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Project: **ELT MCAO Construction – MORFEO**

NASMYTH INTERFACE REQUIREMENTS FOR MORFEO MAIN STRUCTURE SUBSYSTEM and HANDLING TOOLS

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1. Related Documents

1.1. Applicable Documents

MAO-PM0-1.6 Applicable documents

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 the others.

- AD1. Standard Co-ordinate Systems and Basic Conventions ESO-193058 Version 6
- AD2. E-ELT Electrical and Electronic Design Requirements ESO-262825 Version 1
- AD3. ESO Mechanical Standards ESO-192984 Version 2
- AD4. Standard Components and Guidelines for Cooling Circuits; ESO-254314 Version 6
- AD5. Interface Control Document Between the E-ELT SCPs and the SCP Clients ESO-262869 Version 3
- AD6. ESO-191462 ESO Engineering Analysis Standard, issue 2
- AD7. Nasmyth Platform Interfaces ESO-286456 (CAD-135139) Revision 1
- AD8. Common ICD between the ELT Nasmyth Instruments and the Rest of the ELT System ESO-253082 issue 4
- AD9. ICD between MORFEO and MICADO (General) v:3 (ESO-323542)

1.2. Reference Documents

- RD1 Additional Support Points for Instruments on the Nasmyth Platform ESO-321386 (CAD-153255) Revision 4
- RD2 Definition of additional support points for instruments on the ELT Nasmyth platforms ESO-321039 Version 3;



2. Introduction

2.1. Scope

MORFEO (formerly known as MAORY) is the Adaptive Optics Module for ELT.

This document contains the requirements extracted from the ESO-253082 “Common ICD between the ELT Nasmyth Instruments and the Rest of the ELT System” that are applicable to the MORFEO Main Structure and Handling tools.

In this document for Nasmyth instruments we intend MORFEO Main Structure subsystem (fully equipped with payloads and the Handling tools

2.2. Naming Convention

Requirements are identified with a requirement tag following the format [MAO-PM0-XXX], where XXX is a unique, non-speaking number.

In section [7](#) is reported for each requirement the minimum verification method to be applied for the requirement verification during the main project phases.

2.3. Abbreviations and Acronyms

AD	Applicable Document
AIV	Assembly Integration and Verification
arcsec	Arc Second
arcmin	Arc Minute
ART	Adaptive Relay Tower
ARU	Adaptive Relay Unit
BOL	Beginning of Life
CCS	Central Control System
CoG	Centre of Gravity
EH	Entrance Hall
IAA	Instrument Assembly Area at Armazones
ICD	Interface Control Document
LCS	Local Control System
LCU	Local Control Unit
LGS	Laser Guide Star
LOO	Low Order Optimisation



NCR	No Collapse Requirement
NGS	Natural Guide Star
MS	Main Structure
MTR	Main Transit Ring
PFS	Prefocal Station
PTV	Peak to Valley
RBM	Rigid Body Motion
RD	Reference Document
rms	Root Mean Square
SCP	Service Connection Point
TSE	Thermal Self Emission
WFS	Wavefront Sensor

2.4. Definitions

[INFO- **Atmospheric Coherence Length**
INS/ELT-
17] The diameter of a wavefront area over which the instantaneous rms phase variations due to atmosphere optical turbulence are equal to 1 radians ($\lambda/6.28$).

[INFO- **Blind Alignment**
INS/ELT-
18] A mode of operation in which the telescope and its optical units are controlled relying on internal metrologies and look-up-tables to compensate the large amplitude distortions of the main structure under gravity and thermal load. The M1 figure is corrected in real time with position actuators controlling the segments positions in piston, tip and tilt, based on the signals of edge sensors monitoring in real time the relative displacements of adjacent segments. No observation of the sky is needed.

[INFO- **Chopping**
INS/ELT-
19] A process by way of which the **pointing** of the telescope is changed rapidly and periodically by a small amount (ideally with a square wave oscillation). This technique is primarily used to improve suppression of sky background with infrared observations. The oscillation is realised by moving the telescope optics.

[INFO- **Drift**
INS/ELT-
20] The change in a characteristic of the system over time compared to its initial value.

[INFO- **Field Distortion Repeatability and Stability**
INS/ELT-
21] The repeatability and stability of the field distortions includes:
- errors in the third order optical distortion
- errors in plate scale



- errors in field rotation

The error is specified in units of mas (position error of an image in the focal plane) per arcmin (off-axis field distance). Both angles are projected onto the sky as seen from the entrance pupil.

[INFO- **Guiding**

INS/ELT-22] Tracking using an error signal provided by devices measuring optically the pointing error on a reference star.

[INFO- **Low Order Optimisation**

INS/ELT-23] A mode of operation, traditionally called 'active optics', the quasi-static aberrations of the telescope are observed at the Nasmyth adapter by Natural Guide Star probes and corrected by quasi-static adjustment of the mirror units position and mirror shape (when relevant).

[INFO- **Nasmyth Instruments**

INS/ELT-42] In this document for Nasmyth instruments we intend MORFEO Main Structure subsystem (fully equipped with payloads and the Handling tools.

[INFO- **No Collapse Requirement**

INS/ELT-24] A specific set of environmental conditions under which the instruments shall deliver "no collapse" performance. These are defined in the instrument common requirements.

[INFO- **Nodding**

INS/ELT-25] A process by way of which the pointing of the telescope is periodically changed between two neighbouring sky positions. Contrarily to **chopping**, nodding is realized by acting on the telescope kinematics. This is equivalent to a *preset*.

[INFO- **Non-Speaking Number**

INS/ELT-26] In this context a unique number identifying a requirement that has no additional information encoded into it beyond its uniqueness.

[INFO- **Normal Power**

INS/ELT-27] Electrical power supplied by the SCP to support the normal operation of the SCP client. This power source may be subject to power-shedding or interruption.

[INFO- **Offsetting**

INS/ELT-28] In the context of telescope kinematics, the process by way of which the pointing of the telescope is incrementally changed from one sky position to a nearby one. The E-ELT telescope will realise all offsets larger than a small fraction of an arc second by acting on the telescope kinematics.

