



**Programme:** ELT

**Project/WP:** System Engineering

## **ICD between MORFEO and MICADO (General)**

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## Change Record from previous Version

Affected Section(s)	Changes / Reason / Remarks
All	Updated/checked all figures references, numbers, and captions
[AD2]	Already applicable to both consortia, moved to RD30
[AD3]	Already applicable to both consortia, moved to RD36
[AD4]	Already applicable to both consortia, moved to RD31
[AD6]	Already applicable to both consortia, moved to RD32
[AD7]	Already applicable to both consortia, moved to RD33
[AD8]	Updated to version 2 (Nasmyth B)
[AD9]	Already applicable to both consortia, moved to RD34
[AD29]	Added as per <a href="#">M2MICD-81</a>
[RD8]	Changed title to the one in PDM
[RD16]	Added ESO PDM number and inserted title
[RD35]	Added as a placeholder for future list of hazard for MORFEO, in parallel to what is done by MICADO
[RD10]	Corrected the document number from <a href="#">ESO-477297</a> to <a href="#">ESO-648153</a>
Section 2.1	ADs 26-28 added (drawings)
[I-MAO/MIC-18]	“recollimation”: wording changed to “fine tuning of the alignment”
[I-MAO/MIC-20]	Added D verification tag



[I-MAO/MIC-96]	Deleted as per <a href="#">M2MICD-3</a> – #96 superseded by #145
[I-MAO/MIC-97]	Edited the table on Optical Throughput to the newest numbers provided by D. Magrin (Dec. 2024/May 5 2025). Cross reference to #116 removed
[I-MAO/MIC-98]	Cross-reference to [I-MAO/MIC-114] removed. Corrected MICADO's coordinates for Nasmyth B
[I-MAO/MIC-103]	Added sentence that describe the possibility of vignetting the scientific FoV if so required by scientific observations.
[I-MAO/MIC-104]	Transformed in a "will" statement
[I-MAO/MIC-115]	Added D/A verification tag
[I-MAO/MIC-116]	Deleted as per <a href="#">M2MICD-10</a> – already covered by [I-MAO/MIC-97]
[I-MAO/MIC-118]	Text modified to delete reference to #194, which is deleted
[I-MAO/MIC-123]	Update of MICADO attachment points and MICADO AST attachment points. Reference to ELT-DWG-MCD-56303-M00000_E023142-002_ESO_NP_DIF ESO411214 removed.
[I-MAO/MIC-124]	Updated info on MAORY's support structure attachment points. Footnote deleted because not needed anymore. Fig 4 (MAORY attachment points) deleted. Reference to RD15 added. Figure 5 (MICADO support points) also deleted.
[I-MAO/MIC-127]	Reference to static envelope drawing (AD24) added. Reference to MICAD AST enveloped drawing (AD25) added. Figure 6 deleted.
[I-MAO/MIC-131]	Adjusted text to identify the Dynamic Volume with the AIV and maintenance volume. Added note with reference to accessibility requirements.
[I-MAO/MIC-139]	Re-written according to M. Mueller 2025 analysis and with the text provided by telescope Engineering
[I-MAO/MIC-140]	New requirement: according to M. Mueller 2025 analysis and with the text provided by telescope Engineering



[I-MAO/MIC-144]	Deleted as per <a href="#">M2MICD-18</a>
[I-MAO/MIC-145]	“recollimation”: wording changed to “fine tuning of the alignment”. New “worst-case” value with TBC
[I-MAO/MIC-148]	Slightly modified top figure and caption to indicate that the cable routing is TBC
[I-MAO/MIC-150]	Drawings added, AD26, AD27 and AD29 (see also <a href="#">M2MICD-81</a> )
[I-MAO/MIC-151]	TBC resolved
[I-MAO/MIC-156]	Cabinet type for MICADO added. Slightly modified figure and caption to indicate that the cable routing is TBC
[I-MAO/MIC-167]	Included reference to accessibility requirements of MICADO- previously included in #169 and #173.
[I-MAO/MIC-168]	Modified text to include reference to safety, added I verification tag
[I-MAO/MIC-169]	Refence to RD17 for accessibility requirements.
[I-MAO/MIC-170]	Requirement stays, but added reference to [RD16], added I verification tag
[I-MAO/MIC-173]	Reference to RD17 added. Text modified to eliminate repetition with #167. Minor rewording.
[I-MAO/MIC-186]	Text in the caption referring to the frequency of access to MCA deleted (included now in #220)
[I-MAO/MIC-189]	References to AD21 and AD22 added. Modified text to include some details originally in #240.
[I-MAO/MIC-191]	Added list of AST segments to be removed and time required from original #240
Section 6	Created for the accessibility requirements (previous version in 5.3.4 to 5.3.7). Most requirements verification tag is now D/ //



[I-MAO/MIC-241]	New requirement. Third bullet Item changed from “Swagelok PB-12-BK; OD=27.20mm” to “Swagelok PB-12 3/4 HT/Armaflex 10 mm OD=47 mm”. Destination changed from to “MORFEO ICH main cabinet” to “MORFEO SCP Manifold”. ESO’s responsibility clarified with reference.
[I-MAO/MIC-174]	Added as INFO on the AST. Long text from [RD16] split into new requirements when applicable, otherwise taken out because redundant with [RD16]. Originally was #120, which was already taken, so renumbered to #122
[I-MAO/MIC-209]	New requirement from the original text in #174. Including figure in #210
[I-MAO/MIC-211]	New requirement from the original text in #174. Including figure in #212
[I-MAO/MIC-177]	New INFO from the original text in #174, including figures and captions in #178-#185
[I-MAO/MIC-214]	New requirement on LOR accessibility. Figure in #215
[I-MAO/MIC-217]	New requirement on LOR scaffolding. Added Figure 31 as per <a href="#">M2MICD-61</a> (#218 and #219)
[I-MAO/MIC-220]	New INFO on AST dismounting schedule
[I-MAO/MIC-225]	Updated as per <a href="#">M2MICD-20</a>
[I-MAO/MIC-165]	Added D verification tag
[I-MAO/MIC-248]	New text added, eliminated reference to #145 because not relevant (GRO)
[I-MAO/MIC-253]	New requirement, moved from GD ICD and rephrased as a “shall” requirement
[I-MAO/MIC-254]	New requirement, moved from GD ICD and rephrased as a “shall” requirement. Verification tag set as in #252



[I-MAO/MIC-260]	Reformulated text and moved the list of hazards posed by MICADO affecting MAORY to Section 15 Appendix – MICADO Hazards. Added verification tag T
[I-MAO/MIC-261]	Reformulated text and moved the list of hazards posed by MAORY affecting MICADO to Section 16 Appendix – MAORY Hazards. Added verification tag I and T. Also added reference to [RD35] - placeholder
[I-MAO/MIC-185]	Transformed into [INFO] per <a href="#">M2MICD-21</a>
[I-MAO/MIC-187]	New
[I-MAO/MIC-238]	Added D verification tag
[I-MAO/MIC-258]	Added text involving ESO producing an integrated hazard list
[I-MAO/MIC-263]	Added verification tag D / / I/T
[I-MAO/MIC-264]	Added verification tag D / / I/T
Section 15	New. Update hazard analysis from MORFEO



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# 1. Introduction

[I-MAO/MIC-4] This Interface Control Document (ICD) defines requirements for the general interface between the MAORY instrument (also referred to as MAO for brevity) and the MICADO Instrument (also referred to as MIC for brevity). The document contains requirements that are applicable to both sides of the interface; a table at the end of the document identifies which side of the interface is responsible for verifying the requirement.

Apart from being a formal document following ESO's Interface Control Documents (ICD) standards, this ICD shall be used also as a lookup reference for system engineering throughout the MICADO and MAORY design and implementation phases. This document is intended to be continuously extended and updated as the projects progresses. It shall be put under configuration control after being reviewed by all parties, i.e., MAORY, MICADO and ESO, as the owner of the document, and not later than MICADO's FDR.

Later changes to this document shall undergo the formal ESO CRE process, following discussion and agreement between MAORY and MICADO. It is agreed that changes can be initiated by one side of the IF towards the other, with ESO facilitating the process, if needed, but not intervening on the merit of the request unless the change has an impact on any ESO standards/common requirements. This means that once agreed between M&M, the CRE shall be considered as approved. To facilitate the work of the MAORY and MICADO teams and provide a more agile working environment, it is agreed that a new release of this document shall be triggered when substantial changes and/or many minor changes are collected, or in advance of a formal review. In between document releases, all changes will be recorded and made always available to all parties. Details on how this will be done are TBD.

Open issues that at the time of writing are still to be clarified or defined are marked as TBC or TBD.

The MAORY and MICADO technical requirements specifications can be found in [RD1] and [RD2]. Other IFs between specific MAORY and MICADO subsystems and SW can be found in [RD6, RD7 and RD12].

## 1.1 Scope

[I-MAO/MIC-6] This general ICD between MAORY and MICADO covers the following interfaces categories between those elements:

- Optical
- Mechanical and Access
- Alignment
- Electrical



- Cabling and piping
- Functions
- General common AIV requirements

For completeness, we include sections to common interface categories (e.g. Fluids interface) even when they are not applicable to this ICD (e.g. because they are not in common). These categories are clearly marked as N/A in the text.

This ICD does not cover the interfaces related to:

- Software – see [RD12]
- MAORY LOR Module and MICADO SCAO Module (Green Donut) – See [RD6]
- MAORY and MICADO Calibration Assembly (MCA) – See [RD7]
- Common Assembly and Installation (AIV) in Armazones – See [RD10]

## 1.2 Interfacing Elements List

[I-MAO/MIC-8] For the purpose of this ICD the MAORY INS (MAO) is composed by:  
///

- MAORY Main structure and subsystems

For the purpose of this ICD the MICADO INS (MIC) is composed by:

- MICADO Main structure and subsystems (incl. SCAO for the optical I/F)

[I-MAO/MIC-9] The following elements of MAORY are specifically excluded from this ICD:  
///

- MAORY LOR in GD
- MAORY Software

The following elements of the MICADO are specifically excluded from this ICD:

- MICADO SCAO in GD (excluding optical I/F)
- MICADO MCA
- MICADO Software



## 1.3 Definitions and Conventions

### 1.3.1 Statement Identifiers and Verification Tags

[I-MAO/MIC-12] This document contains two types of items: requirements and information. Requirements shall be verified by the INSSs, while information items do not. Both types are binding items. ///

Requirements are identified with a requirement tag following the format [I-XXX/YYY-NNN] where:

- The letter I is intended to convey the meaning "interface requirement".
- XXX = MAO – MAORY
- YYY = MIC – MICADO Software;
- NNN is a unique three digits, non-speaking number. NNN numbers do not necessarily follow a sequential order. They do not change across all versions of this document. Within this document, cross-references to an item (either requirement or information) are made by referring to the number NNN preceded by the prefix "#".

A verification table in Sec.14 identifies which party to the ICD is responsible for verifying each requirement.

[I-MAO/MIC-13] Requirements for which compliance needs to be demonstrated by the INSSs, by the provision of documentary evidence, carry a verification tag stating the minimum verification method(s) (D: Design Review; A: Analysis; I: Inspection; T: Test). Information for which compliance does not need to be demonstrated do not carry any verification tag. ///

The meaning of the verification methods is the following:

Verification Tag	Definition
Design (D/ / I)	Verification by Design consists of using approved records of evidence such as design files, reports, engineering drawings, documents, datasheets, etc, that unambiguously show that the requirement is met.
Analysis (/A/ /)	Verification by Analysis consists of performing theoretical or empirical evaluation using techniques such as mathematical calculations, statistical and qualitative analysis, computer and hardware simulations, and computer modelling. Includes verification by "Similarity".



Inspection (//I)	Verification by inspection consists of determination of physical characteristics using human senses (e.g., vision, hearing, touch), for example inspecting hardware conformance to document drawing or workmanship requirements, physical conditions, software source code conformance with coding standards.
Test (//T)	Verification by test consists of measurement of product performance, functions or features under representative conditions, or under conditions that can be clearly traced to operational ones. Includes the analysis of data derived from the test.

[I-MAO/MIC-14] The key words “shall”, “should”, “will” and “may” in this document are to be interpreted as follows:  
///

- “shall” means that the definition is an absolute requirement of the specification; “shall” is used to indicate a requirement that is binding, meaning it must be implemented, and its implementation verified;
- “should” statement cannot be not used;
- “will” is used to indicate a statement of fact. “Will” statements are not subject to verification;
- “may” is used to express a permissible practice or action; only for statements without verification tag.

### 1.3.2 Abbreviations and Acronyms

[I-MAO/MIC-16] The following abbreviations and acronyms are used in this document:  
///

AIV	Assembly, Integration and Verification
AST	(MICADO's) Access STructure
BoL	Beginning of Life
CoG	Center of Gravity
CRE	Change Request
CU	Calibration Unit
GD	Green Donut
ELT	Extremely Large Telescope
FDR	Final Design Review
FM3	Maory last mirror befor lgs wfs
FoV	Field of View
FP	Focal Plane
GD	Green Donut
HRI	High Resolution Imaging
ICD	Interface Control Document
I/F	Interface



INs	INstruments
IR	InfraRed
LGS	Laser Guide Star
LGSO	Laser Guide Star Objective
LOR	Low Order and Reference (module)
LRI	Low Resolution Imaging
M&M	MAORY and MICADO
MAIT	Manufacturing Assembly Integration and Testing
MAORY/MAO	Multi-conjugate Adaptive Optics Relay
MCA	MICADO's Calibration Assembly
MCAO	Multi-Conjugate Adaptive Optics
MICADO/MIC	Multi-AO Imaging Camera for Deep Observations
MORFEO	Multiconjugate adaptive Optics Relay For ELT Observations (Equivalent to MAORY, MORFEO is the new name)
MXXM	This is the Mirror XX of MAORY mounted on MICADO (e.g. XX=12, 11)
NAS-A	Nasmyth-A
NAS-B	Nasmyth-B
NCPA	Non Common Path Aberrations
NGSWFS	Natural Guide Star Wave Front Sensor/Sensing
PAE	Preliminary Acceptance Europe
PFRO	Post Focal Relay Optics
PFS-B	Pre-Focal Station B
PSF	Point Spread Function
PTV	Peak-To-Valley
RBM	Rigid Body Motion
SCAO	Single Conjugate Adaptive Optics
SCP	Service Connection Point
SCS	Standard Coordinate System
SMR	Spherically Mounted Retroreflector
SR	Strehl Ratio
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
TSS	(MICADO's) Top Support Structure
WFE	WaveFront Error
WFS	WaveFront Sensor/Sensing
Wrt	With respect to

### 1.3.3 Definitions (Glossary)



[I-MAO/MIC-18] D/// **Envelope (static):** it is the permanent volume occupied by any instruments on the Nasmyth platform when in operation.

**Envelope (dynamic):** the dynamic envelope includes the static one and the occupied volume required during AIV and maintenance activities.

**F/# (image space)** is defined as the distance of exit pupil over the exit pupil diameter.

**Fine tuning of the alignment** is the procedure that MAORY executes (if needed and only at beginning of the night) to optimize the optical performance. It consists in re-focusing through mirror M10M and pupil and field re-centering through M11M and M12M.

**Focal extraction:** is the distance between the focal plane delivered by MAORY and the intersection of the chief-ray with the last MAORY mirror (M12M).

### 1.3.4 Coordinates systems

[I-MAO/MIC-20] D/// Unless otherwise specified, the interface characteristics defined in this document and in its applicable documents are based on the Standard Coordinate Systems defined in [AD1]. This system of coordinates shall also be used in all further detail design and definition of the interfaces.

[I-MAO/MIC-21] D/// MAORY is designed to be mounted on the Nasmyth Platform B [AD8]. The global MAORY reference coordinate system is defined as follows.

The MAORY standard reference system: centered at the ELT nominal focal plane (focus A1), X axis pointing to the ELT M5 and normal to gravity and Z parallel and opposite to gravity.

