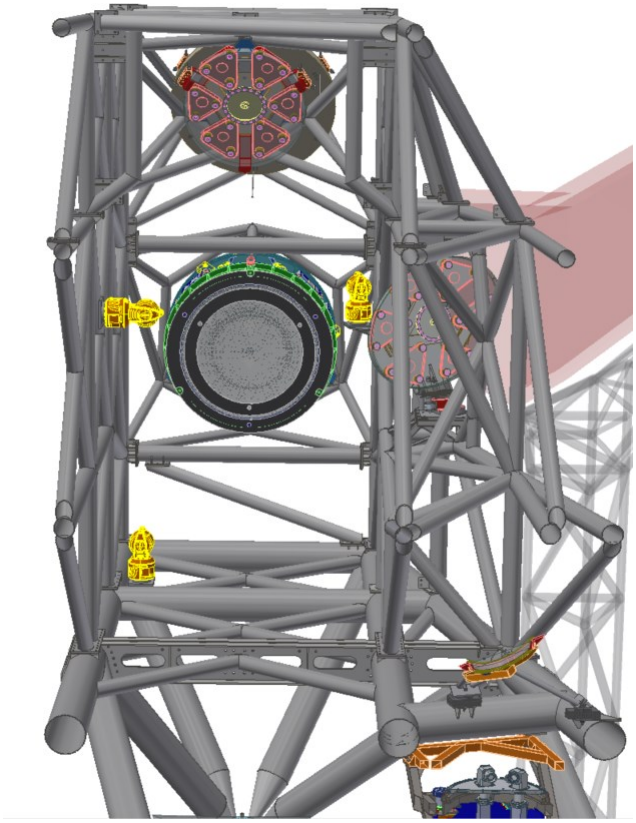


Figure 33: the three inner LTs of the MSS

Notes:

8.4 Interfaces measurements (2d)

Purpose and functionality

To measure the interfaces of all the opto-mechanics with the MSS LTs

Responsible: JFA, ERE, LMA, ECA, GRO

HTs/SEq needed: Scissor Lift, Cherry Picker, Portable Ladders, internal platforms

Success Criteria: all dummies interfaces measured

Duration: 2 days

Prerequisites: 8.3 MSS LTs installed

Procedure: Depending on the interfaces position and shape, using the appropriate nest (see Figure 34) carrying magnetic SMRs, all the interfaces will be measured using the MSS LTs.

Notes:

Figure 34: pin nests on the top left, drift nests on the bottom left, surface nests (with the lower surface rectified) in the centre and LT ball probes, all magnetic, are shown.

8.5 IFP flange installation, measurement and dis-installation (1d)

Purpose and functionality

The IFP flange is installed at the CP interface. PINs will allow to position it with an accuracy of about 10µm wrt its nominal position on the interface flanges. It will be measured to be used as reference for the opto-mechanics alignment. After measuring the IFP flange SMRs with the MSS LTs, it will be dismounted.

Responsible: JFA, ERE

HTs/SEq needed: Bridge crane, Internal platforms

Success Criteria: IFP properly measured

Duration: 1 day

Prerequisites: 8.3 LTs installed

Procedure: The IFP flange (Figure 35 left side) will be installed at the CP interface (Figure 35 right side) carrying it with the crane in position and fixing the screws on the interfaces accessing them from the inner side of the bench, using the dedicated platforms. Two PINs will allow its precise positioning wrt the interfaces (shown in blue colour in Figure 35 right side). Once in position, the three SMRs in the inner side of the IFP flange will be measured with the inner MSS LTs, and the “as built” IFP represented by the three SMRs will be used for the alignment of all the opto-mechanics to be after installed.

Just after the measurement, the IFP flange will be dismounted using the crane.

Notes:

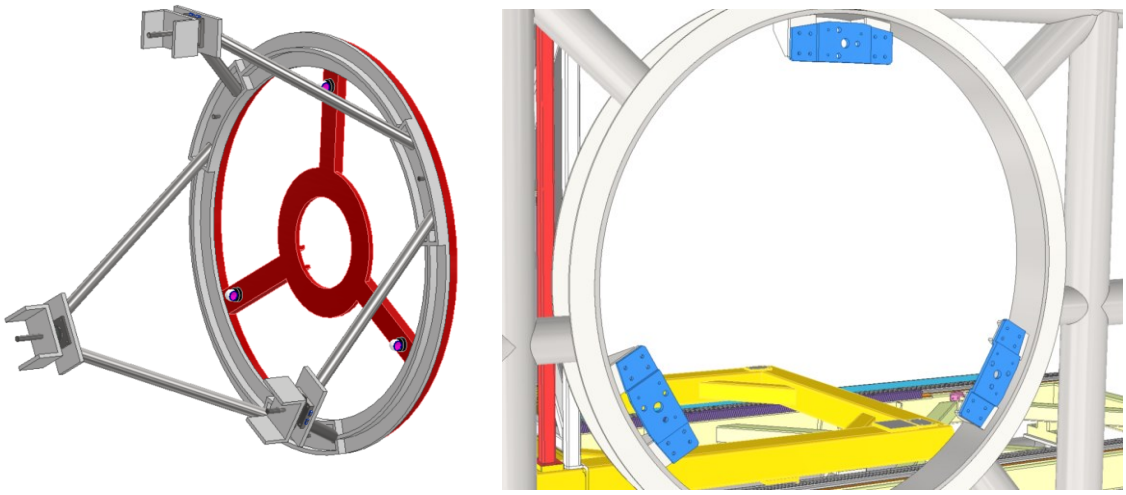


Figure 35: the IFP flange (left side), with the three SMRs on a circle close to the outer diameter of the IFP, on the red spiders; on the right end side, the CP interface flanges, where the IFP flange will be installed (instead of the CP of course)

8.6 Electronic cabinets installation (5d)

Purpose and functionality

Installation of the cabinets in their foreseen position (TBD) and functional test will be performed.

Responsible: IFO, ECA, CER, JFA

HTs/SEq needed: crane, fork lift

Success Criteria: No damage to the cabinets, functional power test all working

Duration: 5 days

Prerequisites: 8.2 MSS installation (may be not necessary, it can be probably done in parallel)

Procedure: The cabinet boxes shall be taken in the entrance hall, opened and the cabinets transported in the IAA. All the cabinets are fixed in their foreseen position and functional power test are executed.

Notes:

8.7 Cables and pipes routing (3d)

Purpose and functionality

Cables and pipes installation and functional test

Responsible: IFO, ECA, CER, JFA

HTs/SEq needed: Scissor lifts, Cherry picker, portable ladders

Success Criteria: all cable and pipe are safely deployed, pin to pin test all working

Duration: 3 days

Prerequisites: 8.2 MSS installation, 8.6 Electronic cabinets installation

Procedure: The cables boxes shall be taken in the entrance hall, opened and the cables transported in the IAA. Cable and pipe trays are installed, cables and pipes are routed from the cabinets to the opto-mechanical sub-systems locations. Cables for power and network delivery are routed from the Power Distribution Cabinet to all the other cabinets.

Notes:

8.8 ICS and RTC WS installation (4d)

Purpose and functionality

The WS will be installed in the foreseen area. SW needed to move to motorized functions of the opto-mechanic sub-systems is installed and tested in simulation.

Responsible: JFA, BSA

HTs/SEq needed: Floppy Disk(s) (“s” in case more than one will be needed)

Success CriteriaCriteria: data transfer, communication and functional test working

Duration: 4 days

Prerequisites:

Notes:

8.9 Corrective Plate Installation (1d)

Purpose and functionality

The CP is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the CP

Responsible: LMA, ERE, JFA, GRO, ECA

HTs/SEq needed: Bridge crane, Dedicated HTs, Internal platforms

Success Criteria: CP properly installed and in the nominal position given by the LTs

Duration: 1 day

Prerequisites: 8.5 IFP flange installation

Procedure: The CP box shall be taken in the entrance hall, opened and the CP transported in the IAA.

This procedure has been modified for the IAA integration, due to the limited working height of the crane hook.

Anyhow, the approach is very similar to the one of the BIH (which is the same of the Nasmyth), even though it will require more operations.

The same handling described for the installation in the BIH and Nasmyth platform shall enter into the MMS on a trolley from the bottom. Due to the limited height of this handling, it can pass through the MMS legs with the correct orientation (i.e., with the hoist ring looking at the crane hook, see Figure 38).

The handling is located in a position where it can be picked by the crane hook, which shall be passing through the aperture shown in Figure 36. This imposes that the supporting structure of M7, in yellow in Figure 37, must not be installed yet.

Once this is done, the crane pick up the handling and lift it up, to free the space at the bottom for the Schmidt Plate. This shall be carried, using a trolley, in the same position the handling was located in the previous step. When it is in position, the handling can be lowered again to pick the Schmidt plate, and then lift it up to its nominal position.

The following steps are the same described for the installation in BIH and Nasmyth Platform. When the installation of the Schmidt Plate is over, the handling is lowered again on its trolley at the bottom of the IAA. At the end, the supporting structure of M7 can be installed.

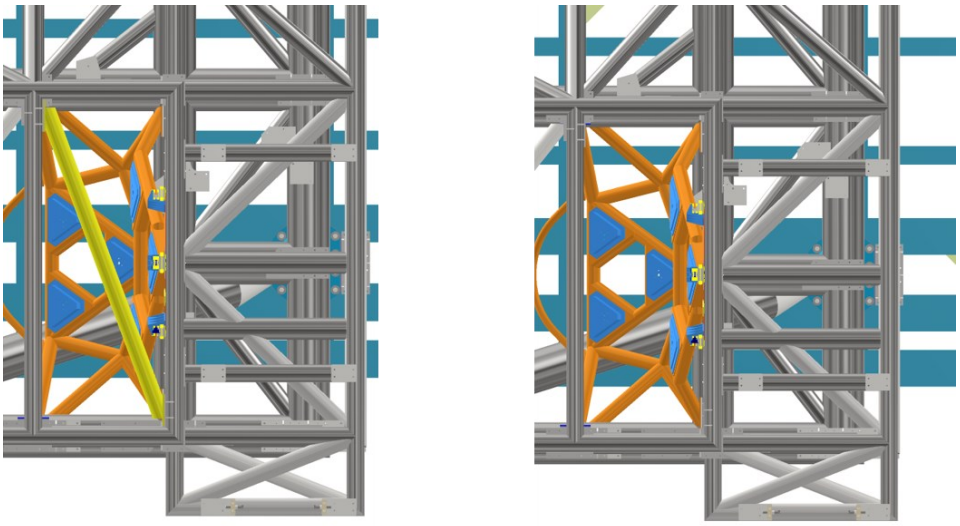


Figure 36: the yellow beam highlighted in left panel shall be removed to allow Schmidt Plate installation/removal from the top.

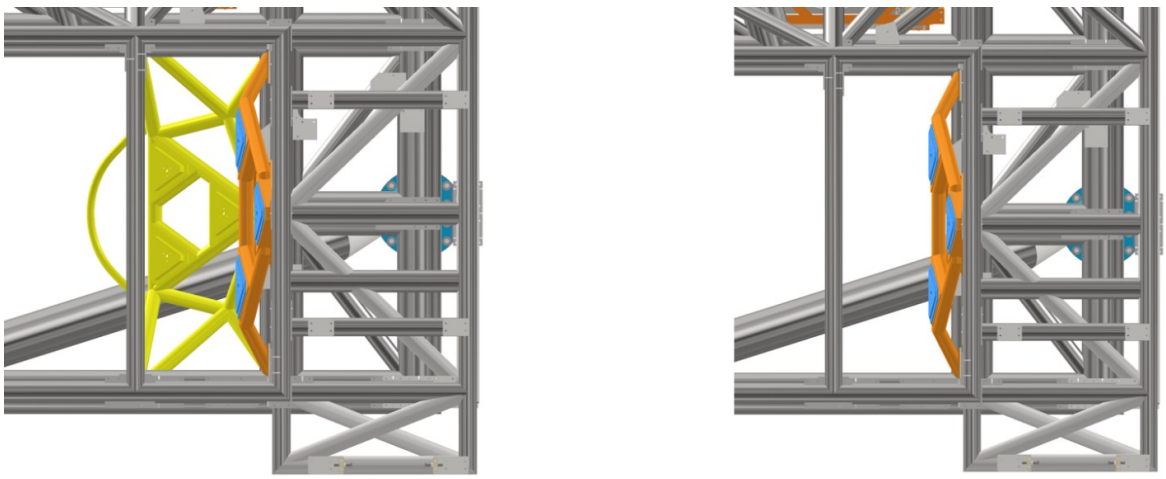


Figure 37: the supporting structure of M7 cannot be in place during this phase, as it would interfere with both the handling and the Schmidt Plate when accessing into the MMS from

the bottom. M7 supporting structure shall be installed after the Schmidt Plate installation is over.

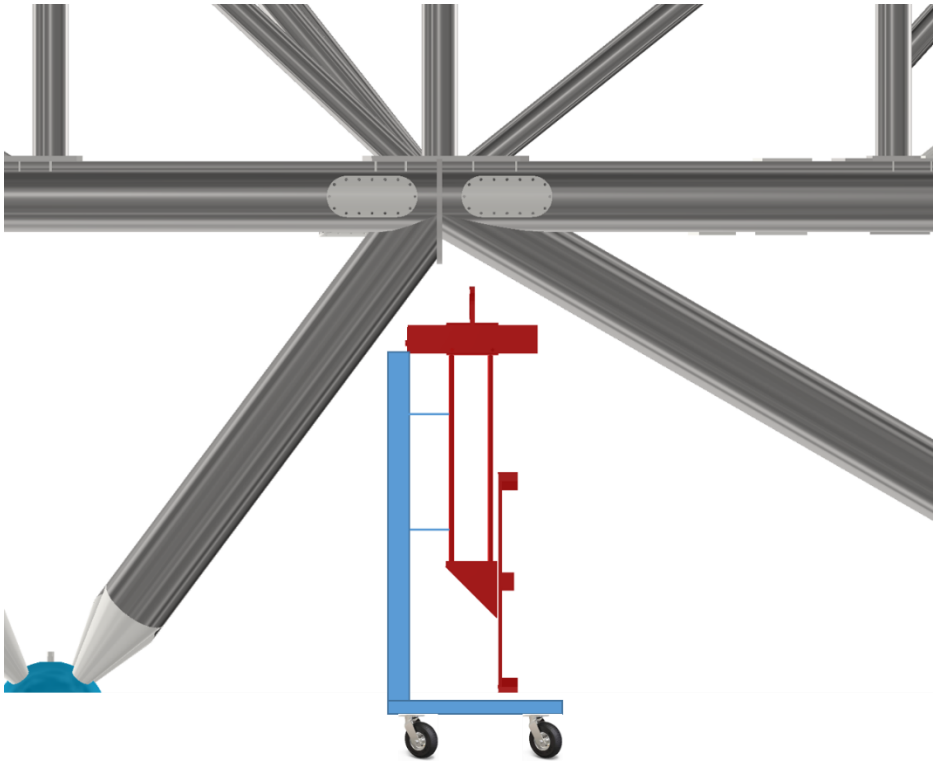


Figure 38: the small dimensions of the Schmidt Plate installation handling allow to access into the MMS from the bottom with the handling vertically oriented, ready to be picked by the crane hook.

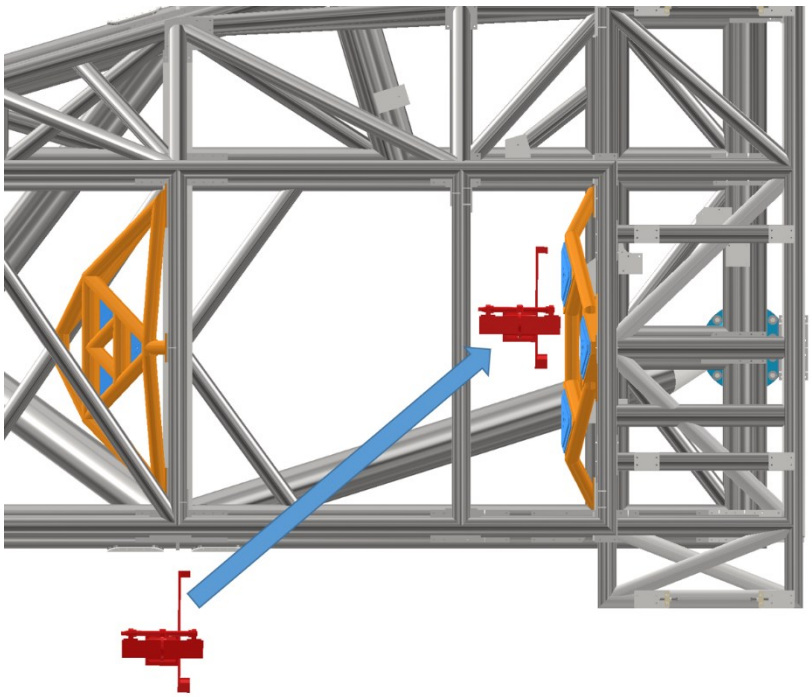


Figure 39: the handling shall be located in a position accessible to the crane hook passing through the same aperture in the MMS used for the installation in the BIH and Nasmyth Platform.

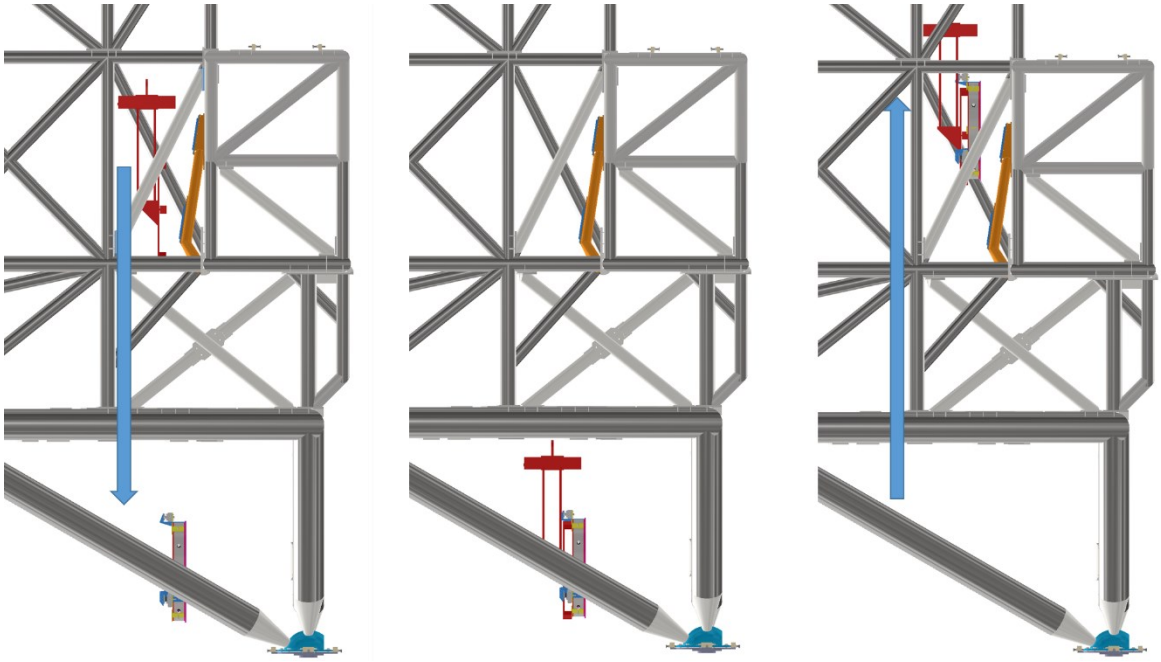


Figure 40: when the Schmidt Plate is in a suitable position at the bottom of the MMS, the handling is lowered, connected to the Schmidt Plate and then lift it up again to the Schmidt Plate nominal position

Notes:

8.10 M6 Installation (1d)

Purpose and functionality

M6 is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: LMA, ERE, JFA, GRO, ECA

HTs/SEq needed: Bridge crane, Dedicated HT, Scissor lifts, internal platforms

Success Criteria: M6 properly installed and in the nominal position

Duration: 1 day

Prerequisites: 8.9 CP installation

Procedure: The M6 box shall be taken in the entrance hall, opened and the M6 transported in the IAA.

While accessing with M6 from the top will not be possible when in IAA, due to limited crane hook height, it is still possible to use the same handling and the crane for its installation.

The handling shall be carried inside the MMS from the bottom, fastened to a trolley with wheels. The short side of the C will be oriented along the gravity vector. In this configuration, the height of the trolley + handling is lower than the available space between MMS legs. When the handling is in position and the yellow beam in Figure 41

removed, the crane hooks can be lowered all the way through MMS and pick the handling. To avoid the handling start swinging inside the MMS when lifted up, it must be constrained to the trolley during this operation, and the constrain will act as a pivot point for the handling. Slowly lift up crane hooks till the handling long side of the C will be oriented along the gravity vector. Now the constrain can be removed and the handling is free from the trolley.

When the handling has the correct orientation, the crane lifts it up by 3-4 meters, and the trolley exits from the MMS following the same route used when it entered.

At this point a new trolley hosting a mount holding M6 with the same orientation it should have when mounted accesses into the MMS.

When M6 is in a suitable position inside the MMS he crane hook shall be lowered all the way down through the same access shown in Figure 41, the handling will be lowered and engaged to M6. When M6 is released from the trolley, the latter can be removed and M6 lifted up.

Finally, the internal ladders shall be mounted to allow 2 people reaching the interface points of M6 inside the MMS. When M6 is secured to its interface, the handling shall be lowered again and laid on its trolley.

Since the crane hoist height from the floor in Chile assembly hall is 7.5 meters and MAORY main structure maximum height is ~ 6.6 meters, the handling shall not protrude above MAORY main structure more than 90 cm.

The C-shaped handling will be dimensioned to protrude less than 70 cm from the top of MSS, when M6 is installed to its support structure, while the trolleys are dimensioned to pass through the MMS legs with clearance.

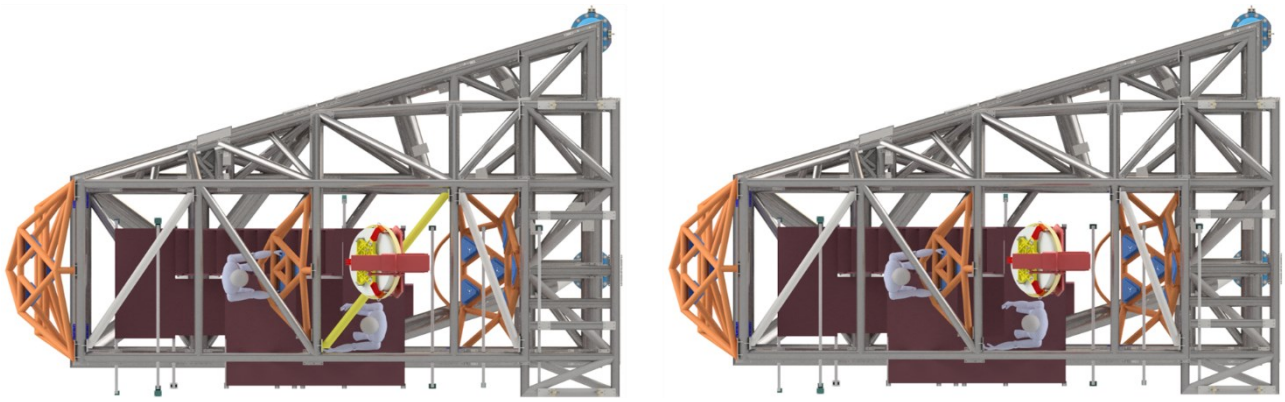


Figure 41: yellow beams shall be removed to allow handling accessing into MAORY main structure.