[INFO- **Plate Scale**

INS/ELT-29] The conversion factor between on-sky angular distances and on-detector linear scales. The concept assumes that the underlying relation is linear, and plate scale is usually given in arc seconds (on-sky) per mm (on-detector). In practice, optical distortion is rarely zero and, depending on the desired level of fidelity, the transformation of object into image coordinates



may require a polynomial expansion (with odd exponents only). In anamorphic systems, distortion may also vary differently along different axes of the image surface.

[INFO- **Pointing**
INS/ELT-
30] The actual direction the telescope is pointing (on-axis direction, defined by sky coordinates of the projection of the origin of the as-built coordinates system at the focus of the telescope).

[INFO- **Pointing Error**
INS/ELT-
31] The difference between actual and required pointing.

[INFO- **Power Shedding**. A strategy for managing the scenario where the available normal power is
INS/ELT- lower than its nominal value. According to this strategy some or all SCP clients within the
32] observatory are required to reduce their "normal" electrical power consumption to a specified value.

[INFO- **Preset**. A preset is defined as a change in the telescope pointing by an angle larger than 60
INS/ELT- arcsec on sky, i.e., larger than 60 arcsec in altitude and 56.4 arcsec in azimuth.
33]

[INFO- **Pupil Compression**. The ratio of the diameters of the entrance and exit pupils.
INS/ELT-
34]

[INFO- **Repeatability**
INS/ELT-
35] The degree to which a characteristic of the system exhibits the same values under the same conditions. This is also known as reproducibility.

[INFO- **Rigid Body Motion (RBM)** of a set of attachment points of an instrument refers to the motion of
INS/ELT- the set of attachment points of the Nasmyth platform which supports a single instrument,
507] assuming this set of points as a rigid body, without local deformations.

[INFO- **Safety Power**
INS/ELT-
36] The only source of electrical power that will remain active under all circumstances e.g. a failure of the external observatory power supply. The purpose of this power source is to supply loads that require continuous electrical supply to ensure the safety of personnel and critical equipment.

[INFO- **Seeing**
INS/ELT-
37] Atmospheric seeing is the integrated, long-exposure effect of the atmospheric optical turbulence across the line of sight. When using Fried's model of free atmospheric seeing it is defined as $\text{seeing} = 0.98 \times \lambda / r_0$ where λ is the optical wavelength and r_0 is the atmospheric coherence length. Unless otherwise stated, seeing values in this document refer to those measured by the observatory astronomical site monitor at zenith and referenced to a wavelength of 0.5 microns.



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[INFO- **Seeing Limited**
INS/ELT-
38] A mode of telescope operation in which the blind and LOO control of the telescope is complemented by an additional field stabilisation correction using the wavefront error signal from the telescope Natural Guide Star probes and correcting with the M4 adaptive mirror and the M5 fast tip-tilt mirror.

[INFO- **Stray Light** is light reaching the telescope focal plane either directly or after reflection or
INS/ELT- scattering from any combination of the telescope surfaces via paths not intended by the
39] telescope design. It includes light originating from the observed celestial source, and from other sources within and outside the telescope field of view.

[INFO- **Telescope**
INS/ELT-
40] For the purposes of this interface requirement specification, Telescope shall mean the main structure equipped with all supplies and hosted units with the exception of the instruments.

[INFO- **Tracking**
INS/ELT-
41] The kinematic function through which the telescope pointing is dynamically changed to follow a reference. The reference can be a look up table or metrology (see for example blind alignment above) or the reference could be a guide star in which case the term "Guiding" is used (see separate definition above).

3. General and System Interface Characteristics

[INFO-INS/ELT-
59] This document concerns the interface between the E-ELT System and the Instruments on the Nasmyth platforms. Figure 1 shows an artists impression of the E-ELT telescope including the Nasmyth platforms (denoted 'Instrument Platforms' in the figure) including notional volumes for the instruments.

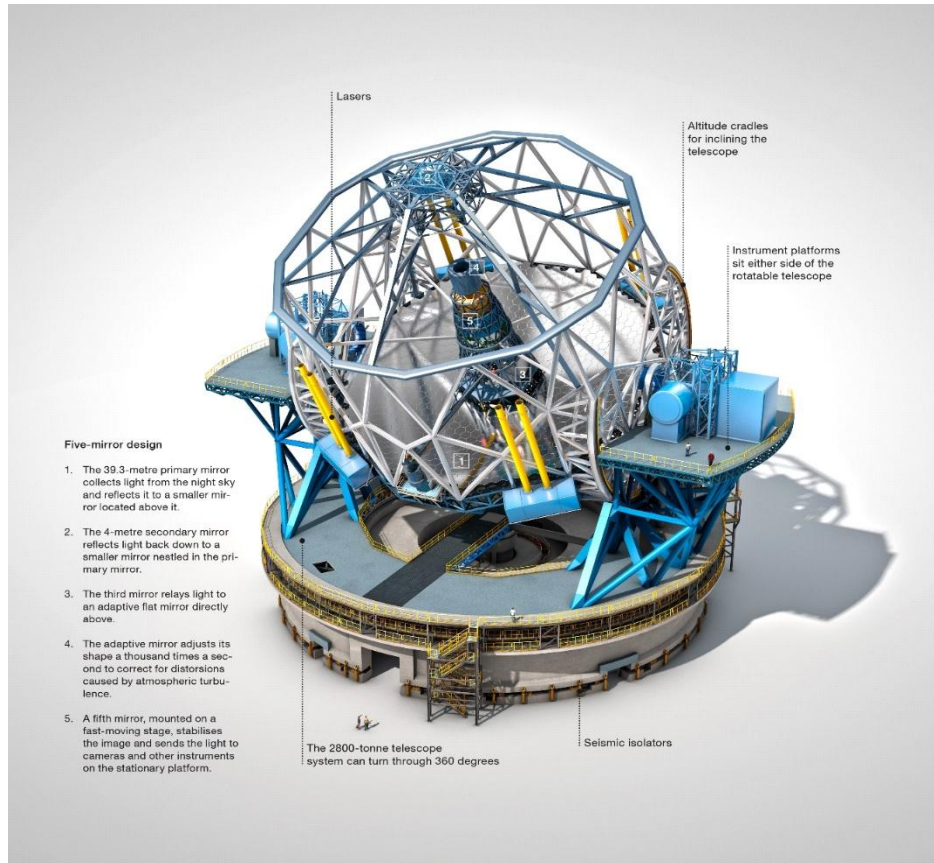


Figure 1: Artists impression of the E-ELT Telescope

3.1. Overall Optical Design

INFO-INS/ELT-61] The optical solution for the E-ELT is a folded anastigmat, in a Nasmyth configuration. The zemax design file for the nominal prescription is given in the Appendix to this document.

