



**Programme:** ELT

**Project/WP:** System Engineering

## **ICD between MORFEO and MICADO (Calibration Unit)**

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## Change Record from previous Version

Version	Affected Section(s)	Changes / Reason / Remarks
1	All	First version
2	[I-MAO/MCA-010]	reference for Nasmyth B coordinates added
	Fig 1:	caption, reference to AD11 volume envelope and Nasmyth B drawing
	2.1	Updates to ADs and drawings added in AD9, AD10 and AD11
	Fig 5	Ref to RD5 drawing
	[I-MAO/MCA-049]	RD17 reference added
	[I-MAO/MCA/102]	Reference to chapter 7.8
	[I-MAO/MCA-057]	Ref to skin temperature requirements AD3
	[I-MAO/MCA-058]	Ref to standalone mode and need to add M&M mode.
	[I-MAO/MCA-061]	Reference to RD1 added for cable chain dimensions.
[I-MAO/MCA-072]	Safety interfaces added.	
3	Authors	Replaced Rob Harris with Benjamin Setterholm Added Vincenzo Cianniello and Vincenzo De Caprio
	All	Replaced "MAORY" with "MORFEO"
	§2	Deleted: AD9, RD2, RD6 Version Update: RD14 V1 to V3, RD16 V1 to V2, RD22 (AD10) V1 to V2, RD23 (AD11) V1 to V2



		Moved from AD to RD: AD1 to RD19, AD3 to RD20, AD7 to RD21, AD10 to RD22, AD11 to RD23
	Figures	Added Figures 6, 7, 9, 10. Updated images in Figures 1, 2, 11. Fixed figure numbering. Removed previous (redundant) figure which depicted the same information as Figure 5 and Table 1.
	[I-MAO/MCA-085]	Provide missing information and depict SMR target positions. Added 'shall'. Removed from Table 3.
	[I-MAO/MCA-094]	Clarify static volume envelope requirement
	[I-MAO/MCA-97]	Define new maintenance volume envelope requirement
	[I-MAO/MCA-101]	Changed to refer to #102 as the main reference, until an update to the DWG [RD5] is available. Added 'T' for test verification tag.
	[I-MAO/MCA-102]	Up to date values from MORFEO added to table and reference to RD5 removed from caption.
	[I-MAO/MCA-108]	Added 'T' for test verification tag
	[I-MAO/MCA-109]	Insert placeholder values
	[I-MAO/MCA-112]	Define SCAO-mode accommodation requirement
	[I-MAO/MCA-116]	Remove strict reference to scissor lift. Add illustration.
	[I-MAO/MCA-118]	New requirements clarifying #115
	[I-MAO/MCA-119]	New requirements clarifying #115
	[I-MAO/MCA-120]	New requirements clarifying #115
	[I-MAO/MCA-121]	New requirements clarifying #115
	[I-MAO/MCA-125]	Update mass cable requirement
	[I-MAO/MCA-126]	Replace Ångström-level CoG positioning requirement with realistic envelope. Remove strict requirement that CoG necessarily lies within the polygon defined by the mounting points
	[I-MAO/MCA-101]	Removed (superfluous, satisfied completely by #140) NB 101 is requirement no from V2.



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[I-MAO/MCA-058]	Removed (not appropriate formulation for this ICD, no alternative proposed). NB requirement no from V2.
[I-MAO/MCA-154]	Updated MCA cable plan
[I-MAO/MCA-156]	Updated MORFEO cable plan
[I-MAO/MCA-154]	Change from 2 cable chains to just 1; new radius requirement TBD
[I-MAO/MCA-159]	Tentative cable conduit length updated
[I-MAO/MCA-163]	MCA dummy requirements expanded
[I-MAO/MCA-165]	MCA to hand over SMRs in Bologna; MORFEO to bring them to Chile
[I-MAO/MCA-171]	New safety interlocks agreement
[I-MAO/MCA-174]	New number for the "second" requirement #072
[I-MAO/MCA-177]	Updated to reflect current requirement set
[I-MAO/MCA-178]	New tests identified and previously TBD tests defined
[I-MAO/MCA-180]	List updated
[I-MAO/MCA-112]	TBD removed
[I-MAO/MCA-120]	Updated wording for clarity.
Table 1	Obsolete values removed and caption edited to reflect RD5 as the baseline reference.
All	Requirement numbers updated due to DOORS export. Requirement numbers in this table change between Version 2 and Version 3. References to requirement numbers in Version 2 changelog are not changed.
[I-MAO/MCA-008]	Removed reference to removed AD9
[I-MAO/MCA-020]	Corrected the description of the sense of the x-axis on Nasmyth B.
[I-MAO/MCA-021]	Updated Figure and caption for Nasmyth B location
RD18	ESO reference and version number added
[I-MAO/MCA-70]	Update of Figure 3 and in wording of figure 3 caption related to the status of this figure and future changes.
[I-MAO/MCA-77]	Update of Figure 5 and its caption.



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	[I-MAO/MCA-96]	Reference to #154 added.
	[I-MAO/MCA-130]	Change reference from [R-INS/ELT-390] to [R-INS/ELT-309]
	[I-MAO/MCA-145]	Added 'T' for test verification tag
	Table 2	Added requirements #97 and #112 with Validators
	Table 3	Removed 085, as no test.
	Table 4	Corrections to TBC/D list after edits



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## 1. Introduction

[I-MAO  
/MCA-4]  
///

The purpose of this document is to define those features, assumptions, and plans which are related to the interface between MORFEO and the MICADO calibration unit, located on the MORFEO main structure to access the entrance focal plane.

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

*As of its current state, this document CANNOT be considered frozen, as there are still key mechanical interfaces that are incomplete, particularly #101/#102 and #156/#157.*

Later changes to this document shall undergo the formal ESO CRE process, following discussion and agreement between MORFEO and MICADO. It is agreed that changes can be initiated by one side of the I/F 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 MORFEO 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 a large number of minor changes are collected, or in advance of a formal review. In between document releases, all changes will be recorded and always made 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 MORFEO and MICADO technical requirements specifications can be found in [RD12] and [RD13]. The general description of I/Fs between MORFEO and MICADO can be found in [RD14] and the SW ICD in [RD15].



## 1.1 Scope

[I-MAO  
/MCA-6]  
/// This Interface Control Document (ICD) defines requirements for the interface (I/F) between the MORFEO instrument (also referred to as MAO for brevity) and the MICADO Calibration Assembly Subsystem (also referred to as MCA 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.

This ICD covers the following interfaces categories between those elements:

- Optical
- Mechanical and Access
- Alignment
- Electrical
- Thermal
- Cabling and piping
- Assembly and Installation (AIV) in Armazones
- Functions (incl. alarms)

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

This ICD does not cover the interfaces related to:

- SW
- SCPs
- MCA in stand-alone mode
- MICADO in stand-alone mode
- MORFEO Calibration Unit

Any other MORFEO and MICADO I/Fs are covered by other documents, especially the General ICD, which can be found at [RD14].



## 1.2 Interfacing Elements List

[I-MAO  
/MCA-8]  
/// For the purpose of this ICD the MORFEO INS (MAO) is composed of:

- MORFEO CU selector up to the interface plates included
- Cable wrap from CU selector down to the floor of the Nasmyth (ESO conduit)

For the purpose of this ICD the MICADO Calibration Assembly (MCA) Subsystem is composed of:

- Base plate/housing and its units (mounting breadboard, electrical patch unit and internal harness)
- MCA units: astrometric calibration unit (ACU), flat field & spectral calibration unit (FCU) and movable source (MCU)

This ICD does not cover the interfaces related to:

- General ICD between MORFEO and MICADO – [RD14]
- Software – see [RD15]
- MORFEO LOR Module and MICADO SCAO Module (Green Donut) – See [RD16]
- Common Assembly and Installation (AIV) in Armazones

## 1.3 Definitions and Conventions

### 1.3.1 Statement Identifiers and Verification Tags

[I-MAO  
/MCA-11]  
/// Each statement in this document is labelled with an identifier following the format [I-XXX/YYY-NNN] where:

- XXX= MAO - MORFEO
- YYY= MCA - MICADO Calibration Assembly
- 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 § 13 identifies which party to the ICD is responsible for verifying each requirement.