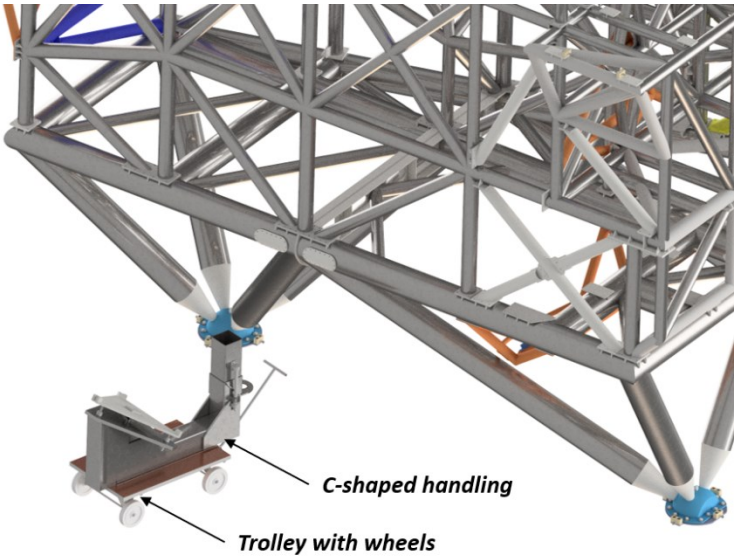


Figure 42: C-shaped handling lies on a trolley with wheels. Height of handling + trolley is low enough to pass between the MMS legs.

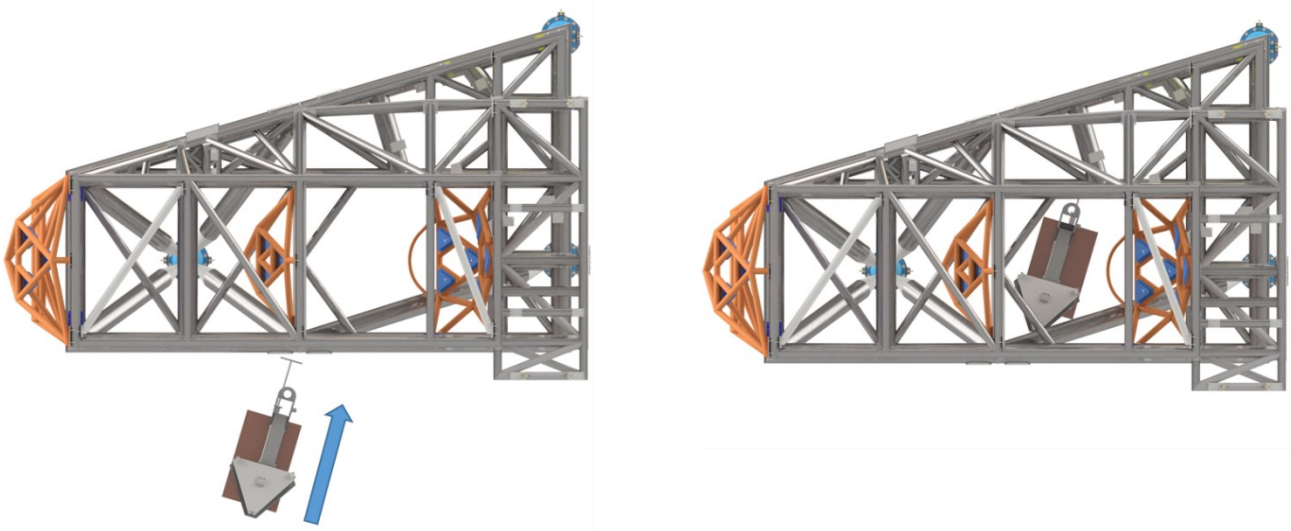


Figure 43: the trolley with the handling is pushed between MMS legs to the position where the handling can be picked by the crane.

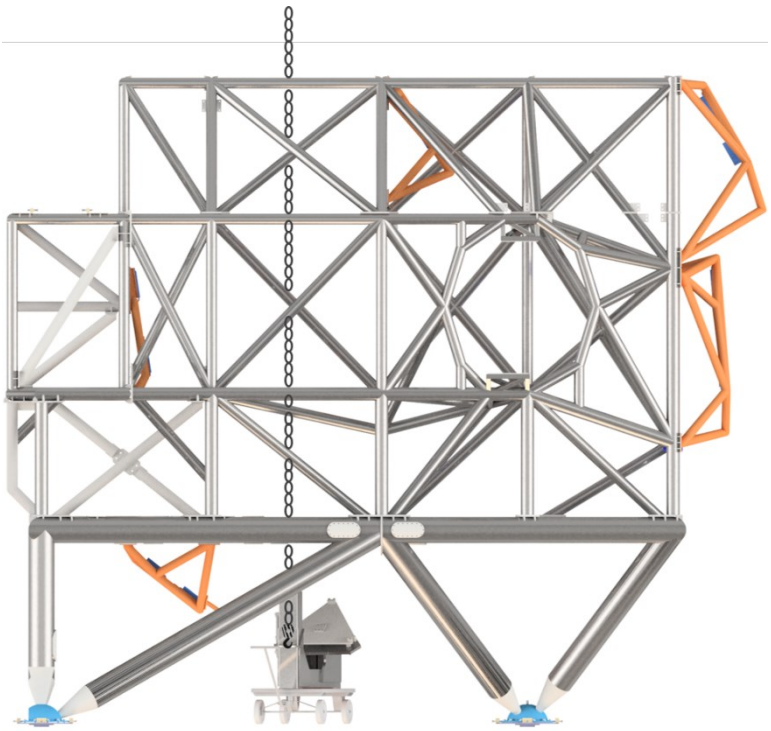


Figure 44: crane hook is lowered all the way down to the position of the handling

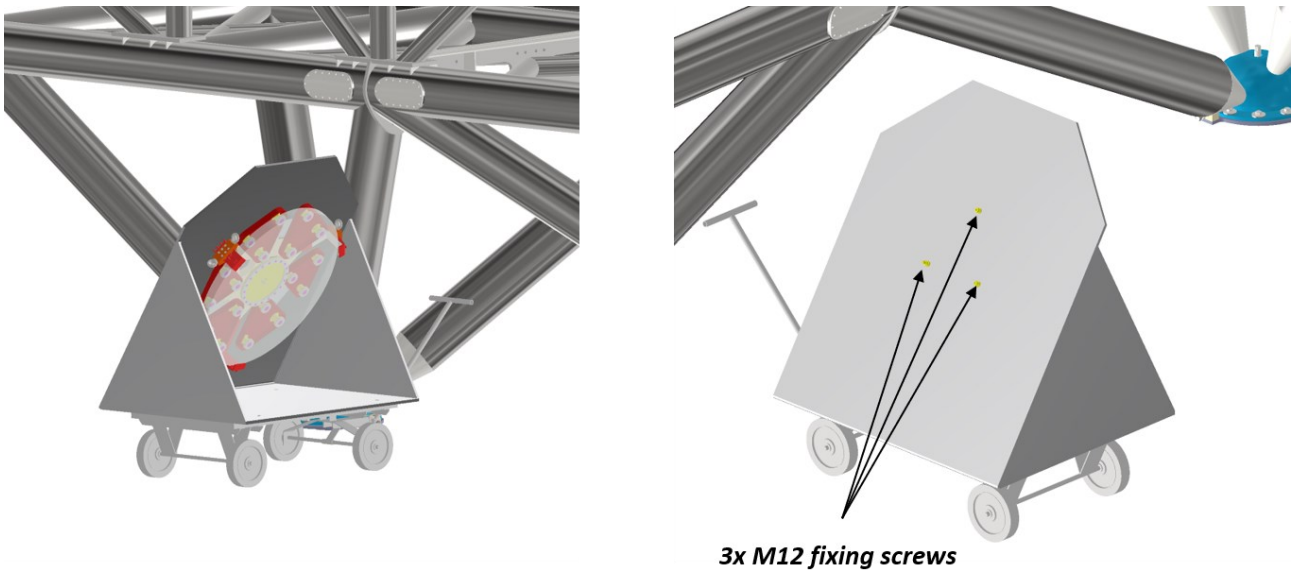


Figure 45: M6 into a mount holding it with the correct orientation to be picked by the handling. The mount is secured to a trolley.

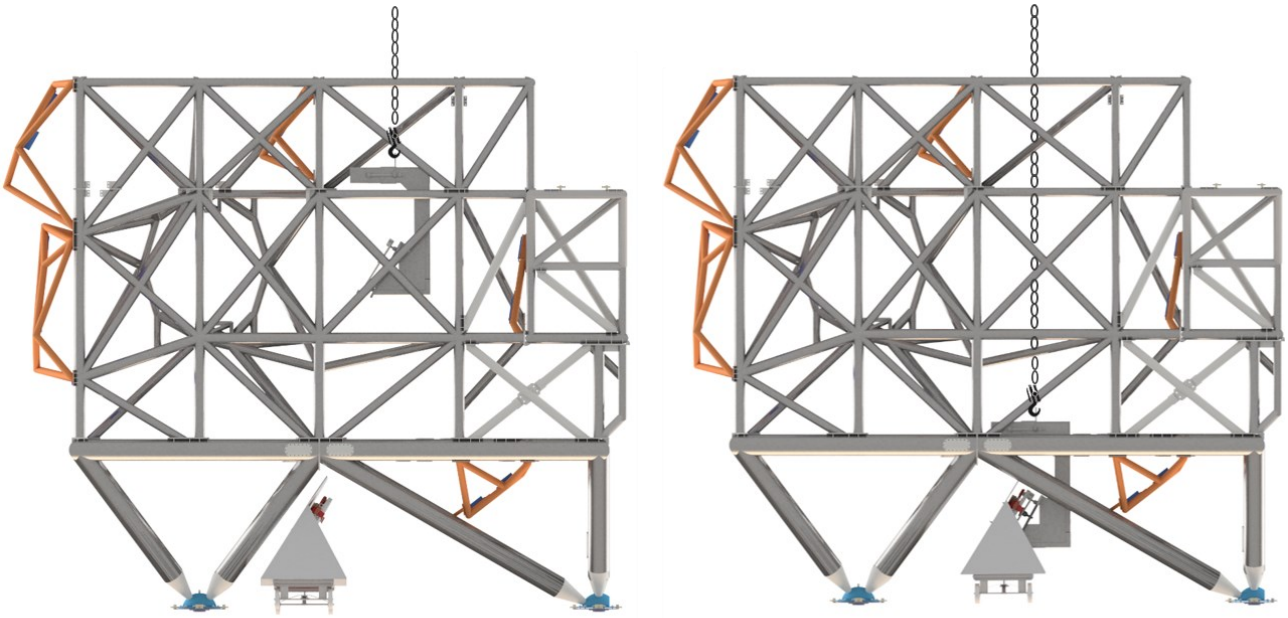


Figure 46: when the trolly with M6 is inside MMS, the handling can be lowered and secured to M6.

8.11 M7 Installation (1d)

Purpose and functionality

M7 is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: ERE, JFA, LMA, ECA, GRO

HTs/SEq needed: Bridge crane, Dedicated HT

Success Criteria: M7 properly installed and in the nominal position

Duration: 1 day

Prerequisites: 8.10 CP installation

Procedure: The M7 box shall be taken in the entrance hall, opened and the M7 transported in the IAA.

In the IAA the approach used in BIH and Nasmyth Platform is not possible, but an approach very similar to what described for M6 installation in IAA is still possible.

The C-shaped handling thus shall enter first from the bottom using a trolley, same way done for M6, it is picked up by the crane and lifted up to free the space at the bottom of the MMS, where M7 shall now enter.

M7 is on a custom mount holding it with the same orientation it will have when mounted in the MMS, which is also the optimal orientation to be picked by the C-shaped handling.

The only difference with respect to M6 approach is that M7 shall be positioned not on a normal trolley but on a small scissor lift, which can raise M7 above its support in the MMS. This is needed because of the MMS structure and M7supporting structure themselves, which do not provide enough room to lift up the handling together with M7 from the ground, but this is only possible when M7 is above its support structure (Figure 47).

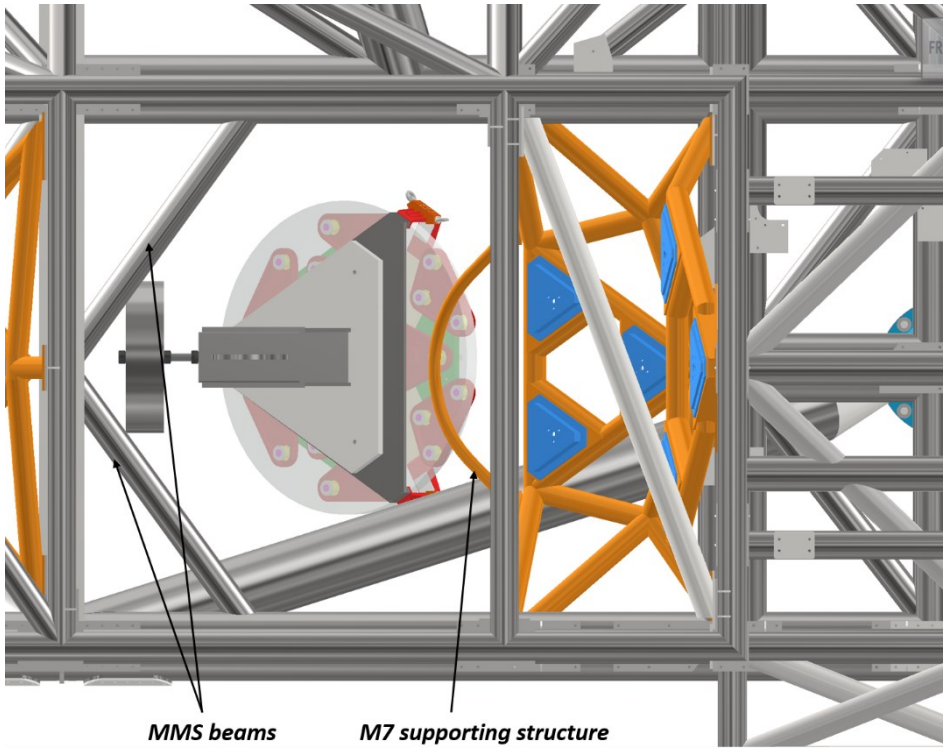


Figure 47: the MMS beams pointed on the left and part of M7 supporting structure pointed on the right prevent the possibility of lifting up the handling + M7 from a quote below the part of M7 supporting structure indicated, as either the handling or the mirror would collide with these structures.

When the handling is fixed to M7 (a small ladder might be needed), the procedure continues in the same way shown for BIH & Nasmyth platform installation, with the only exception that at the end of the mirror installation, the handling shall be removed from the bottom of the MMS, using the same trolley used at the beginning to move the handling inside.

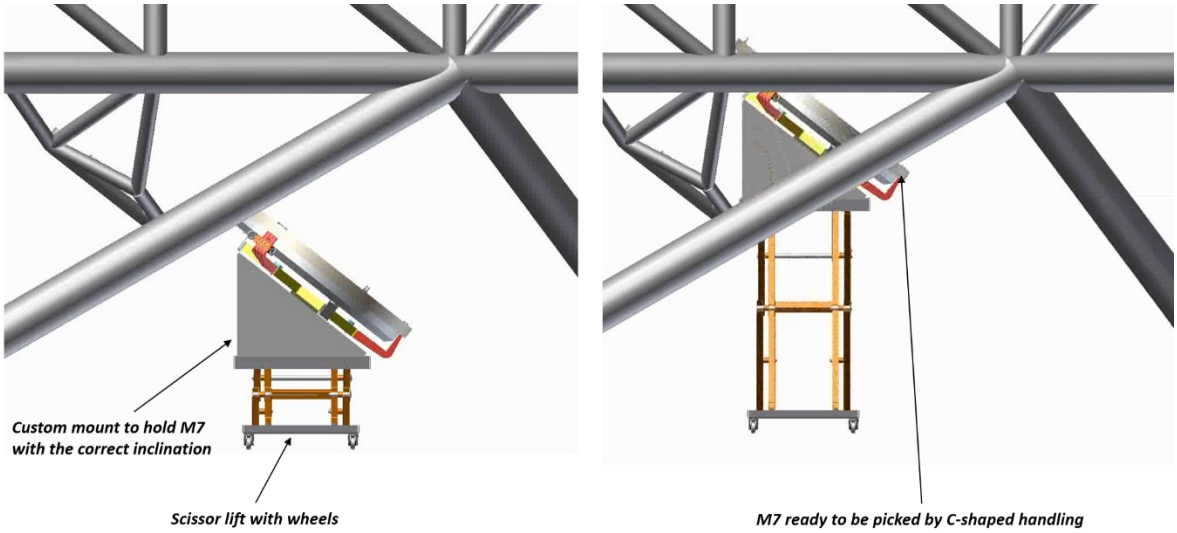


Figure 48: M7 is located close to its support into MAORY main structure using a scissor lift equipped with wheels. A custom mount allows to hold M7 with an inclination close to its finale one.

8.12 M8 installation (1d)

Purpose and functionality

M8 is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: ERE, JFA, LMA, ECA, GRO

HTs/SEq needed: Bridge crane, Dedicated HT, Scissor lifts, internal platforms

Success Criteria: M8 properly installed and in the nominal position

Duration: 1 day

Prerequisites: 8.11 M7 installation

Procedure: The M8 box shall be taken in the entrance hall, opened and the M8 transported in the IAA.

Due to the internal structure of the MMS around M8 position, an approach similar to what described for M6 is not viable.

The procedure in IAA consists of installing M8 + its support on MMS. Due to the external position of M8 within the main structure, this installation can be performed just using 3 hooks, opportunely dislocated on M8 support structure, to interface to the crane. The system is balanced tuning the length of the chains, and finally lifted up and interfaced to MMS.

In this case, access only at the back of the mirror is required as both the interface with the chains, fixing screws and alignment mechanisms are accessible from the back.

A person can easily reach the required position by using a scissor lift or a temporary scaffolding.

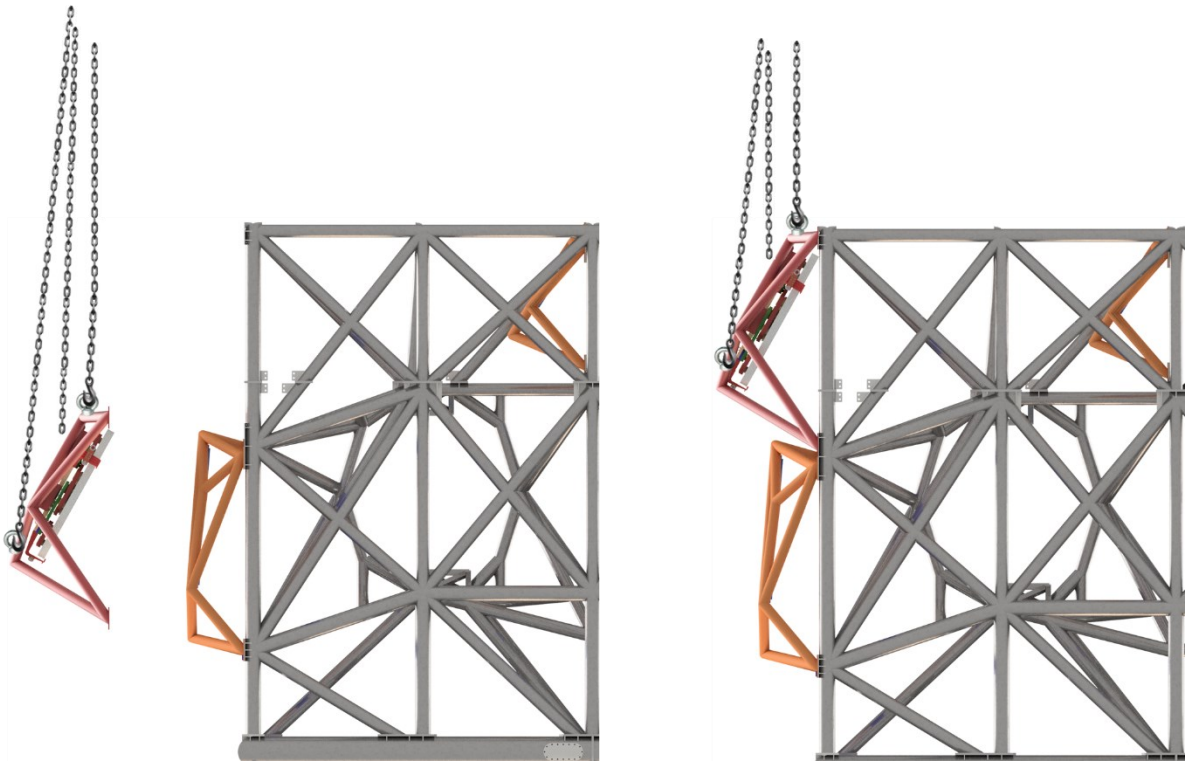


Figure 49: installation of M8 in IAA. In red, the M8 supporting structure. Some dowels between M8 support and MAORY main structure allows repeatable re-positioning of M8 support onto MAORY.

While this approach would be still valid and feasible even for regular maintenance of the mirror, it would not be optimal. In fact, the mirror will be dismounted mainly for re-aluminizing its optical surface, and this operation would require the mirror to be removed from its support anyway.

8.13 M9/DM1 Installation (1d)

Purpose and functionality

M9 is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: MXO, JFA, GRO, ECA, LMA

HTs/SEq needed: Bridge crane, Dedicated HT, Scissor lifts, internal platforms

Success Criteria: M9 properly installed and in the nominal position

Duration: 1 day

Prerequisites: 8.12 M8 installation

Procedure: The M9 box shall be taken in the entrance hall, opened and the M9 transported in the IAA.

In the IAA the access from the top is not possible, and even an approach similar to what seen for M6 and M7 would be problematic, due to the position and the weight of M9. Its installation takes place from the side of the MMS, using a different handling and removing the beam (and the corresponding thermal panel) highlighted in yellow in Figure 51.

This handling is basically a squared tubular beam, interfaced to the top part of M9 flanges, using two M10 screws. The tubular beam is long enough to have the handling hoist ring always outside the MMS. To keep the handling dimension reasonable, a heavy counterweight (300-400 kg) is positioned on a threaded rod at the side opposite to M9. This mass can be moved by acting on two nuts, in order to rebalance the handling when M9 is disengaged.

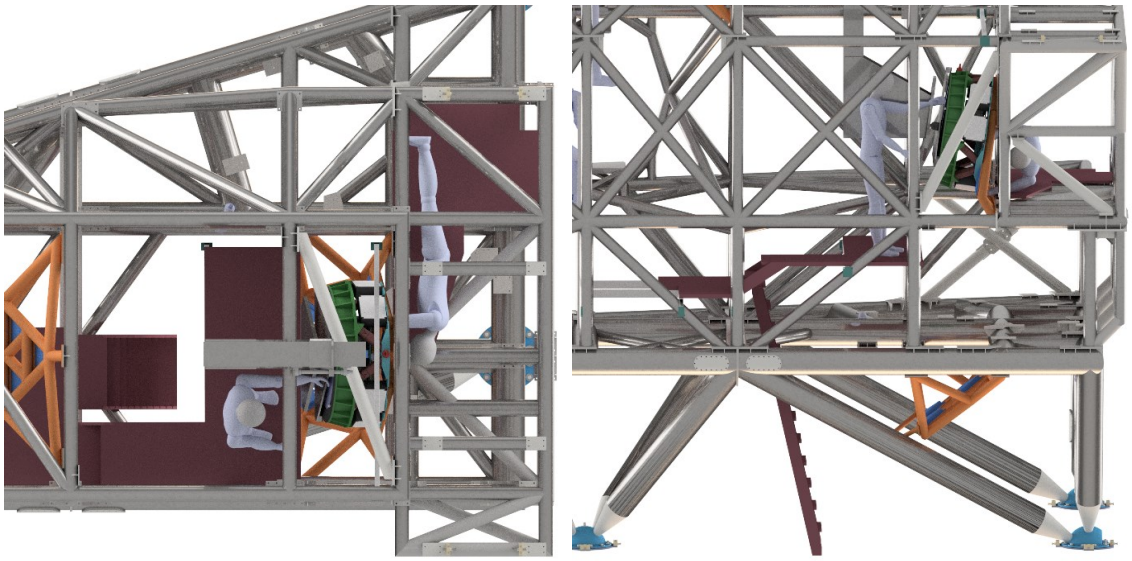


Figure 50: two persons are required to fix M9 to its supporting structure and to release the handling, one at the front and the other one at the back of the mirror. Left panel: MMS top view. Right panel: MMS side view.