	X [mm]	Y [mm]	Z [mm]	□ [deg]	□ [deg]	□ [deg]
<b>MAORY SCS</b>	27200	0	0	0	0	0

Location of MAORY SCS with respect to the ELT Standard Coordinate System (SCS)

The MICADO Standard Coordinate System is centered in the focal plane delivered by MAORY and aligned with the MAORY Standard Coordinate System as defined in following table (with respect to MAORY SCS)

	X [mm]	Y [mm]	Z [mm]	□□[deg]	□ [deg]	□ [deg]
<b>MICADO SCS</b>	-3050	6000	-1800	0	0	0

Location of MICADO SCS with respect to MAORY SCS



## 2. Related Documents

### 2.1 Applicable Documents

[I-MAO/MIC-24] The following documents, of the exact version shown, form part of this document to the extent specified herein. In the event of conflict between the documents referenced herein and the content of this document, the content of this document shall be considered as superseding.  
///

- AD1 Standard Co-ordinate Systems and Basic Conventions  
ESO-193058 Version 6  
<https://pdm.eso.org/kronodoc/HQ/ESO-193058/6>
- AD2 Moved to RD30
- AD3 Deleted – not referenced in the text
- AD4 Moved to RD31
- AD5 Integrated optical model ELT-MORFEO-MICADO  
ESO-488963 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-488963/1>
- AD6 Moved to RD32
- AD7 Moved to RD33
- AD8 MORFEO and MICADO Design Volume on MS-NPB (DWG)  
DE-CAD-264401 Revision 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-489255/2>
- AD9 Moved to RD34
- AD10 MAORY System Static volume  
E-MAO-000-00-00-00-00-MOD-02\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
- AD11 MAORY System dynamic volume  
E-MAO-000-00-00-00-00-MOD-03\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>



- 
- AD12 MAORY walkway volume  
E-MAO-000-00-00-00-00-MOD-04\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD13 MAORY CU extraction dynamic volume  
E-MAO-PU0-00-00-00-00-MOD-03\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD14 MAORY M11M extraction dynamic volume  
E-MAO-PFE-00-00-00-00-MOD-03\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD15 MAORY FM3 extraction dynamic volume  
E-MAO-PFI-00-00-00-00-MOD-03\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD16 MAORY LGS Objective extraction dynamic volume  
E-MAO-PFH-00-00-00-00-MOD-03\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD17 MAORY thermal cover panels removal extraction dynamic volume  
E-MAO-PM0-03-00-00-00-MOD-03\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD18 MORFEO\_SCAO shared volume  
E-MAO-000-00-00-00-00-MOD-05\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD19 MORFEO\_SCAO shared thermal volume  
E-MAO-000-00-00-00-00-MOD-06\_01  
<https://pdm.eso.org/kronodoc/HQ/ESO-517780/1>
  - AD20 MICADO AIV dynamic drawing  
ELT-DWG-MCD-56300-M00000-ENV-E00015103  
<https://pdm.eso.org/kronodoc/HQ/ESO-629403/1>
  - AD21 M12 access DV drawing  
ELT-DWG-MCD-56300-M62200-ENV-E00064327  
<https://pdm.eso.org/kronodoc/HQ/ESO-629405/1>



- AD22 M12 access positions drawing  
ELT-DWG-MCD-56300-M62200-ENV-E00064332  
<https://pdm.eso.org/kronodoc/HQ/ESO-629406/1>
- AD23 ESO NP ELT Nasmyth B drawing  
ELT-DWG-MCD-56303-M00000-DIF-E023142  
<https://pdm.eso.org/kronodoc/HQ/ESO-552317/4>
- AD24 ST0 Design Volume MM Mode  
ELT-DWG-MCD-56303-ST00000-ENV-E023957  
<https://pdm.eso.org/kronodoc/HQ/ESO-629407/1>
- AD25 AST M&M assembly envelope  
ELT-DWG-MCD-56300-M62200-ENV-E00061029  
<https://pdm.eso.org/kronodoc/HQ/ESO-628946/1>
- AD26 asm MM.MECH.IF  
ELT-DWG-MCD-56303-ST22300-DIF-E019194  
<https://pdm.eso.org/kronodoc/HQ/ESO-628949/2>
- AD27 MM.MECH.IF  
ELT-DWG-MCD-56303-ST22300-DIF-E019186  
<https://pdm.eso.org/kronodoc/HQ/ESO-628948/2>
- AD28 LOR scaffolding design volume  
ELT-DWG-MCD-56300-M62200-ENV-E00064008  
<https://pdm.eso.org/kronodoc/HQ/ESO-629404/1>
- AD29 TRS MM mode  
ELT-DWG-MCD-56303-ST22000DIF-E024664  
<https://pdm.eso.org/kronodoc/HQ/ESO-628947/2>



## 2.2 Reference Documents

[I-MAO/MIC-55] 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 MAORY (E-ELT MCAO) Technical Specification  
ESO-254311 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-254311/1>
- RD2 MICADO (E-ELT CAM) Technical Specifications  
ESO-244537 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-244537/2>
- RD3 MICADO SCAO ICD  
ELT-ICD-MCD-56034-0006  
<https://pdm.eso.org/kronodoc/HQ/ESO-324236/2>
- RD4 MAORY System Analysis Report  
E-MAO-SE0-INA-ANR-001 Revision 02  
<https://pdm.eso.org/kronodoc/HQ/ESO-387167/2>
- RD5 MAORY System MAIT Plan  
E-MAO-000-INA-PLA-010 Revision 01  
<https://pdm.eso.org/kronodoc/HQ/ESO-387101/2>
- RD6 ICD between MAORY and MICADO (Green Donut)  
ESO-335249 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-335249/2>
- RD7 ICD between MAORY and MICADO (Calibration Unit)  
ESO-351629 Version 3  
<https://pdm.eso.org/kronodoc/HQ/ESO-351629/3>
- RD8 MICADO Maintenance Manual  
ESO-410912 Version 3  
<https://pdm.eso.org/kronodoc/HQ/ESO-410912/3>
- RD9 MAORY Main Structure 2D drawings  
E-MAO-PM0-00-00-00-00-DWG Revision 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-397594/1>



- RD10 MAORY and MICADO Common AIV Plan  
ESO-648153 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-648153/1>
- RD11 MICADO Hazard Analysis  
ELT-TRE-MCD-56300-0040 Revision 2.4  
<https://pdm.eso.org/kronodoc/HQ/ESO-324302/6>
- RD12 ICD between MAORY and MICADO (Software)  
ESO-351580 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-351580/2>
- RD13 MAORY MMS PDR reference optical design  
E-MAO-SF0-00-00-00-00-DWG Revision 01  
<https://pdm.eso.org/kronodoc/HQ/ESO-387185/1>
- RD14 MAORY Hazard List and Analysis  
E-MAO-000-INA-ANR-003 Revision 01  
<https://pdm.eso.org/kronodoc/HQ/ESO-395703/1>
- RD15 Mechanical Interface of MICADO to the ELT Nasmyth Platform  
ELT-ICD-MCD-56303-0012 Revision 4.0  
<https://pdm.eso.org/kronodoc/HQ/ESO-410905/5>
- RD16 MICADO Technical Note MICADO-MORFEO Access Structure ICD Meeting Agreement  
ELT-TRE-MCD-56300-0177 M&M AST technical note  
<https://pdm.eso.org/kronodoc/HQ/ESO-561398/1>
- RD17 MICADO Accessibility Requirements at ELT Nasmyth Platform  
ELT-SPE-MCD-56300-0162 1 – To be released in PDM  
<https://pdm.eso.org/kronodoc/HQ/ESO-561393/1>
- RD18 Access Structure Design and Analysis  
ELT-TRE-MCD-56303-0014 2.0  
<https://pdm.eso.org/kronodoc/HQ/ESO-493479/2>
- RD19 Technical note on M12 Unit Distorsion from Nasmyth Platform Deflection  
(with LOR and FPM Bench)  
ELT-TRE-MCD-56300-0139\_2.2  
<https://pdm.eso.org/kronodoc/HQ/ESO-563403/2>



RD20 MICADO Hazard Analysis List

ELT-TRE-MCD-56300-0041 2.4

<https://pdm.eso.org/kronodoc/HQ/ESO-394092/5>

RD30 Common ICD between the E-ELT Nasmyth Instruments and the Rest of the E-ELT System

ESO-253082 Version 4

<https://pdm.eso.org/kronodoc/HQ/ESO-253082/4>

RD31 Common requirements for E-ELT Instruments

ESO-254547 Version 3

<https://pdm.eso.org/kronodoc/HQ/ESO-254547/3>

RD32 Earthing, bonding and Protection against Lightning and LEMP of ESO Buildings and Structures

ESO-193873 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-193873/2>

RD33 E-ELT Electrical and Electronic Design Requirements

ESO-262825 Version 1

<https://pdm.eso.org/kronodoc/HQ/ESO-262825/1>

RD34 IEC 60204-1 / EN 60204 Safety of machinery – Electrical equipment of machines

RD35 Deleted (redundant with RD14)

RD36 ESO Engineering Analysis Standard

ESO-191462 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-191462/2>



## 3. Interface Description

### 3.1 Interface Overview

[I-MAO/MIC-85] The General Interface Document between MAORY and MICADO covers all hardware aspects of the combined MAORY-MICADO system and their mutually interaction and dependencies. See #087 and #90 for a short description of the two instruments and refer to [RD1] and [RD2] for the respective technical requirement specifications.  
///

### 3.2 MAORY's view and system description

[I-MAO/MIC-87] MAORY is a post-focal adaptive optics module for the E-ELT first light. As stated in [RD1], MAORY offers MCAO mode to enable the science of MICADO near-infrared camera and the second instrument one. In addition, MAORY supports se SCAO mode of MICADO near-infrared camera.  
///

The main function of MAORY is to relay the light beam from the E-ELT focal plane to the client instrument while compensating the effects of the atmospheric turbulence and other disturbances affecting the wavefront from the scientific sources of interest. MAORY must be installed on the E-ELT Nasmyth platform A. It feeds two focal stations: the gravity invariant port underneath the MAORY Main Structure for MICADO and a second gravity invariant port for another instrument on the opposite side of MICADO.

Figure 1 shows the functional overview of E-ELT, MAORY and MICADO, including an indication of the elements that are moving inside the WFSs.

[I-MAO/MIC-88]  
///

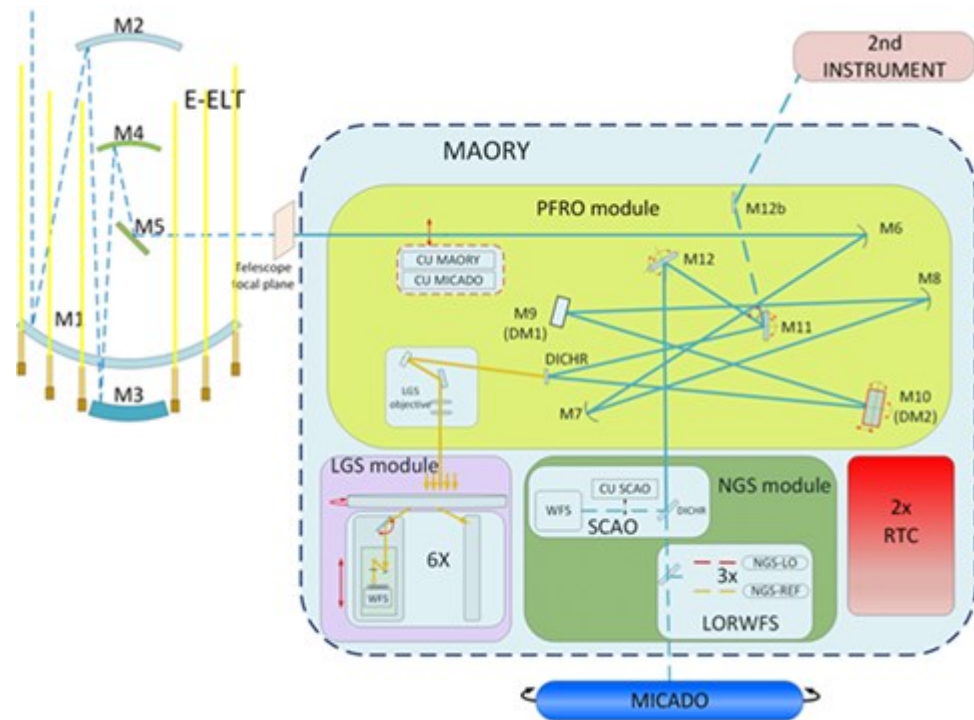


Figure 1: Functional overview of E-ELT, MAORY and MICADO

### 3.3 MICADO's View and system description

[I-MAO/MIC-90]  
///

MICADO is a cryogenic near infrared Multi-AO-Imaging-Camera and Spectrometer developed for the first light operation at the Extremely Large Telescope (ELT). It will operate together with the MAORY multi-conjugate adaptive optics system MCAO as primary AO mode and the single conjugate adaptive optics system SCAO.

MICADO provides a high- (HRI) and low- (LRI) resolution imaging mode with an unvignetted field of view (FoV) of 19"x19" at a pixel scale of 1.5 mas, and 50.5"x50.5" at a pixel scale of 4 mas, respectively.

The MICADO comprises the infrared focal plane imager with its 3 x 3 4k2 HgCdTe detector array and a compact cross-dispersing slit spectrometer and will operate in the wavelength range of 0.8 to 2.4  $\mu\text{m}$ . High contrast imaging is enabled via a configuration of coronagraph and Lyot stops.

Figure 2 provides a schematic overview of MICADO.



[I-MAO/MIC-  
91]  
///

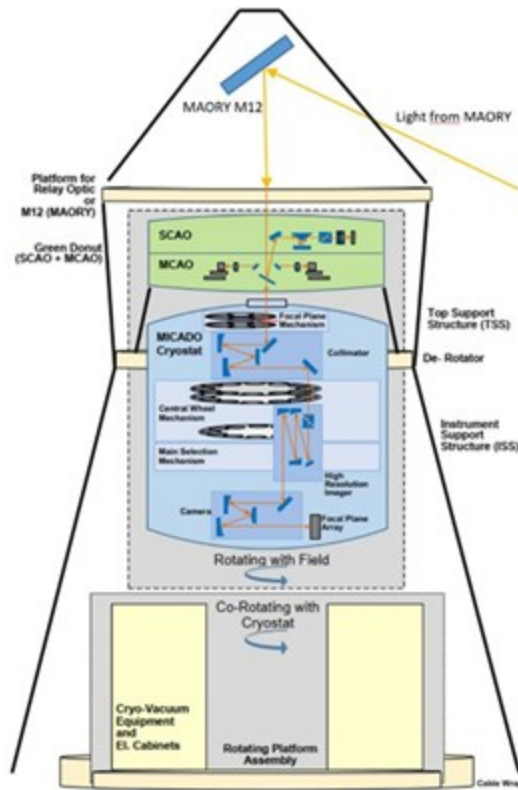


Figure 2: MICADO overview



## 4. Optical Interface requirements

### 4.1 Optical Interface between MAORY and MICADO

[I-MAO/MIC-94]  
D//I Gravity Invariant Port: MAORY shall allow the MICADO instrument to be gravity invariant.

[I-MAO/MIC-95]  
D/A// Optical Interface: MAORY shall provide the following optical interface towards MICADO:

Parameter	Value	Tolerances	Note
(Science) Field of View diameter on MICADO	75 <sup>1</sup> arc seconds diameter (> 250 mm)	N/A	Unobstructed circular FoV. See rationale in #024
(Technical) Field of View diameter of MAORY	160 arc seconds diameter	N/A	Unobstructed circular FoV
F-ratio [F/#] / Scale	17.75	±1%	Including the as-built telescope contribution (0.08%); see [RD30] I-INS/ELT-137
Plate Scale	3.318 mm/arcsec	±1%	Including the as-built telescope contribution (0.42%); see: [RD30] I-INS/ELT-137
Field Curvature	0	tolerance included in the WFE budget	See also #025
Exit pupil distance	+14361 mm	± 400 mm <sup>2</sup>	Static values. MAORY's margins included/ Telescope not included.  In MICADO's coordinate system
Exit pupil diameter	809.3 mm	± 20 mm <sup>3</sup>	Static values. MAORY's pupil blur and ellipticity margins

<sup>1</sup> The nominal science FoV is 72 arcsec diameter of the circle circumscribing the MICADO's large square FoV of 50.5" side

<sup>2</sup> At the MICADO cold stop a pupil distance tolerance of ±400mm equals ±4mm, which can't get compensated in MICADO. Adjusting the cold stop to the increased pupil blur would reduce optical throughput by up to 1.7%.

<sup>3</sup> It is understood that the exit pupil's diameter 809.3±20 mm and distance 14361±400 mm tolerance are not statistically independent, but subject to the f-ratio tolerance of 17.75±1%.



			included/Telescope not included
Exit pupil linear lateral motion	$\pm 0.8\%$ (area) ( $\pm 0.4\%$ linear)		Max dynamic pupil motion for one night. Peak to valley. Does not include MICADO's own motion.  No telescope included

[I-MAO/MIC-96] Deleted  
D/A/I

[I-MAO/MIC-97] **Optical Performance:** MAORY's shall provide the following optical performance towards the MICADO port:  
D/I/T

Parameter	Value	Description
WFE	<150 nm	The as-built MAORY-PFRO (in open-loop) shall not introduce more than 150 nm RMS Wavefront error in average on the scientific field of view at the reference wavelength of 1 $\mu\text{m}$
Intra-epoch Distortion	3.8 mas	MAORY shall not introduce a PSF centroids drift larger than 3.8 mas (intra-epoch distortion variation) over the technical Field of View during an astrometric observation of 120 sec with target altitude equal to 80 degrees.
Inter-epoch Distortion	50 $\mu\text{as}$	MAORY shall permit inter-epoch observations such that the relative position on the sky among unresolved, unconfused sources 1 arcsec apart having optimal brightness with respect to an optimal set of reference sources must be reproducible to within 50 $\mu\text{as}$ (goal: 10 $\mu\text{as}$ ) over a central, circular field of 20 arcsec diameter (goal: 75 arcsec diameter), after having applied astrometric polynomial fit of the distortion pattern.
Optical throughput	The average values <sup>4</sup> per band are:	According to [RD1], R-MAO-91,92,93:

<sup>4</sup> These values are driven by the current MAORY's dichroic's specifications.



Band	$\lambda_{min}$ [ $\mu\text{m}$ ]	$\lambda_{max}$ [ $\mu\text{m}$ ]	Average [%]
LGS	0.589		59.0
SCAO WFS	0.6	0.96	48.8
NGS WFS (REF)	0.63	1	54.9
I band	0.8	0.934	53.1
Y band	0.96	1.115	69.1
J band	1.15	1.345	74.2
H/NGS WFS	1.49	1.78	78.1
Ks band	1.97	2.33	80.9
K ext.	2.33	2.5	69.5

0.6  $\mu\text{m}$  - 0.8  $\mu\text{m}$  Unspecified  
 0.8  $\mu\text{m}$  - 1.0  $\mu\text{m}$  >50%  
 1.0  $\mu\text{m}$  - 2.5  $\mu\text{m}$  >65%

All values are meant for clean optics.

Telescope is included according to <https://jira.eso.org/browse/MAO-1496>.