[I-INS/ELT-62] In this configuration, the beams shall exit the telescope after reflection on two folding flats (M4 and M5), straight towards the Nasmyth focus - see Figure 2. The M5 mirror may be deployed in one of two configurations to direct the output beam to either of the two Nasmyth platforms.
///



[INFO-INS/ELT-63]

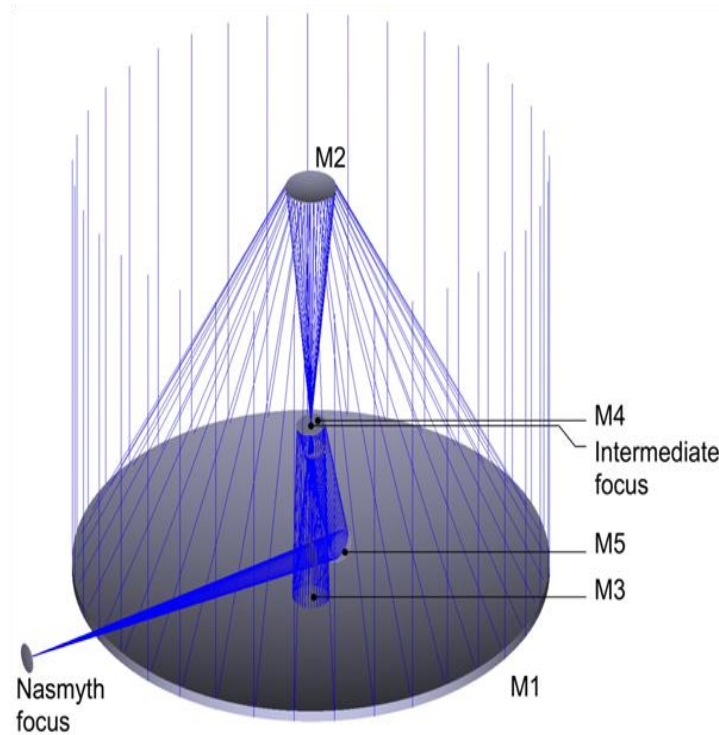


Figure 2. EELT optical solution, Nasmyth foci.

[I-INS/ELT-64] In addition to the straight through Nasmyth focus, the telescope shall provide lateral focus configurations on each Nasmyth platform. In the lateral focus configuration a subset of the field is intercepted by means of a 45 degree folding flat mirror and sent sideways to the Nasmyth foci. There are two lateral Nasmyth foci per Nasmyth platform Telescope Kinematics.

3.2. Telescope Kinematics

3.2.1. Range of Motion

[I-INS/ELT-67] During science observation the telescope shall allow for the following motion range:
///

- Azimuth: -270 to +270deg from the geographical East (or -180 to +360deg from South)
- Altitude: +20 to +88.5deg from the horizon (1.5deg radius blind spot at zenith)

[I-INS/ELT-68] Outside science observation, the telescope shall allow for the following motion range:
///

- Azimuth: -270 to +270deg from the geographical East (or -180 to +360deg from South).
- Altitude: 0 to +90deg from the horizon



3.2.2. Maximum Operational Velocity and Acceleration

[I-INS/ELT-70] The Altitude and Azimuth axes, when fully equipped (or with equivalent dummy masses) shall be able to rotate simultaneously and independently with velocities:
///

- Azimuth from -2 to +2deg/s
- Altitude from -1 to +1deg/s

[I-INS/ELT-71] The Altitude and Azimuth axes shall be able to rotate simultaneously and independently with accelerations anywhere on each axis in the range -0.1 to +0.1deg/s².
///

[I-INS/ELT-72] The maximum deceleration of the telescope during braking shall not exceed 2deg/s² in Azimuth and 10deg/s² in Altitude.
///

4. Mechanical Interface

4.1. Definitions and Conventions

[I-INS/ELT-229] All dimensions in AD7 are valid at 20°C.
///

[I-INS/ELT-230] The geometry of the interface areas defined in the interface drawings shall be understood as applicable under nominal gravity load when the telescope is pointing to Zenith ($\pm 2^\circ$).
///

[I-INS/ELT-231] Displacements of the interface flanges supporting the Nasmyth instruments are expressed in the Azimuth coordinate system.
///

[I-INS/ELT-497] The mean displacements of the instrument attachment points given in the subsequent sections shall be understood as the best fit rigid body motion of the (equally weighted) Nasmyth Plattform interface points of each instrument (for a certain load case). The peak-to-valley displacement numbers defined are the maximum minus minimum of these displacements considering all possible load cases relevant for the requirement.
///



4.2. Design Volume

- [INFO-INS/ELT-233] The design volume allocated to individual instruments will be specified in the corresponding instrument technical specification.
- [I-INS/ELT-234] No element of a Nasmyth Instrument shall extend beyond its design volume.
D/A/I/
- [I-INS/ELT-235] The requirements for design volumes shall be valid in any operational configurations and any survival conditions (earthquake loads, wind load, etc.).
D/A/ /
- [I-INS/ELT-236] With the exception of specifically designated access paths, the requirements for design volumes shall apply during installation and removal of the instrument and during maintenance.
D/ /I/
- [I-INS/ELT-237] The interface areas on the Nasmyth platform shall be assumed rigid when verifying that internal deflection of each Nasmyth Instrument under loads will not violate its design volume constraint.
/A/ /

4.3. Mounting Interface

4.3.1. Mounting Interface Location

- [I-INS/ELT-240] The Main Structure subsystem shall use the mounting interface provided by the Telescope defined in AD6. The attachment points allocated to each specific instrument will be specified in the corresponding instrument technical specification.
D/ /I/
- [I-INS/ELT-241] The attachment points shall be provided by the Telescope.
/ / /
- [I-INS/ELT-498] If it is required by an instrument and if it is demonstrated by design that it will be advantageous for the system, additional support points can be provided by ESO at intermediate positions beyond the ones defined in AD6
D/ /I/
- The possible allowed positions and the design of these additional support points wrt the nominal ones is defined in RD1.
- The exact position on where additional support points shall be placed as well as their respective performance shall be agreed with ESO for each instrument on a case by case basis, see also RD2.
- [I-INS/ELT-242] With the exception of any infrastructure specified in this document (e.g. dome crane), the mounting mechanisms and adjusting devices to place the Nasmyth instruments at their nominal position shall be defined and provided by the instruments.
D/ /I/
- [I-INS/ELT-243] The absolute and combined motion specified below may occur independently or in combination.
/ / /