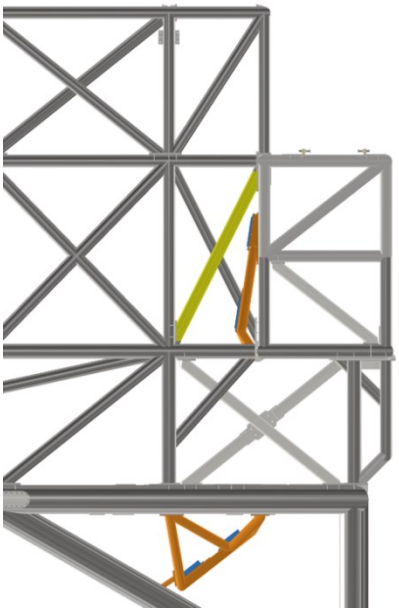


Figure 51: in yellow, the beam to be removed for installation of M9 from the side.

Once the mirror is in correspondence of its interface points in the MMS, two persons in the same locations shown in Figure 50 shall fix the mirror and release the handling.

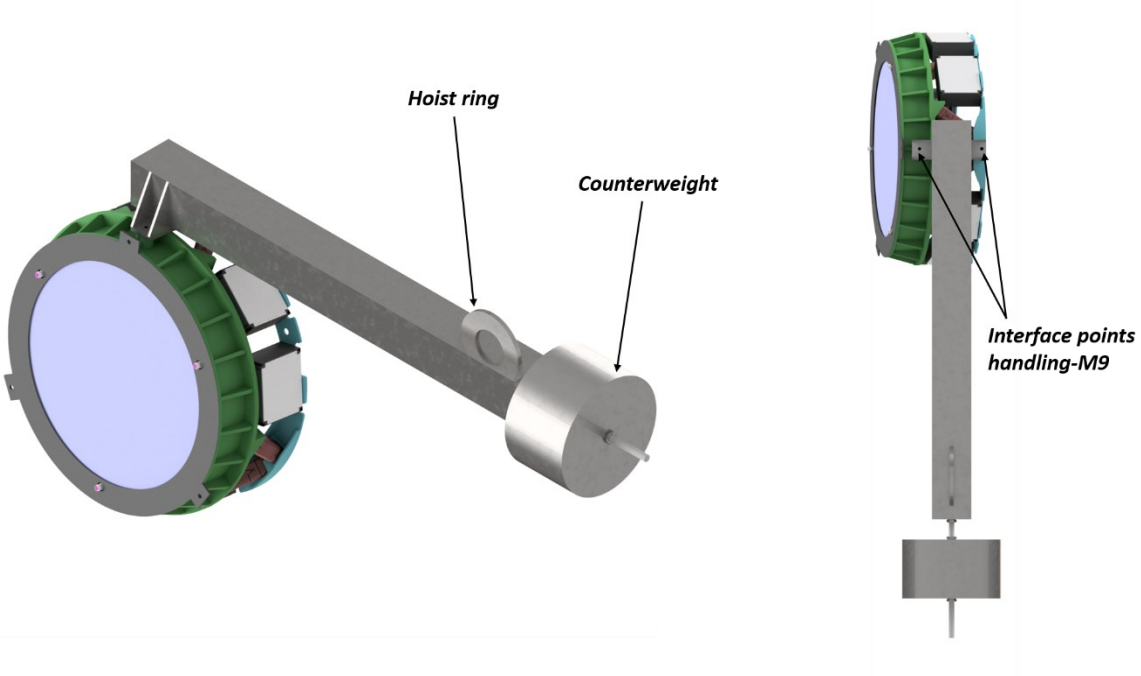


Figure 52: IAA M9 installation handling is a long tubular beam (~ 2m) interfaced to the top part of M9 with two M10 screws. The hoist ring is fixed. The counterweight is close to the hoist ring, to avoid having a very long handling, but this imposes a significant mass for the counterweight.

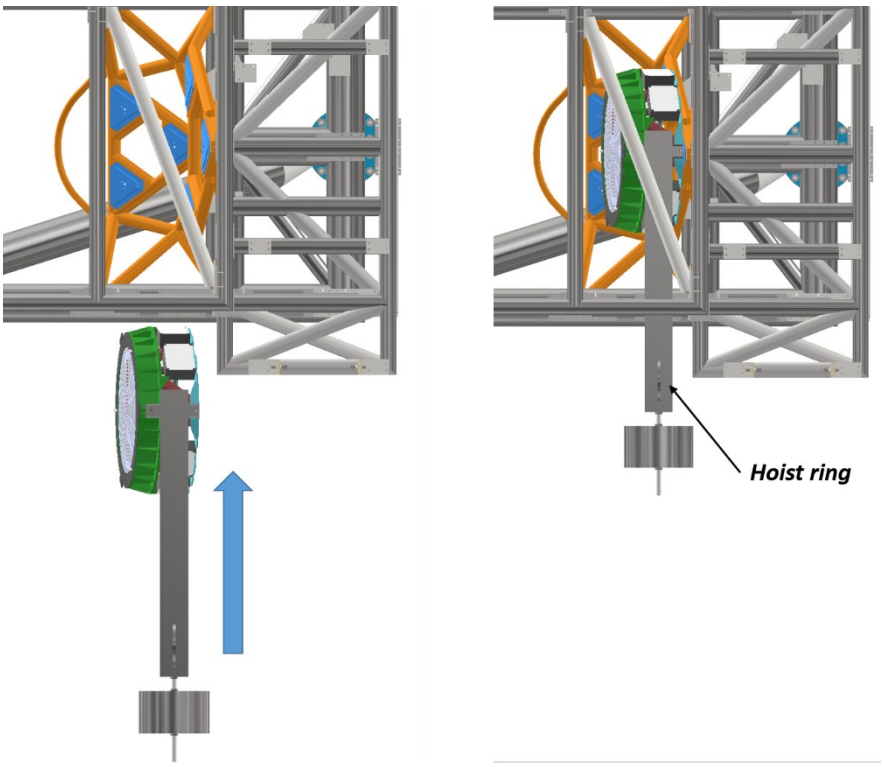


Figure 53: Top view of the MMS. The handling + M9 enters inside MMS from the side. When M9 is in front of its interface points in the MMS, the handling hoist ring is still outside the MMS.

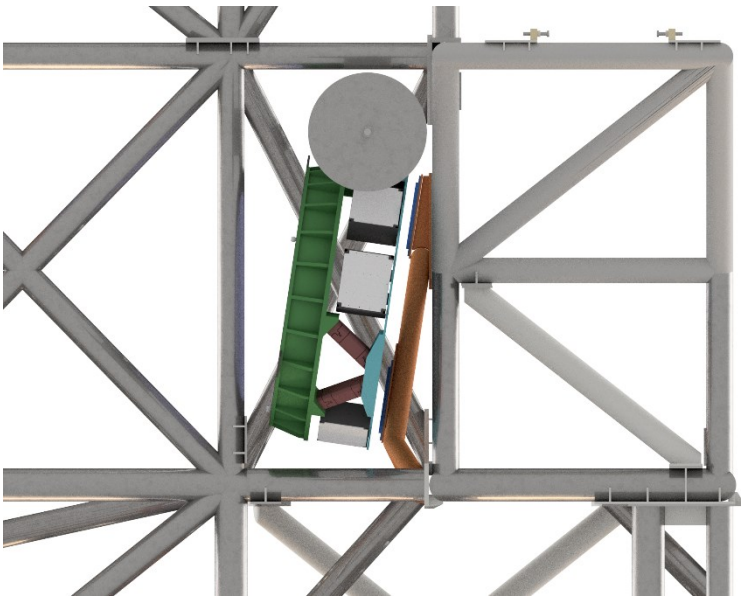


Figure 54: side view of the MMS during installation of M9. In orange, M9 supporting structure.

Notes:

8.14 M10/DM2 installation (1d)

Purpose and functionality

M10/DM2 is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: MXO, JFA, GRO, ECA, LMA

HTs/SEq needed: BBridge crane, Dedicated HTs, Scissor lifts

Success Criteria: M10/DM2 properly installed and in the nominal position

Duration: 1 days

Prerequisites: 8.13 M9/DM1 installation

Procedure: The M10 box shall be taken in the entrance hall, opened and the M10 transported in the IAA.

Due to the internal structure of the MMS around M10 position, an approach similar to what described for M6 is not viable.

The procedure in IAA consists of installing M10 + its support on MMS. Due to the external position of M10 within the main structure, this installation can be performed just using 3 hooks, opportunely dislocated on M10 support structure, to interface to the crane. The system is balanced tuning the length of the chains, and finally lifted up and interfaced to MMS.

In this case, access only at the back of the mirror is required as both the interface with the chains, fixing screws and alignment mechanisms are accessible from the back.

A person can easily reach the required position by using a scissor lift or a temporary scaffolding.

Installation of M10 using this procedure must take place before installation of M8 in IAA, to avoid interference problems with the M8 supporting structure, located just above M10 supporting structure.

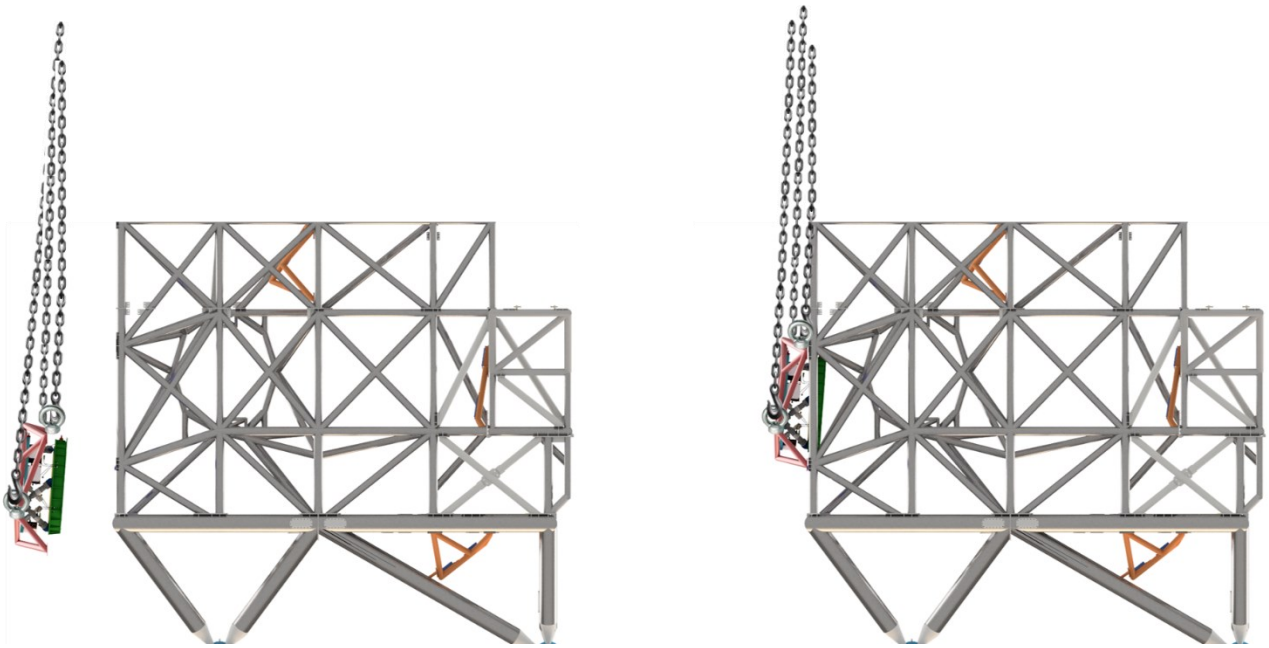


Figure 55: installation of M8 in IAA. In red, the M8 supporting structure. Some dowels between M8 support and MAORY main structure allows repeatable re-positioning of M8 support onto MAORY.

Notes:

8.15 M11 Installation (1d)

Purpose and functionality

M11 is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: JFA, ERE, LMA

HTs/SEq needed: Bridge crane, Dedicated HT, Scissor lifts, internal platforms

Success Criteria: M8 properly installed and in the nominal position

Duration: 1 days

Prerequisites: 8.14 M10/DM2 installation

Procedure: The M11 box shall be taken in the entrance hall, opened and the M11 transported in the IAA.

This mirror is not installed from the top of the MSS, thus it has the same mounting/dismounting procedure at BIH, IAA and Nasmyth Platform.

M11 has a mounting frame different from the ones we have seen in the previous sections, as it is equipped with motorized actuators and rotary base.

The idea for this mirror is to install/remove it together with the motors. This means that the mirror will be extracted together with its interface assembly, thus it is possible to interface the handling to the interface assembly rather than on the branches holding the mirror cover.

The handling has 3 forks to be inserted into 3 slots in M11 interface assembly, and they are secured by screws. A heim joint rod end on the handling allows tuning the position of the mirror in 3 DoFs, using some threaded rods on the fixed part of the handling. When the mirror has the correct orientation in the space, the interface assembly can be fixed to the MAORY main structure. Since the barycentre of the system moves by several centimetres, and mostly in one direction, with and without M11 connected to the handling, to avoid unwanted oscillations of the handling when releasing M11, the handling interface hook with the crane is mounted on a sliding system. Thus, when M11 is secured to MAORY main structure, before releasing the handling, the hook is slid to the position where the stand-alone handling is balanced, and only after this operation the handling is decoupled from M11.

One person is needed to fix M11 to the MSS and to engage/disengage the handling from M11. This person shall be on a scissor lift or a temporary platform located between MAORY and MICADO, in a position not interfering with the tower duct.

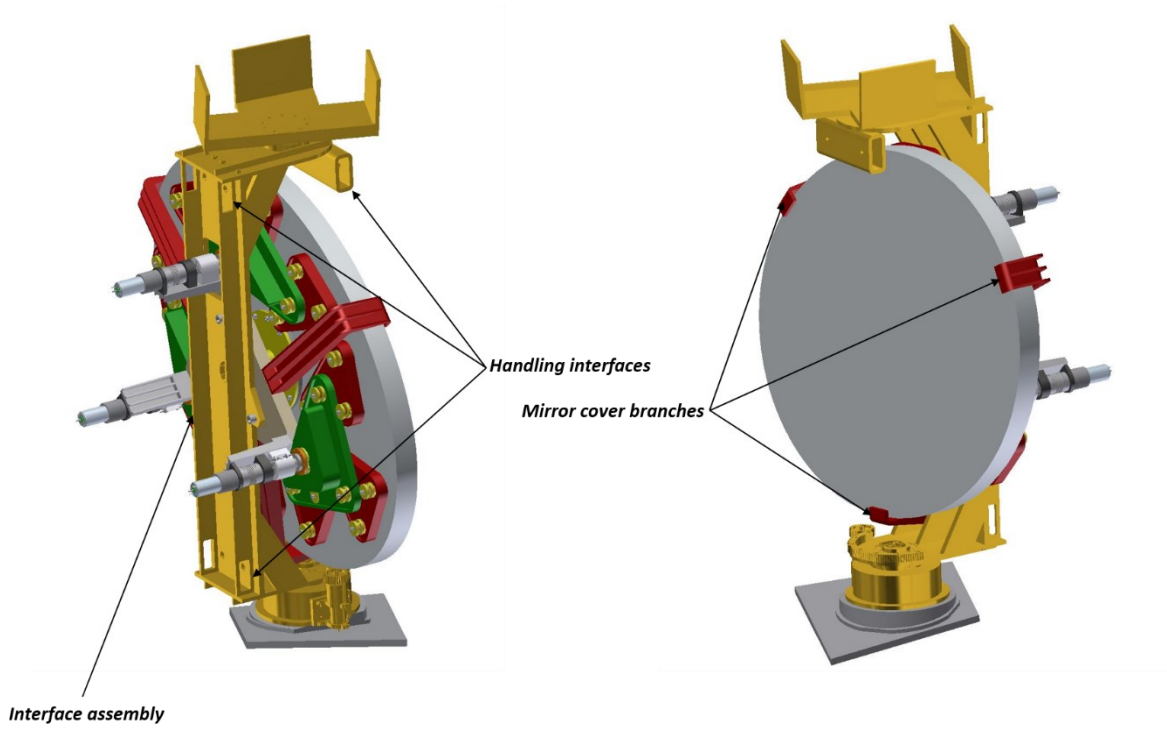


Figure 56: M11 assembly that will be inserted/extracted from the MAORY main structure.

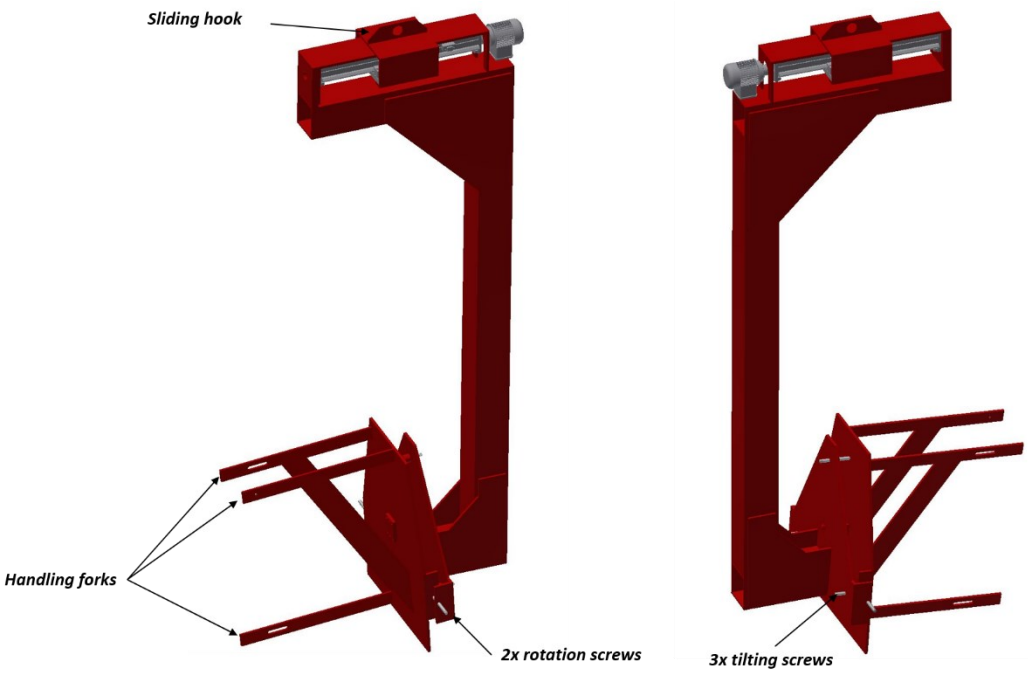


Figure 57: M11 installation/removal handling. The interface will be on the 3 forks. The handling will allow to fine tune the tip-tilt-rotation of the mirror during the installation. A sliding interface hook allows to re-balance the system when M11 is engaged/dis-engaged.

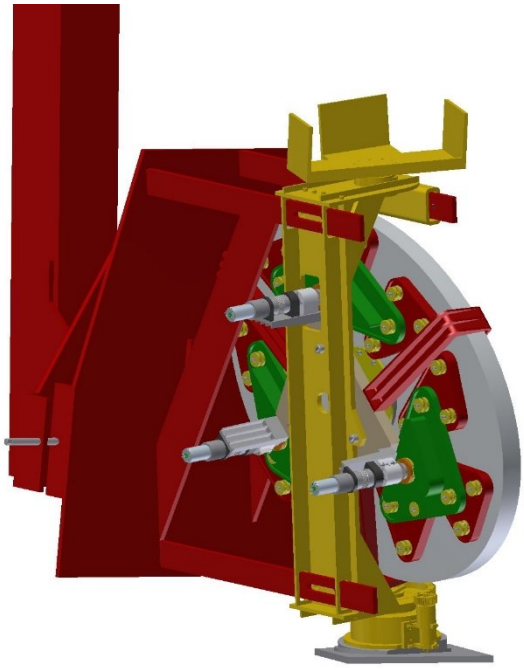


Figure 58: handling engaged to M11.

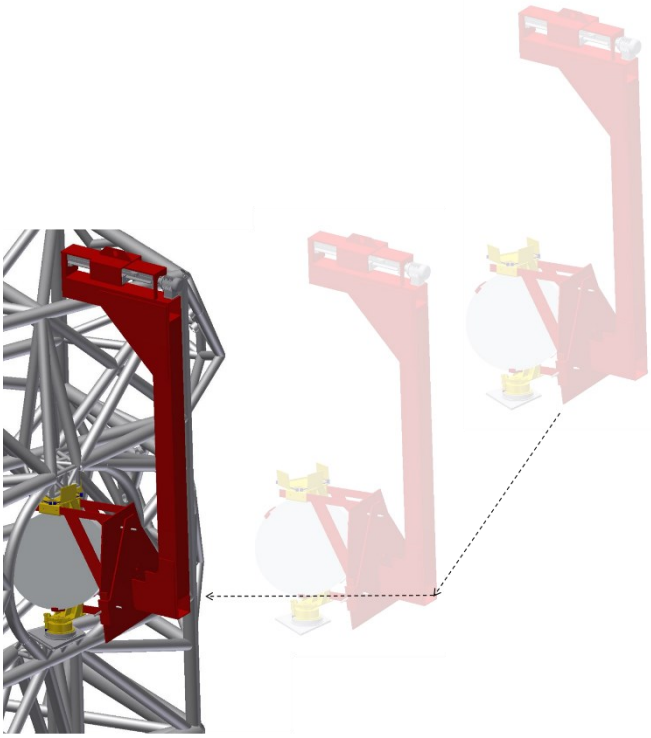


Figure 59: possible M11 installation path into MAORY main structure.

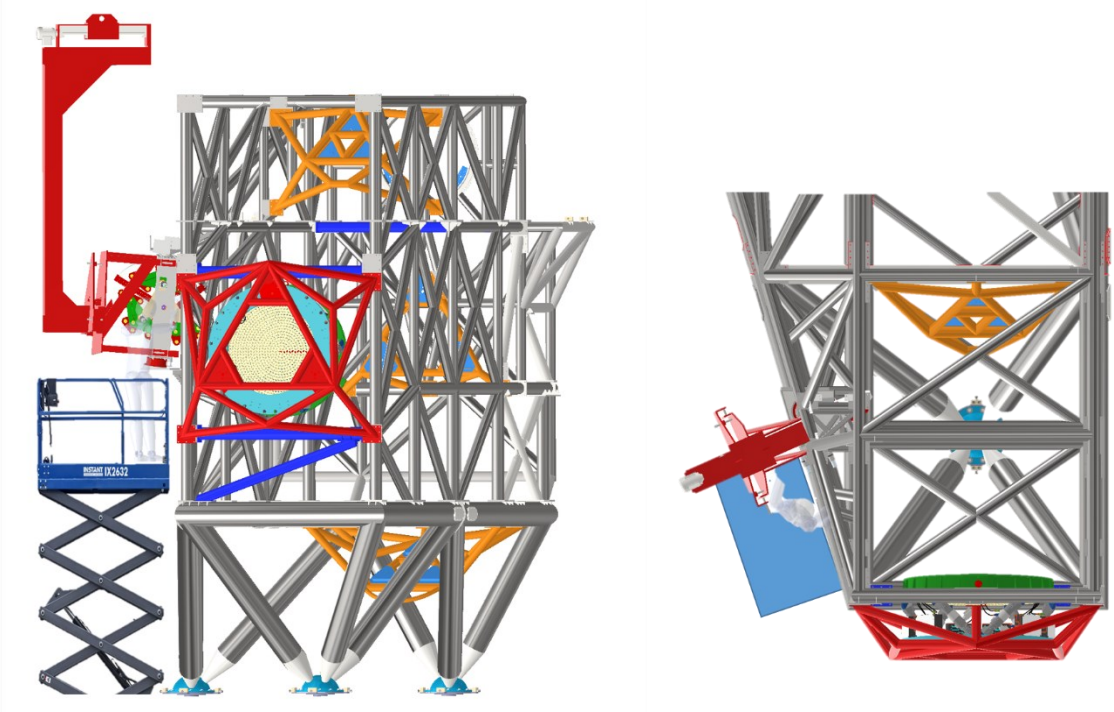


Figure 60: a single person, on a scissor lift or on a temporary platform, is sufficient for installation/removal of M11.