Thermal background	The MAORY MCAO module thermal emissivity should, as a design goal, be less than 55% (TBC) of the thermal background from the sky and telescope measured in a Ks filter. This value is for an assumed temperature of 5°C and sky background of 13.5 mag/arcsec <sup>2</sup> . Assumptions are TBC.	See [RD1], R-MAO-90
--------------------	---	---------------------

[I-MAO/MIC-98]  
D//T

**MAORY's Exit Focal Plane Position:** MAORY shall position its exit Focal Plane (entry FP for MICADO) at the following nominal coordinates in the MAORY Standard Coordinates System (SCS):

X_FP-straight-port [mm]	Y_FP-straight-port [mm]	Z_FP-straight-port [mm]
-3050	6000	-1800



[I-MAO/MIC-99]  
/A/ /T

**MICADO entrance Focal Plane tolerances:** the MICADO as-built entrance focal plane (Figure 3) shall be, with respect to the nominal position defined in #98, within the ranges:

X, Y, Z [mm]	Tilt X, tilt Y [arcmin]
±5	±2

[I-MAO/MIC-100]  
///

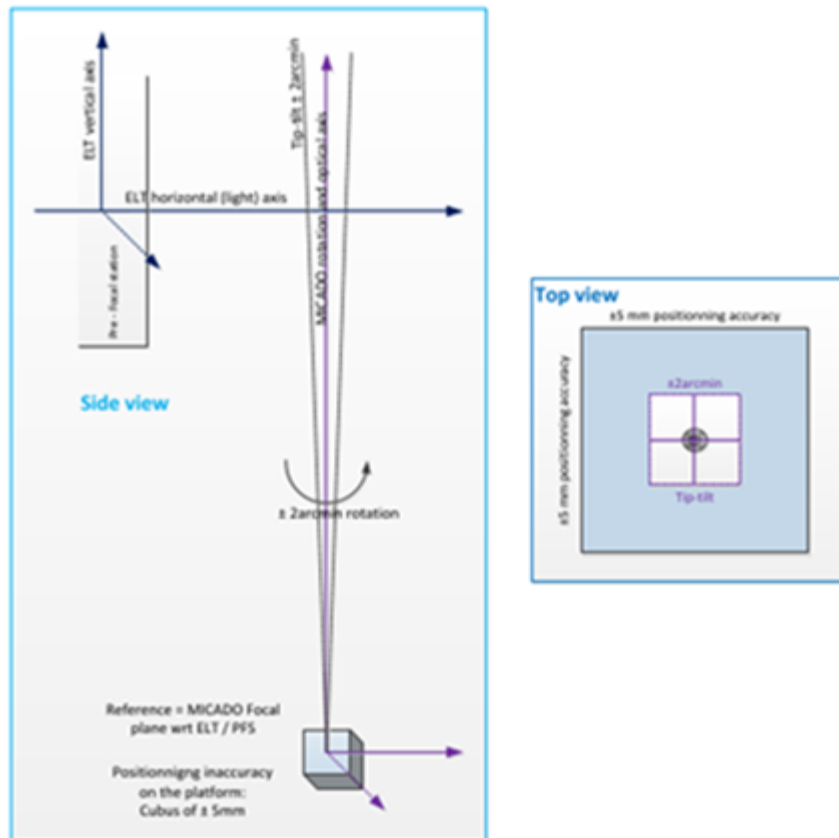


Figure 3: MICADO entrance focal plane

[I-MAO/MIC-101] Deleted  
///

[I-MAO/MIC-102] Deleted  
///

[I-MAO/MIC-103] **Entrance Focal Plane Size Rationale**  
///

MAORY will provide to MICADO a circular unobscured Field of View having diameter > 250 mm.

If so required by the science observations it will be possible for the LOR probes to vignette the scientific FoV.

MICADO is a finite-conjugate imaging relay optics with a nominal magnification of 1.13083. To cover the full detector plane semi-diagonal of 133.9 mm with a margin of 5%, an unobscured object field of view of 250 mm diameter is required. With an effective



focal length of ELT/MAORY of 684307 mm that corresponds to a field of view with diameter 75.4" on sky.

[I-MAO/MIC-104] **Entrance Focal Plane Curvature Rationale**

///

MICADO and MAORY agreed on departing from ELT exit focal plane characteristic.

MAORY will provide to MICADO a flat entrance focal plane. Deviation from infinite radius of curvature will be included in the WFE budget at the MAORY exit pupil.

[I-MAO/MIC-105] **Focal extraction:** MAORY shall provide a focal extraction of at least 1200 mm from the MICADO entrance focal plane.

D///

**Rationale:** M12 receives the optical beam from below, and this requirement avoids vignetting while providing enough free volume for the thermal panels and the supporting structure.

[I-MAO/MIC-106] **No-vignetting:** MICADO shall not vignette the MAORY optical beam provided in [AD5]. A clearance of 2000mm shall be reserved from the MICADO focal plane upwards.

D///

[I-MAO/MIC-107] **Plate Scale:** The as-built MAORY shall deliver a plate scale within 1% from the as-built (i.e. static effects only, excluding dynamic effects) ELT plate scale.

/A/IT

**Note:** *the plate scale is constrained in open loop. In closed-loop MCAO mode, the final plate scale will be determined by the 3 NGSWFS. The capability to modify the plate scale is assured by DM1 (M9M) and limited by its stroke to about 0.2%.*

[I-MAO/MIC-108] **Ghosts:** In imaging mode, the maximum irradiance from ghost-images from any source in the field shall not exceed 0.1% of the source image irradiance.

D///

## 4.2 MICADO SCAO-only relevant optical IFs

[I-MAO/MIC-110] The following relevant parameter shall be considered from the SCAO I/F [RD3]:

D///

The SCAO WFS field of view is 2 arcsec in diameter and its centre can patrol in a field of 17.5 arcsec (57.8 mm) radius

The SCAO wavelength range is  $[\lambda_{\text{blue}}-\lambda_{\text{red}}]$ , where  $\lambda_{\text{blue}} > 589 \text{ nm}$  and  $\lambda_{\text{red}} = 960 \text{ nm}$

[I-MAO/MIC-111] **Pupil blur**

/A/IT

The optical quality of the ELT exit pupil plane re-imaged on the WFS detector shall be such that the spot diagram is less than 0.12% of the pupil diameter, when considering the rays passing through a field of 1 arcsec diameter.

Potential chromatism must be accounted for by considering the spot diagram resulting from the combination of the multi-wavelength spot diagrams in the WFS bandpass: the spot diagram of any pupil point re-imaged after the optics relay shall be smaller, in rms value, than 0.12% of the diameter of the pupil itself, when considering rays passing through a field diaphragm of a  $\emptyset$  of 1 arcsec (3.31 mm).



This shall be verified for any position of the centre of the SCAO WFS field-of-view across the patrol field.

This shall be verified only by analysis. On the nominal configuration up to MAORY-FDR. On the as built configuration up to MAORY-PAE.

[I-MAO/MIC-112]  
/A/ /

**Pupil distortion:** the distortion of the pupil image on the detector shall be less than 0.12% of its own diameter. (This spec is different from the previous one in the sense that it addresses the distortion of pupil image).

Potential chromatism must be accounted for by considering the pupil image resulting from the combination of the pupil images at the wavelengths in the WFS bandpass.

The previous requirement ensures that the pupil image is sharp, the present ones ensure it's not elliptical or else.

This shall be verified only by analysis. On the nominal configuration up to MAORY-FDR. On the as built configuration up to MAORY-PAE.

[I-MAO/MIC-113]  
/A/ /

### **MAORY optical quality at the end of MAORY's AIV**

The aberrations observed on the final system will be the sum of

- Zemax design aberrations
- alignment aberrations
- surface errors (polishing) of mirrors
- relay optics chromatism

The on-axis optical quality delivered by the optics relay shall not be less than a SR of 0.50 in H band, corresponding to 220 nm rms of wave-front error, excluding tip-tilt and defocus.

For information, this will in turn lead to a SR of

≈ 0.30 in J band

≈ 0.01 at 630 nm

[I-MAO/MIC-114]  
/A/ /

### **MAORY optical quality in operation**

The high spatial frequencies (greater than  $0.80 \text{ m}^{-1}$  in M1 space) will not be compensated at all by the system and may lead to static aliased components.

The wavefront error from the optics relay at high spatial frequencies (greater than  $0.80 \text{ m}^{-1}$  in M1 space) shall be better than 40 nm rms. (TBC)

[I-MAO/MIC-115]  
D/A/ /

### **Variations of aberrations in the field**

The **differential** field aberrations shall be smaller than

≈ 90 nm rms at 10 arcsec distance

≈ 170 nm rms at 25 arcsec distance from centre



**Note:** *these requirements are to be considered in the particular in case of drifts of MAORY post-focal DMs, which may occur when left uncontrolled (just with static voltages applied driven by thermal dependent look up table).*

[I-MAO/MIC-  
116]  
/// Deleted

## 4.3 Optical Alignment Interface

[I-MAO/MIC-  
118]  
/// **Pupil registration management:** for the optical alignment MICADO will allow to measure the field position with its focal plane IR array and the pupil position with its pupil viewer. Additionally, SCAO can measure the pupil position.

MAORY will be able to adjust pupil and field position with its motorized M11 and M12 mirrors. Displacement accuracy is given in #145.



## 5. Mechanical Interface Requirements

### 5.1 Design Volume and Static volumes

#### 5.1.1 Attachment points

[I-MAO/MIC-122] D/// The mounting locations inside the shared volume of MAORY and MICADO are listed in Table 1.

[I-MAO/MIC-123] D///

	ID	X <sub>ELT</sub> [mm]	Y <sub>ELT</sub> [mm]	Z <sub>ELT</sub> [mm]
MAORY attachment points (ABC main structure) (DEF thermal pipe support structure <sup>5</sup> )	A	26750	0	-6000
	B	26750	-3000	-6000
	C	31750	0	-6000
	D	31250	-3000	-5950
	E	32250	-3000	-5950
	F	31250	-2125	-5950
MICADO attachment points (ABCD main structure) (EF RPA)	A	27250	-6000	-5950
	B	30250	-3000	-5950
	C	33250	-6000	-5950
	D	30250	-9000	-5950
	E	29750	-6000	-5950
	F	30750	-6000	-5950
MICADO AST contact points to NAS-B Support Points)	1	31430	-9350	-6000
	2	31430	-11150	-6000
	3	30530	-9350	-6000
	4	30530	-11150	-6000
	5	29080	-9100	-6000
	6	29080	-11150	-6000
	7	28180	-9100	-6000



	8	28180	-11150	-6000
	9	30335	-10323	-6000
	10	30335	-11035	-6000
	11	32912	-6529	-6000
	12	32507	-7508	-6000
	13	31758	-8257	-6000
	14	30779	-8662	-6000
	15	29720	-8662	-6000
	16	28741	-8257	-6000
	17	27992	-7508	-6000
	18	27587	-6529	-6000
	19	27587	-5470	-6000
	20	27992	-4491	-6000
	21	28741	3742	-6000
	22	29720	-3337	-6000
	23	30779	-3337	-6000
	24	31758	-3742	-6000
	25	32507	-4491	-6000
	26	32912	-5470	-6000

**Table 1: MAORY and MICADO mounting locations on the Nasmyth B platform**

**(Note: All MICADO attachment points are Intermediate Support points, except AST attachments, which mounts to NP directly)**

[I-MAO/MIC-124] Three main interface flanges are needed for the MAORY Main Support Structure.

/// Other three additional support points (D, E, F) are needed for the MAORY-MICADO Thermal Duct (tower for thermal duct between MAORY. Their location is defined in ET-1307.

The reference MAORY drawings are in [RD9].

The MICADO's attachment points on the Nasmyth platform are shown in the MICADO Nasmyth platform ICD document [RD15] and in [AD23].

### 5.1.2 Static envelope

[I-MAO/MIC-126] Deleted  
///

[I-MAO/MIC-127] The **MICADO ST0 static envelope** is defined in [AD24].

D/// The **MICADO Access Structure envelope** in M&M mode can be seen in the envelope drawing AST\_M&M\_assembly [AD25].

[I-MAO/MIC-128] The **MAORY static envelope** is defined in [AD10] and Figure 4.

D///

[I-MAO/MIC-129]

///

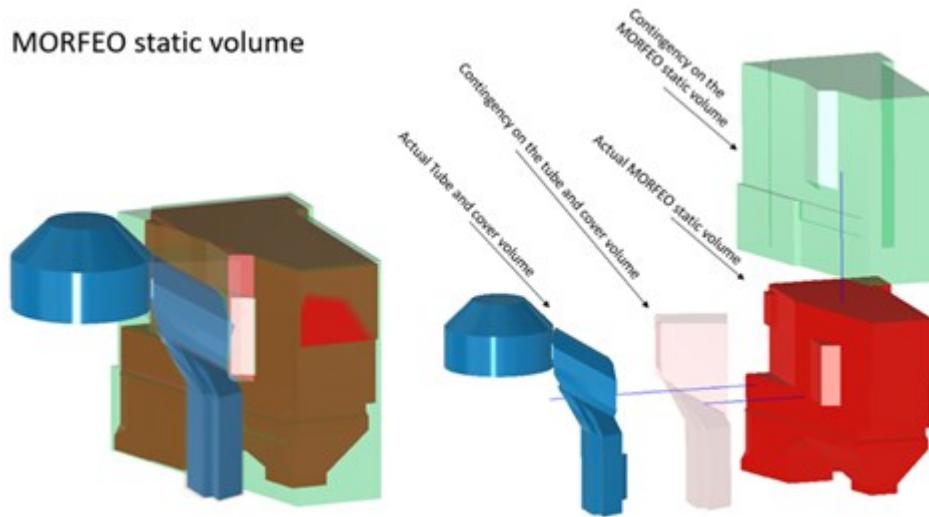


Figure 4: MAORY static volume

[I-MAO/MIC-130] The dynamic **AIV and maintenance envelope of MICADO** can be seen in the drawing MICADO AIV dynamic [AD20].

D///

[I-MAO/MIC-131] The MAORY Dynamic Volume – used for **AIV and maintenance** - is described in [AD11] and in Figure 5.

D///

Note: see also accessibility requirements in Section 6.

[I-MAO/MIC-132]

///

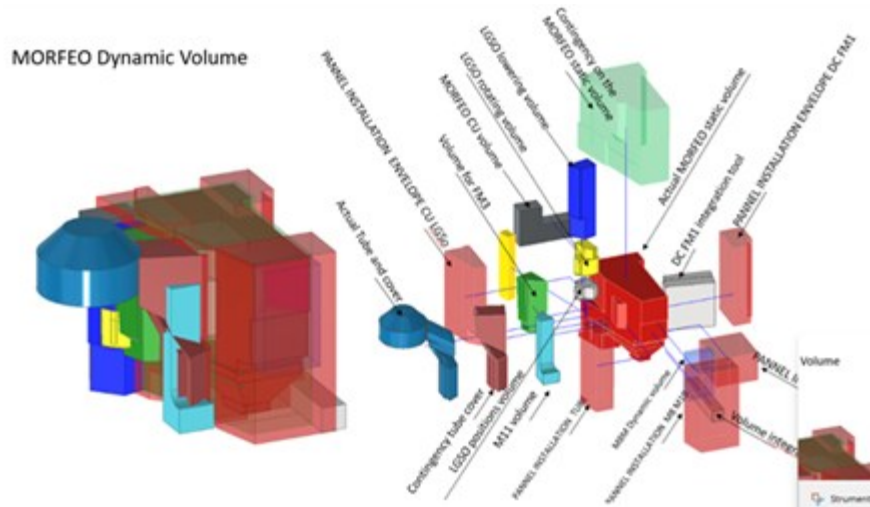
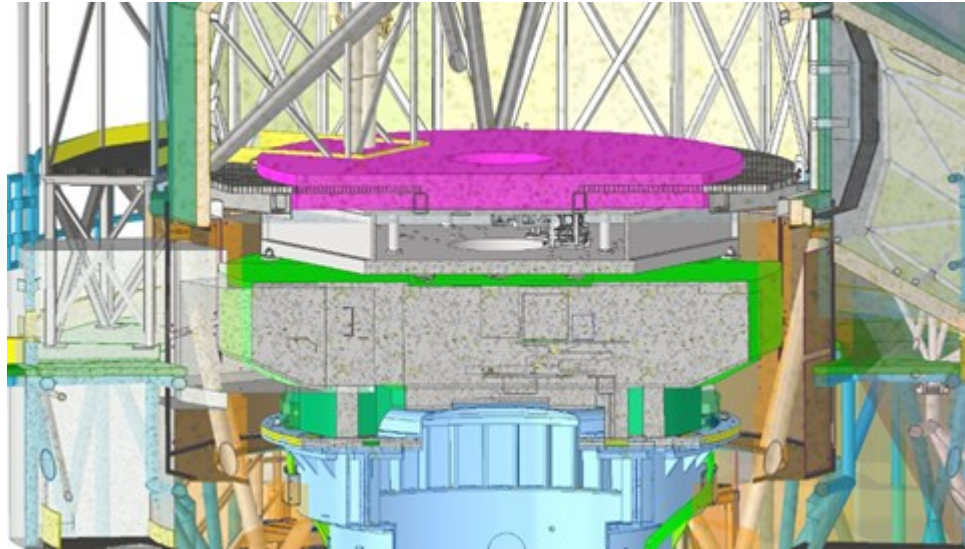


Figure 5: MAORY's AIV and maintenance volume

[I-MAO/MIC-134] **Shared MAORY-SCAO volume:** the shared volume between MAORY and SCAO of MICADO (light violet in the Figure 6) is defined in [AD18].  
D//

**Note:** any component on top of the SCAO will interfere with the accessibility platform for M12M and SCAO maintenance. If this space will be used for any reason, the access strategy to M12M of MAORY and the SCAO of MICADO will have to be redefined.