[I-MAO  
/MCA-12]  
///

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///)	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  
/MCA-13]  
///

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 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  
/MCA-15]  
///

The following abbreviations and acronyms are used in this document:

ACU	Astrometric Calibration Unit
AIT/V	Assembly Integration and Test/Verification
AO	Adaptive Optics
BIH	Bologna Integration Hall
CRE	Change Request
CU	Calibration Unit
CUFM	Calibration Unit Folding Mirror
CoG	Center of Gravity
DM	Deformable Mirror
ELT	Extremely Large Telescope
EMC	Electro Magnetic Compatibility
ESO	European Southern Observatory
FCU	Flat-field and wavelength Calibration Unit
FDR	Final Design Review
FP	Focal Plane
FoV	Field of View
I/F	Interface
IAA	Integration Assembly Area
ICD	Interface Control Document
INS	Instrument
LOR	Low order and Reference module
M&M	MORFEO and MICADO
MAORY	Multi-conjugate adaptive Optics Relay for ELT Observations
MCA	MICADO Calibration Assembly
MCU	Moveable source Calibration Unit
MICADO	Mutli-AO Imaging Camera for Deep Observations
MORFEO	Multi-conjugate adaptive Optics Relay for ELT Observations
N/A	Non-Applicable
NAS	Nasmyth
NGS	Natural Guide Star



RO	Relay Optics
SCAO	Single Conjugate Adaptive Optics
SCP	Service Connection Point
SCS	Standard Coordinate System
SMR	Spherically Mounted Retroreflectors
SW	Software
TBC	To Be Confirmed
TBD	To Be Defined
WAM	Warm Astrometric Mask
WFS	Wave Front Sensor/Sensing

### 1.3.3 Definitions (Glossary)

[I-MAO  
/MCA-17]  
///

**MCA Switched-off:** all lamps switched-off, MCA in parking position

**MCA Homing:** motors and stages initializing

**MCA stand-by:** lamps switched off, MCA in parking position and ready for operation

**MCA operational:** MCA in operation

**MORFEO Open mode:** the MORFEO DMs are in their static configuration and all AO loops are open

**MORFEO Closed mode:** MORFEO operates in AO mode (low-order loops closed, AO correction using the artificial NGS sources provided by the MCA in ACU mode)

MORFEO was previously known as MAORY. As a result, some older drawings and identifiers may still reference the former name. In this document, all instances of "MAORY" have been updated to "MORFEO"; however, the two names should be regarded as synonymous.

### 1.3.4 Coordinate systems

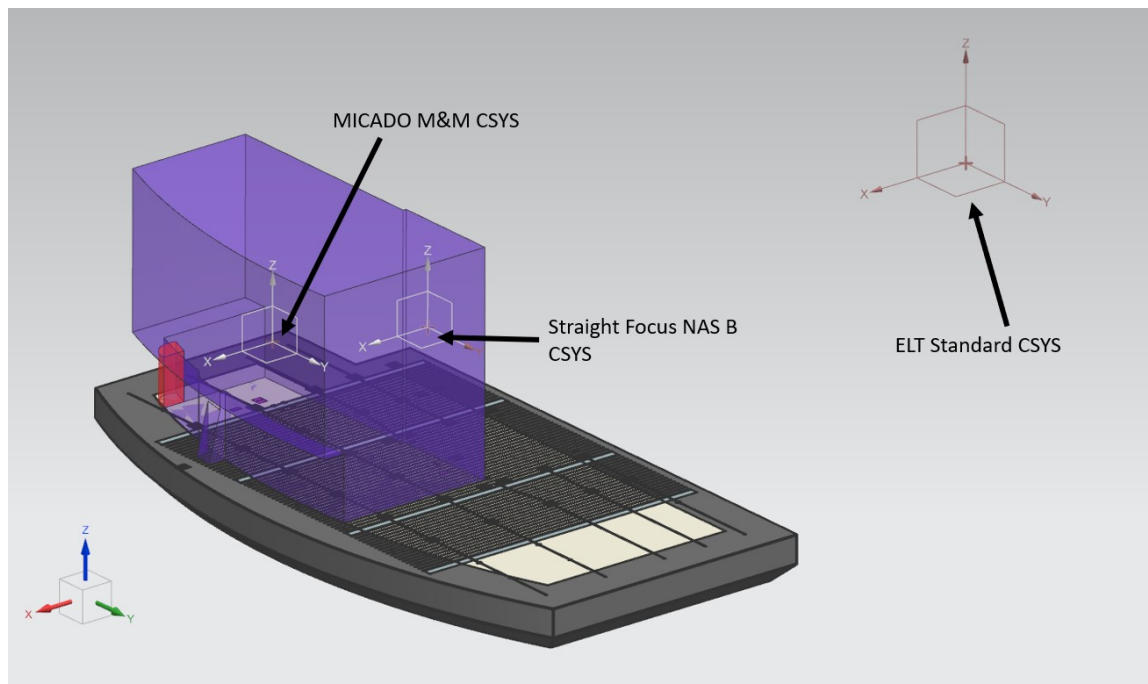
[I-MAO /MCA-19] **General Coordinate System:** Unless otherwise specified, the interface characteristics defined in this document and in its applicable documents are based on the ELT Standard Coordinate Systems defined in [RD19]. This system of coordinates shall also be used in all further detail design and definition of the interfaces.  
///

[I-MAO /MCA-20] The **MAO-MCA local coordinate system** is defined as follows (see Figure 1 in #021):  
///

- Centered on the ELT focal plane focus
- The x axis is parallel to the ELT elevation axis, pointing away from the telescope optical axis
- The z axis is parallel to the ELT azimuth axis, pointing towards the zenith
- The y axis completes the right-handed triad

This coordinate system assumes the location of MORFEO+MICADO on Nasmyth B, as defined in ESO-489256 (i.e. RD22).

[I-MAO /MCA-21]   
///



**Figure 1: The MAO-MCA local coordinate system is centered in the ELT focal plane of the straight through focus on Nasmyth B. The MICADO FP standalone coordinate system is not part of this ICD. The ELT standard coordinate system is also indicated (top right). The violet area is the volume envelope shared by the MORFEO and MICADO instruments (as per RD23).**



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[I-MAO /MCA-22] Note: The coordinates of the MORFEO's SCS with respect to the ELT's SCS (Nas-B) are:  
///

	X [mm]	Y [mm]	Z [mm]	$\alpha$ [deg]	$\beta$ [deg]	$\gamma$ [deg]
MORFEO SCS	27200	0	0	0	0	0

[I-MAO /MCA-23] The optical reference file is [AD4].  
///



## 2. Related Documents

### 2.1 Applicable Documents

[I-MAO  
/MCA-26]  
/// 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 *deleted (now RD19)*

AD2 Earthing, Bonding and Protection against Lightning and LEMP of ESO  
Buildings and Structures  
(GEN-SPE-ESO-50000-0072 rev. 2)  
ESO-193873 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-193873/2>

AD3 *deleted (now RD20)*

AD4 Integrated Optical Model ELT-MORFEO-MICADO  
ESO-488963 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-488963/1>

AD5 *deleted (now RD7)*

AD6 *deleted (now RD5)*

AD7 *deleted (now RD21)*

AD8 E-ELT Electrical and Electronic Design Requirements  
ESO-262825 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-262825/1>

AD9 *deleted*

AD10 *deleted (now RD22)*

AD11 *deleted (now RD23)*



## 2.2 Reference Documents

[I-MAO  
/MCA-39]  
/// 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 MICADO Calibration Assembly Subsystem Interface Control Document  
(ELT-ICD-MCD-56301-0009 rev. 3)

ESO-324229 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-324229/2>

RD2 *deleted*

RD3 MAORY System Analysis Report  
(E-MAO-SE0-INA-ANR-001 rev. 2)

ESO-387167 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-387167/2>

RD4 MICADO Calibration Assembly Design and Analysis Report  
(ELT-TRE-MCD-56301-0023 rev. 3)

ESO-324308 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-324308/2>

RD5 MAORY Main Structure 2D drawings  
(E-MAO-PM0-00-00-00-00-DWG rev. 1)

ESO-397594 Version 1

<https://pdm.eso.org/kronodoc/HQ/ESO-397594/1>

RD6 *deleted*

RD7 ELT-DWG-MCD-56301-M32000-252-06-22\_Housing

ESO-647053 Version 1

<https://pdm.eso.org/kronodoc/HQ/ESO-647053/1>

RD8 MICADO relay optics subsystem requirements specification  
(ELT-SPE-MCD-56301-0026 rev. 3)

ESO-370302 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-370302/2>



- RD9 MICADO Maintenance Manual  
(ELT-MAN-MCD-56300-0122 rev. 0.3)  
ESO-410912 Version 3  
<https://pdm.eso.org/kronodoc/HQ/ESO-410912/3>
- RD10 *deleted*
- RD11 *deleted*
- RD12 MAORY (E-ELT MCAO) Technical Specifications  
ESO-254311 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-254311/1>
- RD13 MICADO (E-ELT CAM) Technical Specifications  
ESO-244537 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-244537/2>
- RD14 ICD between MAORY and MICADO (General)  
ESO-323542 Version 3  
<https://pdm.eso.org/kronodoc/HQ/ESO-323542/3>
- RD15 ICD between MAORY and MICADO (Software)  
ESO-351580 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-351580/1>
- RD16 ICD between MAORY and MICADO (Green Donut)  
ESO-335249 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-335249/2>
- RD17 ELT-DWG-MCD-56301-259-00-1 MICADO RO&MCA FEM model  
ESO-530157 Version 1  
<https://pdm.eso.org/kronodoc/HQ/ESO-530157/1>
- RD18 MAORY System MAIT Plan  
(E-MAO-000-INA-PLA-010)  
ESO-387101 Version 2  
<https://pdm.eso.org/kronodoc/HQ/ESO-387101/2>
- RD19 Standard Co-ordinate Systems and Basic Conventions  
ESO-193058 Version 6  
<https://pdm.eso.org/kronodoc/HQ/ESO-193058/6>



RD20 Common Requirements for ELT Instruments

ESO-254547 Version 3

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

RD21 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>

RD22 DE-CAD-214778\_1 MORFEO & MICADO Design Volume Location and  
Access on MS-NPB (DWG)

ESO-489256 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-489256/2>

RD23 DE-CAD-202415\_1 MORFEO & MICADO Design Volume  
on MS-NPB (DWG)

ESO-489255 Version 2

<https://pdm.eso.org/kronodoc/HQ/ESO-489255/2>



## 3. Interface Description

### 3.1 Interface Overview

#### 3.1.1 MICADO's View and MCA description

[I-MAO  
/MCA-66]  
///

The MICADO calibration assembly (MCA) shall calibrate the MICADO instrument against systematic errors and perturbations coming from the instrument itself (optics and detector) and the mentioned pre-optics (in stand-alone or MORFEO configuration). The MCA has three main units for different functions (see Figure 2):

**Astrometric calibration unit (ACU):** the MCA shall map the instrumental geometric distortions through a Warm Astrometric Mask (WAM) over the instrument sensitivity range 0.8 - 2.5  $\mu\text{m}$ . The WAM is an ultra-stable target mask made of Zerodur with a pinhole pattern in the applied Chromium coating. During calibration it is located at the ELT focal plane and re-imaged by MORFEO (resp. stand-alone RO) and MICADO over the instrument FoV.