Notes:

8.16 CU selector, MCA and CU folding mirror installation (3d)

Purpose and functionality

The CU selector is installed on the MSS with the MCA (TBD with MICADO team) and with the CU folding mirror assembled and integrated on it, motors are plugged and functional test are performed.

Responsible: VDC, VCI, GDR, GRO, JFA

HTs/SEq needed: Bridge crane, Dedicated HTs, Scissor lifts

Success Criteria: Selector, MCA and CU properly installed and functional test all working

Duration: 3 days

Prerequisites: 8.15 M11 installation

Procedure: The CU selector box(and the MCA one, if installed at this stage) shall be taken in the entrance hall, opened and the CU selector transported (and the MCA, if installed at this stage) in the IAA.

Before mounting the subsystem on the MSS we shall:

- Remove the enclosure of the subsystem (Figure 61 left side)
- Mount the Folding Mirror of the CU (FMCU) assembly and the MICADO MCA on the sliding part of the CU Selector (Figure 61 right side)

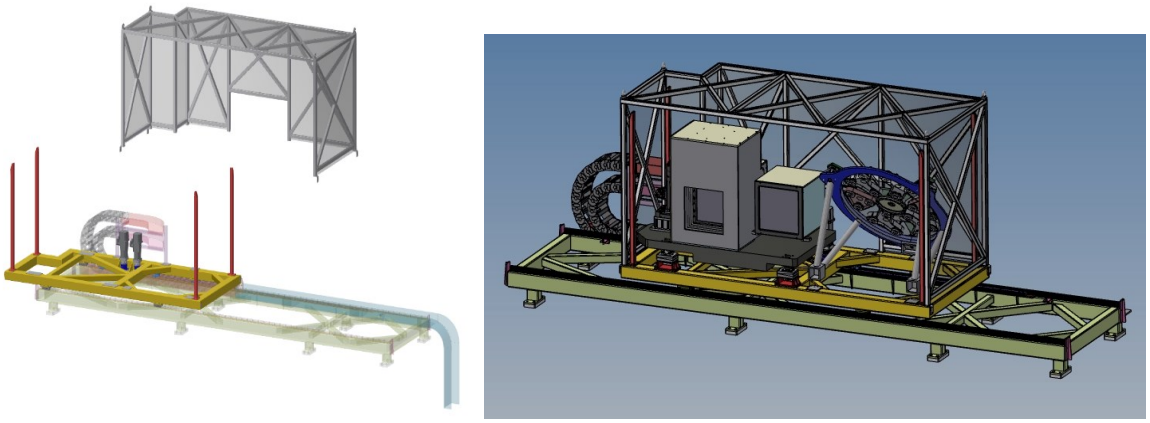


Figure 61: the CU selector with the enclosure removed for the installation of the MCA dummy and of the FMCU (left end side), and the CU selector fully assembled (right end side)

- Install all the cables inside the cable chain
- Test and pre-align the FMCU
- Re-Install the enclosure of the CU sub-system

- Assemble the Enclosure on the MSS bottom part of the CU Selector and in the MSS front side adjacent to the CU selector location, before mounting the CU Selector (Figure 62 left side)

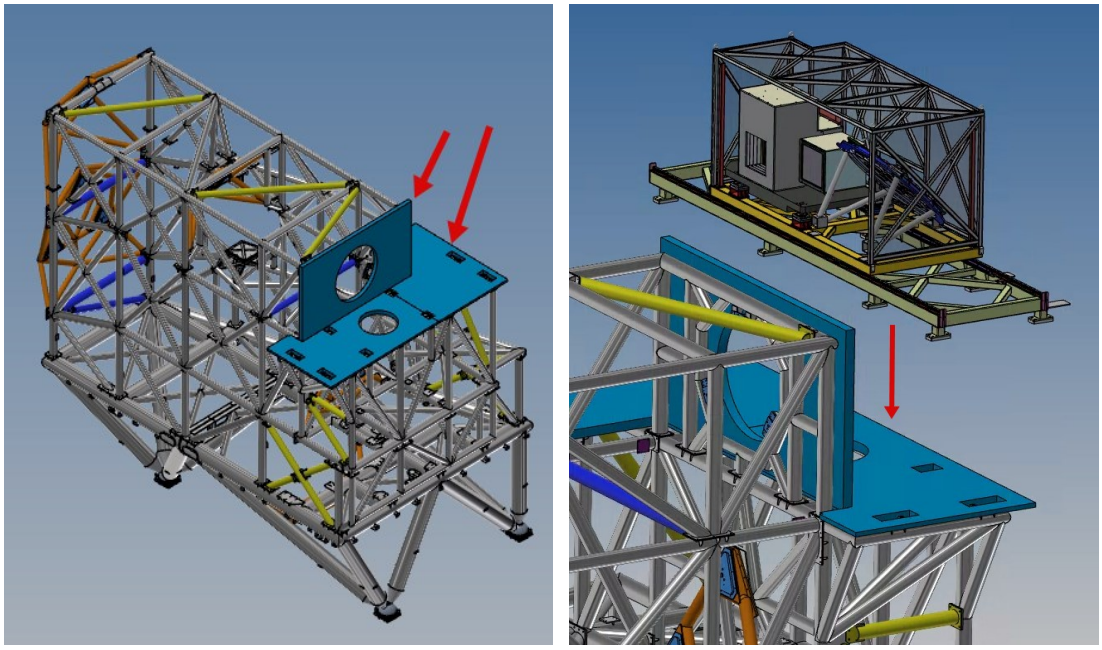


Figure 62: installation of the part of the cover below and adjacent to the CU sub-system (left end side) and craining of the CU selector and CU sub-system on the MSS (rught end side)

The cable chain must be partially disassembled for the part where the cables are not present.

Cables must be collected and provisionally secured.

Then, using four slings connected at the ends of the fixed frame, the Calibration CU selector will be position using the BIH crane and screw it on the MSS ((Figure 62 right side). When the system is in its final position, all the cables can be properly routed to the cabinets and the system can be powered on and functionally tested.

Notes: TBD with MICADO team if the MCA will be installed at this stage.

8.17 Calibration Unit installation (2d)

Purpose and functionality

The CU is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: GDR, IDA, GRO, JFA

HTs/SEq needed: Bridge crane, Dedicated HTs, Scissor lifts, Cherry picker

Success Criteria: CU properly installed and in the nominal position

Duration: 2 days

Prerequisites: 8.16 CU Selector installation

Procedure: The CU box shall be taken in the entrance hall, opened and the CU transported in the IAA.

The MAORY Calibration Unit sources box will be integrated onto MAORY main structure as a single piece, once internally fully aligned.

The concept is quite similar to the one devised for the LGS-o, i.e. lowering with the crane the CU box onto two rails defining the path inside MAORY main structure, and when the CU box is leaning on the rails, push it towards its working position.

The first step is to create an access in the MSS for the CU, and this is done by removing the beam shown in Figure 63. The beam shown in the left panel of Figure 63 (MICADO side) is the one to be removed to actually install/remove the CU, while removing the beam on the opposite side is necessary to allow a person enter into the MSS to fix the CU to its interface points later in the procedure.

Due to the dimensions of the CU, part of the rails will protrude out of the MSS (as for the dichroic and 1st folding mirror), thus a support is required. Also, the rails will be located at 3.5 meters above the ground, so some persons are required at this height to both mount the rails to their supports and, in a second moment, to release the handling lowering the CU on the rails.

Some caged ladders, to be mounted temporarily at both the relevant (for CU installation) sides of MSS, allow to the operators to enter into the MSS and to remove the aforementioned beams. At the MICADO side two small platform, fixed to the ground, have a double scope:

- Providing a working area for two persons, who have to fix the protruding part of the rails to the support beams, to disengage the handling lowering the CU once it is secured to the rails and to release the rails from the supporting beams when CU installation is over.
- Provide support to the rails protruding parts.

A view of the SEq required for CU installation is shown in Figure 64.

The rails are lowered by the crane and then inserted into MSS. Most likely, part of the rails will permanently live inside the MSS, and only a shorter pair of rails will be mounted when necessary. As an alternative, the rails will be anyhow divided in more pieces, to avoid dealing with the installation of very long rails. Two people inside the MSS fix the rails to the supporting plates, while two people on the temporary scaffolding at the MICADO side fix the protruding part of the rails to the supporting beams, that are integrating part of the scaffolding.

For installation, the CU is mounted on a trolley which can slide on the rails, by means of 4 M20 screws. Another handling embraces the CU and is connected to its base frame through 4 others M20 screws. The latter handling allow to pick-up the calibration unit together with the trolley and to position it on the rails. At the top of the handling there is a hoist ring for the crane hook.

When the CU lies on the rails, the two persons on the temporary scaffolding fasten the 4 security clamps on the trolley to the rails (Figure 68). Now, the hoist ring position can be

tuned to the handling barycenter position without the CU and the handling is released by removing the 4 M20 screws.

The CU now can slide inside the MSS (Figure 69). Due to its weight, a system using steel cables and a winch is under study.

CU shall slide inside the MSS till the 3 guiding screws on the CU are aligned to the spherolinder (previously aligned) in the MSS (Figure 70). The two persons working inside the MSS now insert the guiding screws in the spherolinder and also the 2 screw jacks (next to the guiding screws) into their seats (Figure 71).

The 4 M20 screws fixing the CU to the handling can now be removed (Figure 72), and screwing more the 2 screw jacks, one side of the CU is lifted up by ~ 24 mm so to free the trolley, which can now slide out the MSS, where it can be removed with the crane (Figure 73)

At this point, unscrew the screw jacks so that the CU is lowered, remove the guiding screws and replace them with the locking screws, equipped with cup springs (Figure 74).

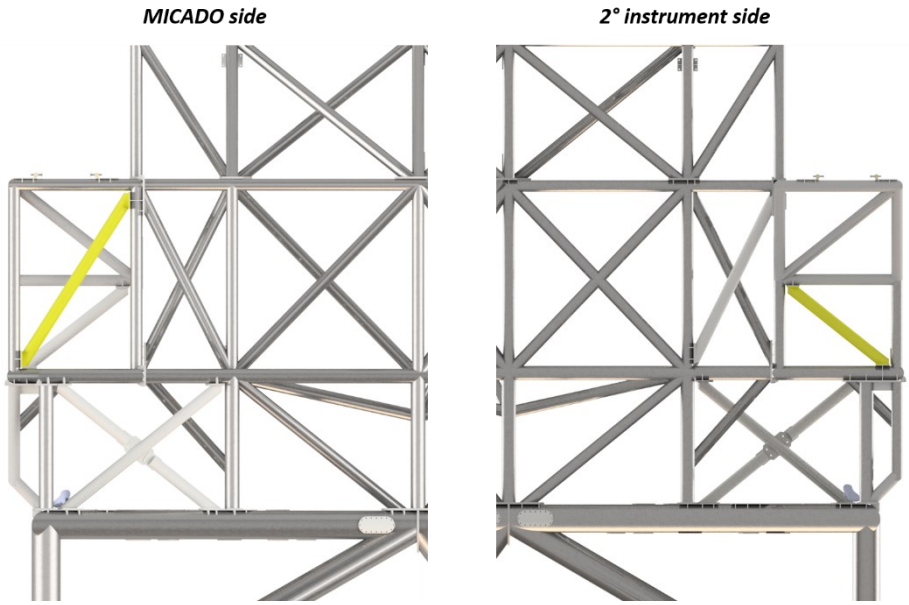


Figure 63: yellow beams shall be removed to allow installation of Calibration Unit box.

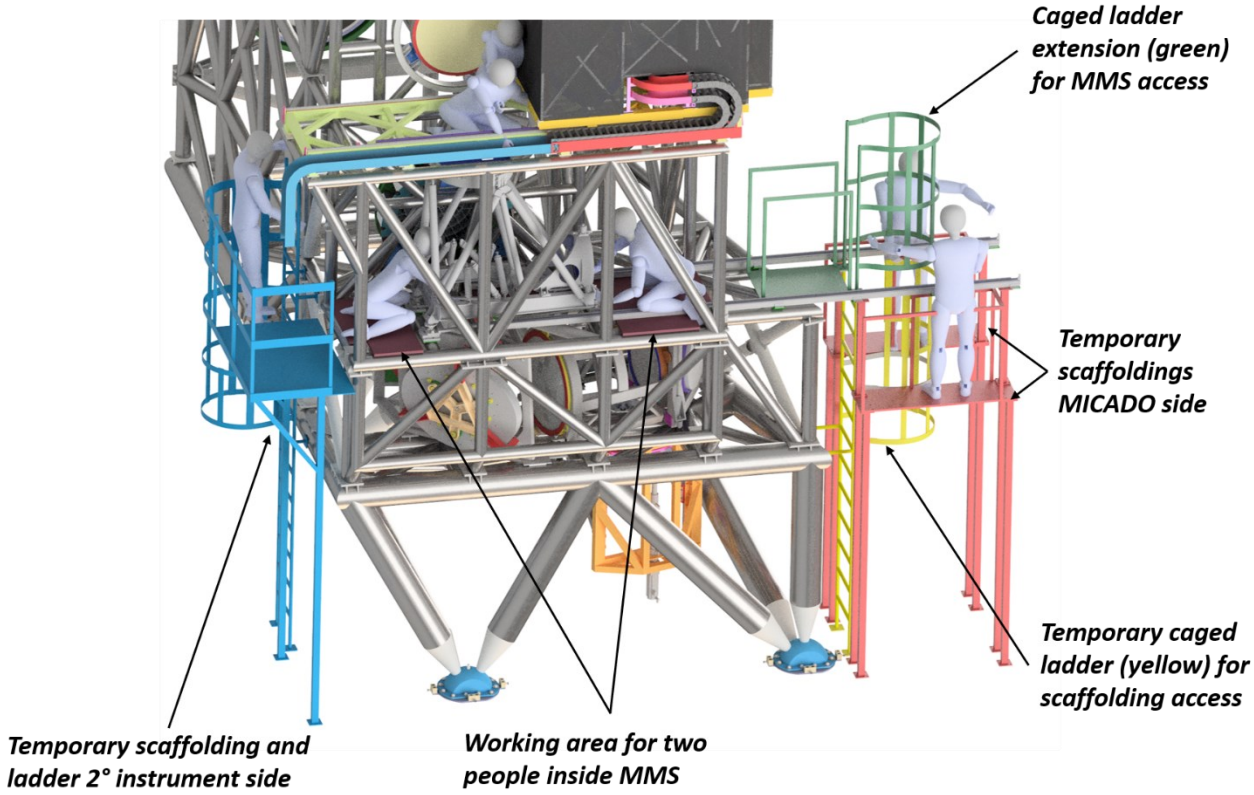


Figure 64: temporary scaffolding mounted at both relevant side of MSS to allow all the operations necessary for CU installation/removal. The blue caged ladder on the left is needed to access the MSS from the 2nd instrument side, while the yellow caged ladder + its green extension allows accessibility into MSS from MICADO side. The green extension shall be removed before lowering the CU on the rails, of course. The yellow caged ladder stand-alone, provide accessibility to the red temporary scaffoldings.

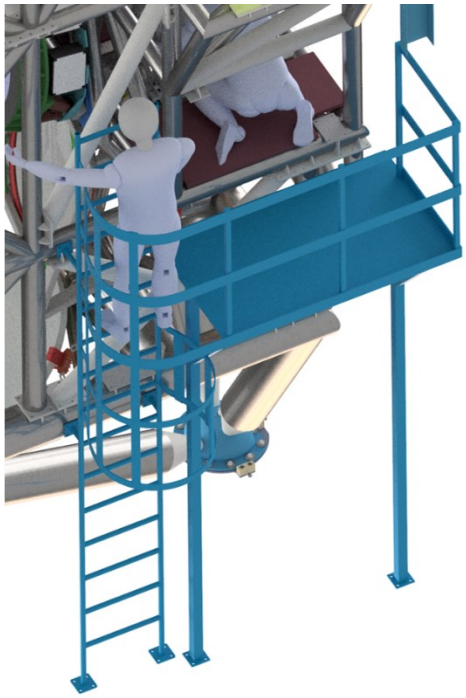


Figure 65: red scaffoldings provide a working area to 2 people and support to the protruding part of the rails.

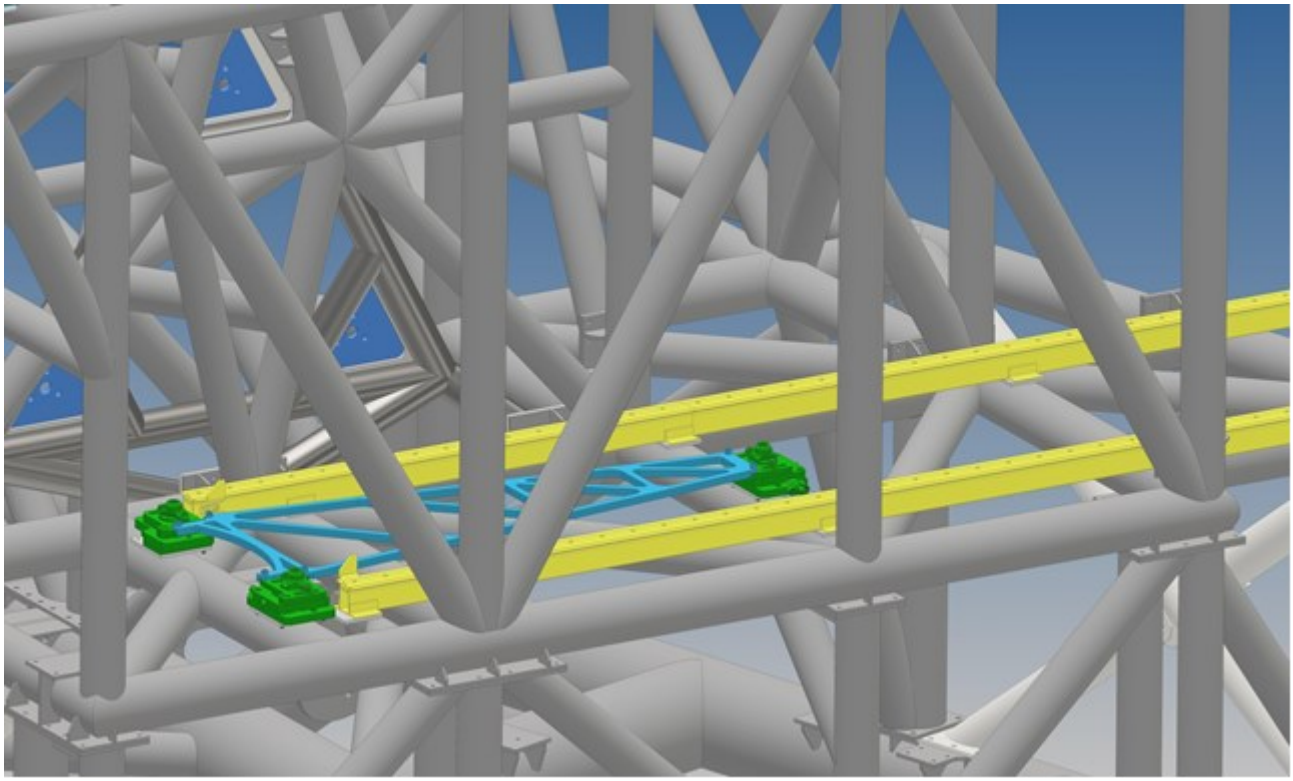


Figure 66: CU rails installed inside MSS (in yellow).

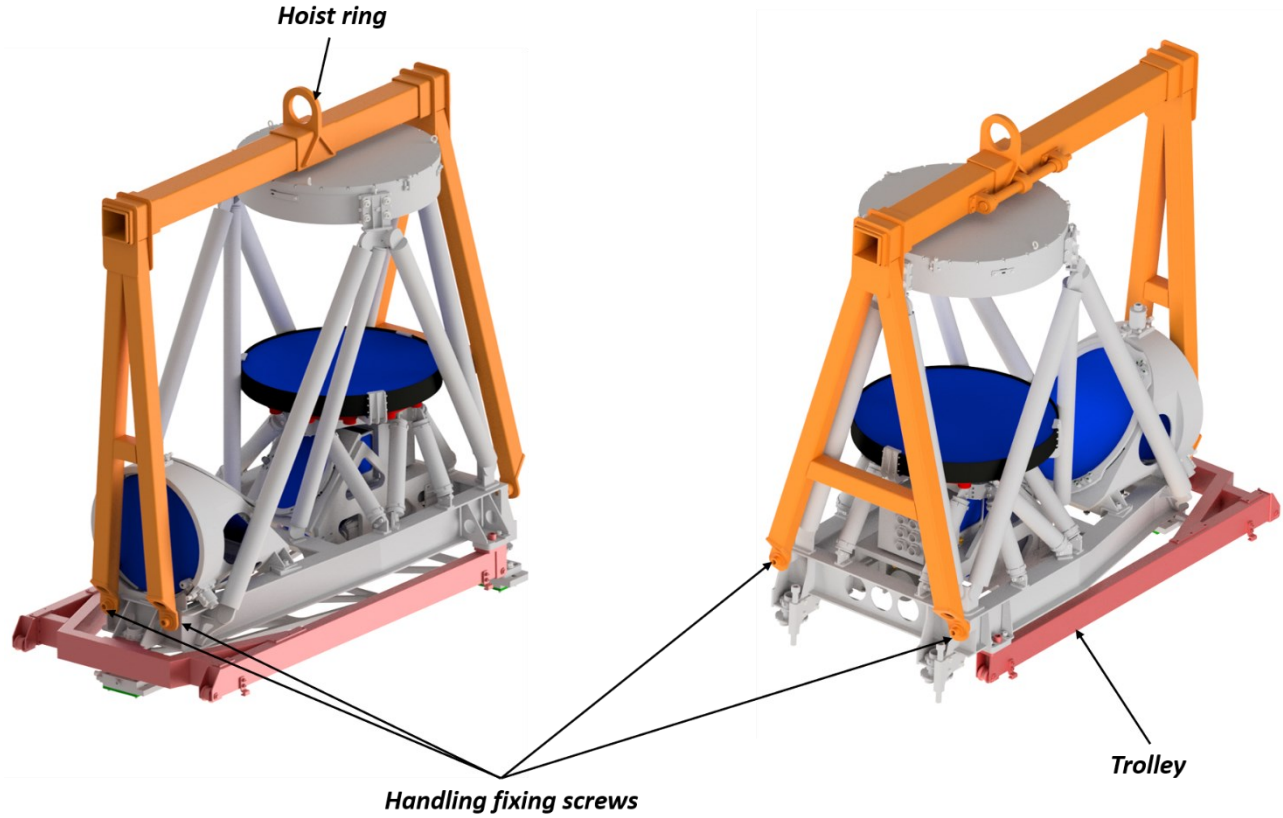


Figure 67: in orange, the handling to pick-up and lower the CU on the rails. It is fixed to the CU base frame with 4 M20 screws. In red, the trolley that will allow the CU to slide on the rails to its nominal position inside the MSS.

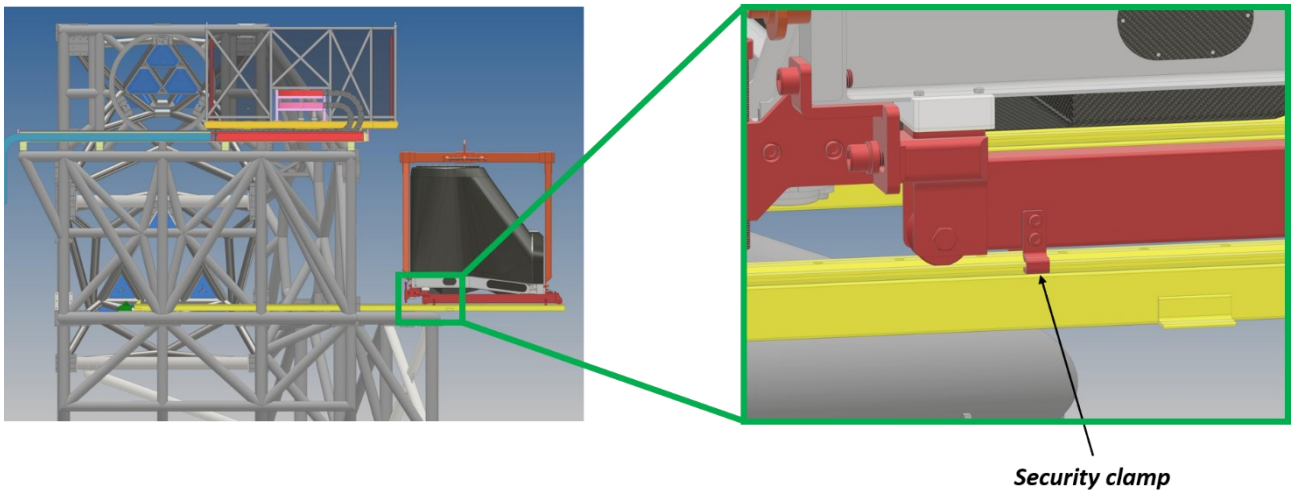


Figure 68: 4 security clamps shall be engaged to the rails before sliding the CU inside the MSS.