4.3.2. Load Handling Capacity and Stiffness

[I-INS/ELT-245] D/A/ / The force exerted by any of the Nasmyth instruments on any attachment point defined in [AD6] shall not exceed a maximum load of:

- Force: 500 kN in the X_{Az} and Y_{Az} directions
- Force: 1000 kN tensile and 1250 kN compression in the Z_{Az} directions

this shall apply in any operational configuration and any survival condition (NCR, earthquake loads, wind load, etc.).

The flanges shall be loaded with the forces directed to the centre of the flanges in order to avoid local moments. The maximum eccentricity of loads as defined in EN 1998-1-8 section 2.7 shall be <10% of the width of the flange.

For the calculation of the forces on the flanges a safety factor $SF=1.3^1$ shall be considered in all load cases, including survival and accidental load cases. This safety factor shall be considered in lieu of the safety factor for allowable stress and material safety factor defined in ESO Engineering Analysis Standard (ESO-191462), those do not apply for the calculation of the support force.

[I-INS/ELT-246] /// The minimum local attachment point stiffness of the interface flanges defined in [AD6] shall be at least:

- $\geq 300 \times 10^6 \text{N/m}$ for $k_x (=F_x/u_x)$ and $k_y (=F_y/u_y)$ in Zone A, and $\geq 200 \times 10^6 \text{N/m}$ in Zone B
- $\geq 300 \times 10^6 \text{N/m}$ for $k_z (=F_z/u_z)$ in zone A and $\geq 150 \times 10^6 \text{N/m}$ in zone B.

Zone A is the main part of the Nasmyth platform.

Zone B corresponds to the outer 13 auxiliary interface flanges.

4.3.3. Attachment Point Displacements During Loading and Unloading

[INFO-INS/ELT-248] The displacement of the instrument attachment points during loading and unloading are specified here as *absolute* motion in the Azimuth coordinate system [AD1].

[I-INS/ELT-249] /// When an instrument is mounted onto (or removed from) the Nasmyth platform, the peak-to-valley Rigid Body Motion (RBM) of the whole set of attachment points supporting the same Nasmyth instrument shall be no larger than the values given in the table below:

Motion	Value	Unit
Displacement X	2.5	mm
Displacement Y	0.25	mm

¹ This requirement has been flown down from the AD8, but the accepted and agreed value as per CRE N°ET-851 is 1.3 instead of 1.5



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Displacement Z	2.5	mm
Rotation X	0.025	mrاد
Rotation Y	0.075	mrاد
Rotation Z	0.025	mrاد

Table 8: Nasmyth Attachment Point Displacement Instrument Loading



[I-INS/ELT-250] The peak-to-valley RBM of the whole set of attachment points supporting one Nasmyth Instrument due to the weight of any other single instrument being mounted onto (or removed from) the Nasmyth platform shall be no larger than:
 ///

Motion	Value	Unit
Displacement X	2.5	mm
Displacement Y	0.5	mm
Displacement Z	2.5	mm
Rotation X	0.175	mrاد
Rotation Y	0.175	mrاد
Rotation Z	0.025	mrاد

Table 9: Nasmyth Attachment Points Displacement Cross Coupling During Instrument Loading

4.3.4. Structural Deflection and Stability Under Operational Conditions

[INFO-INS/ELT-252] The Rigid Body Motion (RBM) of the instrument and PFS attachment points are specified here as *absolute* motion in the Azimuth coordinate system [AD1]. On the straight through focus X is parallel to the direction of light propagation. On the lateral focus, Y is parallel to the direction of light propagation.

[I-INS/ELT-253] The peak-to-valley RBM displacement of the whole set of attachment points supporting the PFS and instruments under all operational conditions shall not exceed the values in the table below. A uniform thermal expansion of the Telescope Main Structure (and the hosted units) with a uniform Coefficient of Thermal Expansion less than or equal to $12.5 \times 10^{-6} \text{K}^{-1}$ has been subtracted from the deformations.

Motion	Value	Unit
Displacement X	5	mm
Displacement Y	2.5	mm
Displacement Z	2.5	mm
Rotation X	0.25	mrاد
Rotation Y	0.25	mrاد
Rotation Z	0.25	mrاد

Table 10: Limits of Absolute Rigid Body Motions of Nasmyth Instruments



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[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 derives from AD9 and supersedes the [I-INS/ELT-253].

	Ux [mm]	Uy [mm]	Uz [mm]	Rotx [urad]	Roty [urad]	Rotz [urad]
Micado	3	1.5	2	100	170	100
Morfeo	3	1.5	2	100	170	100
Morfeo-Micado	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-INS/ELT-254] The repeatability of the RBM of the whole set of attachment points supporting a Nasmyth instrument due to structural hysteresis shall be limited to less than the values shown in table below.
///

Motion	Value	Unit
Displacement X	0.5	mm
Displacement Y	0.25	mm
Displacement Z	0.25	mm
Rotation X	0.025	mrad
Rotation Y	0.025	mrad
Rotation Z	0.025	mrad

Table 11: Repeatability of Absolute Rigid Body Motion of Nasmyth Instruments

[I-INS/ELT-499] For any instrument installed on the Nasmyth platform, the maximum quasi-static peak-to-valley displacement under operational conditions of any individual attachment point on the Nasmyth platform wrt the RBM of the complete set of attachment points corresponding to the same instrument shall not exceed the following values:
///

☐ For instruments supported on a <6x6m footprint: Ux=0.2mm; Uy=0.2mm; Uz=0.3mm

☐ For instruments supported on a <10x10m footprint: Ux=0.2mm; Uy=0.2mm; Uz=0.6mm

This requirement is defined for nominal attachment points defined in [AD.5]. Maximum displacements for additional support points (Section 7.3.1) shall be evaluated in a case by case basis.