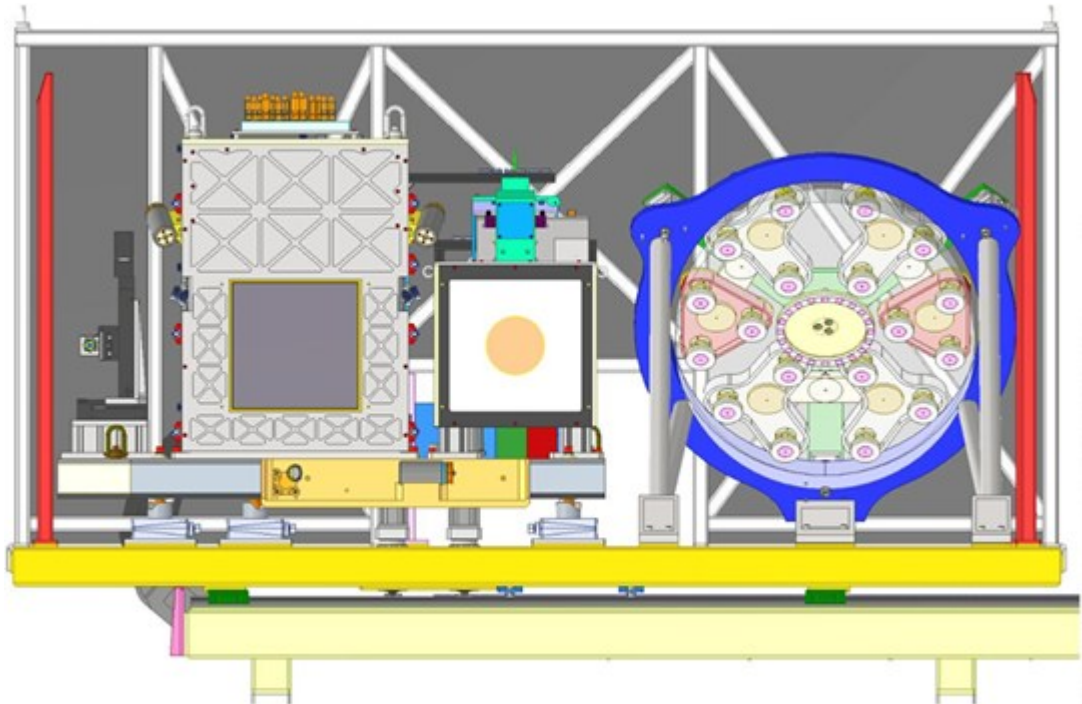
**Flat-field & wavelength calibration unit (FCU):** the MCA shall provide flat-field calibration by providing a uniform illumination over the full MICADO FoV with a black-body source (tungsten lamp) in the range 0.8 - 2.4  $\mu\text{m}$ . This subsystem shall also provide an absolute wavelength calibration to the instrument spectrometer with an accuracy of 3 km/s, by means of four pen ray gas lamps (Ar, Xe, Ne, Kr) and one or more Fabry-Pérot units (option, not in the baseline design for FDR). The light from all the sources is homogenized by a Spectralon panel placed 200 mm behind the ELT focal plane.

**Movable source calibration unit (MCU):** continuously and linearly movable point-like source (0.5 and 1.5  $\mu\text{m}$ ) for alignment / commissioning purposes and non-sidereal, differential tracking motion simulation for the SCAO WFS.

Two versions of an MCA deployment mechanism are being developed in parallel, MCA for the MICADO stand-alone mode – not included in this ICD – and MCA in MORFEO mode respectively – which is part of this ICD.

More details in the design of the MCA are in RD4.

[I-MAO  
/MCA-67]  
///



**Figure 2: Front view showing the MCA units (from left to right: MCU, FCU and ACU) and the MORFEO CU Folding Mirror (CUFM - rightmost position).**

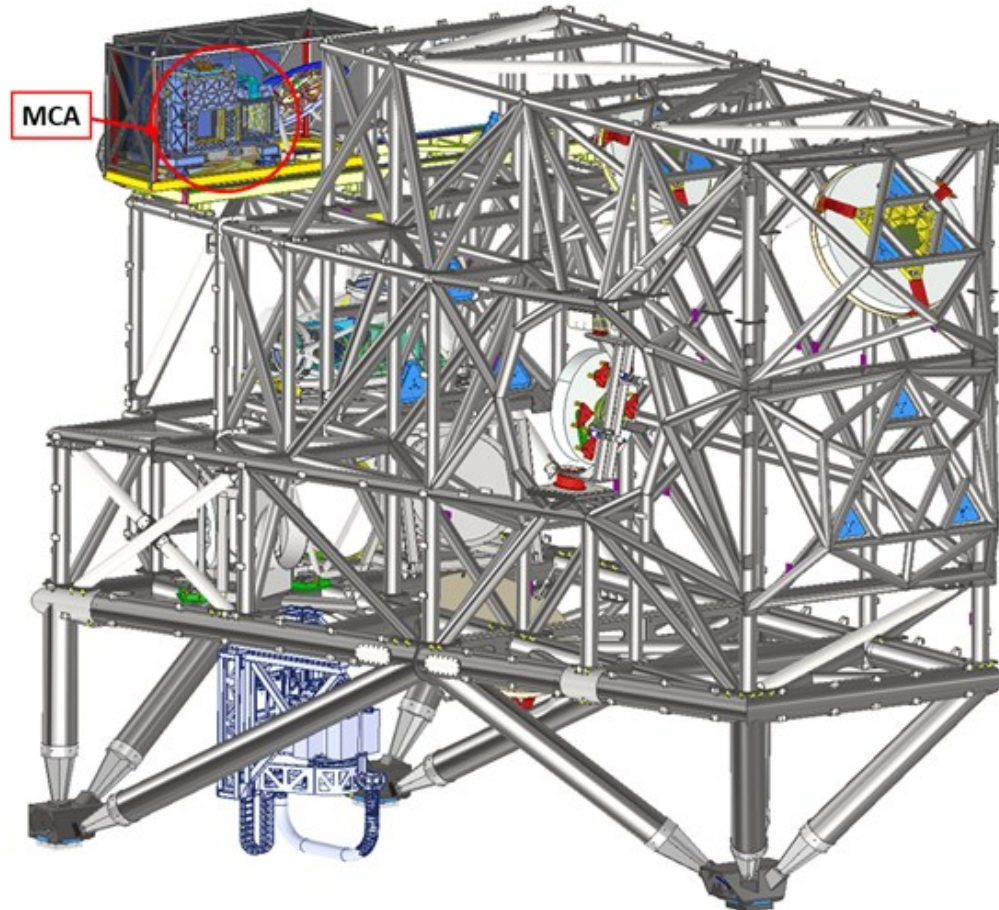
### 3.1.1.1 MCA in MORFEO mode

[I-MAO  
/MCA-69]  
///

The MCA in MORFEO mode is when MORFEO and MICADO operate together (i.e., after the MICADO standalone phase). The MCA is mounted on a sledge/selector system, called MORFEO CU Selector and located inside the MORFEO structure, but outside the MORFEO thermal cover. The sledge hosts the MCA and the MORFEO Calibration Unit Folding Mirror (CUFM). The sledge has several defined positions, for the deployment of the three MCA units ([RD1 § 3.2], #066 and Figure 2), the MORFEO CU mirror and one free slot when the instruments are operated in science mode (i.e., parking position of the sledge).

When MICADO is operating in conjunction with MORFEO, the MCA units are deployed directly at the ELT focal plane (entrance focal plane of MORFEO). During nominal operation (science mode) the sledge is parked in such a way that the optical beam from the telescope directly enters MORFEO.