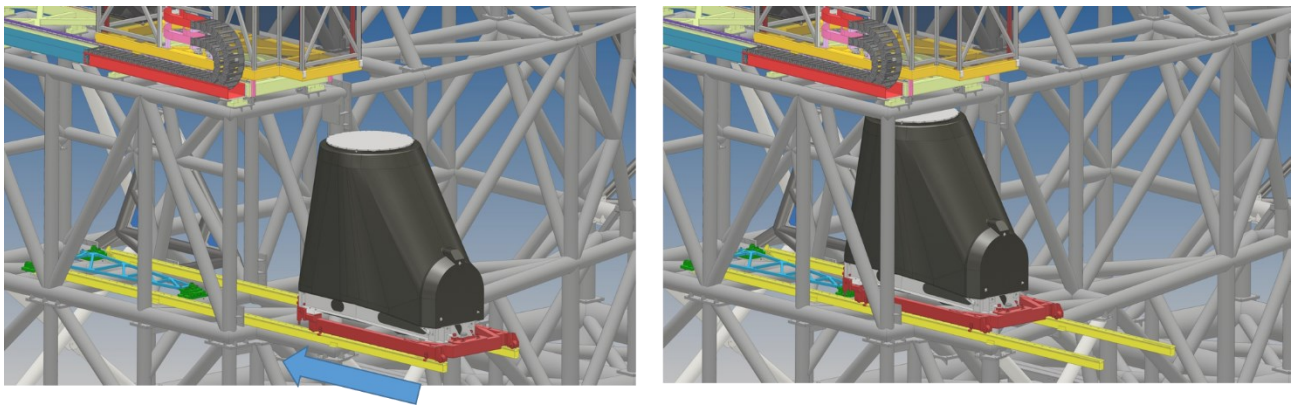


Figure 69: the CU slides inside MSS.

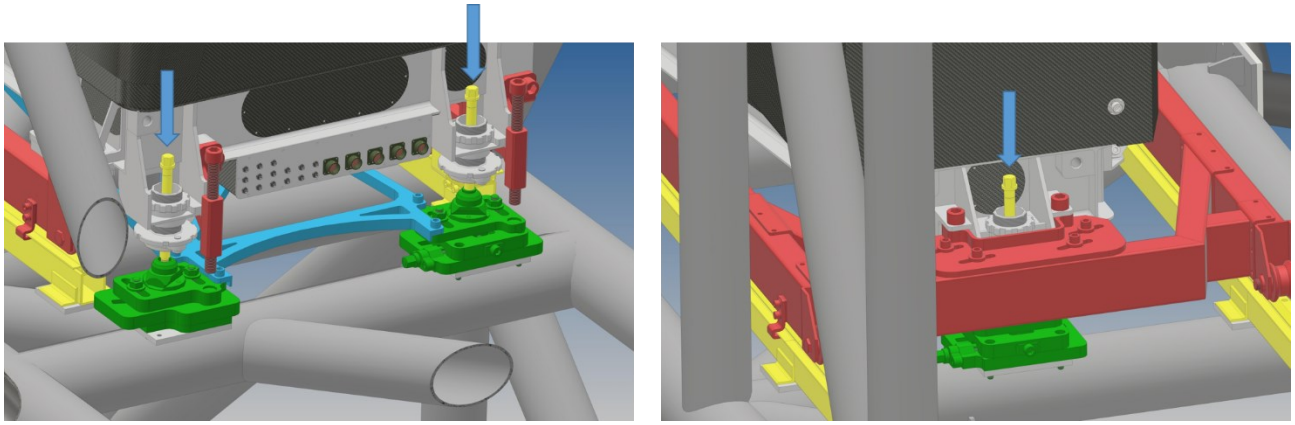


Figure 70: in yellow and pointed by the blue arrows, the guiding screws that must be aligned to the spherolinder (in green)

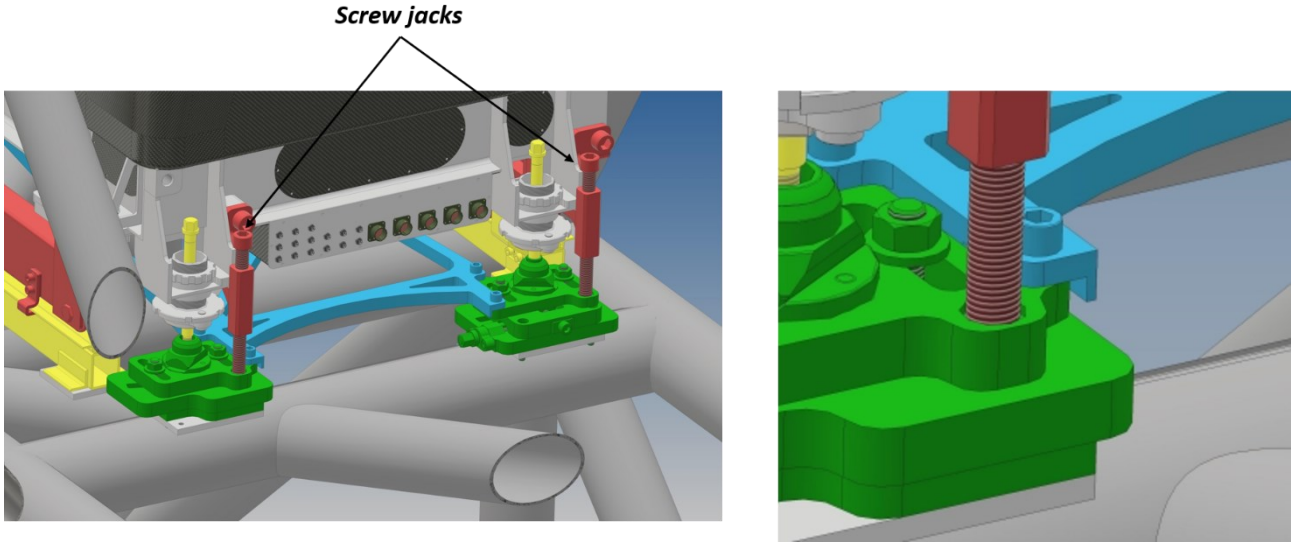


Figure 71: in red, the 2 screw jacks that shall be screwed all the way down till they enter into their seat in the green plate.

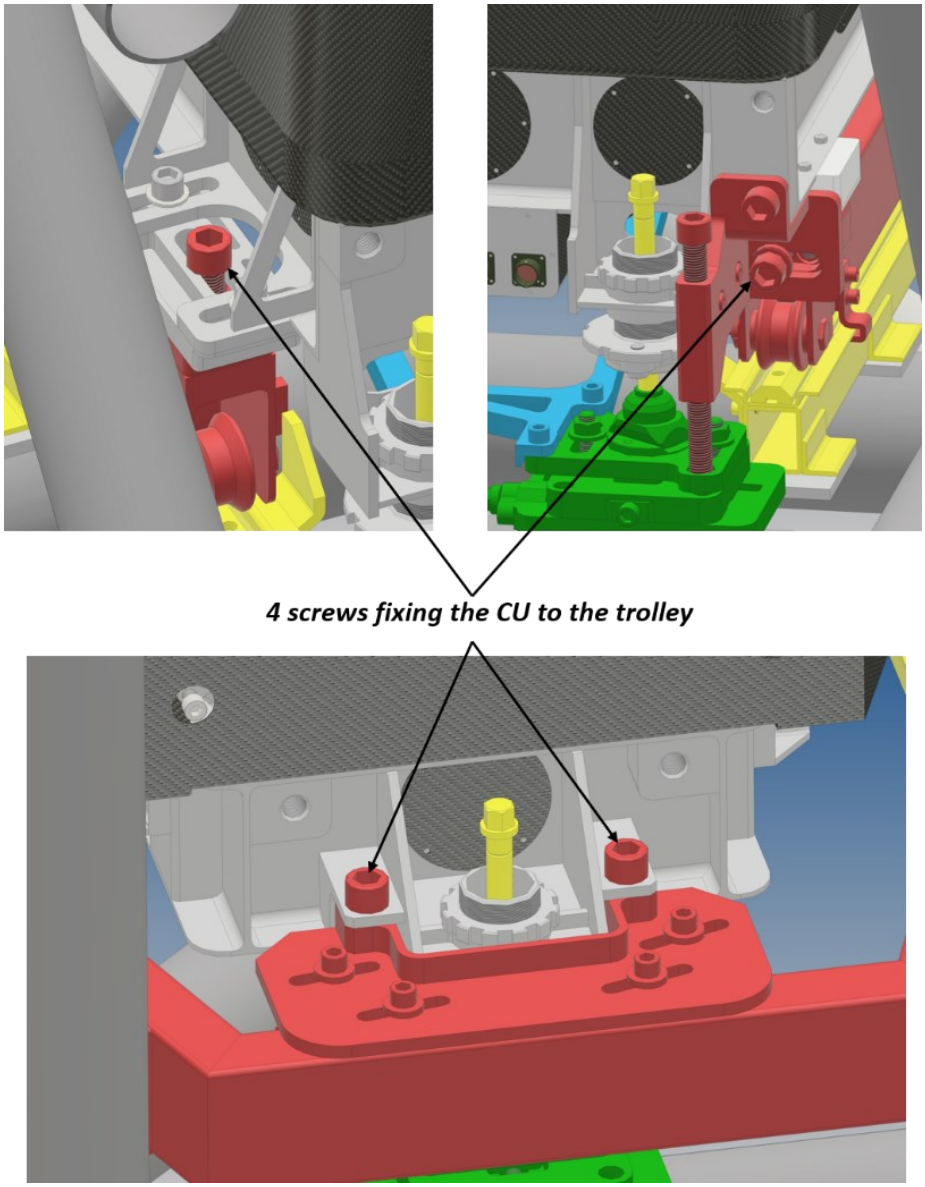


Figure 72: the 4 M20 fixing screws to be removed to free the trolley

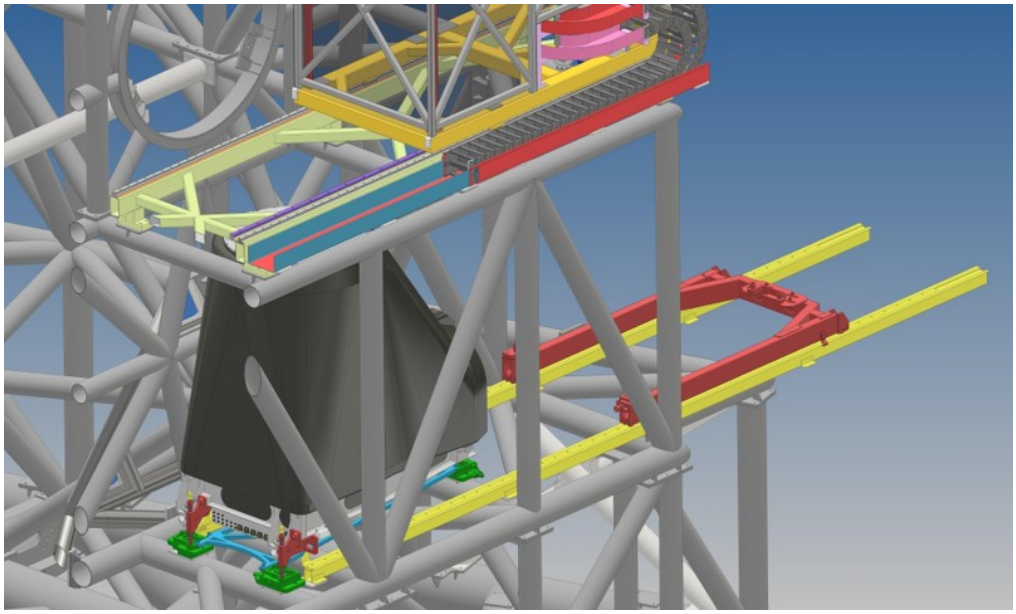


Figure 73: trolley slides out

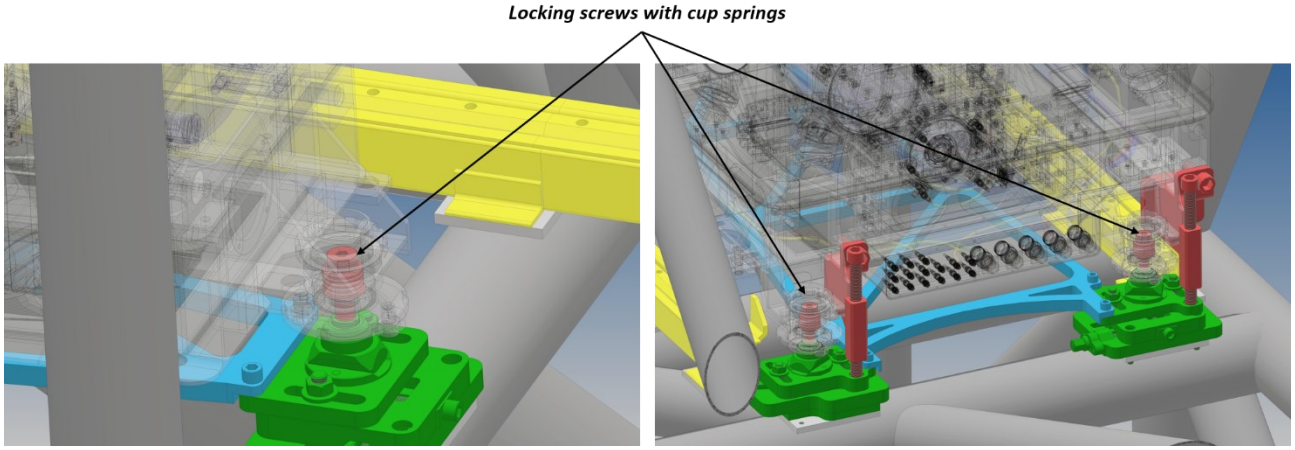


Figure 74: replace the guiding screws with the locking screws and tightnen them.

Notes:

8.18 Dichroic Installation (1d)

Purpose and functionality

The Dichroic is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: LMA, ERE, VDC, VCI, JFA

HTs/SEq needed: BBridge crane, Dedicated HT, internal platform

Success Criteria: Dichroic properly installed and in the nominal position

Duration: 1 days

Prerequisites: 8.17 CU installation

Procedure: The dichroic box shall be taken in the entrance hall, opened and the dichroic transported in the IAA.

Also in this case, the installation/removal procedures are the same in BIH, IAA and Nasmyth Platform.

The Dichroic is installed using a rail system that allows to slide it in its final position. For its installation, an opening on the side of MSS is required, and this is obtained by removing the beams shown in Figure 75.

After removal of the beams and of the corresponding thermal panel, the rail shall be mounted inside the MSS. The rail orientation is optimized to transfer the dichroic from outside the MSS just in front of its interface points inside MSS. To ease the process, it is under evaluation to split the rail in two parts, keeping a part always mounted into the MSS, and having only a short piece of rail to be mounted at the occurrence.

The part of the rail protruding from the MSS unload part of the weights to a beam connected to the ground, while the part inside the MSS is attached to the MSS itself..

When the rail is in place, a special handling is mounted on the carts sliding on the rail. The scope of this handling is to keep the dichroic with the same orientation it will have when mounted in the MSS

In order to position the dichroic on the sliding handling, the plan is to use a C-shaped handling, interfaced to 3 points on the dichroic opto-mech, as for most of the other optical elements in MAORY.

The dichroic connected to the C-shaped handling approaches the sliding handling on the rail, to which it is connected using 3 other points on the opposite side of the opto-mech. When the dichroic is secured to the second handling, the C-shaped handling can be removed and taken away by the crane.

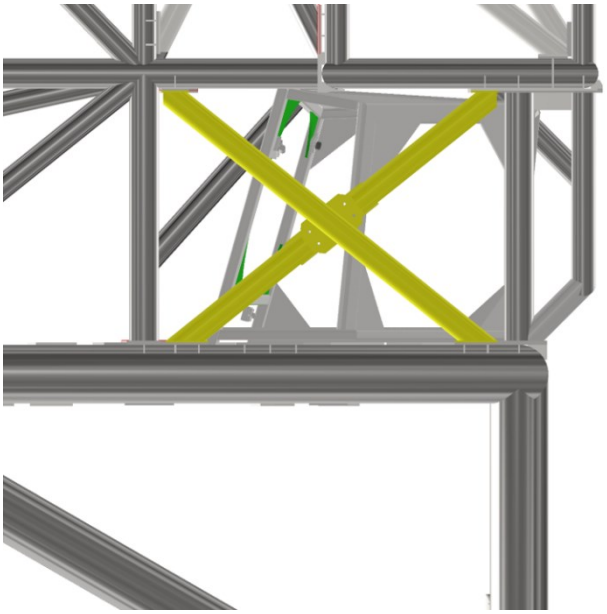


Figure 75: beams to remove to permit installation of dichroic

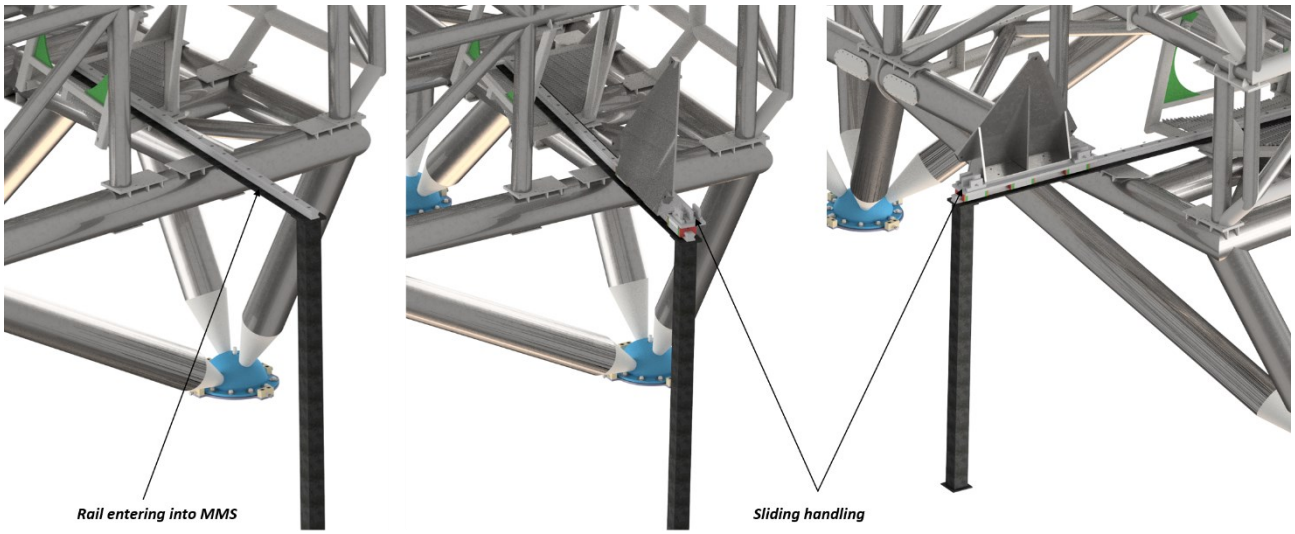


Figure 76: the rail and sliding handling to be used for the installation of the dichroic.

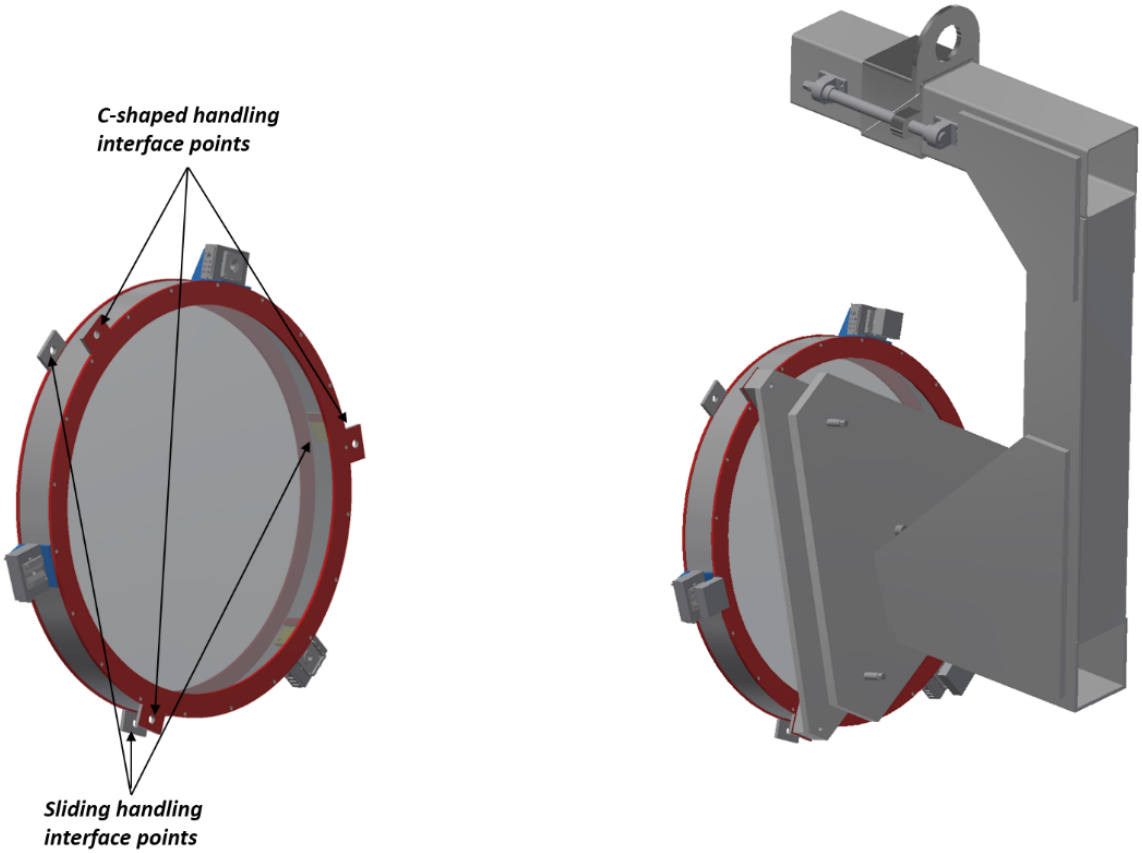


Figure 77: the C-shaped handling used to position the dichroic on the rail system

To allow the right positioning of the dichroic assembly on the cart and to properly connect it to the cart itself, normal portable ladders are used by two persons, positioned one per side of the rail.