[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 derives from AD9 and supersedes [I-INS/ELT-499].

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

Differential flange deformations (in units of microns = [10⁻⁶ m])

4.3.5. Combined Motion Under Operational Conditions

[INFO-INS/ELT-256] The combined motion of the instrument attachment points relative to the focal plane is specified under operational conditions in the Azimuth coordinate system [AD1].

[I-INS/ELT-257] The quasi-static peak-to-valley RBM of the whole set of attachment points supporting a Nasmyth instrument under operational conditions at the straight through focus relative to the focal plane shall not exceed the values in the table below. A uniform thermal expansion of the Telescope Main Structure (and the hosted units) with a uniform Coefficient of Thermal Expansion less than or equal to 12.5x10⁻⁶K⁻¹ has been subtracted from the deformations.
 ///

Motion	Value	Unit
Displacement X	1.5	mm
Displacement Y	1.5	mm
Displacement Z	1.5	mm
Rotation X	0.05	mrad
Rotation Y	0.05	mrad
Rotation Z	0.05	mrad

Table 12: Quasi-static displacement of the Nasmyth instrument attachment points relative to the straight through focal plane

[I-INS/ELT-258] The quasi-static peak-to-valley RBM of the whole set of attachment points supporting a Nasmyth instrument under operational conditions on a lateral focus relative to the focal plane shall not exceed the values in the table below. A uniform thermal expansion of the Telescope Main
 ///



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Structure (and the hosted units) with a uniform Coefficient of Thermal Expansion less than or equal to $12.5 \times 10^{-6} \text{K}^{-1}$ has been subtracted from the deformations.

Motion	Value	Unit
Displacement X	4.00	mm
Displacement Y	5.00	mm
Displacement Z	2.00	mm
Rotation X	0.40	mrad
Rotation Y	0.10	mrad
Rotation Z	0.35	mrad

Table 13: Quasi-static displacement of the Nasmyth instrument attachment points relative to the lateral focal plane



4.4. Accessibility

4.4.1. Access Categories

- [I-INS/ELT-261] For the definition of the access parameters needed for the tasks on equipment installed by ESO or other Contractors, the following access categories are defined:
///
- [I-INS/ELT-262] a. Access Category A: Man-lift Access
- [I-INS/ELT-263] This access solution shall bring persons and material to the specified locations with the use of an aerial work platform.
///
- [I-INS/ELT-264] The basket(s) of man-lift(s) shall provide a minimum floor space of 2m x 1m.
///
- [I-INS/ELT-265] The load in the basket shall be up to 400kg and allow the presence of 2 persons and 200kg of tools or materials.
///
- [I-INS/ELT-266] The transfer of persons from the basket to other platforms or locations shall not be foreseen for the normal operation.
///
- [I-INS/ELT-267] For emergency cases a procedure shall be provided which allows one person to leave the basket and transfer to another location on the Dome or Telescope or suitable ESO equipment in a safe manner.
///
- [I-INS/ELT-268] A procedure for the hand-out of material between persons in the man-lift basket and persons on other suitable locations shall be provided.
///
- [I-INS/ELT-269] The positioning system of the man-lift shall be precise enough to safely move as close as 0.2m to a location or surface where work needs to be done without the danger of contact between the man-lift and other structures.
///
- [I-INS/ELT-270] The access solution shall serve as a rescue facility for persons who need to be rescued from locations on the Telescope or the Dome. This includes the rescue of persons which have been saved by fall protection systems.
///
- [I-INS/ELT-271] The boarding location for the basket shall be reachable via Access Category C.
///
- [I-INS/ELT-272] b. Access Category B: Ladder Access
- [I-INS/ELT-273] This access solution shall bring persons and material to the specified locations via ladders or a combination of ladders and walkways.
///
- [I-INS/ELT-274] Access ladders shall comply with EN ISO 14122-4 Safety of machinery - Permanent means of access to machinery - Part 4: Fixed ladders.
///
- [I-INS/ELT-275] The access solutions shall bring one or up to three persons subsequently to the specified location.
///



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- [I-INS/ELT-276] The persons using the access solution shall be able to carry small tools or materials in secure pockets or backpacks with a maximum weight of 10 kg and maximum volume of 5l.
///
- [I-INS/ELT-277] Enough resting positions shall be foreseen in case of long ascents, also considering the high altitude of the ELT site.
///
- [I-INS/ELT-278] Access walkways shall have a minimum clear width of 600mm and a minimum clear height of 2m.
///
- [I-INS/ELT-279] Access walkways shall support safely 3 persons standing close to each other in any location.
///
- [I-INS/ELT-280] Fall protection shall be installed according to European industrial safety regulations.
///
- [I-INS/ELT-281] The access solutions shall consider that persons use protective clothing for cold weather and working gloves.
///
- [I-INS/ELT-282] The terminals of the routes covered by Access category B shall be reachable via Access Category C.
///
- [I-INS/ELT-283] c. Access Category C: Stair Access
///
- [I-INS/ELT-284] This access solution shall bring persons and material to the specified locations via stairs, walkways, elevators or a combination of them.
///
- [I-INS/ELT-285] The access solution shall allow 2 persons walking side-by side and/or carrying goods in boxes or other suitable containers up to the ergonomic weight limits for 2 persons.
///
- [I-INS/ELT-286] The access solution shall allow the use of barrows with loads of 120kg weight and a size up to 1.0m x 0.9m x 2.0m (LxWxH).
///
- [I-INS/ELT-287] Accesses in the C Category shall have a minimum clear width of 1200mm and a minimum clear height of 2.2m.
///
- [I-INS/ELT-288] Doors in the access walkways shall have a minimum clear width of 1000 mm and a clear height of 2m.
///
- [I-INS/ELT-289] d. Access Category D: Elevator Access
///
- [I-INS/ELT-290] This access solution shall bring persons and material to the specified locations via walkways and elevators or a combination of them.
///
- [I-INS/ELT-291] The access solution shall allow 2 persons walking side-by side and/or carrying goods in boxes or other suitable containers up to the ergonomic weight limits for 2 persons.
///
- [I-INS/ELT-292] The access solution shall allow the use of pallet trucks or other wheeled carriages with loads up to 2000kg weight and a size up to 2.0m x 1.2m x 2.0m (LxWxH) including the carriage.
///
- [I-INS/ELT-293] Doors in the access walkways or into elevators shall have a minimum clear width of 1500mm and a minimum clear height of 2.2m.
///



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[I-INS/ELT-294] e. Access Category E: Scaffolding access
///

[I-INS/ELT-295] This access solution shall bring persons and material to the specified locations via temporarily
/// erected scaffolding.