[I-MAO  
/MCA-70]  
///



**Figure 3: MCA in MORFEO mode (red ovals, inside the housing in parking position). The deployment during calibration runs is realized by a sledge sliding horizontally, which carries the MCA with its three units (leftmost positions in the housing) and the MORFEO CUFM. All MCA units are mounted in the direct vicinity of or directly at the MORFEO focal plane (= ELT focal plane). During science observations the MCA is in a parking position without blocking the beam from the telescope. The sledge and the units on it will be protected against dust and other types of contamination by means of a cover sheet (not shown). This figure may be subject to a later update due to changes in the final design of MORFEO. – TBD**

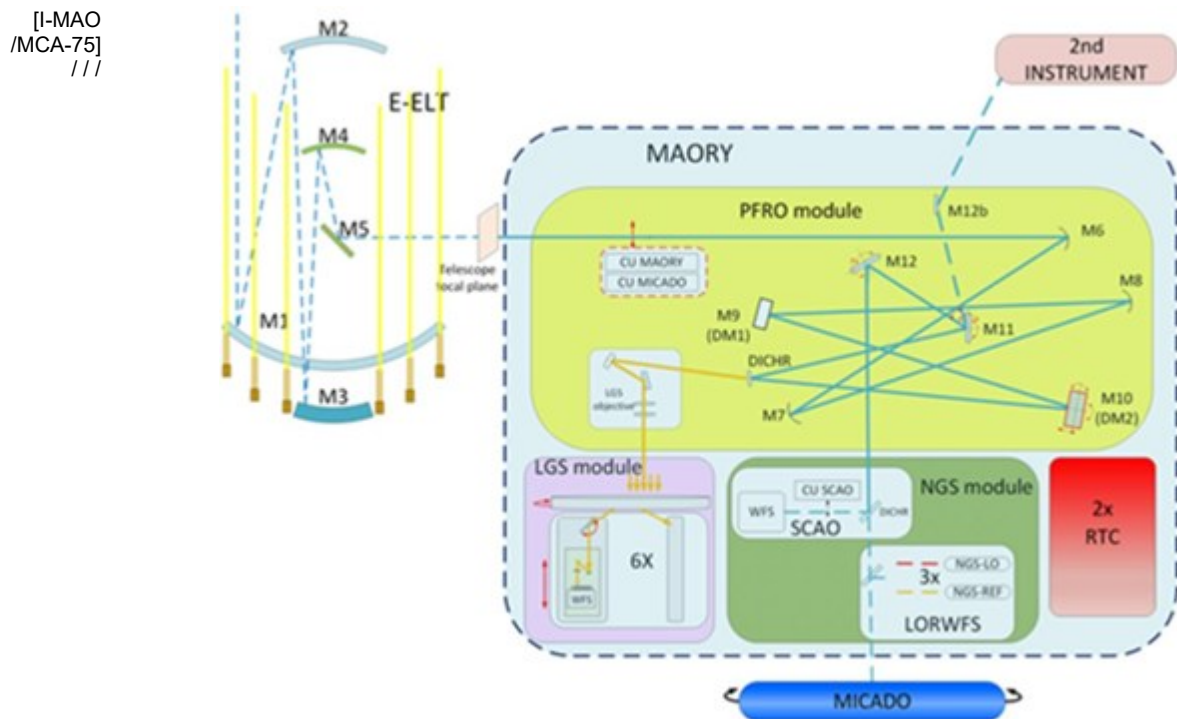
[I-MAO  
/MCA-71]  
D/// The MCA housing shall be retracted from the optical path when in stand-by mode.

[I-MAO  
/MCA-72]  
D/// The MCA housing shall be deployed in front of the ELT output focal plane when in operating mode.

### 3.1.2 MORFEO's view and system description

[I-MAO /MCA-74] MORFEO is a post-focal adaptive optics module for the ELT first light. As stated in [RD12], MORFEO offers MCAO mode to enable the science of MICADO near-infrared camera and the second instrument one. In addition, MORFEO supports the SCAO mode of the MICADO near-infrared camera.

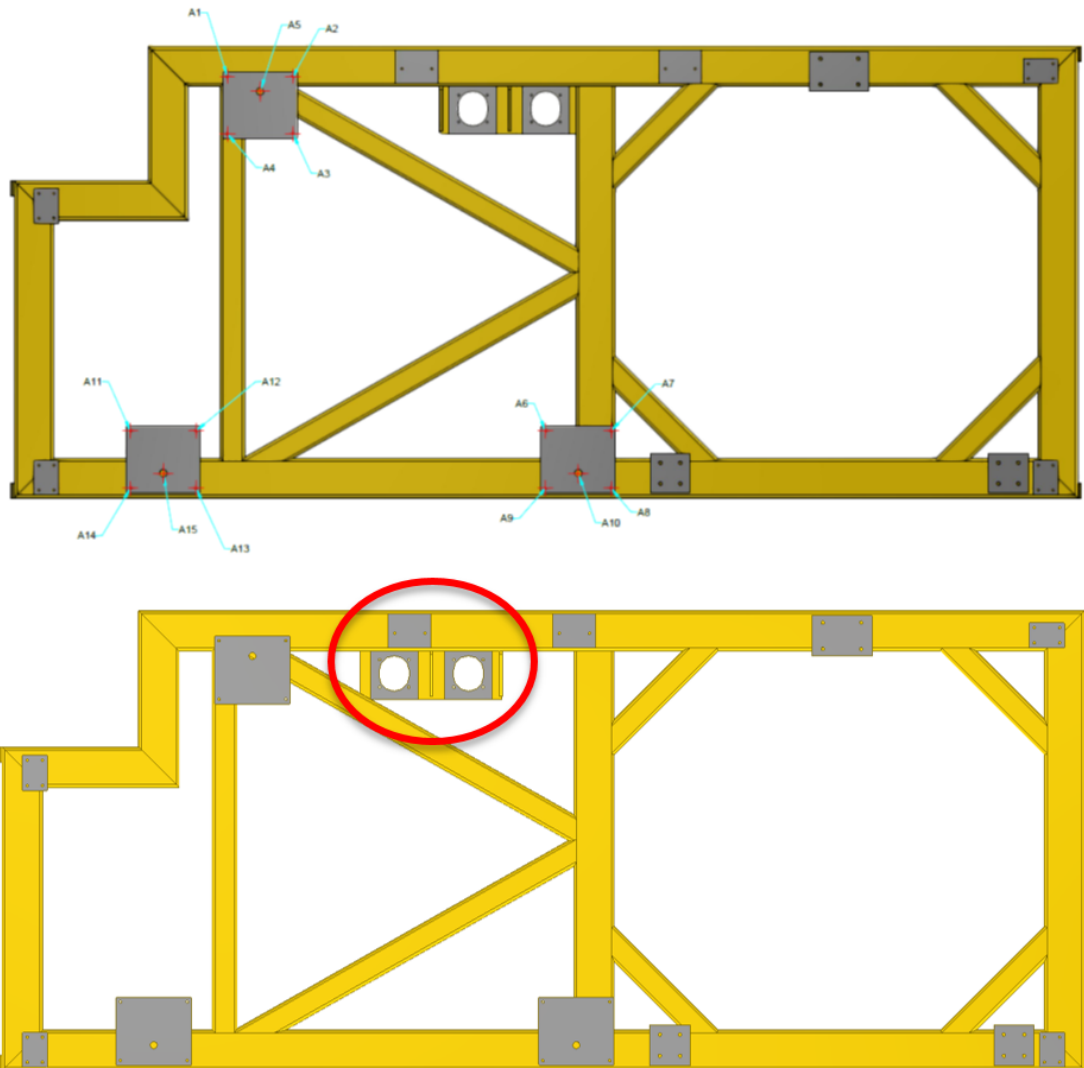
The main function of MORFEO is to relay the light beam from the ELT focal plane to the client instruments while compensating the effects of the atmospheric turbulence and other disturbances affecting the wavefront from the scientific sources of interest. MORFEO must be installed on the ELT Nasmyth platform B. It feeds two focal stations: the gravity invariant port underneath the MORFEO Main Structure for MICADO and a second gravity invariant port for another instrument on the opposite side of MICADO. Figure 4 shows the functional overview of ELT, MORFEO and MICADO, including an indication of the elements that are moving inside the WFSs.



**Figure 4: Functional overview of ELT, MORFEO and MICADO**

[I-MAO /MCA-76] The MCA is hosted on the MORFEO selector unit (sledge) which is a sledge that moves horizontally, parallel and before to the entrance focal plane (Figure 5).

[I-MAO  
/MCA-77]  
///



**Figure 5: MORFEO's Calibration units sledge. detail of the connecting plates of MCA on the MORFEO selector unit (sledge). Top: I/F configuration at PDR, bottom: updated version with the shifted motor position for cable chain re-design.**



## 4. Optical Interface definition

### 4.1 Optical interface

[I-MAO  
/MCA-80]  
D/// The MCA units shall be deployed directly into the ELT output focal plane, which coincides with the MORFEO entrance focal plane.

[I-MAO  
/MCA-81]  
D/// The MCA, when operating, shall feed light to MICADO through MORFEO.