[I-MAO/MIC-135]   
///



**Figure 6: Shared volume between MAORY and SCAO of MICADO**

## 5.2 Stability under operational condition

[I-MAO/MIC-138] All displacements shall be within the tolerances indicated in #99 (TBC)  
D//

[I-MAO/MIC-139] Under all operational conditions, the peak-to-valley R BM (Rigid Body Motion) displacement across the entire set of attachment points supporting MICADO and MORFEO will not exceed the limits specified in the table below.  
///

This requirement supersedes [I-INS/ELT-253] of [RD30].

	Ux [mm]	Uy [mm]	Uz [mm]	Rotx [urad]	Roty [urad]	Rotz [urad]
<b>Micado</b>	3	1.5	2	100	170	100
<b>Morfeo</b>	3	1.5	2	100	170	100
<b>Morfeo-Micado</b>	0.5	0.5	1	10	20	10



Maximum RBM values for MORFEO and MICADO (in units of [mm] (displacements) and [micro rad] (rotations))

[I-MAO/MIC-140] Under operational conditions, the maximum quasi-static peak-to-valley displacement of any individual nominal attachment point on the Nasmyth platform — relative to the rigid body motion (RBM) of the complete set of attachment points supporting MICADO and MORFEO — will not exceed the limits specified in the table below.

This requirement supersedes [I-INS/ELT-499] of [RD30].

	Ux [um]	Uy [um]	Uz [um]
Micado	3	7	8
Morfeo	23	13.5	0

Differential flange deformations (in units of microns = [10<sup>-6</sup> m])

[I-MAO/MIC-141] **MICADO Displacements:** The MICADO displacements of M12/LOR and the focal plane was performed, and the results are included in the technical note [RD19].

*Note: the thermal effects are excluded, but non-significant*

[I-MAO/MIC-142] **Thermal effects** are estimated to be non-significant, considering that MAORY's and MICADO's structures attaching to the Nasmyth are made of steel.

### 5.3 Position Tolerances and Alignment

[I-MAO/MIC-144] Deleted

[I-MAO/MIC-145] **MAORY displacements accuracy**

D/// After the fine tuning of the alignment, MAORY shall be able to accommodate the displacement in #139 and #141 for a positioning accuracy of:

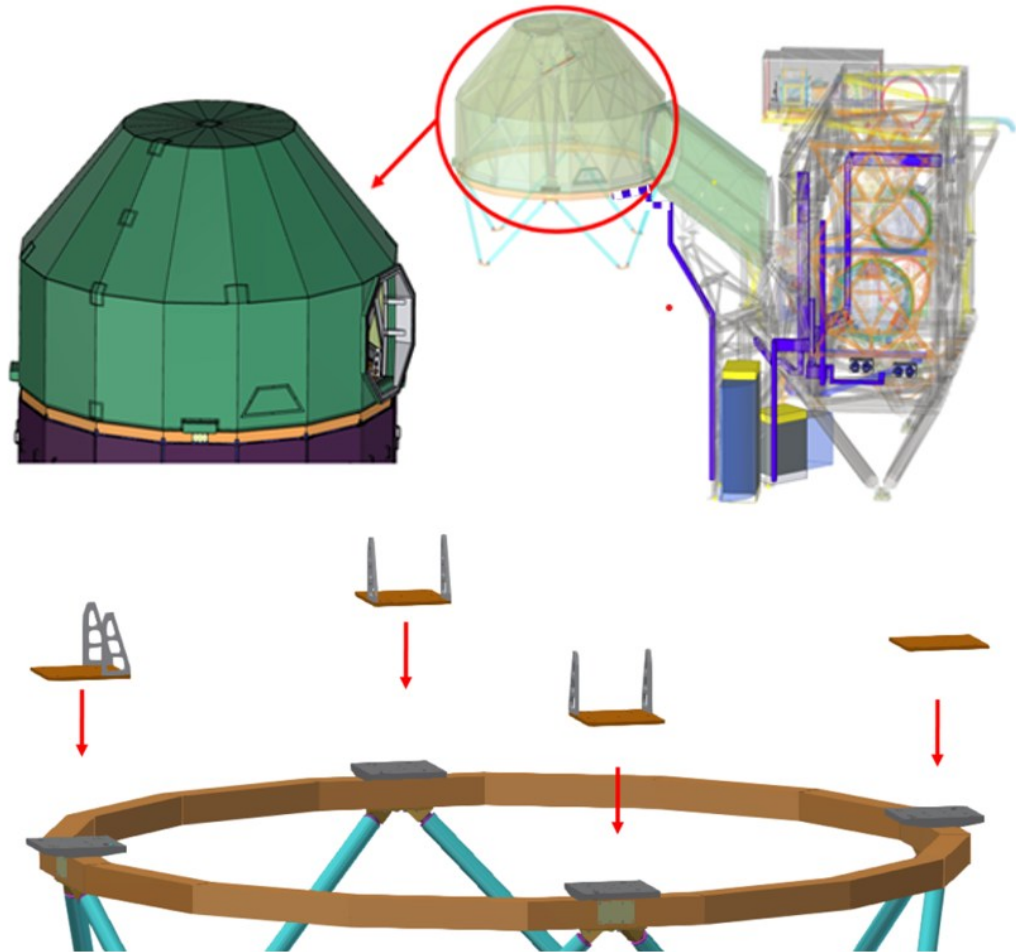
- Focal plane: ±1.1 arcsec (TBC)
- Pupil: 160 µm (PTV) at the cold stop (=0.2% of the pupil size)

#### 5.3.1 Mechanical mounting Locations

[I-MAO/MIC-147] When relocated from NAS-A to NAS-B the direct line of sight to the PFS-B will be hidden by the MAORY's installation. Therefore, MAORY will provide the referencing to the common focal point to enable MICADO to verify its mechanical interface to Nasmyth platform B.

[I-MAO/MIC-148] MAORY's plates (see attached picture, in brown with grey attachment wings for the  
 /// M12M legs) are the mechanical interface to the MICADO flanges (in grey in Figure 7,  
 attached to the MICADO's support structure). The green thermal cover (a subassembly  
 under MAORY's responsibility, in green) and the support legs of M12M (not shown)  
 attach to the MAORY interface flanges only and are therefore not interfacing directly to  
 MICADO.

[I-MAO/MIC-149]  
 ///



**Figure 7: (Top) Green thermal cover of the M12. The location of the cable conduits from MAORY to MICADO in blue is still to be finalized. (Bottom) MAORY's interface flanges attaching to the MICADO flange on the TSS.**

[I-MAO/MIC-150] **TSS vs M12M IF:** The interface between MICADO's Top Support Structure (TSS) and  
 D/// the MAORY 's M12M thermal enclosure (a.k.a. "MICADO thermal Enclosure in MAORY")  
 is provided in [AD26], [AD27] and [AD29] for MICADO

and in the following drawings for MAORY:

- E-MAO-PM0-05-00-00-12-DWG\_01
- E-MAO-PM0-05-00-00-01-DWG\_01
- E-MAO-PM0-05-00-00-02-DWG\_01



Included in [RD9].

[I-MAO/MIC-151] **Position accuracy of IF pads**

D//T The position accuracy for the interface pads on the TSS shall be:

- In X/Y/Z direction  $\pm 1\text{mm}$
- Parallel between the 4 pads: 1mm

Note: The tolerances are also described in the drawings referenced in #149 and #150.

[I-MAO/MIC-152] **Position accuracy of IF pads 2**

D//T The positions in #151 shall be measured to an accuracy of 0.2 mm in X/Y/Z direction.

[I-MAO/MIC-153] The MAORY Interface plates E-MAO-PM0-05-00-00-12-DWG\_01 will be used to compensate the misalignment defined in #151 (TBC)

[I-MAO/MIC-154] **Measurement report:** MICADO shall provide to MAORY a complete measurement report (numbers only or an as-built-drawing) of the I/F defined in #151 and #152.

*Note: The interface shall be measured by MICADO after MICADO's MAIT in Europe and during common AIV on the Nasmyth platform (e.g. with a laser tracker system) to allow the installation of the M12M.*

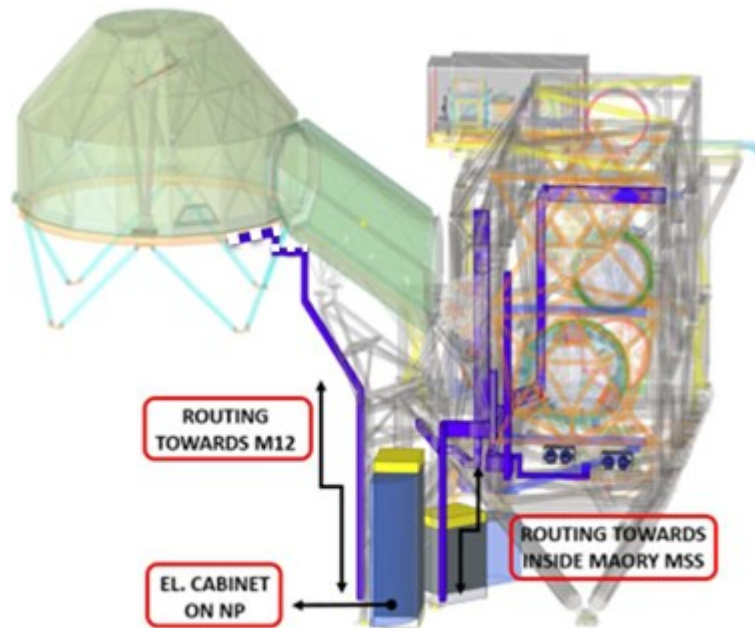
### 5.3.2 Electronic cabinets' locations

[I-MAO/MIC-156] MAORY and MICADO will locate the following electronic cabinets on the Nasmyth Platform:

Instrument	Name	Cabinet type	Positioning constraints
MAORY	Post Focal Relay Optics Cabinet (PFROC)	1x ~34U + heat exchanger	Underneath the support structure for the thermal tunnel. See Figure 8.
MAORY	Proximity Electronics Cabinet (PEC)	1x ~17U + heat exchanger	As close as possible to the LGS unit. See Figure 8.
MICADO	Instrument control station	one touch screen mounted to AST	N/A

MAORY's cabinets on the MICADO's co-rotating platform are included in the GD ICD [RD6].

[I-MAO/MIC-157]  
///



**Figure 8: possible sketch of MAORY showing the location of the cabinets on the Nasmyth platform. Rou. The location of the cable conduits from MAORY to MICADO in blue is still to be finalized.**

[I-MAO/MIC-158] MAORY and MICADO will locate 5 and 6 electronic cabinets below the Nasmyth Platform, respectively  
///

## 5.4 Common mounting components and IFs

[I-MAO/MIC-160] **MAORY's M12M and its thermal cover characteristics**  
D///

Loads	Ax=Ay=2.58g, Az 1.93g
Mass	1130 Kg (TBC)
MOI	TBD
COG	Z +500 mm (TBC)
Acting forces at AI	TBD
Eigenfrequency	30Hz (TBC)

[I-MAO/MIC-161] **Induced Vibrations by MICADO**  
/A/

As long as no detailed system micro vibration analysis is available, the requirement [R-INS/ELT-390] in [RD30] shall be applicable for all interfaces. (TBC)



[I-MAO/MIC-162]  
/A/ / **Induced Vibrations by M12M**

If no detailed system micro vibration analysis is available, the requirement [R-INS-760] in [RD31] shall be applicable for all interfaces. (TBC)

[I-MAO/MIC-163]  
/ / / LOR inside the green donut and cabinet on rotating platform are included in [RD6].

## 5.5 Structural Mathematical model

[I-MAO/MIC-165]  
D / / / The Interchange structural models shall be according to [RD36].



## 6. Accessibility Requirements

[I-MAO/MIC-167]  
D/II Details of the accessibility analysis and requirements from MAORY can be found in chapter 6 of [RD4] and section 8.4 of [RD5].

Details of the MICADO accessibility can be seen in the MICADO accessibility requirements document in [RD8] and in [RD17].

[I-MAO/MIC-168]  
D/II **MAORY Accessibility:** MICADO shall allow accessibility for removal or inspections or maintenance to the following MAORY's subsystem and assemblies [RD9]:

- MAORY Fold Mirror FM3
- MAORY M12M + Thermal Cover
- MAORY LGS Objective + MAORY CU
- MAORY LGS WFS
- MAORY selector mirror M11M
- MAORY LOR

Access to the MICADO AST requires interlocking MICADO.

[I-MAO/MIC-169]  
D/II **MICADO accessibility:** MAORY shall allow accessibility for removal or inspection or maintenance to the following MICADO's subsystem and assemblies:

- MICADO MCA – see #174
- MICADO SCAO (from above, by removing thermal cover and adding proper platform on the interface to MICADO support structure) – see #190
- 

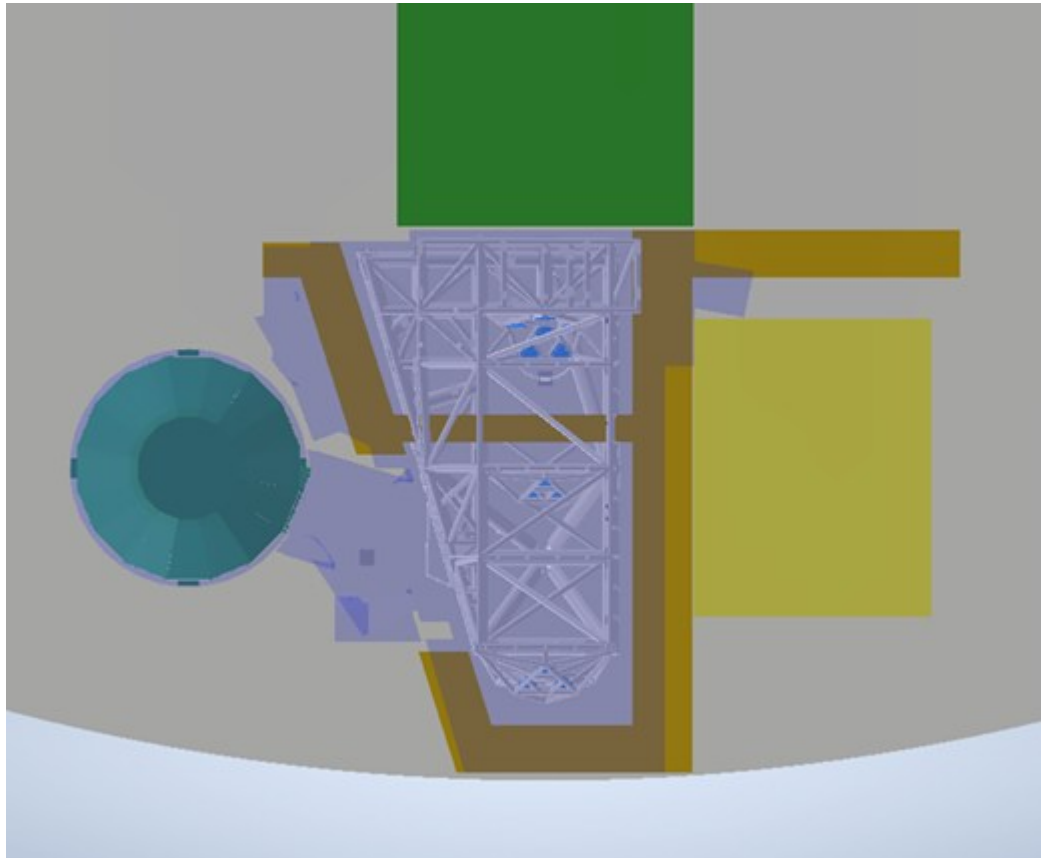
MICADO Cryostat, RPA and de-rotator for service cases.

All details for the MICADO accessibility can be seen in the MICADO accessibility requirements document in RD17.

[I-MAO/MIC-170]  
D/II **Encroachment of volumes:** no permanent structure of either MICADO or MAORY shall encroach both the dynamic and the static volumes except for what is explicitly agreed in this document and in [RD16].

[I-MAO/MIC-171]  
D/II **Walkway:** the walkway (orange path) shown in Figure 9 shall be left free by both MAORY and MICADO to always allow access to the required inspection points. [AD12].

[I-MAO/MIC-  
172]  
///



**Figure 9: Walkway for inspections**

[I-MAO/MIC-  
173]  
D///

### **Accessibility constraints and AST**

A major intervention that requires the MICADO cryostat to be craned out needs access 360 degrees around MICADO to remove cables and screws and mount the crane tools.

An access structure (AST) will be mounted around MICADO to allow access (see #167). This access structure shall be designed such that:

- MAORY can move and crane out the components mentioned in #168 and #177 within the volume as defined in the access volumes files [AD10-AD19]. In some cases, it is necessary to remove parts of the access structure for this purpose.
- The volume of the thermal pipe to M12M and the according tower is not violated.