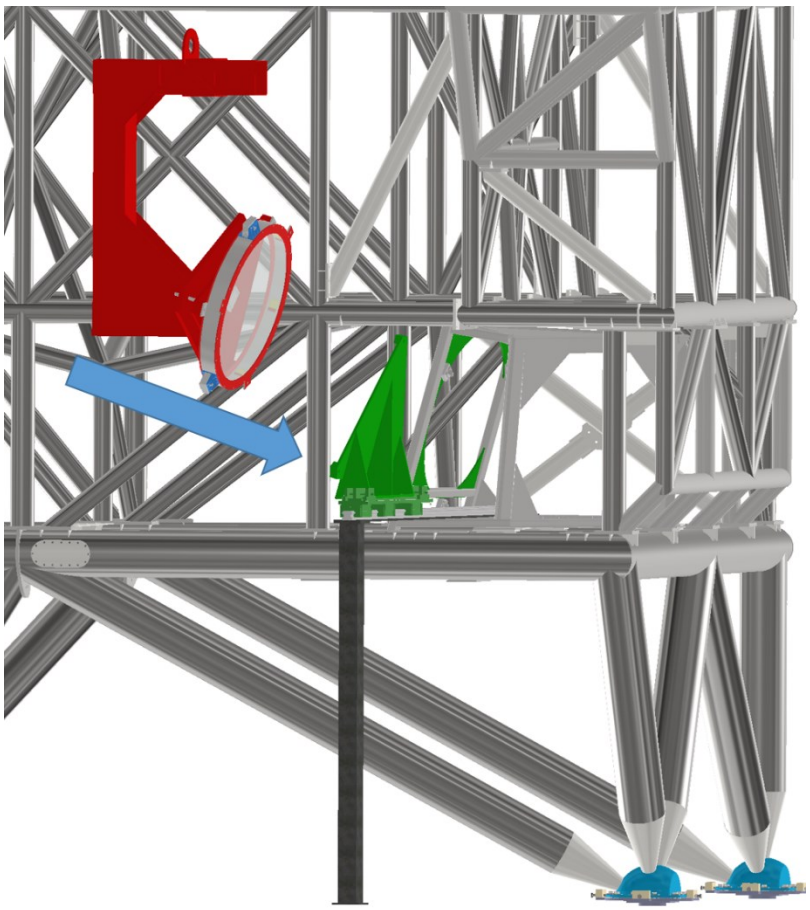


Figure 78: dichroic is installed to the sliding handling (in green in the figure). This handling is on carts which can slide into MAORY main structure.

At this point, the dichroic can be manually slid on the rail toward the mount. Some security blocks on the rail prevent the dichroic to slide off the rail.

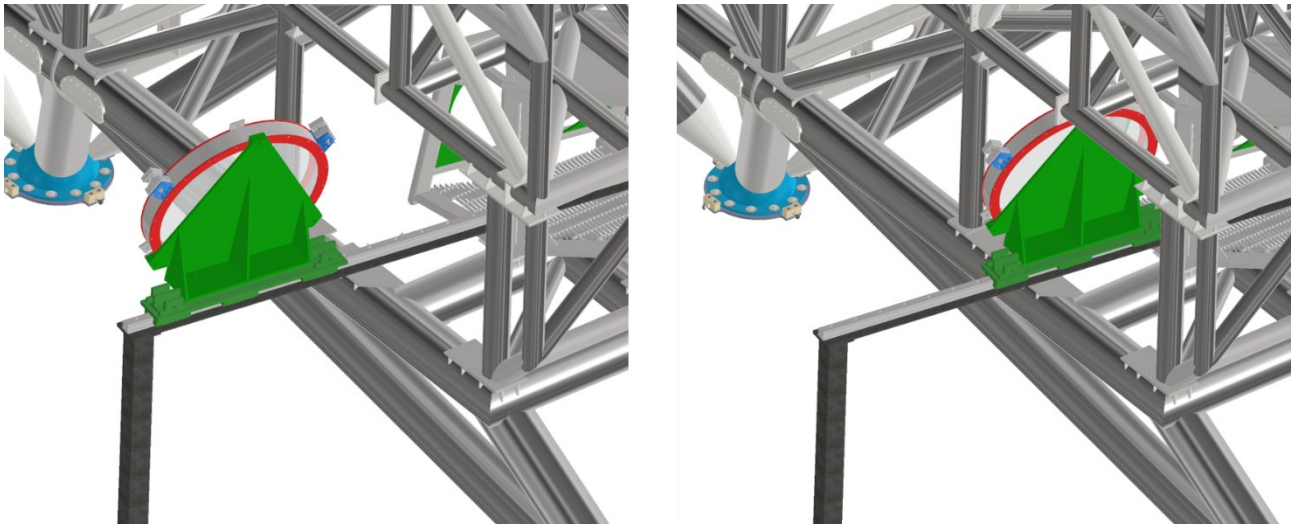


Figure 79: the dichroic assembly connected to the cart sliding on the rail system.

The cart has the possibility to move in the direction of the dichroic optical axis, by acting on two set of screws positioned at the two cart sides, with a total travel of about ±15mm. Thus, the system will be nominally kept at distance of about 10mm with respect to the interfaces where it has to be fixed, and only after reaching the correct position, it will be pushed toward the interfaces, where it will be connected using the dedicated screws.

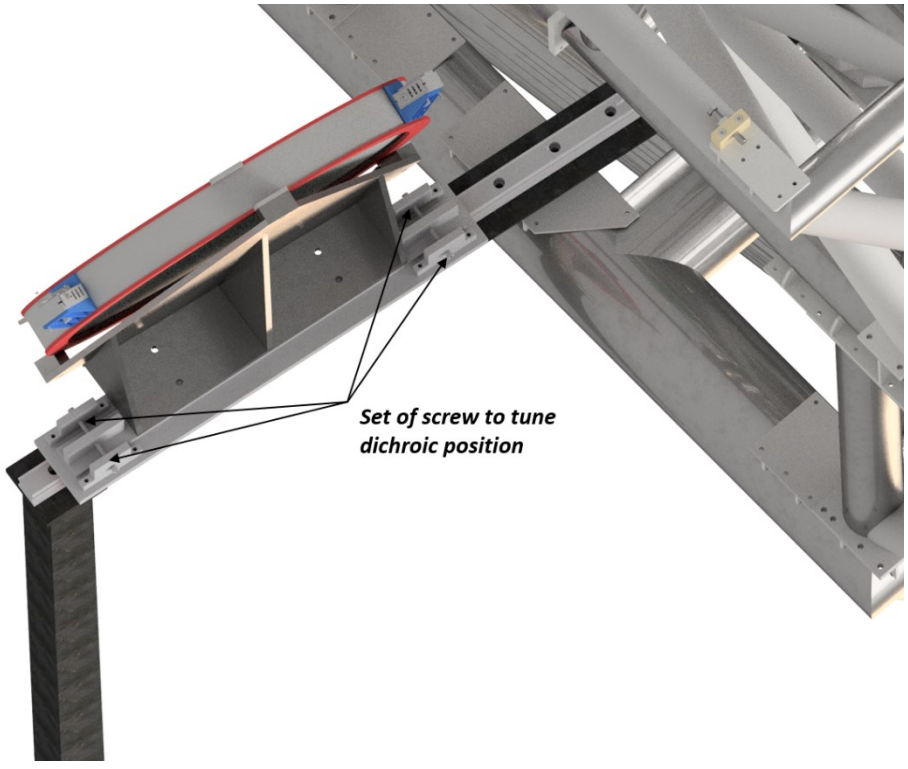


Figure 80: set of screws to adjust dichroic position with respect to its interface to MAORY main structure

One person on a platform positioned on the back side of the dichroic (see Figure 81) can perform this operation, and access to such platform on the bench structure is ensured using a normal portable ladder, due to the low position of the dichroic in the MSS.

For accessibility reasons, the installation of the dichroic will take place before installing the 1st LGSO folding mirror.

All the described operations will not invade the 2nd instrument allocated volume.

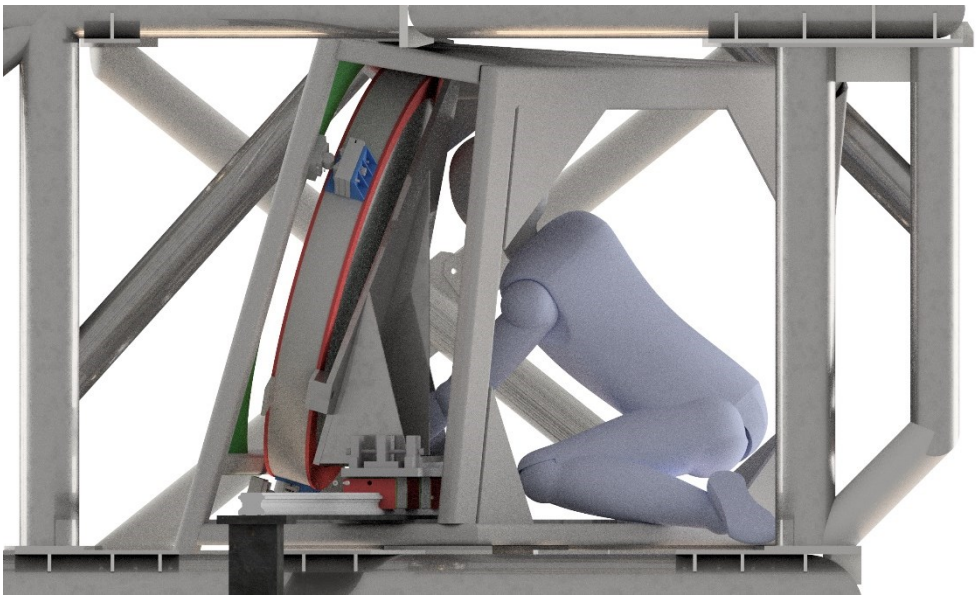


Figure 81: a person will access into the dichroic+1st LGSO folding mirror supporting structure to fix the dichroic to its interfaces and release the sliding handling.

Notes:

8.19 First Folding Mirror LGSO Installation (1d)

Purpose and functionality

The first folding mirror of the LGSO is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: ERE, JFA, LMA, ECA, GRO

HTs/SEq needed: Bridge crane, Dedicated HT, internal platform

Success Criteria: Mirror properly installed in its nominal position

Duration: 1 day

Prerequisites: 8.18 Dichroic installation

Procedure: The box shall be taken in the entrance hall, opened and the first folding mirror transported in the IAA.

The 1st folding mirror LGSO is installed using a rail system that allows to slide it in its final position. For its installation, an opening on the side of MSS is required, and this is obtained by removing the beams shown in Figure 75.

After removal of the beams and of the corresponding thermal panel, the rail shall be mounted inside the MSS. The rail orientation is optimized to transfer the dichroic from outside the MSS just in front of its interface points inside MSS. To ease the process, it is under evaluation to split the rail in two parts, keeping a part always mounted into the MSS, and having only a short piece of rail to be mounted at the occurrence.

The part of the rail protruding from the MSS unload part of the weights to a beam connected to the ground, while the part inside the MSS is attached to the MSS itself.

When the rail is in place, a special handling is mounted on the carts sliding on the rail. The scope of this handling is to keep the 1st folding mirror LGSO with the same orientation it will have when mounted in the MSS

In order to position the dichroic on the sliding handling, the plan is to use a C-shaped handling, interfaced to 3 points on the dichroic opto-mech. In this mirror, the kinematics are mounted at the mirror coated side, differently from all the other mirrors, which have the kinematics at the back side and it is not equipped with any security branch at the front. For this reason, the C-shaped handling will be interfaced to the three M12 fixing screws that will be later inserted into the kinematics Figure 82).

The 1st folding mirror LGSO connected to the C-shaped handling approaches the sliding handling on the rail, to which it is connected using 3 other points and 3 other screws on the opposite side of the opto-mech (Figure 85). When the dichroic is secured to the second handling, the C-shaped handling can be removed and taken away by the crane.

To allow the right positioning of the 1st folding mirror LGSO on the cart and to properly connect it to the cart itself, normal portable ladders are used by two persons, positioned one per side of the rail.

At this point, the 1st folding mirror LGSO can be manually slid on the rail toward the mount. Some security blocks on the rail prevent the dichroic to slide off the rail.

The cart has the possibility to move in the direction of the dichroic optical axis, by acting on two set of screws positioned at the two cart sides, with a total travel of about ±15mm. Thus, the system will be nominally kept at distance of about 10mm with respect to the interfaces where it has to be fixed, and only after reaching the correct position, it will be pushed toward the interfaces, where it will be connected using the dedicated screws. One person at the back of the 1st folding mirror LGSO is necessary to secure it to its interface inside the MSS and to disengage the handling.

All the described operations will not invade the 2nd instrument allocated volume.

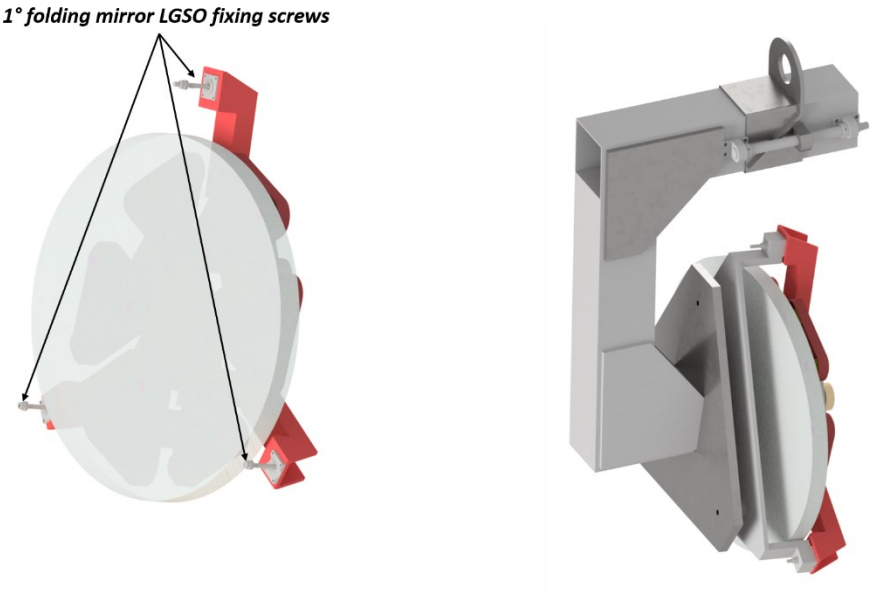


Figure 82: : the C-shaped handling used to position the 1st folding mirror LGSO on the rail system.

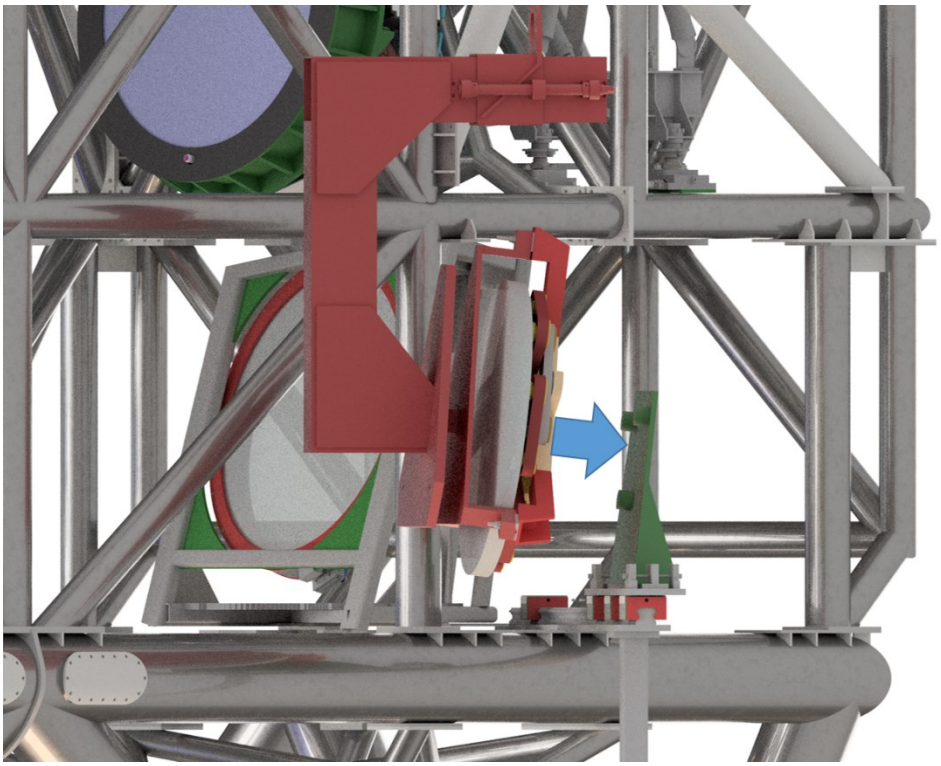


Figure 83: 1st folding mirror LGSO on C-shaped handling approaching the sliding handling on the rail.

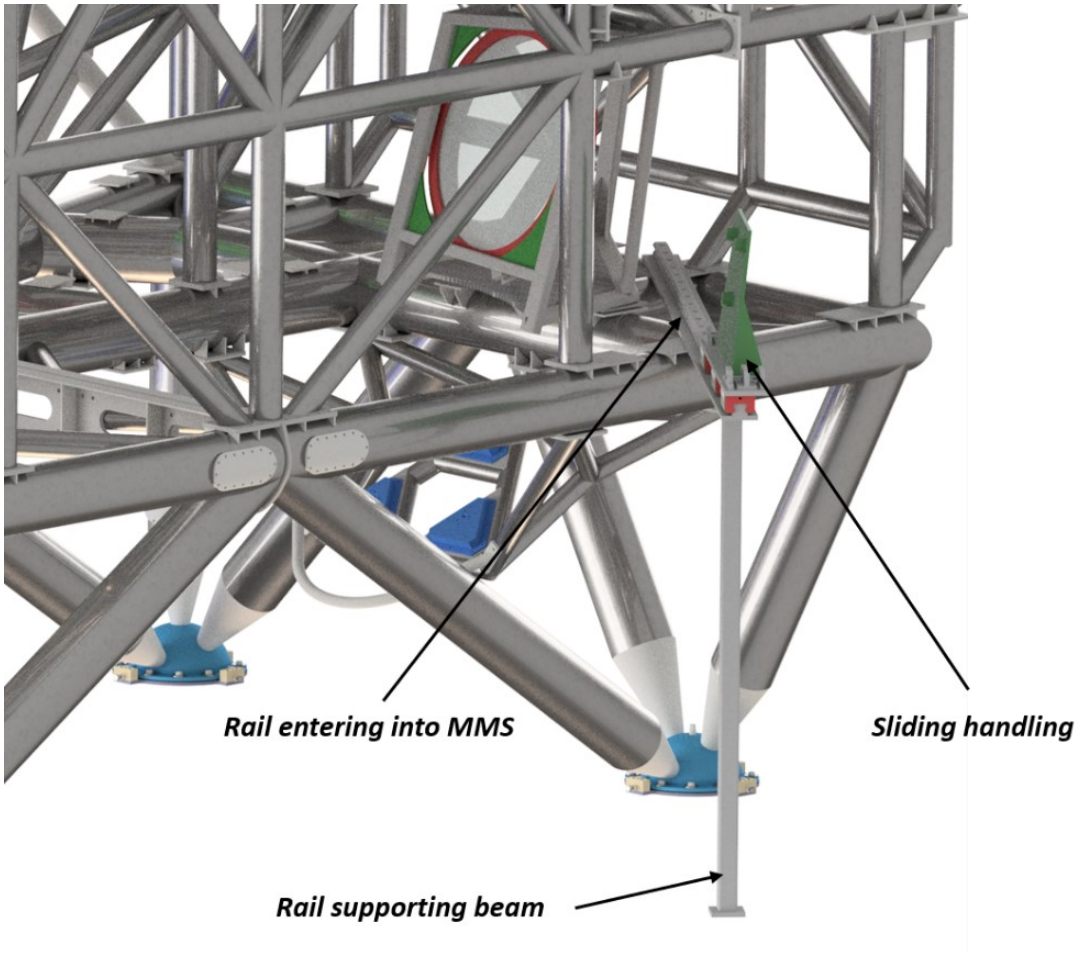


Figure 84: the rail and sliding handling to be used for the installation of the 1st folding mirror LGSO.

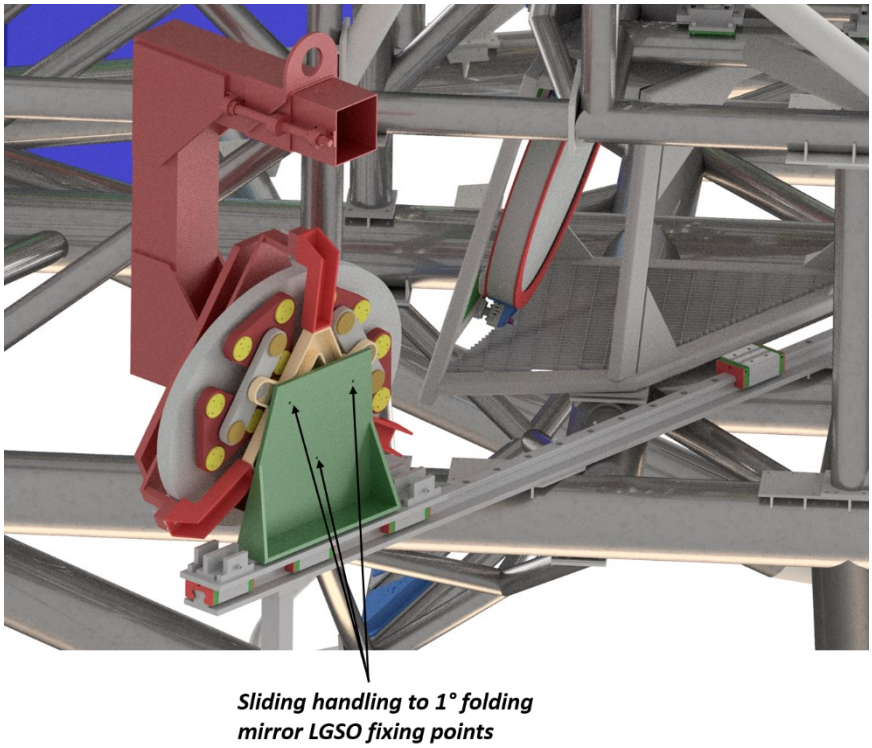


Figure 85: the 1st folding mirror LGSO is interfaced to the sliding handling through 3 screws at the back of its opto-mech.

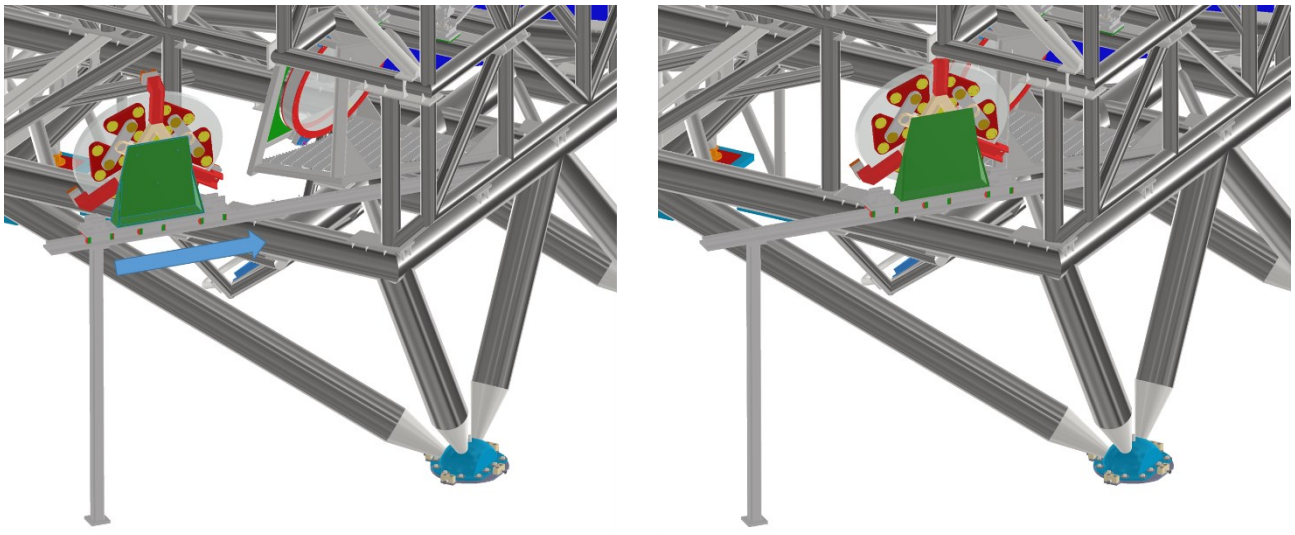


Figure 86: the 1st folding mirror LGSO assembly connected to the cart sliding on the rail system.