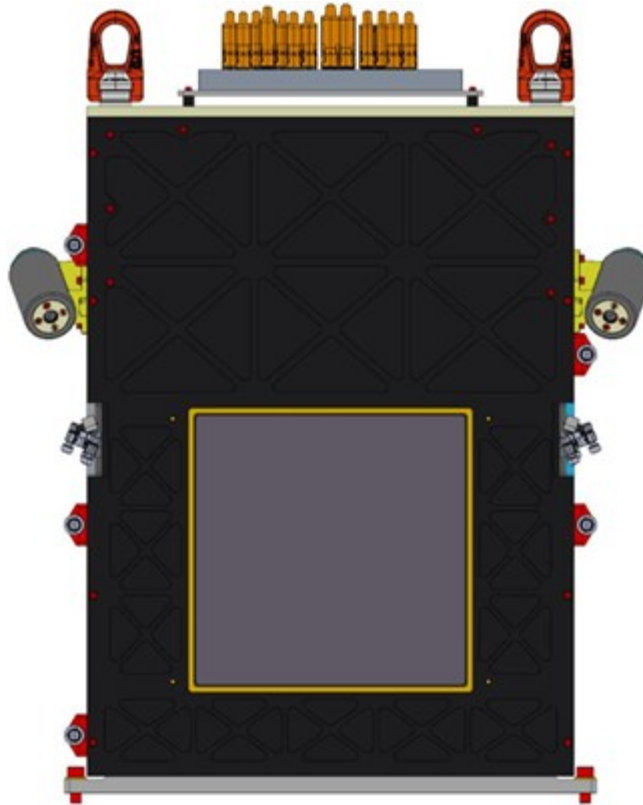
[I-MAO  
/MCA-82]  
D/// The MORFEO relay optics, when the MCA is in operating mode, shall operate either in open (FCU) or closed AO-loop mode (ACU), depending on the type of calibration.

[I-MAO  
/MCA-83]  
/// The MORFEO optics will provide a 1:1 relay of the beam except for the focal plane curvature [RD14].

### 4.2 Optical (needed for) Alignment interface

[I-MAO  
/MCA-85]  
D/A// For the alignment of the MCA to MORFEO, a laser tracker system will be used [RD18]. Five half-inch SMR targets shall be placed on the side walls of the ACU unit for position reference. The FCU and MCU will be pre-aligned with reference to the ACU on the MCA breadboard prior to craning of the entire assembly into MORFEO.

[I-MAO  
/MCA-86]  
///



**Figure 6: Five SMRs, depicted in red mounts, along the sides of the ACU**

### 4.3 Functional description of the optical interface

[I-MAO  
/MCA-88]  
D/// The MCA shall configure its own units (e.g., the ACU hexapod) once deployed.

## 5. Mechanical Interface Requirements

[I-MAO /MCA-90] D/// The MCA shall be mechanically installed on-board the MORFEO CU sledge.

[I-MAO /MCA-91] D/// MORFEO shall provide means to deploy the MCA assembly in front of the ELT output focal plane for the execution of calibrations (MCA operating mode) and to retract the MCA for the execution of scientific observations or storage.

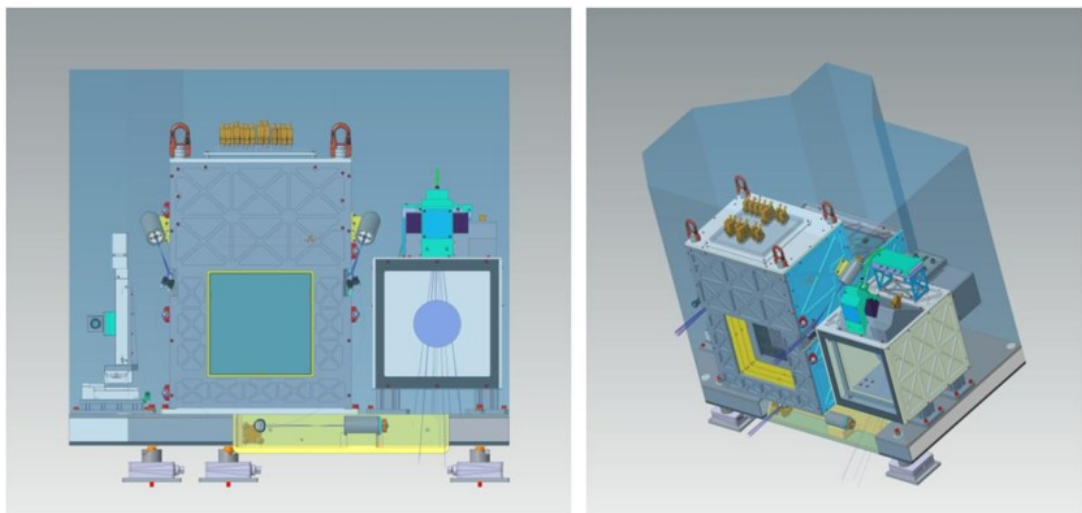
### 5.1 Design Volume, Location and Accessibility Requirements

#### 5.1.1 Volume

[I-MAO /MCA-94] D/// **The static design volume** of the MCA is defined in [RD7]. The “static volume” comprises the sledge-comoving envelope within which the MCA units must entirely reside, including margin for vibrational modes present during an earthquake at Armazones. The static volume follows the contours of the MCA breadboard footprint, with an additional 5 mm extended to the front, and with a vertical height of 96 cm.

Note that the breadboard feet, affixed to the MORFEO structure, are allowed to slightly violate this volume.

[I-MAO /MCA-95] ///



**Figure 7: MCA within the static envelope.**



[I-MAO /MCA-96] **The dynamical envelope** of the MCA shall be defined by the stage mechanism provided by MORFEO and shall include the travel range of the MCA from the stand-by and deployed position of the MCA.  
D/ / /

This volume excludes any additional volume required for the cable chain (see #154)

[I-MAO /MCA-97] **The maintenance envelope** of the MCA is defined as the volume above the MCA reserved for craning activities [RD9]. This volume is defined exclusively for the MCA in the parking position and contains the handling tool and the protecting bars of the CU folding mirror.  
D/ / /

[I-MAO /MCA-98] The MCA cabinets are not part of the MORFEO-MICADO I/F (see RD14).  
/ / /

### 5.1.2 Mounting Interface

[I-MAO /MCA-100] **Type of mounts:** The MCA shall be mounted on the MORFEO stage mechanism by means of three (3) repeatable kinematic mounts (MCA's responsibility). These will be installed on three (3) interface plates, which are under MORFEO's responsibility, see #101 .  
D/ / /

[I-MAO /MCA-101] **Mounting locations:** the attachment points of the MCA shall be according #102 *until an update of [RD5] is available after the MORFEO FDR – TBD.*  
D/ / /



[I-MAO  
/MCA-102]  
D//

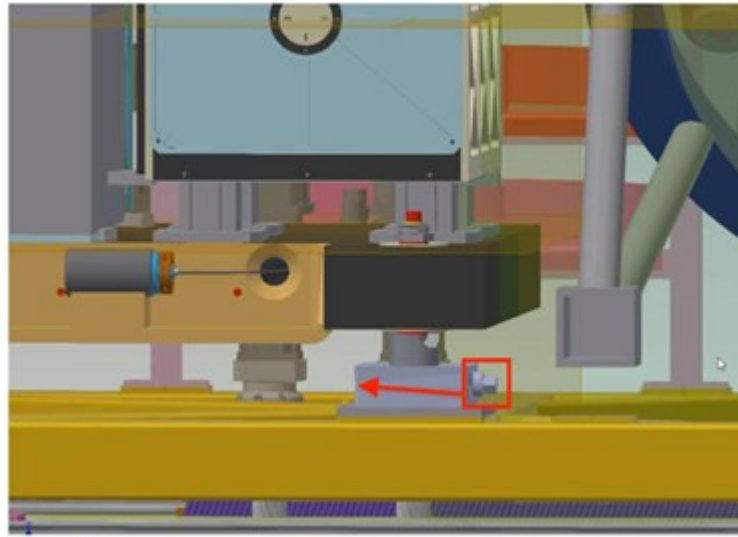
HOLE COORDINATES REFERRED TO MORFEO ORIGIN				
POINT ID.	X	Y	Z	HOLE DESCRIPTION
A1	656.00	2191.00	-404.00	M6x1
A2	656.00	2059.00	-404.00	M6x1
A3	540.00	2059.00	-404.00	M6x1
A4	540.00	2191.00	-404.00	M6x1
A5	625.00	2125.00	-404.00	M16x2
A6	-60.00	1551.00	-404.00	M6x1
A7	-60.00	-1419.00	-404.00	M6x1
A8	-176.00	-1419.00	-404.00	M6x1
A9	-176.00	1551.00	-404.00	M6x1
A10	-145.00	-1485.00	-404.00	M16x2
A11	-60.00	2386.00	-404.00	M6x1
A12	-60.00	2254.00	-404.00	M6x1
A13	-176.00	2254.00	-404.00	M6x1
A14	-176.00	2386.00	-404.00	M6x1
A15	-145.00	2320.00	-404.00	M16x2

**Table 1: MORFEO sledge hole coordinates, with reference to the MORFEO origin. Hole IDs are labelled in Figure 5.**

[I-MAO  
/MCA-103]  
D//

**Design of mounts:** MCA shall define, procure and install the kinematic mounts and levelling tools [RD1].

[I-MAO  
/MCA-104]  
///



**Figure 8: detail of an MCA kinematic mount and levelling tool.**

#### 5.1.2.1 Survival acceleration

[I-MAO  
/MCA-106]  
/A/ The MCA shall survive Earthquake accelerations of  $a_x = a = \pm 3.3g$ ;  $a = 2.185g$ , according to [RD3 § 3.2].