[I-INS/ELT-296] Scaffoldings shall comply with all parts of EN 12810 Façade scaffolds made of prefabricated
/// components and EN 12811 Temporary works equipment, All parts.

[I-INS/ELT-297] Scaffoldings shall have a minimum width of 0.9m and support safely a distributed load of
/// 4.5kN/m².

[I-INS/ELT-298] The access according to the above categories shall be possible during anytime compatible with
/// the safety requirements, at daytime and night-time, with the dome closed and with the MS in
the configuration specified.

4.4.2. Accessibility Requirements

[I-INS/ELT-300] Access to the Nasmyth Instruments shall be for the following purposes:
D/ I/

- installation and deinstallation
- commissioning
- maintenance (preventive and corrective)

[I-INS/ELT-301] Access to the Nasmyth Instruments and PFS for personnel shall be via the Nasmyth platform
///

[I-INS/ELT-302] An elevator and stairway shall allow access to the Nasmyth platforms from the dome transit ring.
///

[I-INS/ELT-303] For installation and deinstallation, the Nasmyth Instruments shall be lifted onto the Nasmyth
/// platform using the Nasmyth Platform Crane. The telescope shall provide a clear path for handling
and installation.

[I-INS/ELT-304] For maintenance it may be necessary to remove and reinstall subsystems of the Nasmyth
/// Instruments using the Nasmyth Platform Crane. Representative dimensions for such a subsystem
(including the handling tool) are W4m x L4m x H4m. The telescope shall provide a clear path for
handling. Characteristics of the handling crane are given in a later section of this document.

[I-INS/ELT-305] The Nasmyth Instruments shall provide interfaces consistent with the above accessibility
D/ I/ requirements (e.g. attachment points for lifting equipment)



4.5. Vibrations and Acoustic Noise

[I-INS/ELT-309] Under the following conditions:
///

- observation Alt/Az motion ranges,
- primary environmental conditions (excluding wind inside Dome but assuming wind load on Dome structure, i.e. Dome closed),
- Telescope Main Structure tracking,
- Dome tracking synchronously with the Telescope Main Structure,
- Air conditioning 'off',
- Cooling liquid running with nominal rates,
- ambient ground or environmental vibration levels,
- hosted units in observing mode

the level of vibration produced by the telescope at the interface with the Nasmyth Instruments shall not exceed the values specified in the table below. The vibration levels are specified as an RMS [$\mu\text{m/s}$] velocity per one-third octave frequency bands in the frequency ranges indicated in the table below.

Unit	Frequency Range (Hz)		
	1-4.45	4.45-56	56-110
Nasmyth Instruments Vibrations (RMS [$\mu\text{m/s}$])	3	1	3

Table 14: Maximum RMS velocity [$\mu\text{m/s}$] per one-third octave frequency bands for different frequency ranges induced by the Telescope

5. Instrument Assembly and Installation

[INFO-INS/ELT-356] The characteristics of the following facilities that might be used by an instrument throughout its life cycle are given in this section:



- E-ELT Auxiliary Building Entrance Hall
- E-ELT Auxiliary Building Instrument Assembly Area
- E-ELT Dome Main Transit Ring
- E-ELT Telescope Nasmyth Platform
- Paranal New Integration Hall

Note that facilities will be allocated on an instrument-specific basis.

5.1. Areas within the E-ELT Dome

5.1.1. Entrance Hall

Location and Access

[I-INS/ELT-360] This is the area within the Auxiliary Building of the E-ELT Dome at Armazones where instruments will be unloaded after transportation and prepared before moving them into the clean IAA and the dome areas.
///

[I-INS/ELT-361] The clear cross-section of the access between the outside world and the Entrance Hall shall measure at least 10m x 7.5m (wxh).
///

Use and Function

[I-INS/ELT-363] The Entrance Hall shall be, as a minimum, 32mx10mx8m (lxwxh) in size.
///

[I-INS/ELT-364] The floor of the Entrance Hall shall be capable of transiting a forklift class FL6 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1
///

[I-INS/ELT-365] The floor loading capacity of the Entrance Hall shall be classed as Category G as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1
///

Handling Equipment

[I-INS/ELT-367] The Entrance Hall shall be equipped with an overhead travelling crane which covers the whole specified area except for the last 2.5m from the walls.
///

[I-INS/ELT-368] The Entrance Hall crane shall provide two crabs with a single hook, each with a capacity of 10 tonnes, and a hoist height from the floor to 7m above floor level.
///

[I-INS/ELT-369] Parallel and also independent operation of both crabs and hooks shall be possible.
///



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[I-INS/ELT-370] The crane shall have a load indication with a minimum accuracy of 2% of the maximum load with remote readout.
///

[I-INS/ELT-371] The lateral speed shall be adjustable from 9mm/sec to 80mm/sec and will allow a minimum step of 2mm.
///

[I-INS/ELT-372] The vertical speed shall be adjustable from 1mm/sec to 50mm/sec and will allow a minimum step of 0.5mm.
///

Services

[INFO-INS/ELT-374] The Entrance Hall shall be equipped with Service Connection Points Parts A2-B-C as defined in AD5.