Notes:

8.20 LGSO installation (2d)

Purpose and functionality

The LGSO is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the structure

Responsible: ERE, LMA, JFA, ECA, GRO

HTs/SEq needed: Bridge crane, Dedicated HTs and SEqs, Scissor lifts, Portable ladders

Success Criteria: LGS-O properly installed in its nominal position

Duration: 2 days

Prerequisites: 8.19 First LGSO folding mirror installation

Procedure: The LGSO box shall be taken in the entrance hall, opened and the LGSO transported in the IAA.

The LGSO structure is composed by four lenses and three mirrors. These elements are separated in three different groups: the first folding mirror FM1 is attached to the structure that hold at the same time the dichroic. The third folding mirror FM3 is mounted on a separate structure above the LGS module. The other elements (all the lenses and the second folding mirror) are mounted inside a structure that has been previously assembled in a lab or by the manufacturer.

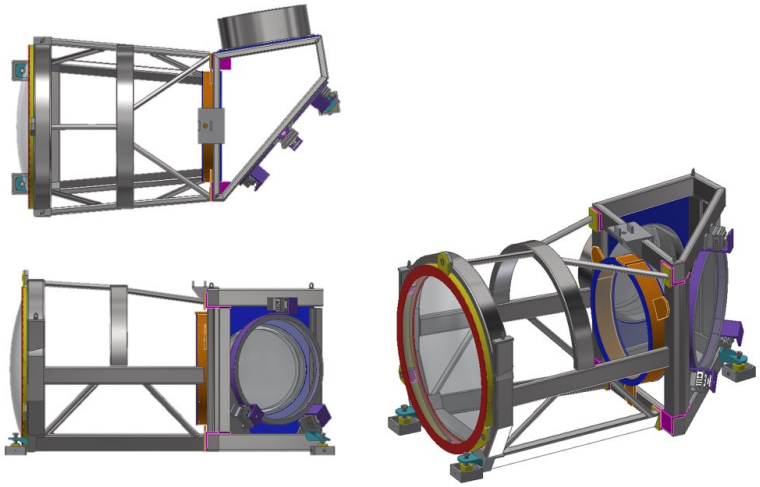


Figure 87 LGSO scheme after the manufacturer integration

In order to insert the LGSO inside the MAORY main structure the first operation is to remove the two beams that block the entrance for the LGSO, at the MICADO side of the MSS. Then, in order to have the possibility to move the objective inside the MSS, guide rails must be installed. These consist in two rails of different shapes (v-groove and Plane). The position where the rails are fixed inside the MSS is reported in Figure 88. Figure 89 shows the beams, in yellow, that shall be removed to allow LGSO installation. They can be unscrewed from the outside.

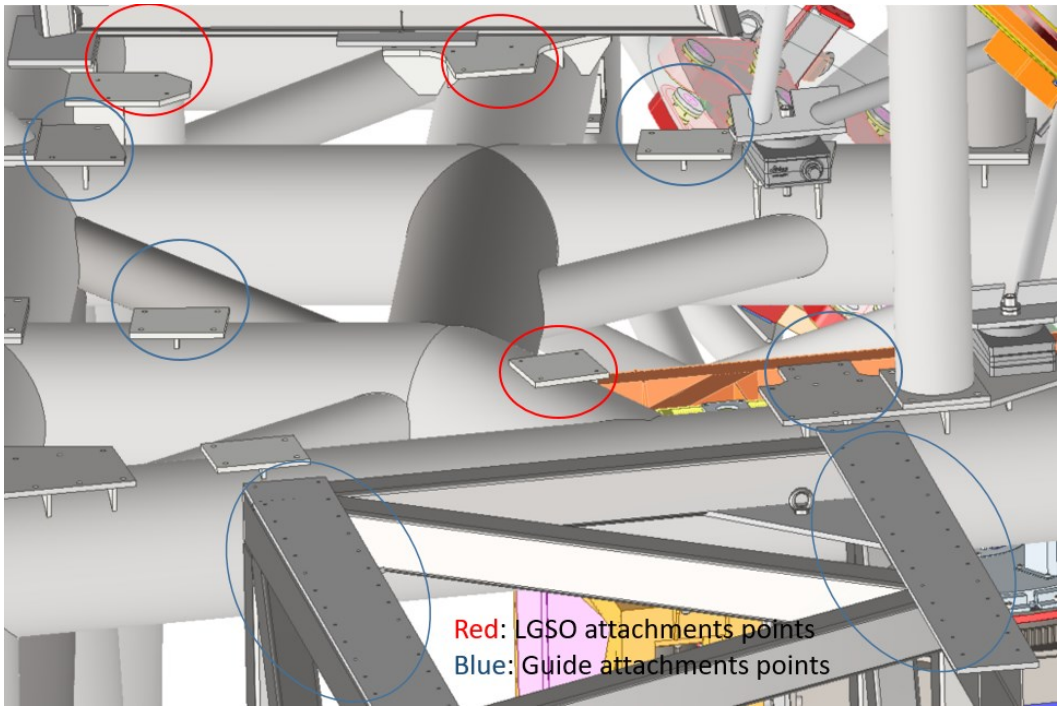


Figure 88 LGSO and Guide attachments points

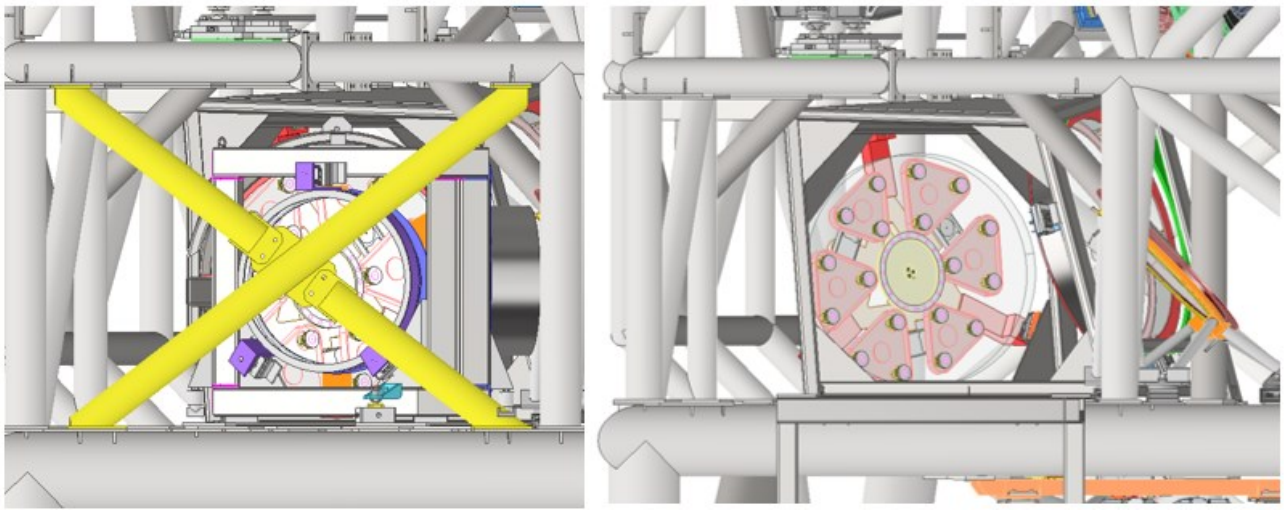


Figure 89 1st operation: MSS beams that must be removed in order to insert the objective

Since part of the rails protrude outside the MSS, before installing them, an external support structure shall be placed next to the aperture obtained in the MSS. This can be lowered with the crane thanks to the four eyebolt on the top part of the structure. Once the structure reaches the floor, it can be easily moved as it is equipped with four wheels and aligned to the MSS. The structure can be finally fixed to the ground lowering the feet and screwing it to the floor.

Figure 90 2nd operation: lower the external support structure

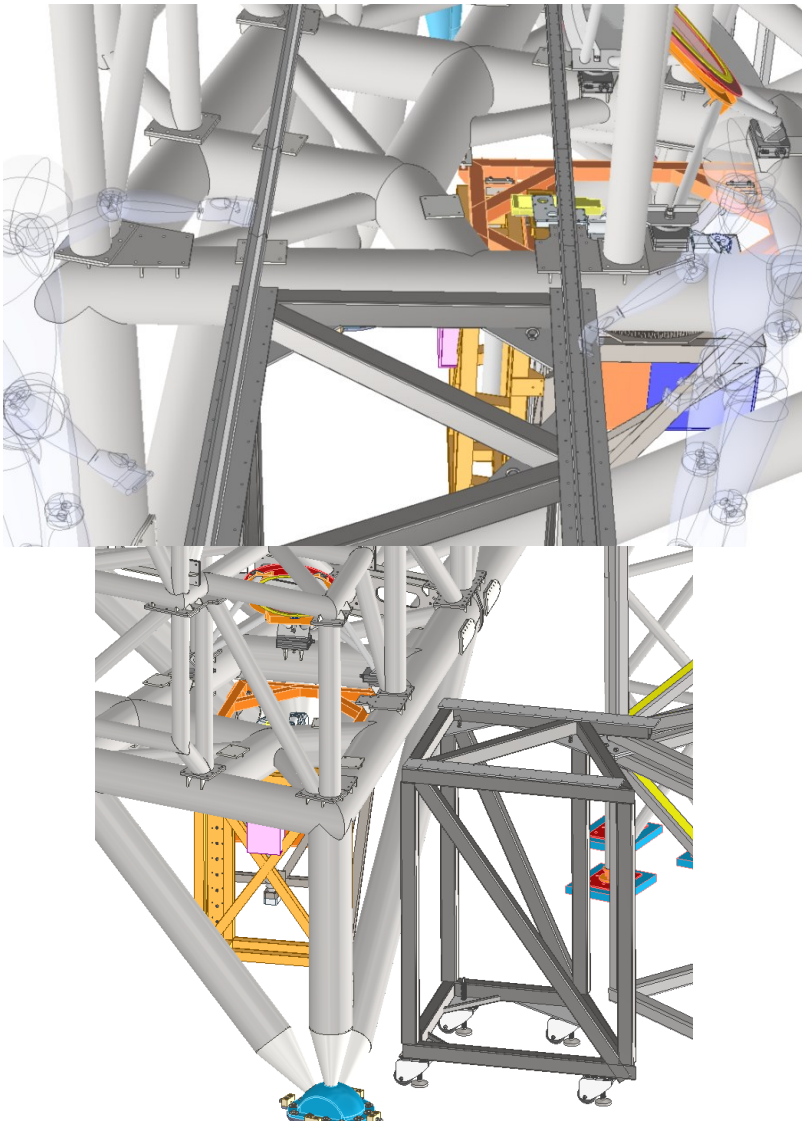


Figure 91 3rd operation: align the external structure the MS and guide rails installation

Figure 91 shows the structure aligned to the MSS. The rails are installed on top of the support structure. To avoid very long rails, each rail is split in two parts, one living permanently into the MSS and the second part installed on the support structure. When the rails are in position and fixed, the objective can be lowered on top of them. Figure 93 shows the LGSO lying on the guide rails outside of the MSS. The guide rails are joined in correspondence of the most external interface plates on the MSS, and the second part of the rails is aligned to the guides already installed in the MSS. The size and weight of these guide rails allow transportation from a single man. The shape of the guide rails avoid to the spherical wheel to fall outside of the rails. Furthermore, at the end of the guide there will be a mechanical hard end stop preventing the LGSO to slide off the rails.

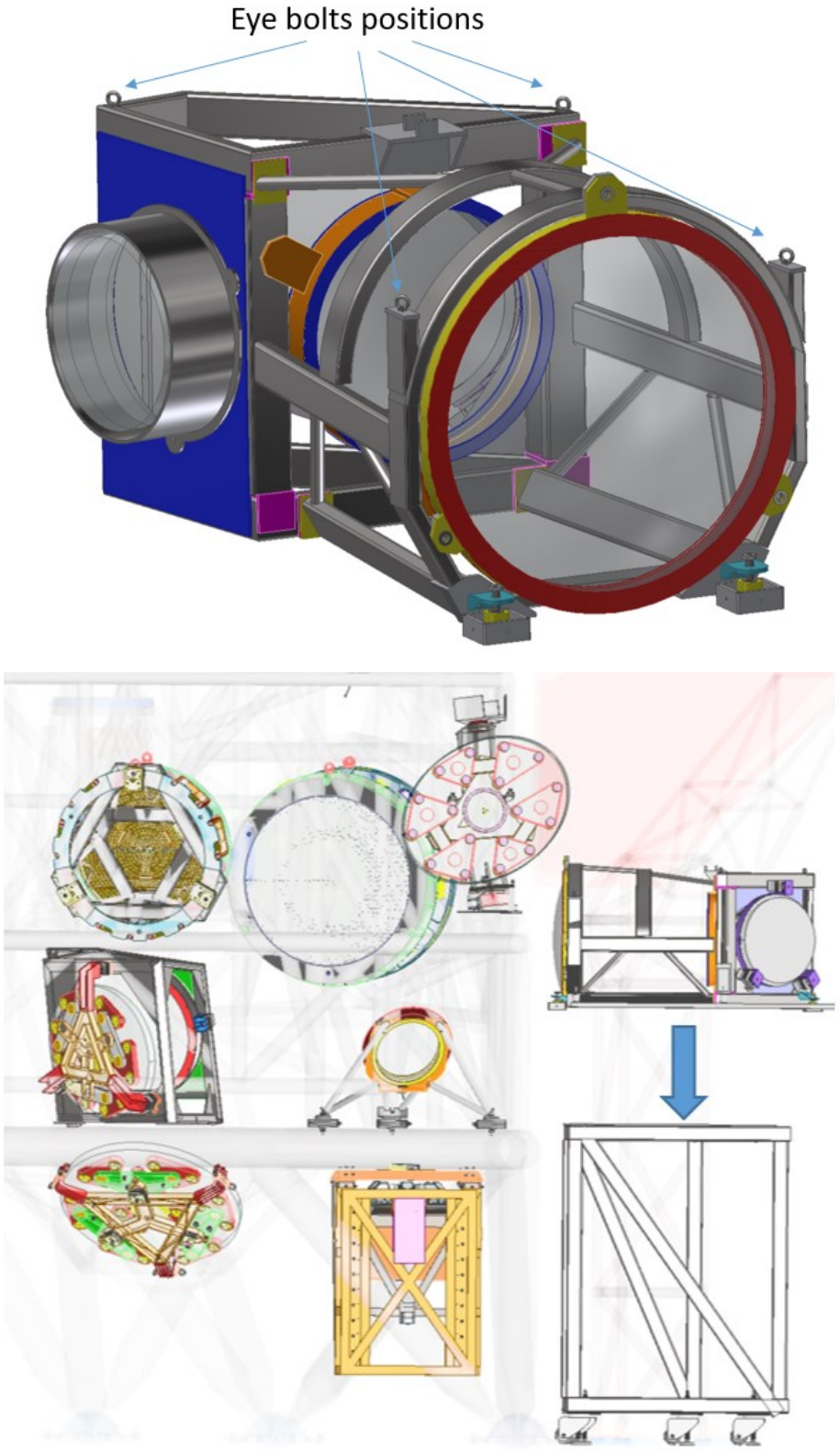


Figure 92 4th operation: lowering the objective

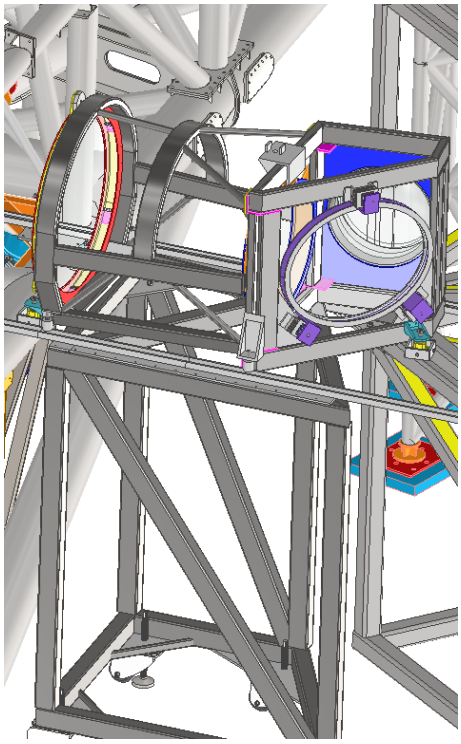


Figure 93 Position of the LGSO on top of the integration structure

The LGSO is manually slid inside the MSS. When the final position of the LGSO is reached inside the main structure, the threaded rod holding the spherical wheels of the LGSO are unscrewd. In this way, the whole LGSO is lowered till its feet lie in their seats in the MSS. Retroreflector mounted on the outer part of the LGSO can be now seen from the LT mounted inside the MSS and used for alignment purposes. The fine tuning of the LGSO position is done acting on the screw pushing against the LGSO feet shown in Figure 95.

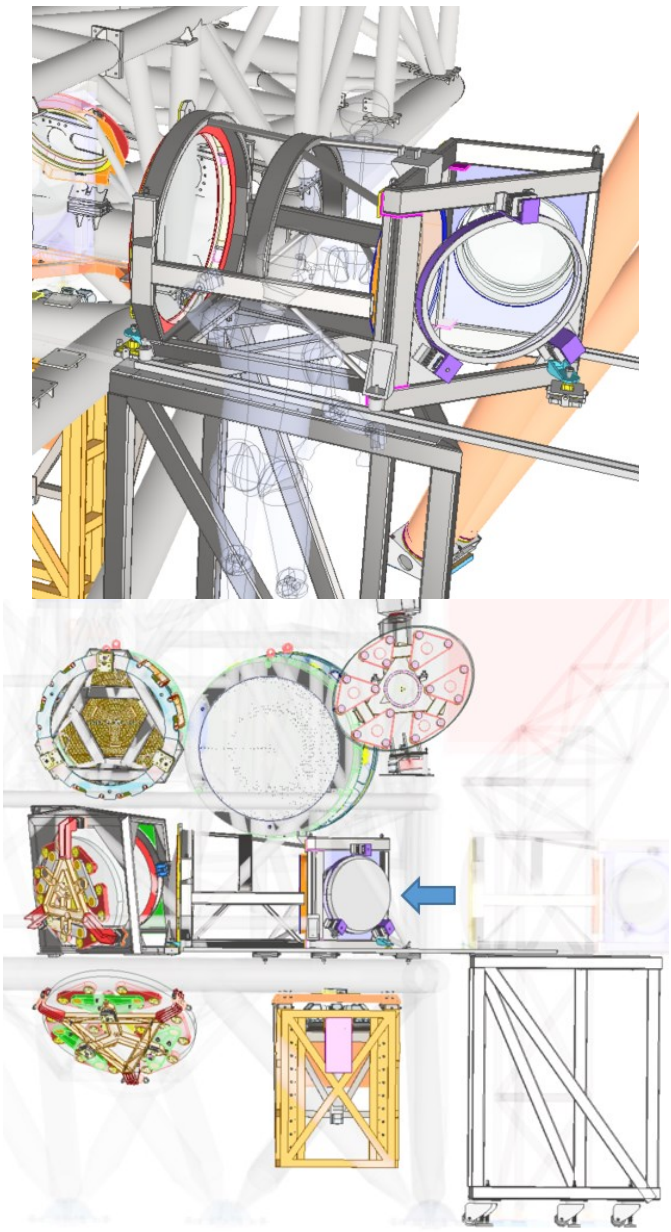


Figure 94 5th operation: move inside of the main structure the LGSO

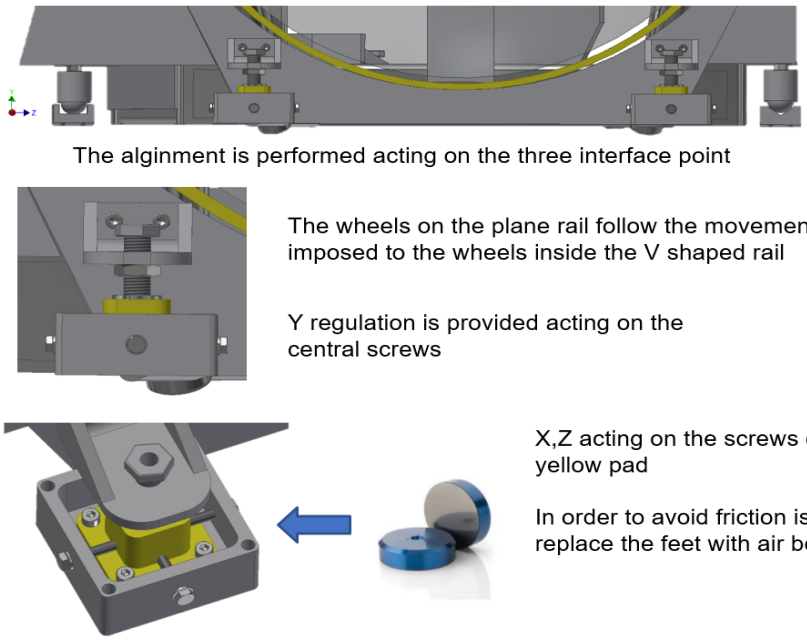


Figure 95 6th operations: final alignment

To reduce the friction between the LGSO feet moving part (yellow Figure 96, left panel) and the LGSO feet fixed part (grey in Figure 96, right panel) and to make the alignment of the LGSO smooth, each LGSO foot movable part will move on an air bearing. Acting on the frictionless feet the resolution is increased since there isn't the problem to overpass the friction between the static and the moving part. In Table 2 are reported all the estimated number foreseen for the alignment of the LGSO. In Figure 96, left panel, is possible to see the 4 feet of LGSO. When the alignment of the LGSO is completed, all the feet are locked using four M8 screws per foot. The first operation to do when the LGSO is close to its nominal position is to screw the grey pads to the MSS, then acting on the alignment screws that moves the yellow part finely tune the LGSO position and finally lock it using four M8 screws securing the yellow part to the grey pad.

The yellow part in Figure 96 will be updated in the next phase in order to integrate an air bearing in order to reduce the friction between the parts. The Y regulation (Figure 95) is used for two reasons:

- When the LGSO is inserted the feet are in a higher position respect to the guide in order to avoid the collision with the main structure. When the fixing point are reached the feet will be lowered.
- the alignment in Y, pitch and roll regulation are provided by the central vertical screw that has a bilateral joint (spherical connection wrt the yellow part). When the alignment is reached a nut fix the position of the system as is possible to see in Figure 95

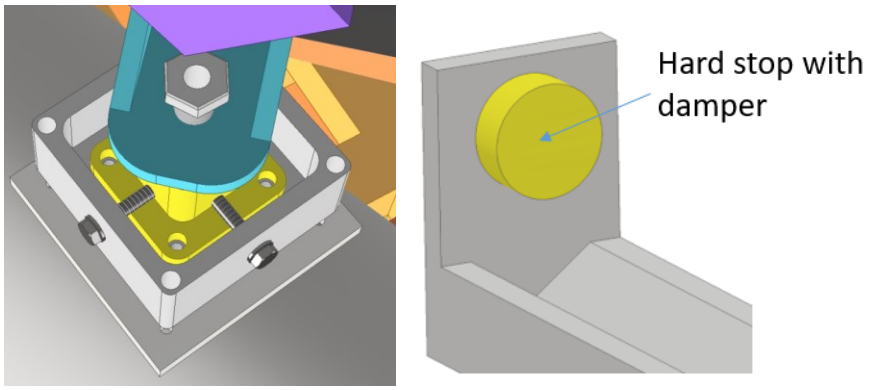


Figure 96 The LGSO foot is screwed to the main structure and guide hard stop

Table 2 Estimated alignment ranges and resolutions

ID	Components used as compensator	Range	Resolution	Foresee accuracies from sensitivity*	How
1	Whole LGSO	+/- 10 mm	0.1 mm	+/- 0.3 mm	Regulation at the feet level
2	FM1	+/- 1°	2 arcsec	+/- 10 arcsec	wedges
3	FM3	+/- 1°	2 arcsec	+/- 20 arcsec	wedges
4	L4	+/- 10 mm	0.1 mm	+/-1 mm	Shims

*Assuming such accuracies, the impact on the LGSO budget (WFE, telecentricity, WFNO, focal plane position) is about 10% of the overall budget

In Figure 97 is possible to see the space around the LGSO and the other elements.