#### 5.1.3 Position tolerances, alignment, and stability

[I-MAO  
/MCA-108]  
D//T MCA's units positions: three different positions are required for positioning all MCA elements in front of focal plane and are defined in [RD1].

- FCU @ - 1593.55 mm TBC
- ACU @ - 2043.55 mm TBC
- MCU @ - 2463.55 mm TBC

With respect to the Y axis of the MORFEO coordinate system (#021), with the 0 defined in the MCA's parked position (#069)

[I-MAO  
/MCA-109]  
D//T **Repositioning repeatability in longer time scales**

The MCA can accommodate drifts of approximately 2 mm in each of X, Y, and Z and 1° in each of  $\alpha$ ,  $\beta$ , and  $\gamma$ . Note that these are not yet derived from any FEA and need to be revisited prior to MORFEO FDR. – TBD



[I-MAO  
/MCA-110]  
D//T

**Repositioning repeatability** is the most stringent when the ACU unit is in use. With respect to the local MAO-MCA coordinate system (#020) when using the ACU ([RD4 §6.4.3]), MORFEO shall be able to position the MCA over a period 5 minutes – 1 day with the following repeatability:

- $\Delta Z, \Delta Y = \pm 0.5\text{mm}$
- $\Delta X = \pm 0.1\text{mm}$
- $\Delta\alpha, \Delta\beta = \pm 0.05^\circ$
- $\Delta\gamma = \pm 0.5^\circ$

[I-MAO  
/MCA-111]  
D//T

**Positioning stability** of the MCA with respect to the local MAO-MCA coordinate system (#020) during daytime calibration once the ACU is deployed (see [RD4 §6.4.3]) provided by MORFEO in closed loop (LOR only on calibration sources) over a period  $t < 20$  sec shall be:

- $\Delta X, \Delta Y = \pm 4 \mu\text{m}$
- $\Delta Z = \pm 100 \mu\text{m}$
- $\Delta\alpha, \Delta\beta = \pm 0.0002^\circ$  (TBC during MORFEO's FD)
- $\Delta\gamma = \pm 0.001^\circ$  (TBC during MORFEO's FD)

These numbers do not include the telescope's contribution, because the baseline is that the telescope is not "quiet".

[I-MAO  
/MCA-112]  
D//T

**SCAO/MCAO mode switching:** The MORFEO post focal DM(s) shall be used to correct for the nominal ~10 mm ELT focal plane shift toward MICADO when the SCAO dichroic is inserted into the beam path so that the actual ELT focal plane remains co-located with the fixed MCA focal plane in either SCAO or MCAO operational mode of MORFEO.

#### 5.1.4 Accessibility Requirements

[I-MAO  
/MCA-114]  
D//T

The MCA's electrical patchboard and the fibre feedthrough shall be accessible from MORFEO for maintenance purposes.

[I-MAO  
/MCA-115]  
D//T

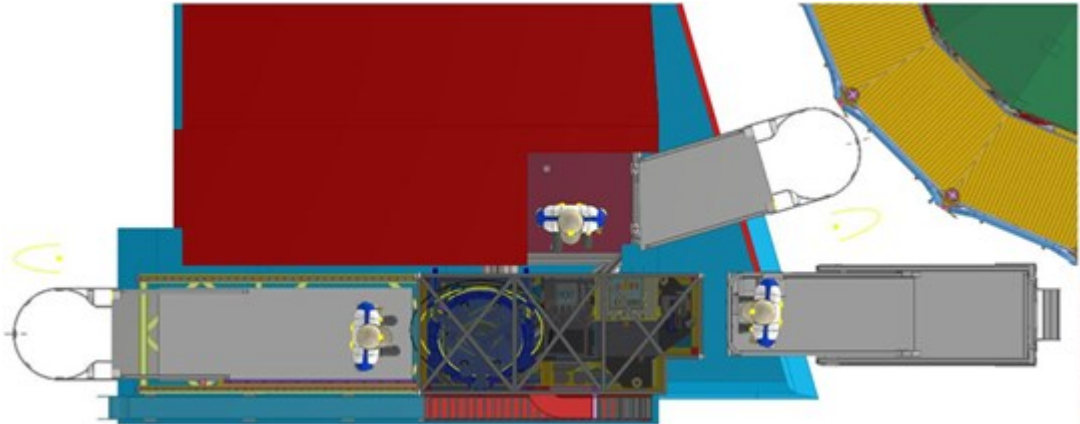
Overall accessibility to the MCA is required. For details of scenarios see [RD8, RD9].

[I-MAO  
/MCA-116]  
D//T

Access to the MCA shall be provided by MORFEO with the MCA in the parking position. Access positions are depicted in Figure 9.



[I-MAO  
/MCA-117]  
//



**Figure 9: Access to the MCA will be made available via ladder or scissor lift at the locations indicated by persons in the drawing above**

[I-MAO  
/MCA-118]  
D/ //

The FCU gas lamps are scheduled to be regularly replaced on a 2-year cadence, as per the maintenance plan [RD9]. This maintenance will be completed in-situ, with access available from the front of the MCA (see the “top-most” person in Figure 9). Based on anticipated usage, the expected lifetime of these lamps is 5+ years; this scheduled replacement should mitigate most “sudden occurrence” replacement potentialities.

[I-MAO  
/MCA-119]  
D/ //

All other maintenances will include craning of the entire MCA. Such maintenance activities will only occur in response to unexpected failures that are not expected to occur during the operational lifetime of the MCA. Craning hooks will be installed onto the MCA breadboard only during these activities (see Figure 10). A craning tool will be provided by MICADO which will attach to these points. Safety rods will be provided by MORFEO to protect the MORFEO CUFM from damage during MCA craning.

[I-MAO  
/MCA-120]  
D/ //

Cable duct accessibility: the CU cable duct along the MORFEO thermal cover, along its entire span, shall be accessible for maintenance and inspection of cables (MCA & MORFEO) and fibres (MCA)

[I-MAO  
/MCA-121]  
D/ //

Cable duct accessibility: the CU cable duct shall be accessible for maintenance and inspection of cables (MCA & MORFEO) and fibres (MCA).

### 5.1.5 Functionality Requirements

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

MORFEO shall provide means to protect MCA from dust when in parking position (i.e., static vertical panel)

## 5.2 Physical characteristics

[I-MAO  
/MCA-125]  
D//IT

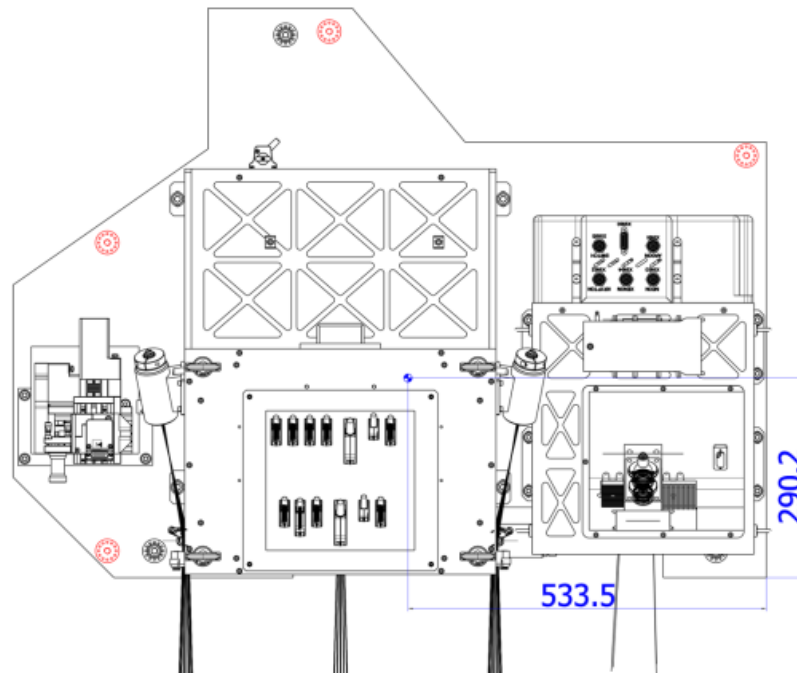
The mass of the MCA shall be < 200 kg

The mass of the cables inside the cable chain along the MORFEO structure shall be < 40 kg.

[I-MAO  
/MCA-126]  
D//IT

**Location of CoG:** the CoG of the MCA shall be located within or near the MCA's volume defined by the mounting points to facilitate craning activities. The approximate position of the CoG is provided below; the precise location of the CoG will differ by a few cm due to cable routing and cable scaffolding structures not included in the model.

[I-MAO  
/MCA-127]  
///



**Figure 10: Approximate location of the MCA barycenter marked in blue. Locations of the mounting points marked in red.**

[I-MAO  
/MCA-128]  
///

**Moments of Inertia at CoG:** N/A (no rotating parts)



### 5.2.1 Vibrations

[I-MAO  
/MCA-130]  
/AJ/ **Induced Vibrations by MORFEO:** if no detailed system micro vibration analysis is available, the requirement [R-INS/ELT-309] in [RD21] shall be applicable for all interfaces.