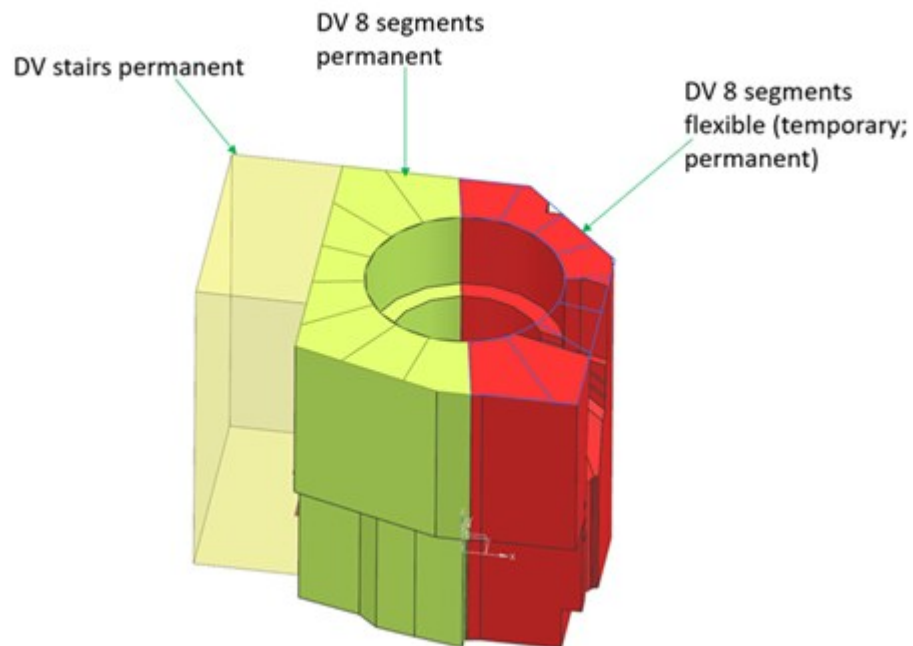
[I-MAO/MIC-  
174]  
///

### **MICADO AST Design Volume**

The MICADO AST design volume is included in [AD25].

The MICADO AST design volume for M&M mode on NAS-B consists of three sections, as shown in Figure 10.

[I-MAO/MIC-175]  
///



**Figure 10: MICADO AST DV**

[I-MAO/MIC-176]  
///

The DV for the stairs in yellow is a permanent reserved volume where the stairs for access to the first and second floor is located. In light green the volume for the permanent section can be seen. This volume contains 180° of the overall AST structure. The 180° section can internally again be divided in 8 segments as it can be seen in Figure 10 on the top surface sketch. For now, this is the current design status, if the permanent section has later 90°, 120° or 180° will be clear after all FEA calculations were made with the as built design. Anyway, this has no impact to the MORFEO instrument.

The red volume shows the flexible temporary/permanent part of the other 180° of the AST DV. This volume can again be divided in 8 segments. The segments can be removed when MORFEO needs the access in this area. The volume contains also a large cut-out for the MORFEO thermal duct.

[I-MAO/MIC-177]  
///

**Integration and maintenance cases with possible I/F to the MICADO's AST**

For maintenance and integration cases, MORFEO's and MICADO's dynamic design volumes are applicable (#129 #132). The volumes must be kept free to ensure a trouble-free maintenance or inspection operation.

For the most frequent access needs the access will be allowed without any/or minimal dismounting of the AST segments.

The identified maintenance cases are:

- MICADO's MCA access (Figure 11, #178) – no need to dismount AST's segments
- MAORY's LGSO coating (Figure 16,#183) - need to dismount segments 13, 14 and 15. Frequency >4 years

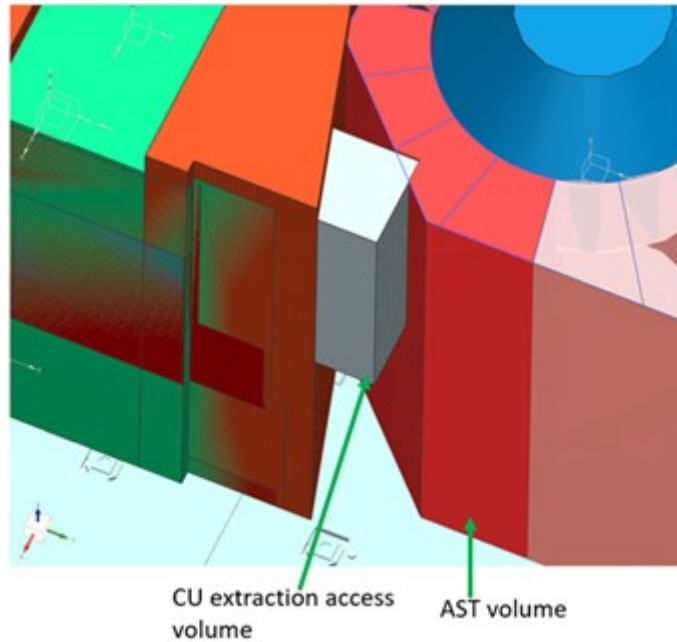
- MAORY's CU extraction (Figure 12, #179) - no need to dismount AST's segments
- MAORY's FM3 removal (Figure 21, #196) – need to dismount segments 13 and 14. Frequency >4 years
- MAORY's M11M removal (Figure 15, #182) - no need to dismount AST's segments
- MAORY's Thermal cover (Figure 24, #205) - no need to dismount AST's segments
- MAORY's recoating campaign (Figure 25, #208) – need to dismount 8 segments. Frequency >4 years
- MAORY's Thermal duct removal (Figure 14, #181) - no need to dismount AST's segments
- MAORY's M12M (Figure 17, #184) - no need to dismount AST's segments
- MAORY's LOR (Figure 18, #185 Figure 29, #216 ) – need to dismount the second floor of segments 13,14 and 15.

[I-MAO/MIC-  
178]  
///



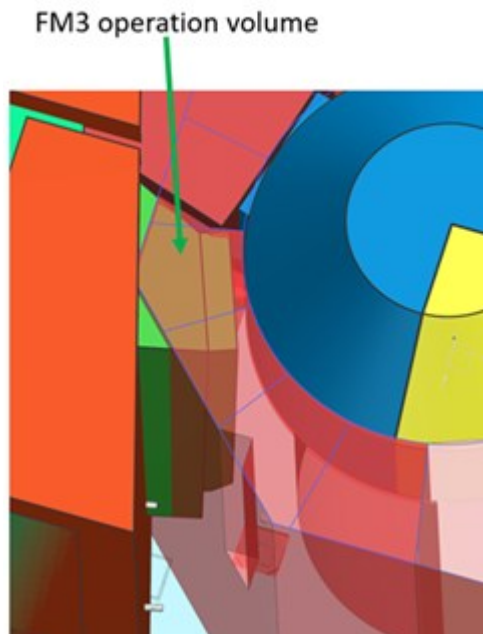
**Figure 11: MORFEO MCA access volume**

[I-MAO/MIC-179]  
///



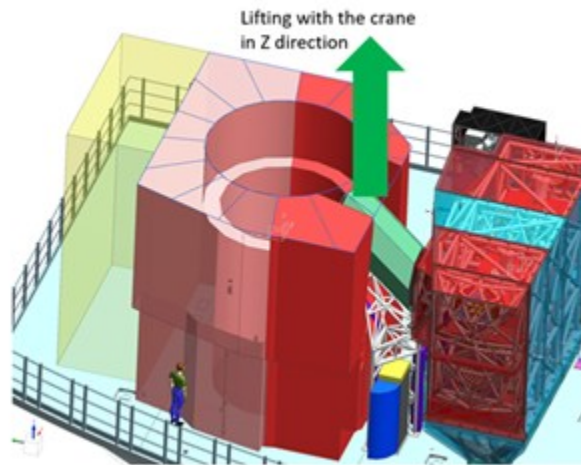
**Figure 12: MORFEO CU extraction volume**

[I-MAO/MIC-180]  
///



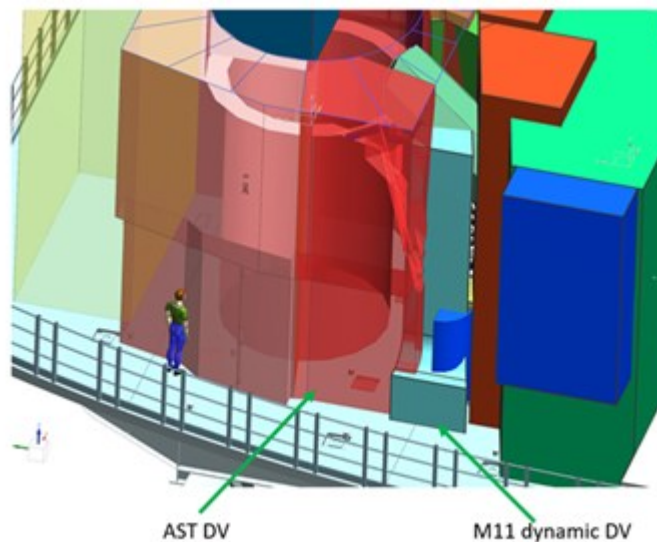
**Figure 13: MORFEO FM3 volume (see [AD11]) overlapping with the AST DV ([AD25]). Since currently the dismounting of FM3 is planned once every four years, at the same time as the recoating of the LGSO, this has only a minor impact on the effort required by on-side personnel.**

[I-MAO/MIC-181]  
///



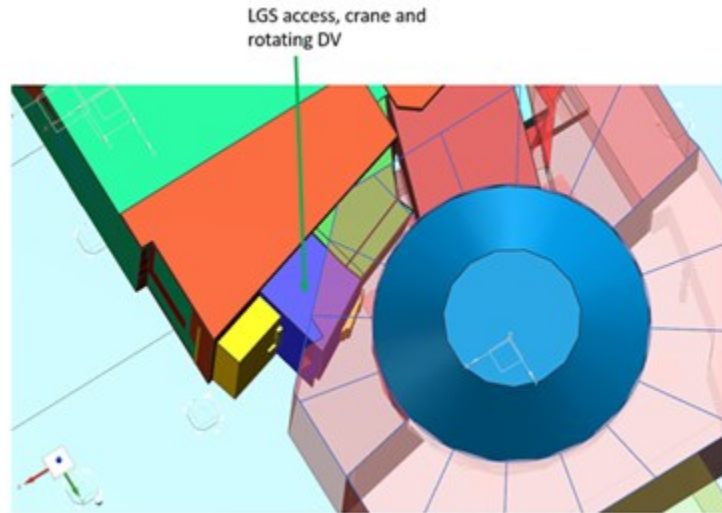
**Figure 14: Free space for MAORY's thermal duct removal**

[I-MAO/MIC-182]  
///



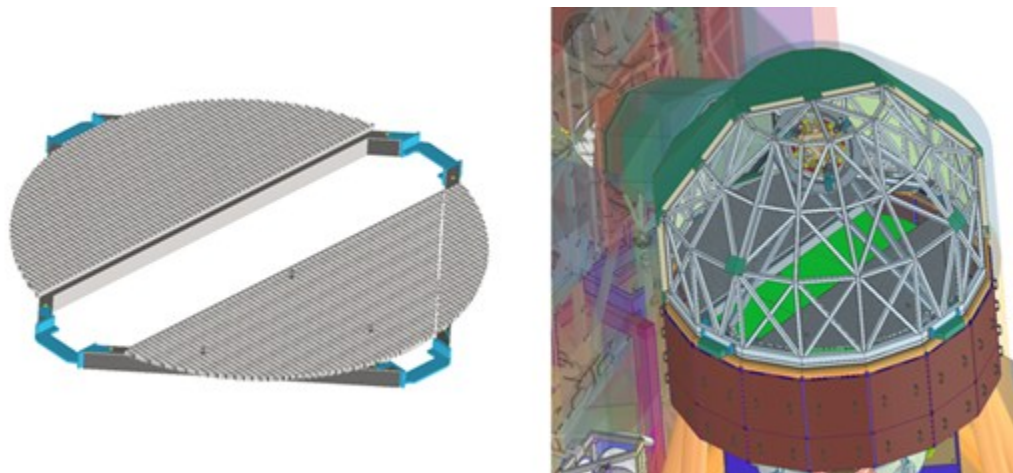
**Figure 15: M11 removal DV on NAS B (see [AD25]). The M11 removal case for recoating is expected to happen once every four years. Nevertheless, after earthquakes the access space is needed for visual inspection.**

[I-MAO/MIC-183]  
///



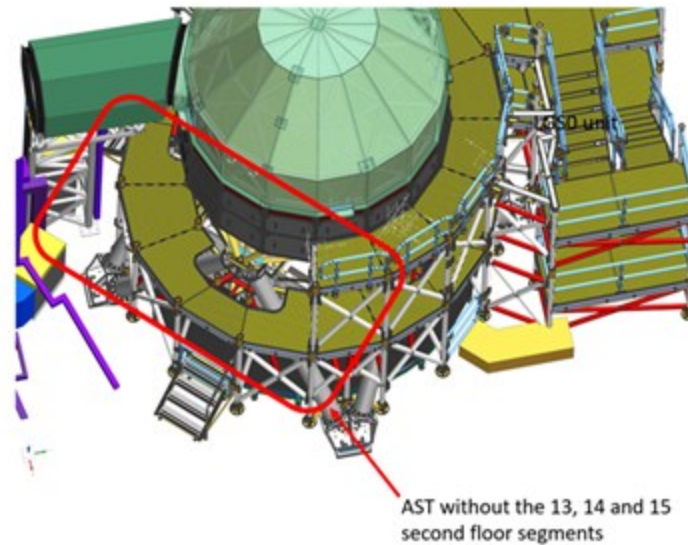
**Figure 16: LGS0 design volumes.**

[I-MAO/MIC-184]  
///



**Figure 17: (right) the M12M mirror on top of MICADO needs to be accessed to maintain the motors or removing the mirror for recoating. For that operation the fully thermal cover of the M12 will be dismantled without any additional access structure. MORFEO will provide two half-bridges, which can be seen in the (left).**

[I-MAO/MIC-185]  
///



**Figure 18: MICADO AST in MAORY's LOR maintenance configuration**

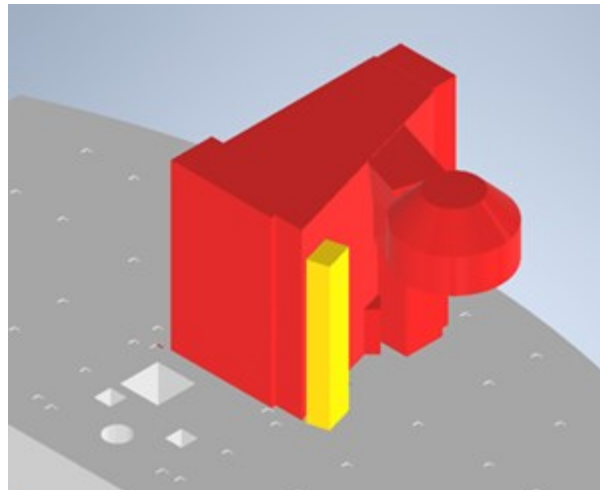
[I-MAO/MIC-186]  
D/ //

**MCA access**

MICADO's MCA accessibility shall be possible for maintenance purpose via the MAORY structure. See Fig. 19

**Note:** MICADO's AST in the nominal configuration shall not interfere with the dynamic volume for the extraction of MCA (see also #177)

[I-MAO/MIC-187]  
///



**Figure 19: Volume (yellow) to access MCA**

[I-MAO/MIC-189]  
D/ //

**M12M accessibility**

MAORY's M12M accessibility for maintenance shall be possible via the MICADO access structure, by removing the MAORY's thermal cover and adding an external platform. This platform shall be designed and procured by MAORY to fit on the interface (See #150) to the MICADO Top Support Structure.



This access tool shall be interfaced at the same plates of the top support structure where in the MICADO stand-alone mode the Relay Optic subsystem is mounted. The interface shall be designed for 1.25 tons and calculated with full earthquake loads. MICADO shall provide the mass limitation for the TSS mounting plates and the IF drawing.

As with the LOR scaffolding, the responsibility for this entrance bridge shall be entirely with MORFEO.

The design volume for the M12 access can be seen in the drawing in [AD21].

The possible positions for the M12 access are in the drawing in [AD22].

[I-MAO/MIC-190]  
D/ //

### SCAO accessibility

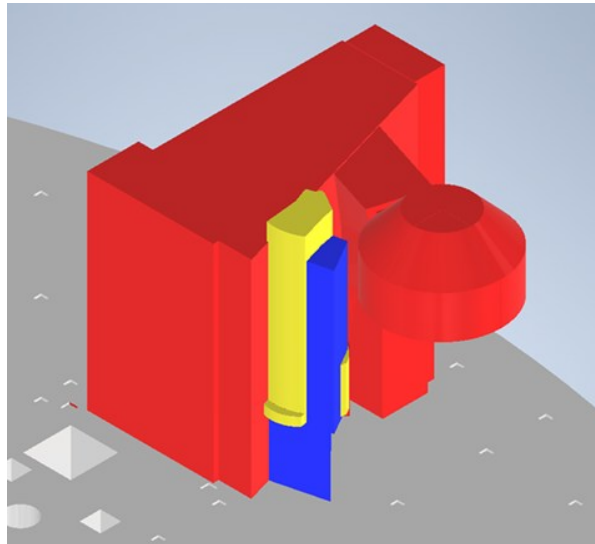
MICADO's SCAO accessibility from the top shall be possible for maintenance [RD8], by removing the MAORY's M12M thermal cover (Figure 17) and adding an external platform. This platform shall be designed and procured by MAORY to fit on the interface (See #150) to the MICADO Top Support Structure.

[I-MAO/MIC-191]  
D/ //

**Removal of MAORY LGSO:** MAORY LGS Objective's removal shall be possible with moving and craning it out via a path defined in (Figure 20) [AD16].