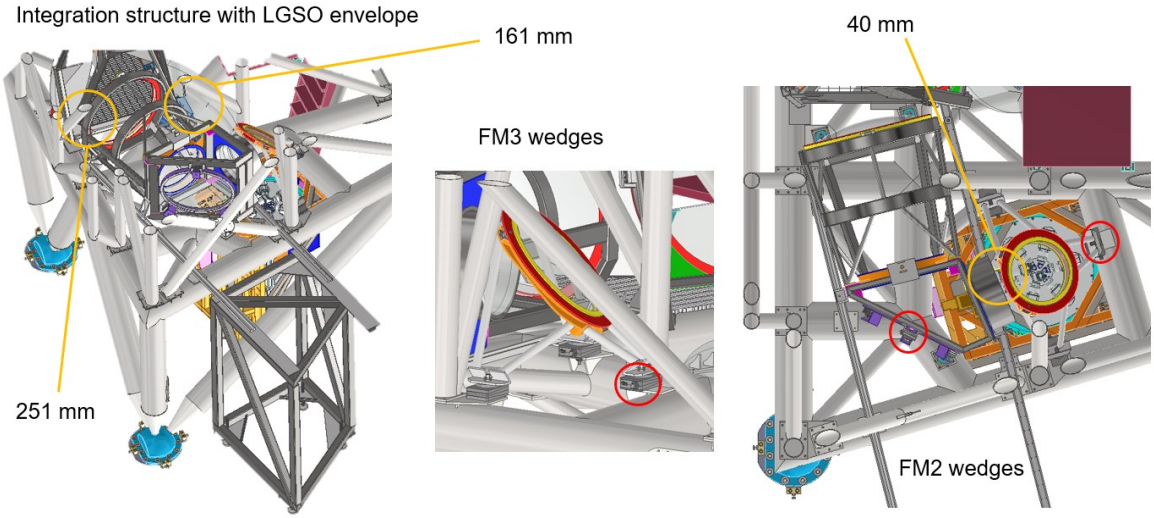


Figure 97 Space around the LGSO volume

Notes:

8.21 Third folding mirror LGSO Installation (1d)

Purpose and functionality

The third folding mirror of the LGSO is installed on the MSS and its preliminary alignment is carried on using the MSS LTs and the SMRs positioned on the mirror

Responsible: ERE, LMA, ECA

HTs/SEq needed: Bridge crane, Dedicated HT

Success Criteria: Mirror properly installed in its nominal position

Duration: 1 day

Prerequisites: 8.20 LGSO installation

Procedure: The box shall be taken in the entrance hall, opened and the third folding mirror transported in the IAA.

This mirror can be inserted/removed from an opening on the side of the MSS (MICADO side). Due to its relatively small dimension, it only requires dismounting the relative thermal panel, but no beams from the structure. Due to its small weight and position inside the MSS, a C-shaped handling is not an optimal solution for its installation/removal, as it would result in a very long and heavy handling.

For this mirror, the handling is a simple squared tubular beam with an interface plate for the mirror at one edge, a hoist ring for the crane hook and a movable counterweight at edge opposite to the mirror. Since the hoist ring for the crane shall remain outside of the MSS during the whole process, the part of the handling on mirror side is light-weighted (but maintaining 3 contact points at 120deg with the mirror), while on the opposite side a counterweight is required. The counterweight is mounted on a threaded rod, and 2 nuts allow to fine tune its position to compensate for the barycenter shift when the mirror is disengaged.

The mirror is inserted/removed from MICADO side. The handling does not interfere with MICADO volume, but the MICADO temporary platform shall not be in place during this phase.

When the mirror is secured to its supporting structure inside the MSS, the handling is removed, after readjustment of the movable counterweight position.

In order to secure the mirror to its support structure and to disengage the handling one person inside the MSS, with a small ladder close to M7 position, and one person outside, next to the handling, are necessary.

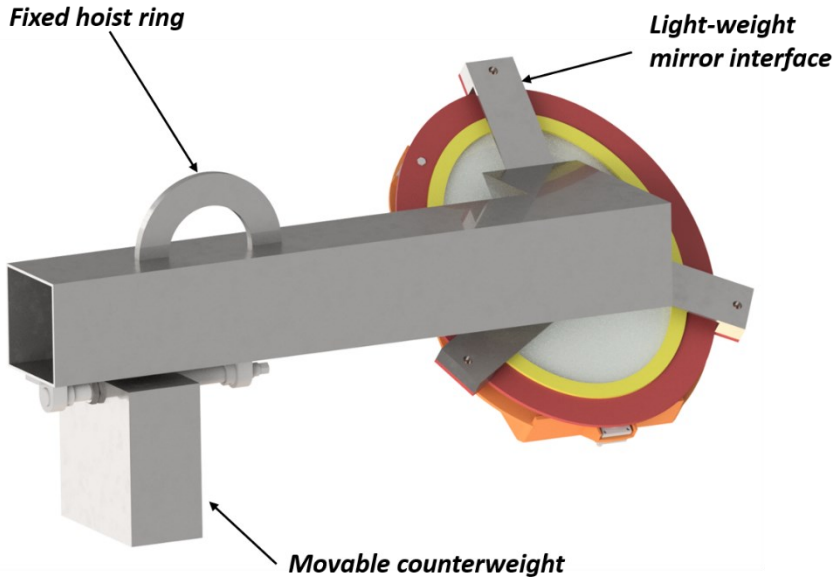


Figure 98: the handling for LGSO FM3 installation/removal.

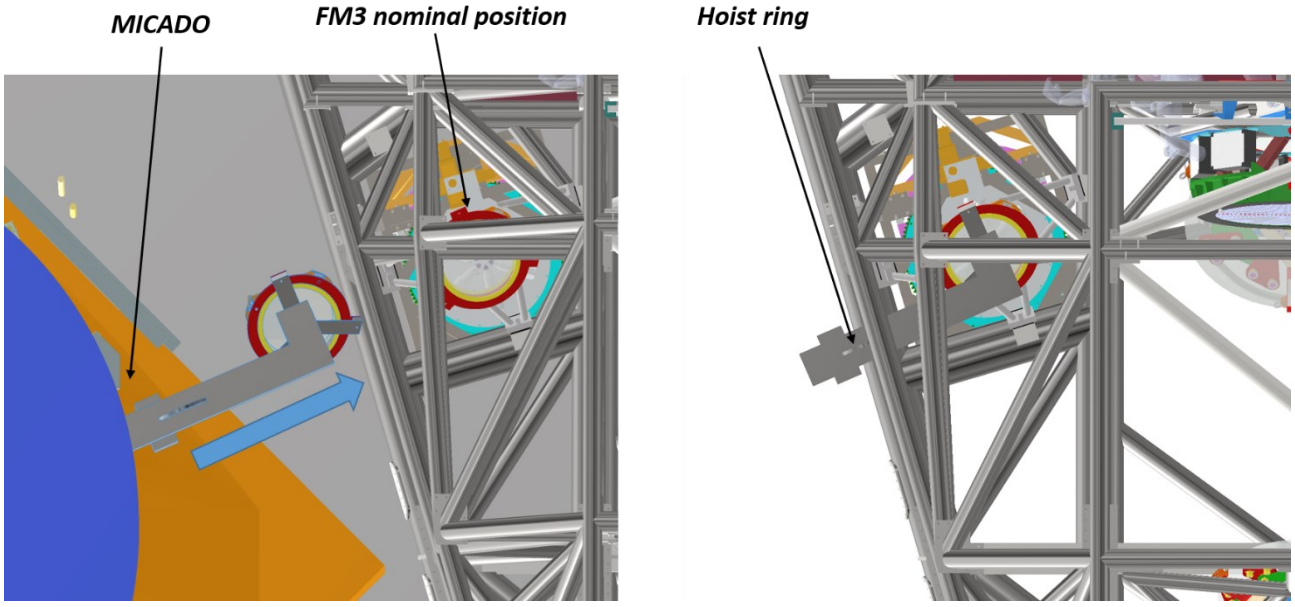


Figure 99: in the left panel, the handling with FM3 totally extracted from the MSS. There is no interference with MICADO volume, but its temporary platform shall not be in place for this operation. In the right panel, FM3 in its nominal position. The hoist ring for the crane is still outside the MSS.

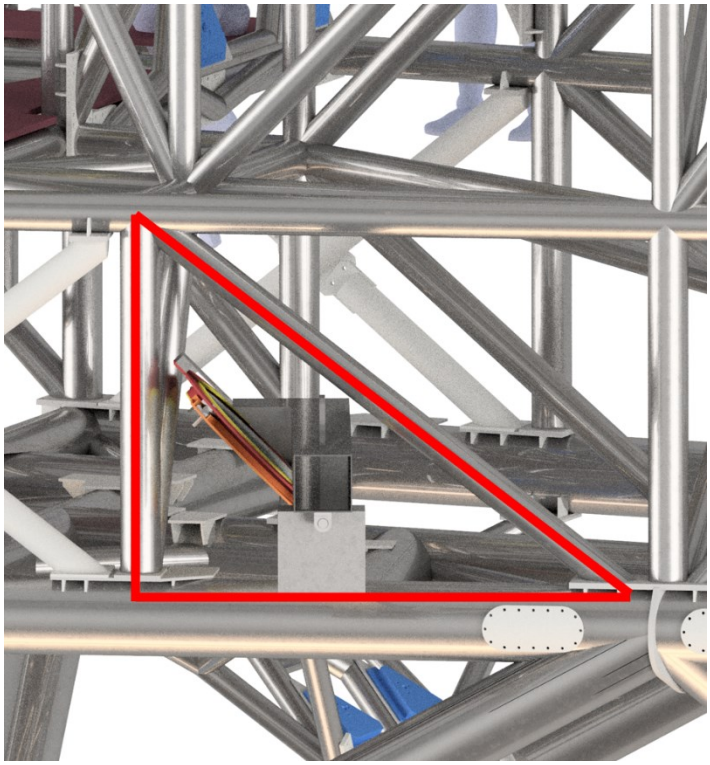


Figure 100: FM3 is mounted/dismounted using the aperture marked by the red triangle, which provide enough room for the procedures even without removing the diagonal beam.

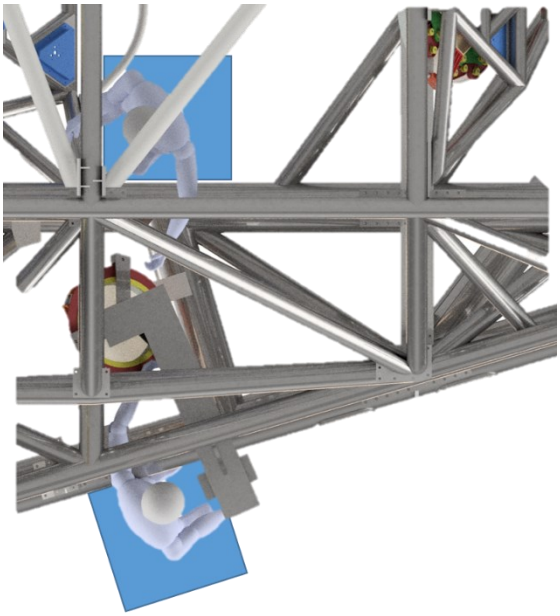


Figure 101: two persons on small portable ladders can fix LGSO FM3 to its support structure and release the handling.

Notes:

8.22 LGS WFS installation (1d)

Purpose and functionality

The LGS is installed on the MSS. Also the control electronics of the LGS will be installed and the cables routed and connected, and functional test will be performed on the system.

Responsible: ZHU, TMO, JFA, LMA

HTs/SEq needed: LGS HTs

Success Criteria: LGS properly installed in its nominal position

Duration: 1 day

Prerequisites: 8.21 LGSO third folding mirror installation

Procedure: The LGS WFS box shall be taken in the entrance hall, opened and the LGS WFS transported in the IAA.

It will be installed from the bottom, using a special handling allowing to rotate and lift up the LGS. The rotation is necessary as the physical dimensions of the LGS do not allow it to pass through the legs of the MSS with its final orientation, but only rotated. This handling is still under study, to define the optimal rotation angle and where to place the pivot point, considering the mechanical constraints of the MSS. Once the LGS passed through the MSS legs, it can be rotated vertical, in the area in front of M7, then moved towards its interface points on the MSS and finally lifted up. Since it is installed at a very low height, the operators do not need any particular SEq for its installation.

Being an installation from the bottom, the procedure is the same in BIH, IAA and Nasmyth Platform.

Figure 102: The cart allowing to transport the LGS WFS with the right angle to fit into the structure; the same cart allows to rotate the LGS WFS in the right orientation to lift it up and install it on the MSS

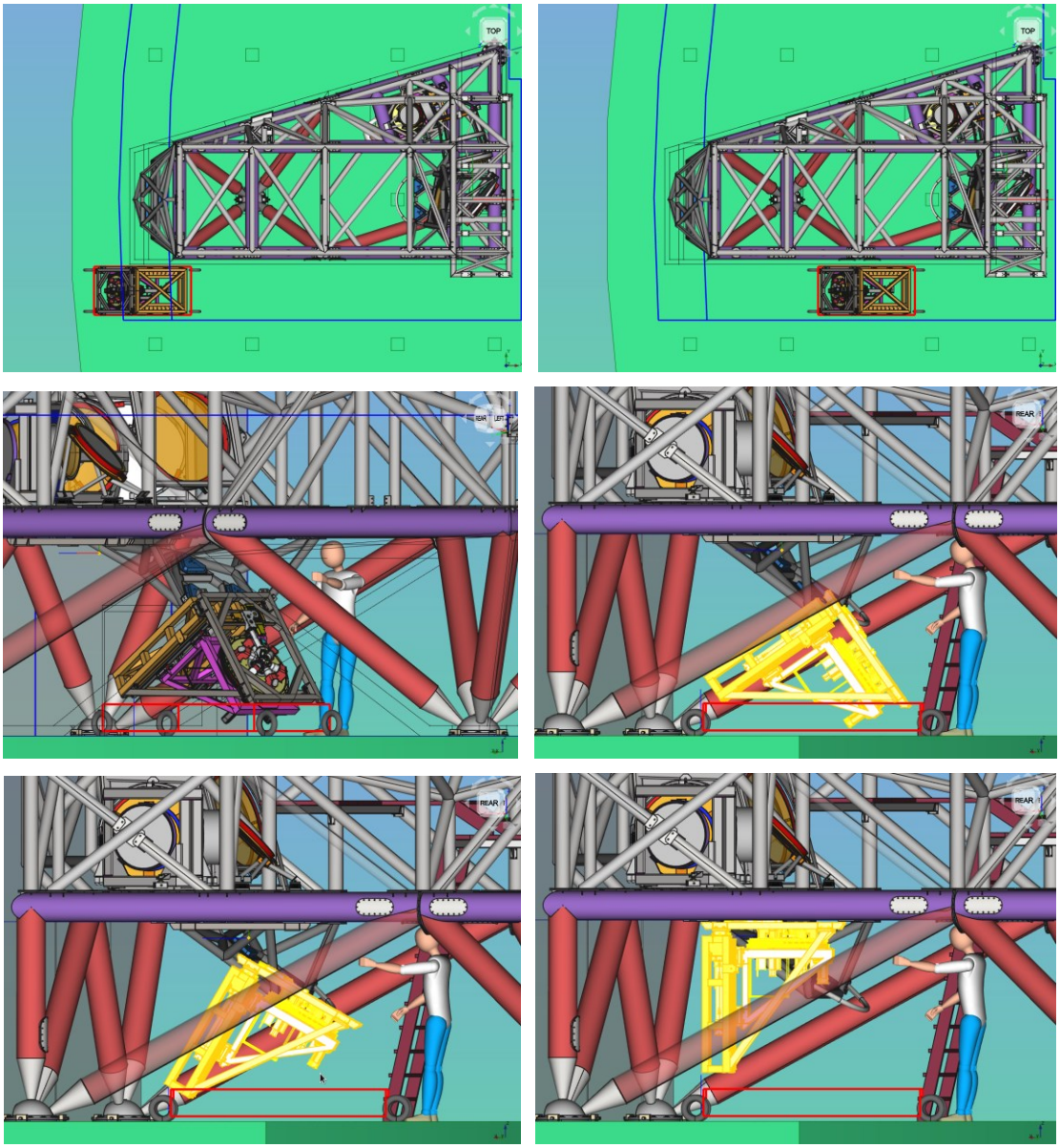


Figure 103: sketch of the installation of the LGSWFS inside the MSS.

Notes:

8.23 ICS SW functional test (1d)

Purpose and functionality

The full SW to control the instrument is functionally tested

Responsible: BSA, JFA

HTs/SEq needed:

Success Criteria: functional test all working

Duration: 1 day

Prerequisites: 8.25 Electronics functional test

Procedure: the MAORY ICS SW will be integrated with the instrument and test it

1. Install SW in target system
2. Perform functional tests
3. Produce installation and test report
4. Report issue through tracking system

Notes: More details will be provided for the FDR.

8.24 S-RTC functional test (1d)

Purpose and functionality

The RTC is installed and functionally tested

Responsible: ABA, JFA

HTs/SEq needed:

Success Criteria: functional test all working

Duration: 1 day

Prerequisites: 8.23 ICS SW installation and test

Procedure: the RTC is integrated in the ICS and with the Instrument Hardware (LOR and LGS WFSs cameras, DMs). The external contractor will provide support for the H-RTC and Telemetry Recorder.

More details will be provided for the FDR.

Notes: More details will be provided for the FDR.

8.25 M10, M11 and M12 functional test (1d)

Purpose and functionality

All the motorized axis of the sub-systems previously installed are functionally tested

Responsible: IFO, ECA, CER, JFA

HTs/SEq needed: BIH Bridge crane, Dedicated HTs, Scissor lifts, Cherry picker

Success Criteria: functional test all working

Duration: 1 day

Prerequisites: 8.8 Engineering ICS SW installation and test

Procedure:

- The TT and focus motorized axis of the M10 system will be tested checking the range and accuracy

- The TT motorized axis of the M11 system will be tested checking the range and accuracy
- The TT motorized axis of the M12 system will be tested checking the range and accuracy

Notes:

8.26 DM1 and DM2 functional test (1d)

Purpose and functionality

DM1 and DM2 are functionally tested

Responsible: IFO, ECA, CER, JFA

HTs/SEq needed: BIH Bridge crane, Dedicated HTs, Scissor lifts, Cherry picker

Success Criteria: functional test all working

Duration: 1 day

Prerequisites: 8.24 RTC installation and test

Procedure:

TBD for FDR

Notes:

8.27 LOR functional test (1d)

Purpose and functionality

The LOR system is extensively functionally tested

Responsible: MBO, LBU, GRO, LMA, ECA, JFA

HTs/SEq needed:

Success Criteria: functional test all working

Duration: 1 day

Prerequisites: 8.24 RTC installation and test

Procedure: the motors and the detectors of the LOR WFS will be functionally tested.

Notes:

8.28 LGS arm alignment (2d)

Purpose and functionality

The purpose of this procedure is to align the LGS ARM to the Main Path optical beam.

Responsible: JFA, GRO, LMA, ECA

HTs/SEq needed: portable ladders, internal platforms, IFP flange SEq, 2 plates with targets

Success Criteria: LGS ARM aligned

Duration: 2 days

Prerequisites: 8.24 RTC Installation

Procedure: The LGS arm alignment procedure is the following:

- Install the IFP flange in its alignment configuration, see SEq 7.1
- The laser is positioned in order to materialize the chief ray of the central field of the optical system (system previously aligned in the lab). The laser beam has the aim to visualize the intermediate pupil position of the as-aligned main path. Given that the laser has to be transmitted by the dichroic, its wavelength has to be close to 589 nm.
- we foresee to position two irises, one before L1 and one after L4, centered on the lenses at laser tracker precision (the SMRs positioned at the mountings of the lenses can be used as references for such operation), or otherwise pre-aligned and positioned by the company which will align internally the LGSO.
- The LGSO (including the two irises) has been previously installed into the structure in its nominal position (by using LTs against 3 SMRs coarsely placed on the LGSO structure. The laser will go across the LGSO lenses. Accounting for the divergence angle, we have estimated the laser footprint size on each surface. The results are shown in Table 3.

Table 3: Laser footprint size on the LGSO surfaces.

	RMS Spot Diameter [mm]	Geometrical Spot Diameter [mm]
DICH	9.4	12.4
FM1	10.0	14.4
L1S1	8.2	10.6
L1S2	7.8	10.2
L2S1	4.6	6.2
L2S2	4.6	6.0
FM2	4.4	6.6
L3S1	2.6	3.4
L3S2	2.6	3.4
L4S1	2.6	3.4
L4S2	2.4	3.2

- The LGSO is then aligned to the laser beam, by acting on the FM1 tip/tilt and decentering the whole LGSO along X-Y direction (local coordinates system in L1), so that the laser passes through the two irises. A possibility is to use the target on L1 to centre the LGSO with the laser beam and the target on L4 to for the tilt FM1. In such way, the optical axis of the LGSO is aligned to the laser, i.e. to the chief ray of the central field.

At this working level, we have assumed that the combination of the errors due to laser source positioning, positioning accuracy of the irises on the L1 and L4 and the accuracy on the determination of laser spot centre is less than +/-2 millimetres.

The impact on the performance is a worsening of the average WFE less than 10%, while the LGSO focal plane maximum displacement is less than +/-5 mm in X, Y, Z direction with respect to the nominal position.

Notes: There are two alternative procedures that we are exploring, which will be studied in more detail for the FDR:

- A fully mechanical alignment, that would lead to a worse result in term of WFE (30% instead of 10%)
- An alignment performed by looking at the back-reflections of the lenses, which should perform more or less as the baseline here presented

8.29 LGS WFS functional test (1d)

Purpose and functionality

The LGS is functionally tested with its SW and Electronics. Also, the focal plane and the pupil plane have to be placed in the correct positions within the WFS.

Responsible: JFA, ZHU, GRO, LMA, ECA

HTs/SEq needed: portable ladders, internal platforms

Success Criteria: functional test all working, pupil and focal planes aligned within tolerances

Duration: 1 day

Prerequisites: 8.28 LGS arm alignment

Procedure: Perform **f**unctional test all the motorized functions and all the detectors.

Notes: The internal pupil and focal planes adjustments can only be performed on the Nasmyth after the alignment to MICADO be performed

8.30 Thermal enclosure installation and functional test (2d)

Purpose and functionality

The thermal enclosure is installed.

Responsible: JFA, MAL

HTs/SEq needed: BIH Bridge crane, Dedicated HTs, Scissor lifts, Cherry picker, portable cranes, BIH LTs, T sensors PT100, Lakeshore electronics

Success Criteria: Thermalization within requirements

Duration: 2 days

Prerequisites: 8.29 LGS WFS Alignment

Procedure: TBD for FDR

Notes:

8.1 ICS and RTC SW test (2d)

Purpose and functionality

SW needed to move to motorized functions of the opto-mechanic sub-systems is installed and tested by moving the motorized axis of the installed opto-mechanics (elevator, CU, M10 TT and focus, M11 TT) and fine tuning the motor controller parameters; Overall functional test of every motorized function will be carried on at this stage

Responsible: JFA, BSA

HTs/SEq needed: Floppy Disk(s) (“s” in case more than one will be needed)

Success CriteriaCriteria: data transfer, communication and functional test working

Duration: 2 days

Prerequisites: 8.7 Cables and Pipes routing

Notes:

8.2 MCA Installation (TBD)

Add

8.3 MAORY Instrument preparation for the transport (2d)

Purpose and functionality

To prepare the MSS fully integrated and the LOR WFS for the transportation to the Nasmyth platform

Responsible: JFA

HTs/SEq needed: TBD transporter

Success Criteria:

Duration: 2 days

Prerequisites: 8.30 Thermal Enclosure Installation

Procedure:

TBD for FDR (system powered off, cables unplugging from the cabinets, cables must be collected and provisionally secured to the MSS structure and to the LOR structure, transporter preparation)

Notes: As already mentioned, we are studying the possibility to use the same NIP as a transporter, lifting it up with the whole bench and positioning 4 low profiles carts below it, but this study will be carried on during the FDR phase.

9. The MAORY AIV in the ELT Nasmyth

TBD in collaboration with MICADO AIV team.