[I-INS/ELT-375] The Entrance Hall shall be equipped with a hot and cold water supply
///

[I-INS/ELT-376] The Entrance Hall shall be equipped with a drainage connection.
///

[I-INS/ELT-377] The Entrance Hall shall be equipped with two standard compressed air supply points.
///

[I-INS/ELT-378] The Entrance Hall shall be equipped with 15x 230V (16A) electrical sockets.
///

[I-INS/ELT-379] The Entrance Hall shall be equipped with a single telephone socket.
///

[I-INS/ELT-380] The Entrance Hall shall be equipped with 8x RJ45 outlets.
///

[I-INS/ELT-381] The illumination level of the Entrance Hall shall be 500 Lux.
///



5.1.2. Instrumentation Assembly Area

Location and Access

[I-INS/ELT-384] This is the area within the Auxiliary Building of the E-ELT Dome at Armazones where an instrument can be assembled and test before integration on the Telescope. This area includes:
///

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

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

[I-INS/ELT-385] The Instrumentation Assembly Area shall be connected to the Entrance Hall via an access path having a clear cross-section of at least 10x7.5m (wxh).
///

[I-INS/ELT-386] The Instrumentation Assembly Area shall be connected to the Instrument Assembly Area Auxiliary Room via an access path having a clear cross-section of at least 2x2.5m (wxh).
///

[I-INS/ELT-387] The Instrumentation Assembly Area shall be connected to the Instrument Electronics Maintenance Area via an access path having a clear cross-section of at least 2x2.5m (wxh).
///

Use and Function

[I-INS/ELT-389] The volume available to instruments within the Instrumentation Assembly Area shall be, as a minimum, 22x10x8m (lxwxh) in size.
///

[I-INS/ELT-390] The floor of the Instrumentation Assembly Area shall be capable of transiting a forklift class FL6 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1
///

[I-INS/ELT-391] The floor loading capacity of the Instrumentation Assembly Area shall be classed as Category E2 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1
///

[I-INS/ELT-394] The instrument assembly area shall be equipped to reach ISO class 8 (100,000) cleanliness.
///

[I-INS/ELT-395] The Instrumentation Assembly Area Auxiliary Room shall be, as a minimum, 6x5x3m (wxlxh) in size.
///

[I-INS/ELT-396] The Instrumentation Electronics Maintenance Area shall have a floor area of at least 30 square metres.
///



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Handling Equipment

- [I-INS/ELT-398] The Instrumentation Assembly Area shall be equipped with an overhead travelling crane which covers the whole specified area except for the last 2.5m from the walls.
///
- [I-INS/ELT-399] The Instrumentation Assembly Area crane shall provide a bridge crane with two hooks, each with a capacity of 12 tonnes, and a hoist height from the floor to 7.5m above floor level.
///
- [I-INS/ELT-400] The lateral speed shall be adjustable from 9mm/sec to 80mm/sec and will allow a minimum step of 2mm.
///
- [I-INS/ELT-401] The vertical speed shall be adjustable from 1mm/sec to 50mm/sec and will allow a minimum step of 0.5mm.
///

Services

- [I-INS/ELT-403] The Instrumentation Assembly Area shall be equipped with 2 Service Connection Points Parts A2-B-C as defined in AD4.
///
- [I-INS/ELT-404] The Instrumentation Assembly Area shall be equipped with a supply of cryogenic fluids as specified in #340,#341 and #342.
///
- [I-INS/ELT-405] The Instrumentation Assembly Area shall be equipped with a hot and cold water supply and drainage connection.
///
- [I-INS/ELT-406] The Instrumentation Assembly Area shall be equipped with two standard compressed air supply points.
///
- [I-INS/ELT-407] The Instrumentation Assembly Area shall be equipped with 15 x 230V (16A) electrical sockets, 5 x 230V (16A) Safety Power Sockets and 5 x 400V (32A/phase) electrical sockets.
///
- [I-INS/ELT-408] The Instrumentation Assembly Area shall be equipped with 2x telephone sockets.
///
- [I-INS/ELT-409] The Instrumentation Assembly Area shall be equipped with 8x RJ45 outlets.
///
- [I-INS/ELT-410] The illumination level of the Instrumentation Assembly Area shall be 750 Lux.
///
- [I-INS/ELT-411] The Instrumentation Electronics Maintenance Area shall be equipped with a Service Connection Point Parts A2-B-C as defined in AD4.
///



5.1.3. Main Transit Ring

Location and Access

- [I-INS/ELT-414] This is the area between the Telescope Pier and the Dome Foundation. It shall permit the hosted units to be manoeuvred into a position where they can be accessed by the Dome cranes.
///
- [I-INS/ELT-415] The Main Transit Ring shall be connected to the Entrance Hall as well as various other functional rooms within the Auxiliary Building of the Dome.
///
- [I-INS/ELT-416] The access path between the Main Transit Ring and the Entrance Hall shall have a clear cross-section of at least 10mx7.5m (wxh).
///

Use and Function

- [I-INS/ELT-418] The floor of the Main Transit Ring shall be capable of transiting a forklift class FL6 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1.
///
- [I-INS/ELT-419] The floor loading capacity of the Main Transit Ring shall be classed as Category E2 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1.
///
- [I-INS/ELT-420] The floor of the Main transit ring in the dome shall be designed for a rubber tired vehicle with a total weight of 30 tonnes and supported on 4 wheel pairs spaced minimum 3m x 3m.
///

Handling Equipment

- [INFO-INS/ELT-422] The characteristics of the Nasmyth platform crane are given in the corresponding section later in this document.

Services

- [I-INS/ELT-424] The Main Transit Ring shall be equipped with 4 Service Connection Points Parts A2-B-C as defined in AD4.
///
- [I-INS/ELT-425] The Main Transit Ring shall be equipped with a drainage connection.
///
- [I-INS/ELT-426] The Main Transit Ring shall be equipped with a 230V double Socket every 10 to 15m on both the Telescope Pier wall and Dome Foundation Wall.
///
- [I-INS/ELT-427] The Main Transit Ring shall be equipped with a 400V 32A CEE 5 pole socket every 10 to 15m on both the Telescope Pier wall and Dome Foundation Wall.
///
- [I-INS/ELT-428] The Main Transit Ring shall be equipped with 4x telephone sockets equispaced around the circumference.
///



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- [I-INS/ELT-429] The Main Transit Ring shall be equipped with 12x RJ45 outlets equispaced around the circumference.
///
- [I-INS/ELT-430] The general illumination of the Telescope Chamber shall deliver a lighting level of 200lux measured at the level of the floor except in those areas where maintenance is required where the lighting level is of 300lux. Where specialized maintenance activities are expected, the task lighting level will be determined by the maintainability analysis.
///
- [I-INS/ELT-431] In case of power outage, the emergency lighting and signage shall be automatically and immediately activated. All the devices shall have battery support for 1.5h in case of total power blackout.
///
- [I-INS/ELT-432] It shall be possible to switch off completely all (non-emergency) lighting equipment locally, or in a centralised manner.
///