**Note:** For this procedure the segments 13, 14 and 15 of the MICADO access structure must be dismantled. Dismounting 3 AST segments requires 0.5-1 working days (see #177)

[I-MAO/MIC-192]  
//



**Figure 20: Volume (yellow and blue) reserved for the extraction of the MAORY LGSO**

[I-MAO/MIC-194]  
D/ //

### AST ladder

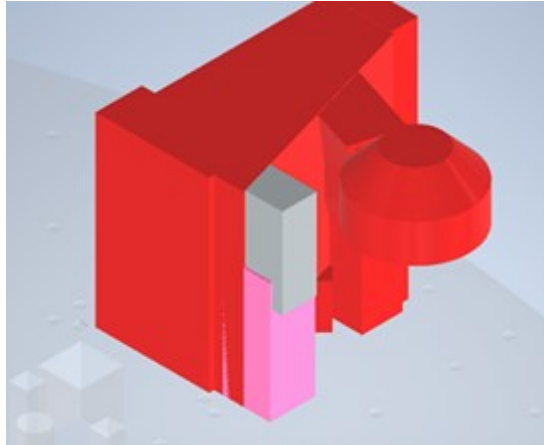
MICADO shall provide a ladder to access the platform defined in #189 and #190

[I-MAO/MIC-195]  
D/ //

**MICADO AST volume vs MAORY CU:** in the nominal configuration the MICADO AST shall not interfere with the dynamic volume for the extraction of the MAORY CU (Figure 21) [AD14].

**Note:** the above operations shall be possible without any required intervention on AST (see also #177)

[I-MAO/MIC-196]  
///



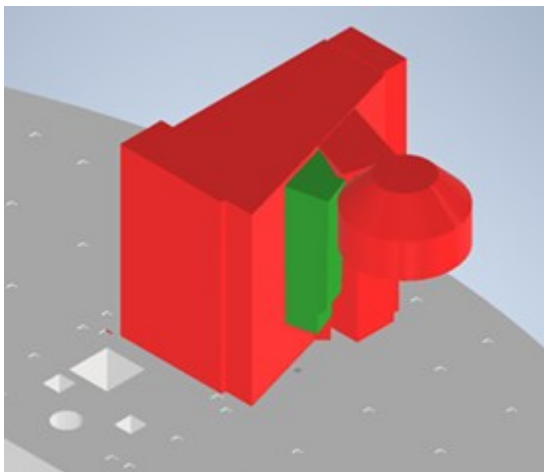
**Figure 21: Volume (grey & pink) reserved for the extraction of the MAORY Calibration Unit**

[I-MAO/MIC-198]  
D/ //

**MICADO's AST volume vs MAORY FM3:** in the nominal configuration the MICADO AST shall not interfere with the dynamic volume for the extraction of the FM3 (Figure 22) [AD15].

**Note:** For this procedure the segments 13 and 14 of the MICADO access structure must be dismantled (see also #177).

[I-MAO/MIC-199]  
///



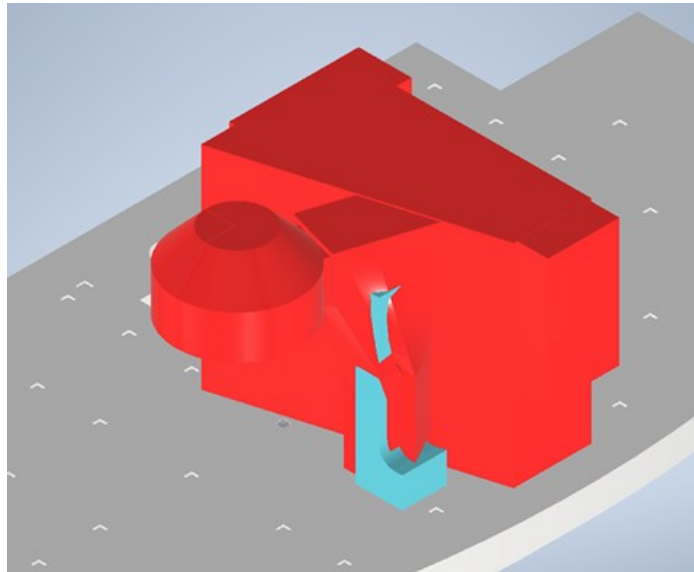
**Figure 22: Volume (green) reserved for the extraction of FM3**

[I-MAO/MIC-201]  
D/ //

**MICADO's AST volume vs MAORY M11M:** in the nominal configuration the MICADO AST shall not interfere with the dynamic volume for the extraction of the M11M (Figure 23) [AD14].

**Note:** the above operations shall be possible without any required intervention on AST.

[I-MAO/MIC-  
202]  
///



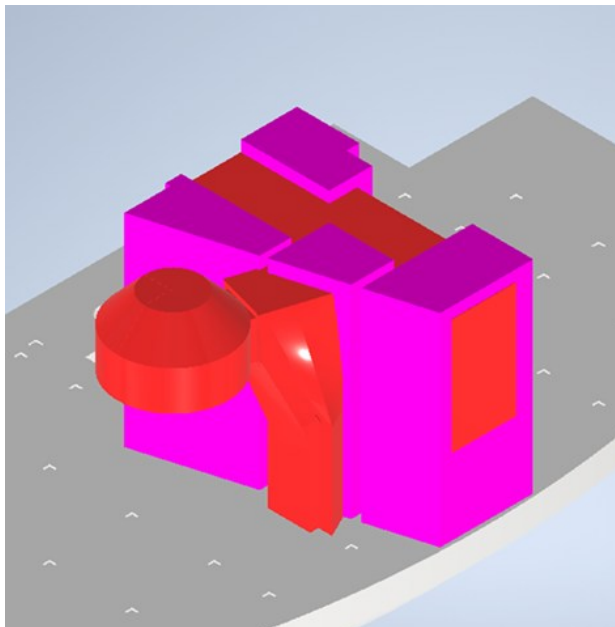
**Figure 23: Volume (blue) reserved for the extraction of M11M**

[I-MAO/MIC-  
204]  
D/ //

**MICADO's AST volume vs MAORY thermal cover:** in the nominal configuration the MICADO AST shall not interfere with the dynamic volume for the removal of the thermal cover panels (Figure 24) [AD17].

**Note:** *the above operations shall be possible without any required intervention on AST.*

[I-MAO/MIC-  
205]  
///



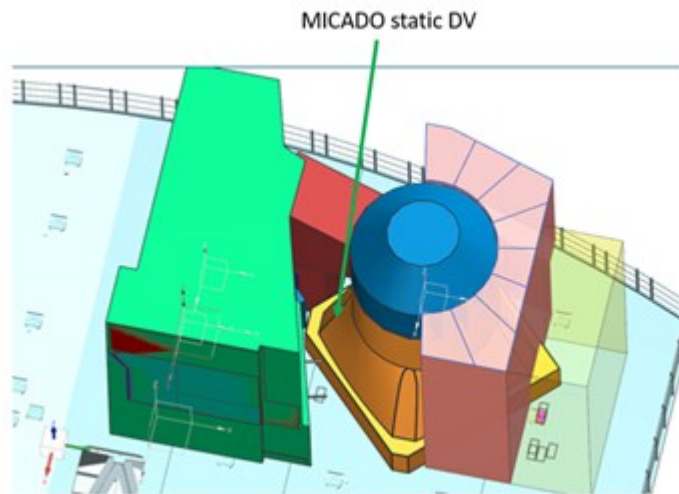
**Figure 24: Volume (purple) reserved for the extraction of the MAORY thermal cover**

[I-MAO/MIC-  
207]  
D/ //

**MICADO AST vs. MAORY mirrors recoating:** during the MAORY recoating campaign, which will last at least 14 days every 4 years (TBC) the corridor between MAORY and MICADO shall be freed by means of dismounting at least 8 of the 16 segments of the MICADO AST.



[I-MAO/MIC-208]  
///



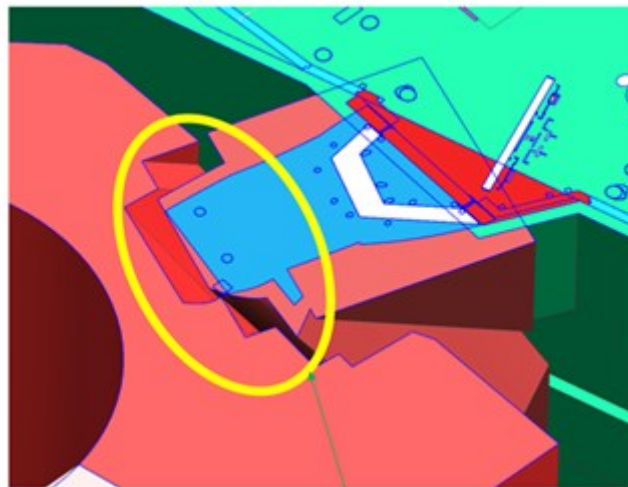
**Figure 25: MICADO static design volume with 8 segments of the access structure removed. The estimated time for removal of 8 segments is 2 working days**

[I-MAO/MIC-209]  
D/ //

**MAORY & MICADO AST safety gap**

The MAORY and MICADO's AST design volumes shall have a safety gap of ~100mm (see Figure 26)

[I-MAO/MIC-210]  
///



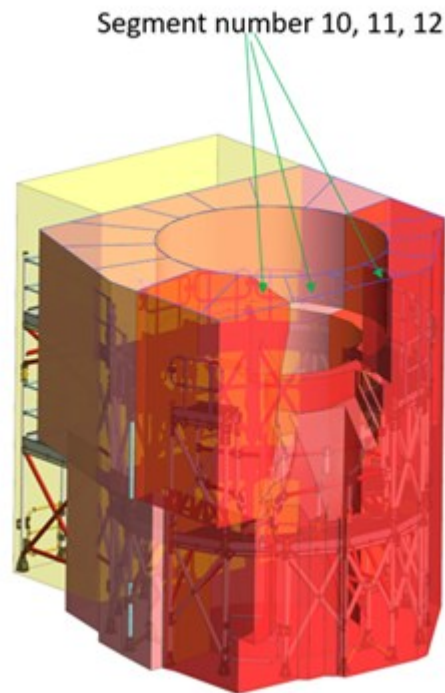
**Figure 26: Cut in Z-direction of both design volumes (from [RD16])**

[I-MAO/MIC-211]  
D/ //

**MICADO's AST volume vs MAORY's thermal duct:** in the nominal configuration the MICADO AST shall have a cut out to accommodate MAORY's thermal duct static and dynamic volumes (ref #55 and #57 respectively. See also Figure 27 and [RD18]))

**Note:** the above operations shall be possible by removing the second floor of segments 10,11 and 12' (see also #177).

[I-MAO/MIC-  
212]  
///



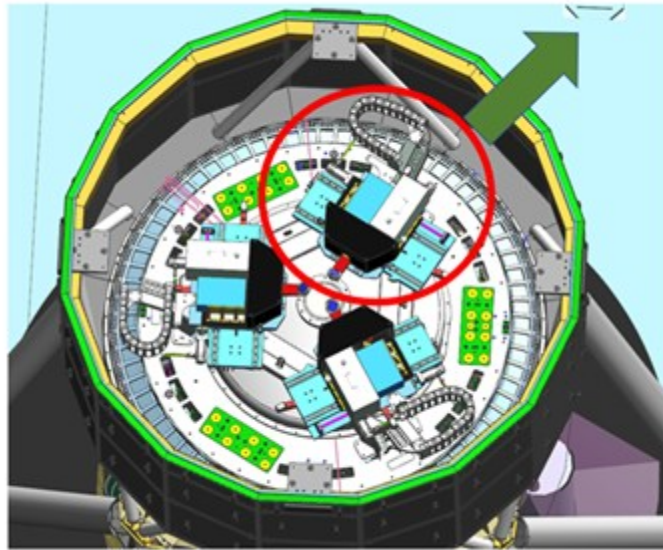
**Figure 27: Cut-out thermal duct**

[I-MAO/MIC-  
214]  
D/ //

**MAORY's LOR accessibility:** MICADO shall allow access to the LOR (Figure 28) by means of the first floor of the AST and the installation of the MAORY's LOR scaffolding (#218) in the volume shown in Figure 29 and defined in [AD28]. MICADO shall also provide the interface dimensions to screw it on the AST.

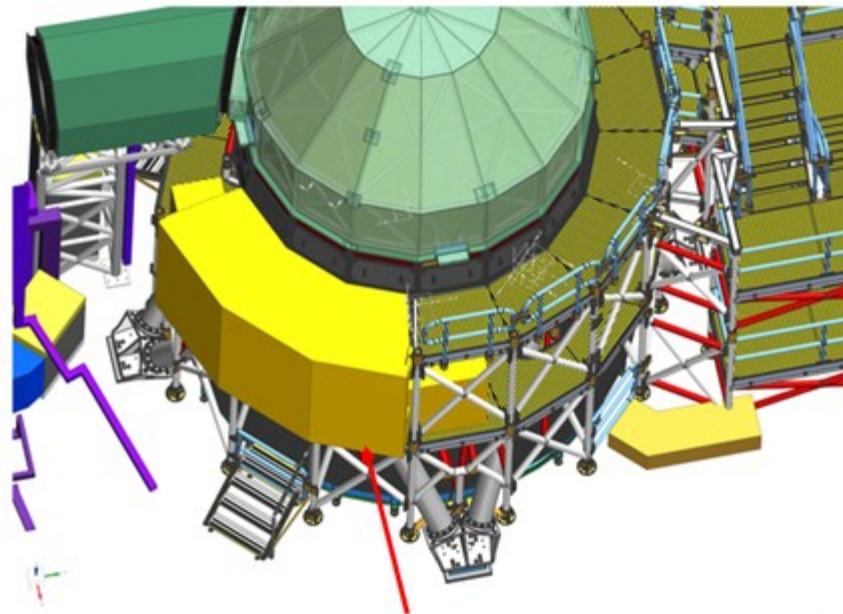
**Note:** *the tolerances are estimates at the time of writing, the fixed tolerances will be clear when the manufacture is known.*

[I-MAO/MIC-215]  
///



**Figure 28: LOR Module's top view showing the possible extraction of one of the arms.**

[I-MAO/MIC-216]  
///



**Design volume for the LOR scaffolding**

**Figure 29: Design volume for the installation of the LOR Tool**

[I-MAO/MIC-217]  
D/ /I/

**LOR scaffolding:** MAORY shall design (see Figure 30: conceptual design of the MAORY's LOR scaffolding, analyse and procure the LOR scaffolding in #218, with a mass limit of 200kg within the design volume provided in [AD28].

[I-MAO/MIC-218]  
///

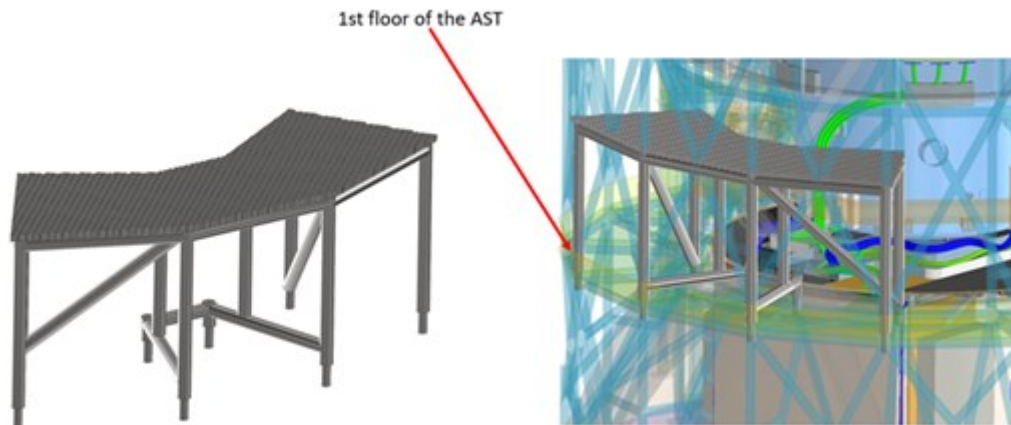


Figure 30: conceptual design of the MAORY's LOR scaffolding

[I-MAO/MIC-219]  
///

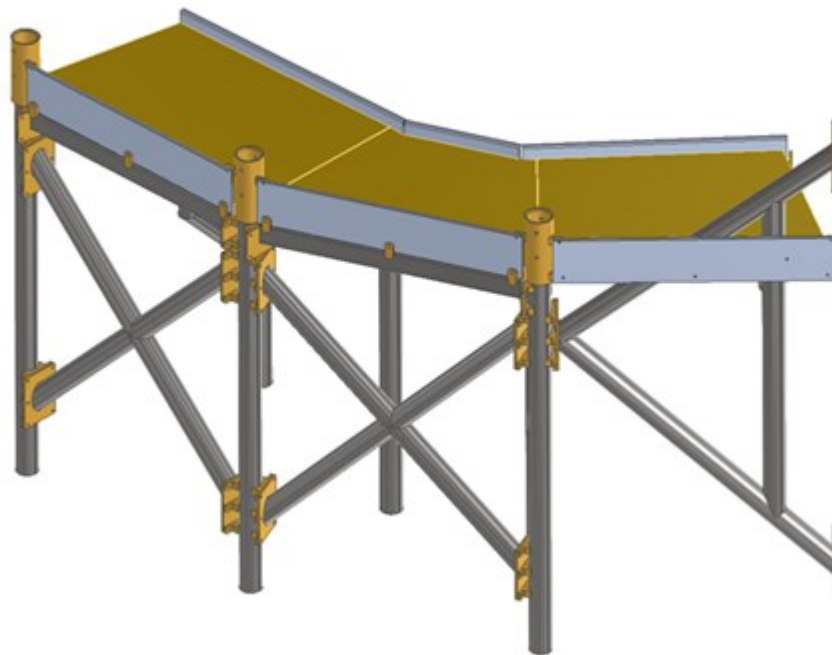


Figure 31: Design of the LOR scaffolding (as per M2MICD-61)



[I-MAO/MIC-220]  
///

**AST dismounting operation's estimated time:**

<b>Task</b>	<b>AST impact [# of Segments]</b>	<b>Frequency</b>	<b>Days included AST assembly work</b>
FM3 recoating/maintenance	Dismounting 3 segments	4 year	8-16 working days
LGS0 recoating/maintenance	Dismounting 3 segments	4 year	15-16 working days
Back-up plan that more space is needed due to situations not yet seen	Dismounting 8 segments	4 year	18 working days
LOR access	Dismounting 3 2 <sup>nd</sup> floor segments	2 years	3 working days

**Table 2: estimated AST dismounting operation**



## 7. Electrical Interface requirements

### 7.1 EMC

[I-MAO/MIC-223] All EMC requirements are defined in [RD32] and [RD33], Sect 3.3. No further EMC requirements are foreseen.  
///

### 7.2 Electrical Bonding

[I-MAO/MIC-225] All general electrical bonding requirements are defined in [RD32].  
///T The following configuration shall be tested:

- MICADO MCA: particular attention to ground loops shall be given if common bonding points need to be implemented.
- Both MICADO and MAORY shall make sure that there is no potential difference between them.
- All power to LOR electronics will be provided by the MICADO SCP, and the LOR subsystem shall become part of the grounding concept of MICADO.