*TBD by MORFEO team.*

[I-MAO  
/MCA-131]  
/AJ/ **Induced Vibrations by MCA:** if no detailed system micro vibration analysis is available, the requirement [R-INS-760] in [RD20] shall be applicable for all interfaces.

### 5.2.2 Eigenfrequencies

[I-MAO  
/MCA-133]  
/AJ/ **The lowest eigenfrequency of the MCA** shall be equal or higher than  $50 \text{ Hz} \pm 5 \text{ Hz}$ . The corresponding analytical verification shall assume infinitely rigid interfaces.



## 6. Electrical Interface

### 6.1 Electric Power Interface

[I-MAO /MCA-136] N/A (TBC? – see #006)  
///

### 6.2 Data Communication Interface

[I-MAO /MCA-138] N/A  
///

### 6.3 EMC I/F description

[I-MAO /MCA-140] MORFEO and MCA shall comply to [AD8 § 3.3]. No further EMC requirements will be foreseen. For an analysis of the MCA EMC see [RD1 § 7.8].  
D/A/ /

### 6.4 Electrical grounding

[I-MAO /MCA-142] All electrical interfaces of MORFEO and MCA shall comply with the requirements on grounding and bonding in [AD2].  
D/A/ /

[I-MAO /MCA-143] For an analysis of the MCA electrical grounding see [RD1 § 7.8].  
///

#### 6.4.1 Electrical bonding

[I-MAO /MCA-145] MORFEO shall provide a common grounding between the CU moving stage and the fixed parts  
///T



## 7. Thermal I/F

[I-MAO /MCA-147] MCA will be outside MORFEO's thermal cover.  
///

[I-MAO /MCA-148] The MORFEO and MCA skin temperature requirements are specified in RD20 § 8.12.2] Thermal Requirements.  
/AJ /

[I-MAO /MCA-149] MORFEO shall not transfer any heat towards the MCA when the latter is in operation.  
/AJ /

*Note: the only active MORFEO's heat source possibly relevant for the MCA is the selector stage's motor, which is not operated when the MCA is deployed and in operation. The heat load is expected to be minimal and for a short, <60 sec, time-(TBC during MORFEO's FDR). The heat can be transferred from MORFEO to MCA only through the interface plates (see #008 and #100), which follow the external dome temperature.*

## 8. Fluid Interface requirements

[I-MAO /MCA-151] N/A  
///

## 9. Cabling, Piping and Cable Trays I/F

[I-MAO /MCA-153] MORFEO shall design, procure, and install the cable chain for the cables of the MCA with input and acceptance from the MCA team.  
D/ / /

[I-MAO /MCA-154] The cable chain shall be dimensioned to host the following cables of the MCA. Details can be found in [RD1].  
D/ / /

For the purpose of grouping and routing the MCA cables, groups are defined based on the signal characteristics of the cables:

- Green: low noise, sensitive/ susceptible cables (i.e. 20 mA sensors signals, 3V encoder signals, 24V DC supplies)
- Red: noise sources (i.e. DC motor currents, but still < 1A, earth cables)
- Blue: optical fibre cables, not EMC relevant



[I-MAO  
/MCA-155]  
///

MCA Harness in MORFEO					
<i>Note: This table gives the current design status (as of July 2024). The final cables/fibers may change depending on procurement (availability) conditions.</i>					
Harness Section-1 (long section outside cabinets)					
Cable Nr	Function	Cable Structure/Fibre type	External diam. [mm]	Min bend radius [mm] – Moving	Weight [g/m]
1	FCU Illumination and sensors	(4x0.5 + 4x2x0.34)	8.9	89	129
2	ACU Illumination and sensors	(4x0.5 + 4x2x0.34)	8.9	89	129
3	Hexapod Power	(5G0.5)	7.5	94	62
4	Hexapod data#1	(40x2x0.08)	11.2	112	150
5	Hexapod data#2	(40x2x0.08)	11.2	112	150
6	MCU Encoders#1	(14x2x0.25)	11.9	119	176
7	MCU Encoders#2	(14x2x0.25)	11.9	119	176
8	MCU Motors#1	(9G0.5)	8.8	66	127
9	MCU Motors#2	(9G0.5)	8.8	66	127
10	Temp. and humidity sensors	(4x2x0.25)	7.6	57	75
11	FCU Gas Lamps Supply	(6x2x0.25)	9.3	70	143
12	ICS10 Ground (MCA)	1x10mm <sup>2</sup>	6.2	48	112
13	MORFEO	1x10mm <sup>2</sup>	6.2	48	112



ICD between MORFEO and MICADO  
(Calibration Unit)

	Ground				
14	MCU Fiber#1	6 x 9/125 µm SMF in PUR cable	11.0	99.0	95
15	MCU Fiber#2	6 x 9/125 µm SMF in PUR cable	11.0	99.0	95
16	NGS (CLS) fiber#1	2x 200/230 µm SMF in TPE cable	8.5	77	57
17	NGS (CLS) fiber#2	2x 200/230 µm SMF in TPE cable	8.5	77	57
18	NGS (CLS) fiber#3	2x 200/230 µm SMF in TPE cable	8.5	77	57
19	Fabry- Perot  Fiber#1 (FCU)	6.5/125 µm ZBLAN SMF in PVC cable	7.0	110	50
20	Fabry- Perot  Fiber#2 (FCU)	6.5/125 µm ZBLAN SMF in PVC cable	7.0	110	50
Overall minimum bend radius:				119 mm	
Total weight per unit length:				2.13 kg/m	

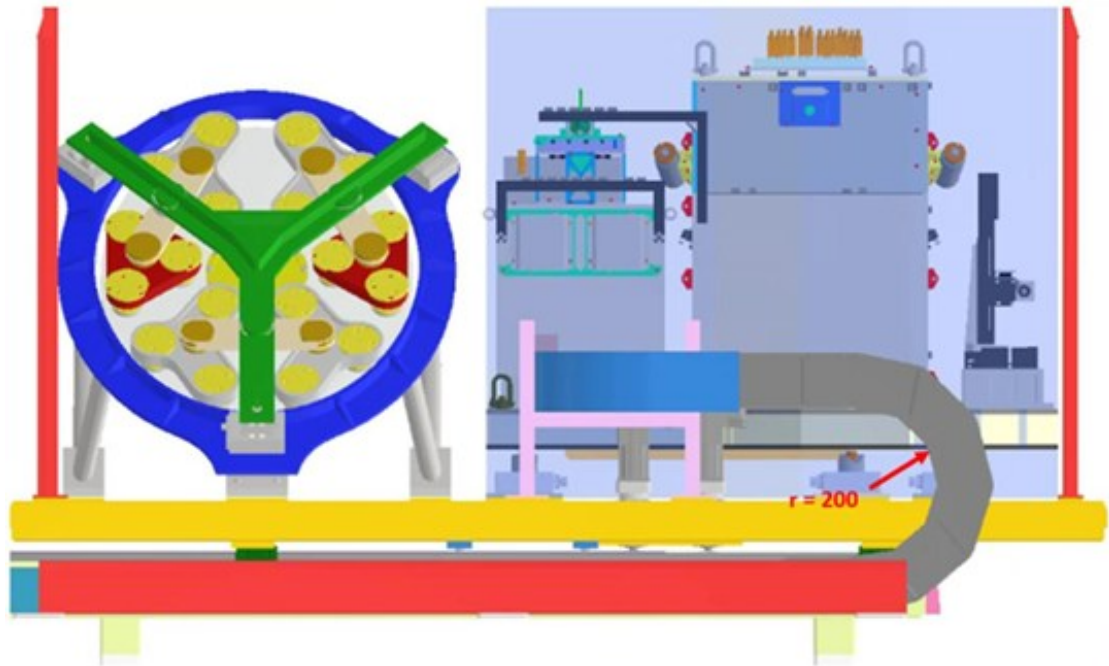
[I-MAO  
/MCA-156]  
///

MORFEO's sledge cables are hosted in a common cable chain with the MCA cables (#154) and fibres, but possibly in a separate internal volume. *The TBCs will be resolved with the MORFEO FDR:*

Function	Cable structure/fibre type	External Diam. [mm] (TBC)	Min. bend radius [mm] – Moving	Weight [g/m]
Communication	2 x TBC	8	TBC	TBC
Motors & breaks	2 x TBC	13	TBC	TBC
Encoders	2 x TBC	12	TBC	TBC
Limit Switches	2 x TBC	8	TBC	TBC
Interlocks	2 x TBC	8	TBC	TBC
Monitoring (Temperature etc.)	2 x TBC	8	TBC	TBC
TBD				

[I-MAO /MCA-157] D// MORFEO shall provide the cable tray that hosts the cables exiting the cable chain towards the MCA's electronic cabinet ending at the Nasmyth feedthrough, considering the list of cables defined in #154 with input and acceptance from the MCA team. A description of the MCA harness can be found in [RD1 § 7.7].

[I-MAO /MCA-158] ///



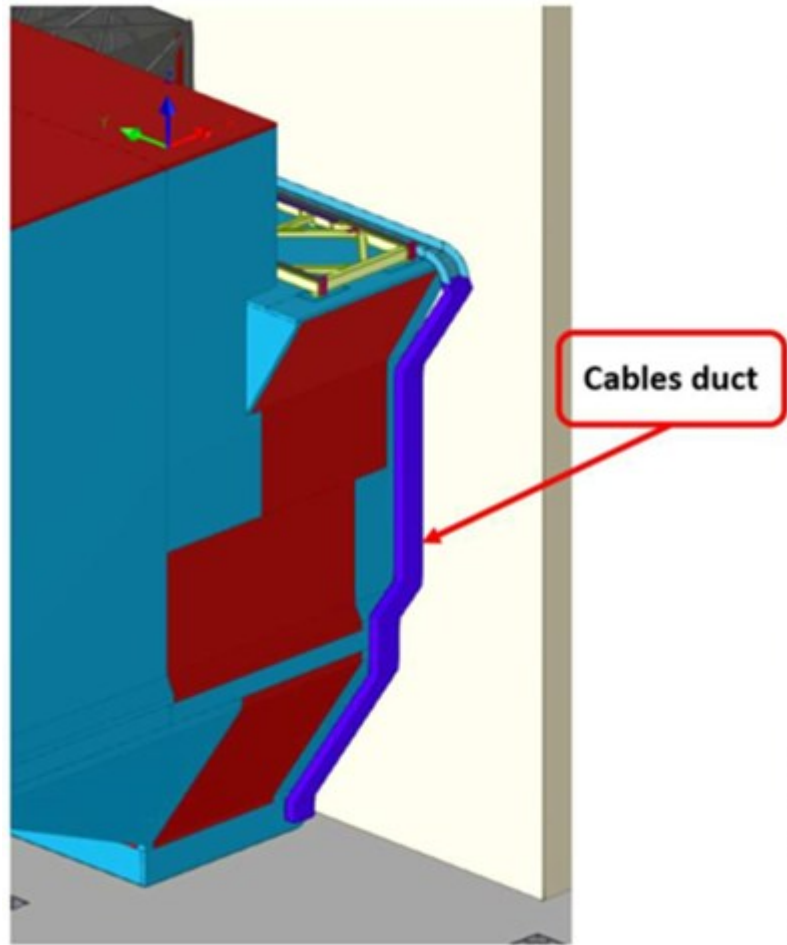
**Figure 11: View of the CU Selector and cable chain. All the electrical components of the CU Selector need to be reached by the electrical cables. These cables, which serve the motors and the modules, are hosted within the cable chain shared among MORFEO and MICADO. MORFEO TO ADD A BENDING RADIUS REQUIREMENT (minimum 119 mm (see #154) – TBD).**

[I-MAO /MCA-159] D// MORFEO shall define the routing path for the above cable tray with input and acceptance from the MCA team, considering the overall available design volume and the location of the MCA cabinet near to the Nasmyth interface plates at the following coordinates:

- X:-450mm; Y:0mm; Z:-6010 mm

This results in an overall length of *about 15 meters (TBC)* from the cable tray to conduit within the MORFEO volume. See #160

[I-MAO  
/MCA-160]  
///



**Figure 12: example design of the cable duct**



## 10. AIT/V interfaces

### 10.1 AIT/V equipment

[I-MAO /MCA-163] / I / T **MCA “Dummy”:** MICADO shall provide to MORFEO a “dummy” MCA representative of the real MCA. This will consist of dummy MCU, FCU, and ACU units, each with a representative mass, volume envelope, and CoG. The dummy units will not be functionally capable of calibration activities, but will include necessary mechanical and electrical interfaces to facilitate MORFEO's AIT phase in Europe. Additionally, the following interfaces will be included:

- The dummy MCU will include a fibre mount at the nominal on-axis focus location
- The dummy ACU will be delivered with the three natural guide star sources for alignment activities (these will later be moved to the real ACU at the ELT)
- The dummy ACU will be delivered with laser tracker targets for alignment activities (these also will later be moved to the real ACU)

The MCA dummy units will be delivered together with the final MORFEO-mode MCA breadboard, which will later be used with the real MCA units once at the ELT.

[I-MAO /MCA-164] / I / T MICADO shall provide the final MORFEO-mode harness for testing of the cable chain during MORFEO's AIT phase in Europe.

[I-MAO /MCA-165] D / I / MICADO shall provide the five SMR targets to be installed in Chile with the delivery of the “dummy” MCA to Bologna (#163).

[I-MAO /MCA-166] D / I / MORFEO shall provide the laser tracker to allow alignment of the MCA to the optical reference.

[I-MAO /MCA-167] D / I / T MICADO shall provide all the required handling tools for any AIT/V and maintenance operation.

### 10.2 Common AIT/V operations

[I-MAO /MCA-169] / I / MICADO shall provide the MCA - appropriately modified for the operation of M&M- on MORFEO is foreseen in IAA on Armazones.

The MCA will be installed onto the MORFEO sledge together with MORFEO CU folding mirror (CUFM). The whole assembly will be then integrated onto MORFEO and aligned



and tested. MCA functional tests (fibres/cables etc) are essential to this phase due to limited access post installation.

The MCA will then go to the Nasmyth-B already installed onto MORFEO.

Common AIV requirements will be described in a separate document.

## 11. Safety interface

[I-MAO  
/MCA-171]  
D//T

To enable safe maintenance operations that require operators' access to the MCA, MORFEO shall provide means to power-off the MORFEO's sledge motor and prevent unintentional power-on of this motor. In example, this can be done by a lockable switch of the sledge motor power supply inside a MORFEO cabinet. Or by implementing emergency stop buttons located at accessible locations near the MCA sledge. In this case a safety motor power-off function shall be implemented.

Likewise, to enable safe maintenance operations at the MCA or MORFEO that require operators' access to the MCA, MCA shall provide means to power-off the MCA components at the MORFEO sledge and prevent unintentional power-on of these components. In example, this can be done by a key lockable switch of the MCA power supply inside the MCA cabinet.

## 12. Other I/Fs

### 12.1 SW interface

[I-MAO  
/MCA-174]  
///

The SW Interface is included in [RD15].



### 13. Verification

[I-MAO /MCA-176] /// The interface requirements defined in this ICD will be verified according to a verification plan to be agreed by MORFEO, MICADO and ESO. This plan should consider the suggested verification tag specified for the requirements.

[I-MAO /MCA-177] /// Table 2 specifies which side of the ICD is responsible for verifying each requirement:

ID#	Validator	ID#	Validator	ID#	Validator
071	MAO, MIC	072	MAO, MIC	080	MAO
081	MAO, MIC	082	MAO	085	MIC
088	MIC	090	MAO, MIC	091	MAO
094	MAO, MIC	096	MAO, MIC	100	MAO, MIC
101	MAO, MIC	103	MIC	106	MIC
108	MIC	110	MAO	111	MAO
114	MIC	115	MAO	118	MIC, MAO
119	MIC, MAO	120	MAO, MIC	121	MAO, MIC
123	MAO	125	MIC	126	MIC
130	MAO	131	MIC	133	MAO, MIC
140	MAO, MIC	142	MAO, MIC	148	MAO, MIC
149	MAO	153	MAO	154	MAO
157	MAO	159	MAO	163	MIC, MAO
165	MIC	167	MIC	169	MAO, MIC
171	MAO	102	MAO	109	MAO, MIC
116	MAO	164	MIC	166	MAO
97	MIC	112	MAO, MIC		

**Table 2: verification table. Each interface requirement, identified by its NNN ID number shall be assigned to either MAO or MIC or both.**

[I-MAO /MCA-178] /// Test verification: the specifications for common test verification environment, verification of software, and simulators will be defined during the MORFEO final design phase.



[I-MAO  
/MCA-179]  
///

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

ID#	Verification procedure
101	Check I/F compatibility between MCA bench & MORFEO sledge (BIH)
108	Deploy MCA in its three calibration positions with MORFEO sledge (BIH)
110	Repeatability position of MCA with MORFEO sledge (BIH+NAS-B) – see also 085
111	Stability of MCA position using optical feedback from MICADO (NAS-B)
112	Check that the MCA can be focused by MORFEO optics with and without the SCAO dichroic (NAS-B)
085	Align MCA with the MORFEO laser tracker feedback (BIH+IAA+NAS-B) – see also 165
083	Check optical quality of MCA FPs onto MICADO detector (NAS-B)
125	Check MCA mass - dummies (BIH) and real units (IAA)
126	Check that the craning tool can lift the MCA without tilt (BIH+IAA)
140	EMC, mutual disturbance inter-system tests (NAS-B)
163	Train MCA AIV procedure using dummy units onto MORFEO bench (BIH)
167	Tested with MCA bench and MCA dummy units integration onto MORFEO bench (BIH) - see also 169
171	Test the CU Sledge interlock (BIH+NAS-B)
109	Repositioning repeatability > 30 days using LOR WFSs (BIH+NAS-B)
145	Electrical grounding between CU sledge and MORFEO bench (BIH+NAS-B)
164	MCA Harness for cable chain, test of routing procedure (BIH+IAA)

**Table 3: list of requirements that have been assigned a test verification tag with the expected location of the verification test. BIH is the Bologna Integration Hall.**

[I-MAO  
/MCA-180]  
///

Requirements which have a TBC/TBD:

	ID #
TBD	070, 101, 109, 130, 156, 158
TBC	108, 111, 136, 149, 156, 159

**Table 4: list of requirements that have a TBC/TBD**

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