### 7.3 Grounding and isolation

[I-MAO/MIC-227] All electrical interfaces between MAORY and MICADO and their subsystems shall comply with the requirements on grounding and bonding in [RD32] and in [RD34] (continuity of protective bonding) sect. 8.2 and 18.2.  
///

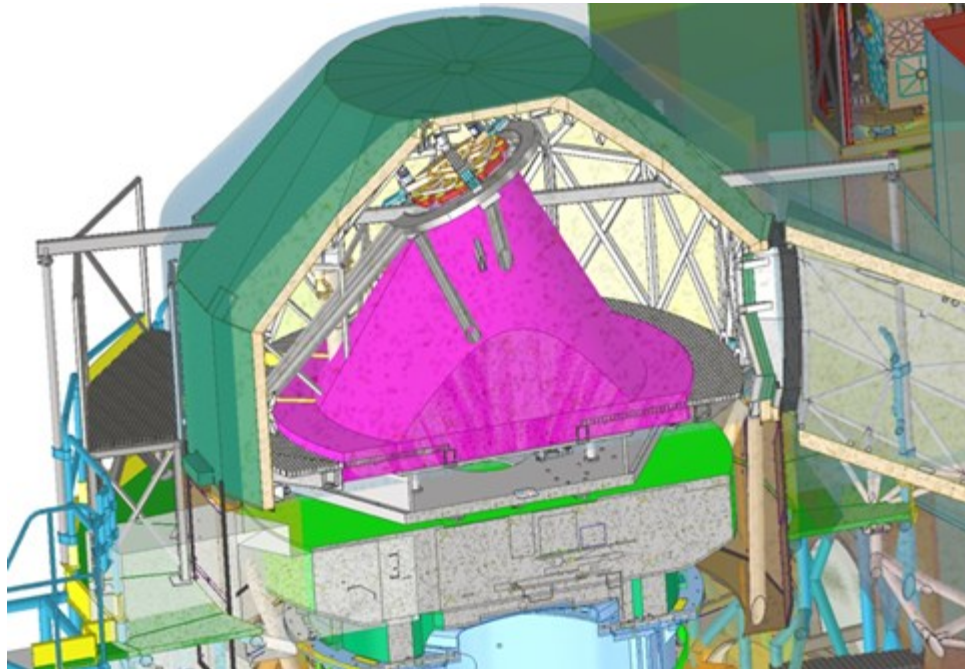
## 8. Thermal Interface requirements

[I-MAO/MIC-229] **Shared thermal volume above MICADO:**

D// The shared thermal volume above MICADO is defined in [AD19] (Figure 32).

*Note: this definition is used only for the thermal stabilisation. It shall not be intended as a potentially available volume.*

[I-MAO/MIC-230]  
//



**Figure 32: shared thermal volume (purple) above MICADO**

[I-MAO/MIC-232] The heat dissipation limit of SCAO is defined in [RD6].

//

[I-MAO/MIC-233] **Green Donut cover:** MICADO shall enclose the green donut area to prevent airflow between the MAORY's M12M thermal cover to the ELT Dome.

D//

[I-MAO/MIC-234] **Prevention of convection:** MICADO shall insulate any possible source of convection inside the M12M's thermal enclosure volume to limit the  $\Delta T$  to within  $+1^\circ$ .

D//



## 9. Fluid Interface Requirements

[I-MAO/MIC-236]  
D/// N/A.

/// The fluid interfaces for the LOR and the SCAO are described in [RD6]. There are no other fluid interfaces.

## 10. Cabling and Piping Interface Requirements Cable Trays

[I-MAO/MIC-238]  
D/// MICADO and MAORY shall follow the design practices are defined in the ESO Electrical design requirements [RD34].

[I-MAO/MIC-239]  
D/// **Owners of cables, pipes:** MICADO and MAORY shall apply what specified in [AD2]-[I-INS/ELT 348] for their respective cabling, piping and cable trays.

[I-MAO/MIC-240]  
D/// **MAORY M12M harness:** the harness for M12M and its thermal cover shall not invade the static volume of MICADO and the AST [AD25].

The requirements for the harness of the MCA are included in the CU ICD [RD7] and the requirements for the harness of the LOR in the GD ICD [RD6].

[I-MAO/MIC-241]  
D/// **Items to be routed on the Nasmyth**

- 12x duplex fibers for the camera → to SCP-B
- 2xduplex fiber for the EtherCAT → to MORFEO ICH main cabinet (1x in use and 1x spare)
- 2x water pipes (Swagelok PB-12 3/4 HT/Armaflex 10 mm OD=47 mm; bending radius=178mm; weight=370g/m)→ to MORFEO SCP Manifold

This requirement is under ESO responsibility within what specified in [RD30, #345 and #348]



## 11. AIV Interface requirements

### 11.1 General

[I-MAO/MIC-244] // The common AIV plan is described in [RD10]. In the following, the interface requirements are defined.

[I-MAO/MIC-245] D // **Pupil plane alignment tool design requirement:**

The MAORY CU shall host a pair of pupil plane sources at the CU intermediary pupil plane, one source placed on-axis and the other placed off-axis at approximately 20 mm from the centre of the pupil.

[I-MAO/MIC-246] D // **Pupil plane alignment tool functional requirement:**

The MAORY's CU pupil plane sources shall support the system mutual alignment to MAORY and to the SCAO WFS.

[I-MAO/MIC-247] D // **Pupil plane alignment tool performance requirement:**

The MAORY's CU pupil plane sources shall have a physical size of 200  $\mu$ m and they shall emit light at 633 nm.

[I-MAO/MIC-248] D // **M&M focal plane sources for AIV:**

MAORY and/or MICADO shall provide a set of focal plane sources for the mutual alignment of the instrument's focal planes to materialize through optical feedback the position of the MICADO derotator mechanical axis and to register the lateral and axial position of the focal plane with respect to the MICADO entrance focal plane aperture wheel.

[I-MAO/MIC-249] D // **MICADO's SMRs:** MICADO shall provide the number and positioning for the SMRs on-board MAORY needed for its alignment on the Nasmyth with respect to the PFS.

[I-MAO/MIC-250] D // **MAORY's SMRs:** MAORY shall provide the number and positioning for the SMRs on-board MICADO needed for the alignment of M12M with respect to its entrance focal plane.

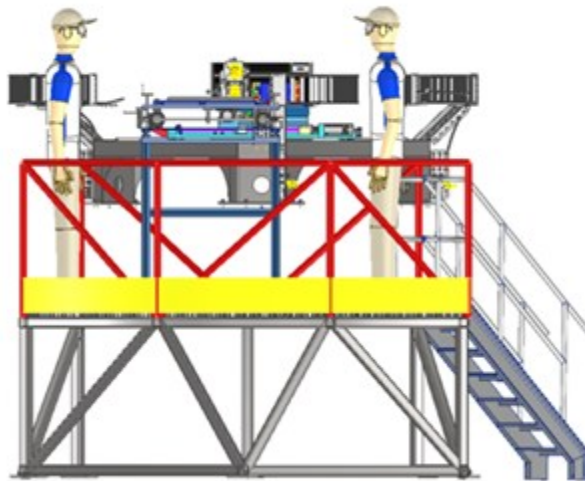
### 11.2 LOR/SCAO modules AIT

[I-MAO/MIC-252] // T MAORY shall, at a minimum, provide MICADO with a "dummy" LOR subsystem representative of the real LOR, including mass, center of gravity (CoG), interface mounts, and mechanical flanges, for use during the AIT phase in Europe.

[I-MAO/MIC-253] MICADO shall, at a minimum, provide MAORY with a "dummy" SCAO subsystem //IT representative of the real SCAO, including mass, center of gravity (CoG), interface mounts, and mechanical flanges, for use during the AIT phase in Europe.

[I-MAO/MIC-254] MAORY shall provide an access structure to the LOR to be mounted on the MICADO AST. The volume and mechanical interface for the LOR access on the MICADO AST D/A/IT shall comply with [AD28]

[I-MAO/MIC-255] //I



**Figure 33: Access structure to access the LOR arms for maintenance/removal**

[I-MAO/MIC-256] MICADO shall allow removing the black panels located all around the external side of the LOR module and intervening parts of the support structure in order to allow the removal of LOR arm. D//I



## 12. Safety Interface requirements

[I-MAO/MIC-258] General safety requirements are included in Section 10 of [RD34].  
D/ I/ I

The MAORY hazard analysis is given in [RD14].

The MICADO hazard analysis is given in [RD11].

ESO will prepare, with the help of MAORY's and MICADO's teams an integrated hazard list once the one mentioned in #260 and #261 are consolidated. This new list will be included in this document as an RD

[I-MAO/MIC-259] **Maintenance operation:** no maintenance activities shall be done when either MICADO or MAORY are performing daily tasks (e.g., calibration).  
D/ I/ I

[I-MAO/MIC-260] **MICADO hazards that affect MAORY:**  
D/ I/ I/T

At the time of release, the MICADO hazards that affect the I/F to MAORY are listed in **Section 15 Appendix – MICADO Hazards**. This list is considered preliminary. It is acknowledged by all involved parties that updates or modifications to this list may occur up to the PAE (Preliminary Acceptance Europe) milestone. Such changes do not require a formal Change Request (CRE), provided that all affected parties explicitly agree to the modifications. At PAE, a final and stable version of the list shall be established and formally baselined.

See also [RD20].

[I-MAO/MIC-261] **MAORY hazards that affect MICADO:**  
D/ I/ I/T

At the time of release, the MAORY hazards that affect the I/F to MICADO are listed in **Section 16 Appendix – MAORY Hazards**. This list is considered preliminary. It is acknowledged by all involved parties that updates or modifications to this list may occur up to the PAE (Preliminary Acceptance Europe) milestone. Such changes do not require a formal Change Request (CRE), provided that all affected parties explicitly agree to the modifications. At PAE, a final and stable version of the list shall be established and formally baselined.

See also [RD14].



### 13. Function and Control Interfaces

**NCPA measurements:** MICADO shall allow measuring NCPAs from (defocused TBD) images taken by the IR focal plane array.

[I-MAO/MIC-263]  
D/ I/T

This requirement is included in [RD12].

*Note: detailed procedure shall be provided.*

**NCPA correction:** MAORY shall allow applying correction for the NCPA in #263.

[I-MAO/MIC-264]  
D/ I/T

This requirement is included in [RD12]

### 14. Verification

The interface requirements defined in this ICD will be verified according to a verification plan to be agreed by MAORY, MICADO and ESO. This plan should consider the suggested verification tag specified for the requirements.

[I-MAO/MIC-266]  
I/I

Table 14 specifies which side of the ICD is responsible for verifying each requirement:

[I-MAO/MIC-267]  
I/I

ID #	Validator	ID#	Validator	ID#	Validator
94	MAO	95	MAO	97	MAO
98	MAO	99	MIC	105	MAO
106	MAO	107	MAO	108	MAO
110	MAO	111	MAO	112	MAO
113	MAO	114	MAO	122	MAO, MIC
123	MIC	127	MIC	128	MAO
130	MIC	131	MAO	134	MAO, MIC
138	MAO, MIC	141	MIC	145	MAO
150	MAO, MIC	151	MAO, MIC	152	MAO, MIC
154	MIC	160	MAO	161	MIC
162	MAO	165	MAO, MIC	168	MIC
169	MAO	170	MAO, MIC	171	MAO, MIC
186	MAO	189	MIC	190	MAO
191	MIC	194	MIC	195	MIC



198	MIC	201	MIC	204	MIC
207	MIC	209	MAO, MIC	211	MIC
214	MIC	217	MAO	225	MAO, MIC
227	MAO, MIC	229	MAO, MIC	233	MIC
234	MIC	238	MAO, MIC	239	MAO, MIC
240	MAO	241	ESO	245	MAO
246	MAO	247	MAO	248	MAO, MIC
249	MIC	250	MAO	252	MAO
253	MIC	254	MAO	256	MIC
259	MAO, MIC	260	MIC	261	MAO
263	MIC	264	MAO		
20	MAO, MIC				

Table 14: verification table. Each interface requirement, identified by its NNN ID number shall be assigned to either MAO or MIC or both.

[[I-MAO/MIC-268] Test verification: the specifications for common test verification environment, verification of software, and simulators will be defined during the MAORY final design phase. / / /

The current list of requirements that foresee a Test verification include:

ID #	Verification procedure
97	TBD
98	TBD
99	TBD
107	TBD
151	TBD
152	TBD
154	TBD
225	TBD
227	TBD
247	TBD
252	TBD
253	TBD
254	TBD
260	TBD
261	TBD



263	TBD
264	TBD

**Table 3: list of requirements that have been assigned a test verification tag.**

[I-MAO/MIC-269] Requirements which have a TBC/TBD:  
///

	ID #
TBD	263
TBC	114,138,145,153,161,162,207,

Table 4



## 15. Appendix – MICADO Hazards

[I-MAO/MIC-271] List of MICADO Hazards affecting MAORY – See #260:  
///

N°	HAZARD SOURCE/ ORIGIN	POTENTIAL CONSEQUENCE / EFFECT	OBSERVABLE SYMPTOMS (provisional)	COMPENSATION PROVISION RISK CONTROL MEASURE(S) (preventive actions)	Note for M&M
<b>Mechanical Hazards</b>					
1	Loss of stability of the complete instrument	Damage to further instruments, components, infrastructure, or humans	unexpected change of position, cracks	-Appropriate means of anchorage must be incorporated and indicated in the instructions. -Adequate design safety ensured by structural analysis and seismic analysis -Inspections and functional checks shall be performed upon significant seismic events -All structurally relevant components are accessible from the outside. Damage to secondary structures and equipment shall be assessed by functional checks via potential performance degradation	common mechanical interface
2	Loss of stability of components or fittings.	Damage to further instruments, components, infrastructure, or humans	moving, overturning, or falling	-Appropriate means of mounting must be incorporated and indicated in the instructions. -Adequate design safety ensured by structural analysis and seismic analysis -Instructions and precautions to be	common mechanical interface



				included in AIT plans and procedures	
4	Falling or ejected objects	Damage to components or humans	loose objects	No loose objects, everything is firmly fixed. Use a safe working platform during installation. Only use proper devices	An Object can fall from LOR on e.g. Cryostat
5	rough surfaces, sharp edges, sharp angles	Damage to the touched components or humans	visible rough surfaces, sharp edges, sharp angles	No danger at accessible parts through adequate design (smooth surfaces, rounded edges, marking of protruding parts) Check the design review.	People on the AST could be injured by LOR
8	Variations in operating conditions	Damage to the component	components get crashed, overheat	Any change of agreed operating conditions shall be reassessed Add a note to the operations manual.	The agreed operating conditions also Include the information from the ICD.
9	moving parts	Drawing in or running over body parts	moving components (Co- and De-Rotator, Relay Optic inlet door)	Access is only for trained persons slow rotation speed (max. 1°/s) wear safety boots Emergency Stop at each platform	Work on AST is necessary
13	Uncontrolled movements during maintenance	Personal injury	working motors, while people are working on MICADO	Before maintenance, power will be switched off (lock-out switch). Uncontrolled movement of the de-/co-rotator is prevented by an interlocking access restriction facility, a lock-out procedure will be implemented, and manual control by handset To be added to the	Work on AST is necessary



				maintenance procedure	
15	narrow openings (e.g., during maintenance and repair	Being trapped	If trapped, escape is not possible	Maintenance and repair shall be performed by qualified and trained personnel only.	e.g LOR cabinet
16	spilled liquid, slippery surface	Slipping, tripping, or falling, personal injury	slippery surface	Handling liquids: wear slip-resistant shoes design of platforms: slip resistant (e.g., minimum R9 according to DGUV 208-041) If necessary, plan fixation points for the fall protection harness (see LPO-MAN-ESO-20100_0001)	Work on AST is necessary
17	errors of fitting/refitting of components	components get damaged, also resulting in danger to humans	Wrong position of components	only trained personnel, If necessary: assembly instructions	common mechanical interface
18	Closed access restriction installation	Being trapped inside	The access door has to have the possibility to be opened from inside	A guard lock equipped with an escape release opens a locked guard from the inside without tools. Category B according to EN ISO 13849-1:2008 door width according to ESO-206280 8.7.1.1	Work on AST is necessary
19	Moving Co- & De-Rotator while people are close to rotating components	injury	necessary movement while persons are working on MICADO, no regular operation	- Warning light/lamp (or horn) to indicate movement (while persons are working on MICADO) - Operation only by trained persons - Uncontrolled movement of the de-	Work on AST is necessary



				/co-rotator is prevented by an interlocking access restriction facility, and a lock-out procedure will be implemented. -manual control by handset with SIL-level (see right)	
20	No direct view of activated/ moving components	injury	No safe access to all areas where intervention is necessary	safe access to all areas where intervention (e.g., for maintenance) is necessary is possible. Uncontrolled movement of the de-/co-rotator is prevented by an interlocking access restriction facility, a lock-out procedure will be implemented, and manual control by handset with a hold-to-run button.	Work on AST is necessary
25	Wrong handling of materials	Contamination of optics during maintenance	optics contaminated	Follow provisions required by maintenance manual Add notification to maintenance manual	common mechanical interface
26	wrong handling of materials	Contamination of optics during observation	optics contaminated	Contamination prevention provisions Ensure that specified environment will be maintained.	common optical interface
27	Inadvertence	Inadvertent damage during maintenance		Follow provisions required by maintenance manual	e.g LOR /SCAO
28	dark areas with not enough light for safe walking or working on MICADO	Personal injury	dark areas, where people walk or work	provide work light (e.g. under working platform) lighting level of 200 lux measured at the level of the floor and 300lux where maintenance is required. See also Ergonomic No. 1	Common areas
29	Inappropriate cleaning of	Damage to optical surfaces	scratches on optical surfaces,	cleaning instructions warning signs on /	common optical interface



	optical surfaces		damaged coating	close to sensitive surfaces	
30	fingerprints, dirt and dust from ambient air, dirty covers, people	Contamination of optics	optical inspection	optics are covered or transported in clean, maybe airtight containers, and wear adequate workwear (gloves, hair net, face mask, coat)	common optical interface
31		particulate contamination	optical inspection	Cover optics when not used, work in a clean environment	common optical interface
33	inadequate design, location or identification of manual controls (emergency stops)	increase of various risks		Location of the control elements are described in the rotating platform assembly documentation. Electrical implementation is described in the "Control electronics design & analysis" document ELT-TRE-MCD-56302-0014_2, chapter "Safety controller".	Work on AST is necessary.
34	dropping, crushing, inappropriate handling during transport of (sub-) systems	Damage / injury	damaged object, injured person	only use of allowed hoist manual handling according to regulations	common mechanical interface
35	uncontrolled relocation of iron particles	contamination of permanent magnetized parts with iron particles	iron particles on permanent magnetized parts	remove iron particles, where possible Cover permanent magnetized parts careful handling and inspection before operation	common mechanical interface
45	objects falling down from the structure outside	Personal injury, damage of component(s)	objects falling outwards	PPE (mandatory hard hat), stringer on the outside	Work on AST is necessary



	(e.g., tools)				
47	in earthquake case swinging AST hitting MICADO	damage of component(s)	dangerous swinging movements	resulting deformation/swing considered in the design variables	common mechanical interface
48	small objects falling through grating grid and hitting personnel	Personal injury	objects falling through grating grid	PPE (mandatory hard hat)	Work on AST is necessary
49	personnel working on RO bench falling horizontally in earthquake case	personal injury	No additional safety in the event of a fall	safety harness, guardrails	Work on AST is necessary
50	personnel falling down to outside	personal injury	no way to hold on	guardrails, safety harness,	Work on AST is necessary
51	LOR WFS boxes could collide with dichroic from SCAO	damage of the system and personal injury	Moving parts, even when staff are present, crashing	Locking when SCAO is not in park position or when access to the AST is granted.	common mechanical interface
<b>Electrical Hazards</b>					
1	static electricity cables get connected or disconnected or by direct contact with PCBs	damage of components by electro-static discharge of electronic circuits shock for humans	electric arc, electric shock by contact electrostatic discharge, loss of function	designed to prevent or limit the build-up of potentially dangerous electrostatic charges and/or be fitted with a discharging system. Integration and maintenance only by trained personnel Wear provided ESD	common electrical interface to LOR



	and equipment			wrist straps when working on electronics integration of connectors for ESD protection on CCD-controller	
2	no function of warning devices	injury, damage	no signal	Warning device is activated (e.g. in Maintenance mode) when persons are working on MICADO Warning devices are only additional. Handheld movement control device has a safe connection. (SIL for Warning device and Handelt see Mechanical No° 19)	Work on AST is necessary
3	short circuit of main power supplies (230 VAC and 400 VAC)	Electrical shock, fire, soot or noxious gases	penetration of cables or failure of an instrument	Residual current device (for service sockets) Circuit breaker Automatic switch (off) in case of excessive temperature. Rooting of cables through a cable wrap. On ground level all cables are protected in cable trays or under cover	common electrical interface to LOR
4	short circuit of secondary power supplies (5VDC, 12VDC, 24VDC, +/-15V, 48VDC)	Electrical shock, fire, soot or noxious gases	penetration of cables or failure of an instrument	Circuit breaker Automatic switch (off) in case of excessive temperature. Rooting of cables through a cable wrap. On ground level all cables are protected in cable trays. Cables on the floor are protected.	common electrical interface to LOR



5	failure of power supply (especially non-UPS), power outage	Loss of instrument control various uncontrolled situations: mechanism positions, in-advert movements, undefined state of the (sub-) systems	instruments not working	Any devices will stop operation upon power failure. Dependent functions will be shut down. Warning signals will occur to indicate malfunctions. By power failure controlled shut down for sensitive elements	common electrical interface to LOR
7	short circuit by failure of a device	Fire or burning of cables, components or cabinets, contamination by soot or noxious gas	Loss of function	Current limitation by control electronics Smoke/fire detection by ESO infrastructure (for assembly and testing) short circuit in vacuum is not considered hazardous. Using EN60332-3 conform cables when cables are laid in bunches. Other cables are EN 60332-1 conform. Use of low-smoke zero-halogen (LSZH) types.	common electrical interface to LOR
10	Electromagnetic interference	Degraded performance or malfunctioning	degraded performance or malfunctioning	design of electric components and cables according to possible electromagnetic interferences cable selection according to eso specification testing by eso in Chile (PAE and PAC)	common electrical interface to LOR
11	excessive heat up, disturbed heat dissipation	overtemperature in control cabinet	malfunction of components in cabinets, over temperature	Integration of over temperature protection in electrical cabinets (where cooling is necessary)	common electrical interface to LOR



13	emission of electromagnetic radiation by devices	influence on other equipment	malfunction of components / equipment	Use of CE certified commercial devices. For custom devices, compatibility is specified in the design and analysis documents Measurements of the instrument in cooperation with ESO	common electrical interface to LOR
14	Electrical hazard. Direct or indirect contact with live parts when faults occur in electrical components.	Electrical shock	Electrical shock when touching	Design electrical equipment after DIN EN 60204-1. Only trained specialists have access to the relevant locations. Electrical equipment is tested according to the current legal regulations (DIN VDE 0100-600)	common electrical interface to LOR
<b>Thermal Hazards</b>					
5	failure of cabinet cooling	Injury on hot front panels or overheating of electronic units	hot surfaces, hot components	Shut down of instruments upon detection of excessive temperature.	common electrical interface to LOR
11	blackout / failure of cooling circuit	no transportation of thermal energy	overheating of components (e.g. turbo pumps, el. Cabinets)	indication of coolant flow via flow sensor, pressure monitoring, leakage detection, shut down of components, if necessary, shut off valves to stop further coolant loss, use of ESO approved components according to ESO-254314	common electrical interface to LOR
<b>Vibration Hazards</b>					
2	vibrations of motors / gears in system (MICADO)	vibrating components (e.g. mirrors)	vibrations get transmitted	No impact on humans Design review for vibration level	common mechanical interface



4	vibration generated by fans of electronic cabinets.	Degradation of measurements	Transmitted vibrations to system	Selection of qualified equipment and tuning	common mechanical interface
5	Various vibration sources (e.g. human caused, earthquakes, ...)	shifts in alignment of optical components	hard vibration / shock wave	earthquake simulation, design review for protection against human caused shocks, general design review	optical interface
<b>Radiation Hazards</b>					
1	internal radiations of different wavelengths	Disturbed operation	radiation (e.g. light) immission	Design review (sensitive areas are protected)	optical interface
2	external radiations of different wavelengths	Disturbed operation	radiation (e.g. light) immission	Design review (sensitive areas are protected)	optical interface
5	Emission and / or immission	The unwanted mutual influence	Motor controllers and power lines can emit LF fields that may cause electromagnetic interference (EMI), including Electrical Fast Transients (EFT) or H-field Interference that can affect electrical components located nearby.	Design compatible to 2014/30/EU Test according ESO 262825 section 4.3 The EMC Measures are described in ELT-TRE-MCD-56302-0014 e.g. chapter "Grounding   shielding   bonding"	common electrical interface



6	Emission and / or imission	The unwanted mutual influence	-improper operation of radio and telecommuni cations equipment or other operating equipment -not able to work as intended without unacceptable impairment	Design compatible to 2014/30/EU Test according ESO 262825 section 4.3 The EMC Measures are described in ELT-TRE-MCD-56302-0014 e.g. chapter "Grounding   shielding   bonding"	common electrical interface
<b>Materials Hazards</b>					
6	leakage of cooling fluid (water, LN2)	affect the support structure by freezing, corrosion, short circuit	leakage of cooling fluid	Design review for safe design: all pipes are designed according to the principles described in the documents ESO-409169 "Cryogenic Requirements for ELT Instruments" and ESO-046147 "Vacuum and Cryogenics Standard Components" and that these constructions are regularly checked according to the four-eyes principle.	common mechanical interface including cooling fluid
<b>Ergonomic Hazards</b>					
1	dark areas with not enough light for safe walking or working	higher concentration necessary, higher fault rate	dark areas	see also mechanical No28 Lamps for possible dark areas Lighting level according to ESO requirement (lighting level of 200lux measured at the level of the floor and 300lux where maintenance is required)	common walkways between M&M and on ATS



2	narrow walkways	the danger of damaging objects in the vicinity limited means of escape	narrow walkway objects on walkway	Design of walkways according to ESO regulations	common walkways between M&M and on ATS
3	exposed objects are not seen	personal injury	no marking, no warning sign	marking of exposed components placement warning sign(s) fence / shield exposed objects	Work on AST is necessary
5	safety harness damaging RO components when working on RO bench		loose straps	gantry for safety harness running over 2nd story, safety harness with retraction mechanism	Work on AST is necessary
<b>Environmental Hazards</b>					
1	Shock wave, various vibrations (also during assembly)	Damage of components	hard vibration, shock wave	earthquake simulation, design review for protection against human caused shocks, general design review	common mechanical interface



## 16. Appendix – MAORY Hazards

[I-MAO/MIC-273] List of MAORY Hazards affecting MICADO – See #261:  
///

N°	Hazard Source/Origin	Potential Consequence/ Effect	Observable symptoms	Risk Reduction Measures	Type of Hazard NOTES
1	Falling of objects -during AIT/V of <b>LOR</b> -during Maintenance of LOR (dismounting/mounting)	Harm on humans	Impact	Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.  PPE.	Mechanical
2	Falling of objects -during AIT/V of <b>LOR</b> -during Maintenance of LOR (dismounting/mounting)	Harm on products below: MICADO/SCAO	Impact	Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.  Protective covers on optics below.	Mechanical
3	Falling of objects	Harm on humans	Impact	Use of systems which	Mechanical



	<p>-during AIT/V of <b>LOR Cameras</b></p> <p>-during Maintenance of LOR Cameras (dismounting/mounting)</p>			<p>provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.</p> <p>PPE.</p>	
4	<p>Falling of objects</p> <p>-during AIT/V of <b>LOR Cameras</b></p> <p>-during Maintenance of LOR Cameras (dismounting/mounting)</p>	Harm on products below: MICADO/SCAO	Impact	<p>Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.</p> <p>Protective covers on optics below.</p>	Mechanical
5	<p>Falling of objects</p> <p>-during AIT/V of <b>LOR Arms/Probes</b></p> <p>-during Maintenance of LOR Arms/Probes (dismounting/mounting)</p>	Harm on humans	Impact	<p>Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.</p> <p>PPE.</p>	Mechanical



6	<p>Falling of objects</p> <ul style="list-style-type: none"><li>-during AIT/V of <b>LOR Arms/Probes</b></li><li>-during Maintenance of LOR Arms/Probes (dismounting/mounting)</li></ul>	<p>Harm on products below: MICADO/SCAO</p>	<p>Impact</p>	<p>Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.</p> <p>Protective covers on optics below.</p>	<p>Mechanical</p>
7	<p>Contact due to proximity / volume violation by personnel or handling tools/support equipment</p> <ul style="list-style-type: none"><li>-during AIT/V of <b>CU Selector, FMCU, MCA</b></li><li>-during Maintenance of CU selector</li></ul>	<p>Harm to products in the proximity: MCA</p>	<p>Impact from approach of a moving element to a fixed part</p>	<p>Proper procedure</p>	<p>Mechanical</p>
8	<p>Contact due to proximity – volume violation by personnel or handling tools/support equipment</p> <ul style="list-style-type: none"><li>-during AIT/V of <b>Correcting Plate</b></li><li>-during Maintenance of Correcting Plate (dismounting/mounting for recoating, cleaning on site)</li></ul>	<p>Harm on products in the proximity: MCA</p>	<p>Impact from approach of a moving element to a fixed part</p>	<p>Proper procedure</p>	<p>Mechanical</p>



9	<p>Falling of objects</p> <ul style="list-style-type: none"> <li>-during AIT/V of <b>M12 and Thermal Cover</b></li> <li>-during Maintenance of M12 (dismountung/mounting for recoating)</li> <li>-during Maintenance of M12 and (Cleaning on site)</li> </ul>	Harm on humans	Falling of objects	<p>Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.</p> <p>PPE.</p>	Mechanical
10	<p>Falling of objects</p> <ul style="list-style-type: none"> <li>-during AIT/V of <b>M12 and Thermal Cover</b></li> <li>-during Maintenance of M12 (dismountung/mounting for recoating)</li> <li>-during Maintenance of M12 and (Cleaning on site)</li> </ul>	Harm on products below: MICADO/SCAO, LOR	Falling of objects	<p>Use of systems which provide restraint and fall arrest safety devices to prevent accidental tool drops in the workplace.</p> <p>Protective covers on optics below.</p>	Mechanical
11	<p>CU selector translation uncontrolled movements</p> <ul style="list-style-type: none"> <li>-during AIT/V of <b>CU Selector, FMCU, MCA</b></li> <li>-during Maintenance of CU selector, FMCU, MCA</li> </ul>	Harm to humans	Impact	<p>MORFEO functions to be powered OFF when MICADO is in Maintenance. Interlock on MORFEO.</p> <p>CU Selector powered OFF.</p>	Mechanical/Electrical



				<p>Interlock (hard wired) to power off the CU.</p> <p>When powered off, motors are braked.</p> <p>Hard stop: if electronic control fails, a physical limit will avoid the CU selector to run out from the rail</p>	
1 2	<p>CU selector translation uncontrolled movements</p> <p>-during AIT/V of <b>CU Selector</b>, FMCU, MCA,</p> <p>-during Maintenance of CU selector, FMCU, MCA</p>	<p>Harm to product: FMCU, MCA</p>	<p>Impact</p>	<p>MORFEO functions to be powered OFF when MICADO is in Maintenance. Interlock on MORFEO.</p> <p>CU Selector powered OFF. Interlock (hard wired) to power off the CU.</p> <p>When powered off, motors are braked.</p> <p>Hard stop: if electronic control fails,</p>	<p>Mechanical/Electrical</p>



				a physical limit will avoid the CU selector to run out from the rail	
1 3	<p>CU selector translation uncontrolled movements</p> <p>-during AIT/V of <b>CU Selector</b>, <b>FMCU</b>, <b>MCA</b>,</p> <p>-during Maintenance of CU selector, <b>FMCU</b>, <b>MCA</b></p>	Disalignment of FMCU, MCA	Impact	<p>MORFEO functions to be powered OFF when MICADO is in Maintenance. Interlock on MORFEO.</p> <p>CU Selector powered OFF. Interlock (hard wired) to power off the CU.</p> <p>When powered off, motors are braked.</p> <p>Hard stop: if electronic control fails, a physical limit will avoid the CU selector to run out from the rail</p> <p>Proper procedure</p>	Mechanical/Electrical
1 4	<b>M12</b> uncontrolled movements	Harm on humans/product	Impact	M12 shall be stopped (and	



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	-during AIT/V MICADO/SCAO  -during Maintenance of MICADO/SCAO			protected with cover)	
1 5	<b>M12</b> uncontrolled movements  -during AIT/V MICADO/SCAO  -during Maintenance of MICADO/SCAO	Harm on humans/product	Impact	M12 shall be stopped and protected (with cover)	
1 6	<b>LOR</b> uncontrolled movements	Harm on humans	Impact	Interlock on MICADO	Mechanical/Ele ctrical
1 7	<b>LOR</b> uncontrolled movements	Harm on products: LOR, MICADO/SCAO	Impact	Interlock on MICADO	Mechanical/Ele ctrical
1 8	Contamination during <b>FMCU</b> maintenance/clea ning onsite	Contamination of cleaning consumables on Correcting Plate and MCA	Contamina tion	Proper cleaning procedure.  Protective covers on optics below.	Materials
1 9	Contamination during <b>M12</b> maintenance/clea ning on site	Contamination of cleaning consumables on MICADO, LOR	Contamina tion	Proper cleaning procedure.  Protective covers on optics below on MICADO/S CAO, LOR.	Materials
2 0	<b>ThCS</b> : Leakage from hoses behind ALICE and FRED A cameras	Leakage on MICADO.  Low pressure, low probability of drops.	Leakage	Leakage sensors behind camera: closure of valve.  Protection in most critical points (TBC).	Materials



				Periodic Inspection.  Replacement of ThCS every 5 yrs.	
2 1	<b>ThCS:</b> Leakage from quick connectors	Leakage on MICADO.  Low pressure, low probability of drops.	Leakage	Leakage sensors behind camera: closure of valve.  Protection in most critical points (TBC).  Periodic Inspection.  Replacement of ThCS every 5 yrs.	Materials