5.1.4. Nasmyth Platform

Location and Access

- [INFO-INS/ELT-435] The Nasmyth Platforms are located on the either side of the Azimuth Structure of the telescope Main Structure.
- [INFO-INS/ELT-436] The floor of the Nasmyth Platforms are at a height of 27m above the floor of the Main Transit Ring.
- [I-INS/ELT-437] An access category D (elevator access) shall be provided for both Nasmyth platforms.
///
- [I-INS/ELT-438] In addition, an access category C (stair) shall be provided for both Nasmyth platforms.
///
- [I-INS/ELT-439] An access category A shall be provided for the circumference of both Nasmyth Platforms.
///
- [I-INS/ELT-440] A category A access shall bring persons and material to the specified locations with the use of an aerial work platform.
///

Use and Function

- [I-INS/ELT-442] The floors of the Nasmyth Platforms shall be capable of transiting a forklift class FL3 as according to section 6.3 of EN 1991-1-1:2002 Eurocode 1.
///

This value defines also the maximum floor capacity for concentrated loads.

For the estimation of the allowable exerted load a safety factor SF=1.5 shall be considered in all load cases, including survival and accidental load cases. This safety



factor shall be considered in lieu of the safety factor for allowable stress and material safety factor defined in ESO Engineering Analysis Standard (ESO-191462), those do not apply for the calculation of the exerted load.

[I-INS/ELT-443] The floor loading capacity of the Nasmyth Platforms shall be $q_k=10\,000\text{ N/m}^2$ as
/// according to section 6.3 of EN 1991-1-1:2002 Eurocode 1.

For the estimation of the allowable exerted load a safety factor $SF=1.5$ shall be considered in all load cases, including survival and accidental load cases. This safety factor shall be considered in lieu of the safety factor for allowable stress and material safety factor defined in ESO Engineering Analysis Standard (ESO-191462), those do not apply for the calculation of the exerted load.

Handling Equipment

[I-INS/ELT-445] The Dome shall provides a crane with a single crane hook which can move loads
/// between the Nasmyth platform and the Main Transit Ring when the Telescope is parked in zenith and in horizon pointing.

[I-INS/ELT-446] The crane range shall cover the complete area of both Nasmyth platforms.
///

[I-INS/ELT-447] The capacity of the crane shall be at least 20 tonnes.
///

[I-INS/ELT-448] The crane shall have a load indication with a minimum accuracy of 2% of the maximum
/// load with remote readout.

[I-INS/ELT-449] The crane hook shall be capable of being placed at any height from 0 to 15m above the
/// surface of the Nasmyth platforms or the main Transit Ring up to a radius of 29m measured from the Azimuth axis. Beyond this radius and up to the edge of the Nasmyth platforms, the height can be reduced linearly from 15m down to 12m, between 29m radius and 32.4 m radius.

[I-INS/ELT-451] Load attachment shall be with commercial slings with an angle between slings of
/// maximum 45deg..

[I-INS/ELT-452] The transport route shall allow the passage of a volume of 7x7x6m (L x W x H).
///

[I-INS/ELT-453] The lateral adjustment shall allow a minimum step of 1cm and minimum speed of
/// 1cm/sec.

The vertical adjustment shall allow a minimum step of 1.5mm and a minimum speed of 2.5mm/s.

[I-INS/ELT-454] The crane drives shall be equipped with adjustable acceleration and deceleration ramps
/// which allow the adjustment of the acceleration and deceleration rates for a smooth start and stop of movements when delicate equipment like optics is handled. The acceleration



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or deceleration from stop to any speed in the given speed range is linearly adjustable in a range from 0.5s to 5s minimum.

[I-INS/ELT-455] The crane transfer time from the main transit ring to the Nasmyth platform shall be no longer than 10min.
///

Services

[I-INS/ELT-457] The Nasmyth Platforms shall be equipped with 5 Service Connection Points Parts A2-B-C on each platform.
///

[I-INS/ELT-458] The Nasmyth Platforms shall each be equipped with a drainage connection.
///

[I-INS/ELT-459] The Nasmyth Platforms shall be equipped with 2x telephone sockets per platform.
///

[I-INS/ELT-460] The Nasmyth Platforms shall each be equipped with 8x RJ45 outlets and WIFI Access.
///

[I-INS/ELT-461] The illumination level of the Nasmyth Platforms shall be 300 Lux.
///

5.2. General Handling Equipment

5.2.1. Internal Transporter

[I-INS/ELT-480] ESO shall provide a general transporter for use within the buildings of the E-ELT Dome
///

[I-INS/ELT-481] The internal transporter shall have a load carrying capacity of 20 tonnes.
///

[I-INS/ELT-482] The load carrying surface of the internal transporter shall measure 3m x 6m (lxw).
///

[I-INS/ELT-483] The height of the load carrying platform shall be adjustable in the range 0.8m - 1.0m
///

[I-INS/ELT-484] Objects being moved by the internal transporter shall be secured by means of commercially available cargo straps.
///

[I-INS/ELT-485] The internal transporter shall provide a number of attachment points for restraining straps.
///



Verification

[I-INS/ELT-487] D/// The interface characteristics defined in this ICD and identified for verification by the instrument shall be verified according to a verification plan to be agreed by ESO. This plan should take into account the suggested verification tag specified for the requirements.

[I-INS/ELT-488] /// The table below specifies which side of the ICD is responsible for verifying each requirement:

ID	Validator	ID	Validator	ID	Validator
43	ESO MS vendor	222	ESO	360	ESO
62	ESO	223	ESO	361	ESO
64	ESO	509	ESO	363	ESO
67	ESO	225	ESO	364	ESO
68	ESO MS vendor	226	ESO	365	ESO
70	ESO	229	ESO	367	ESO
71	ESO	230	ESO	368	ESO
72	ESO	231	ESO	369	ESO
78	ESO	497	ESO MS vendor	370	ESO
79	ESO	234	MS vendor	371	ESO
80	ESO	235	MS vendor	372	ESO
81	ESO	236	MS vendor	375	ESO
83	ESO	237	MS vendor	376	ESO
84	ESO	240	MS vendor	377	ESO
85	ESO	241	ESO	378	ESO
88	ESO	498	ESO MS vendor	379	ESO
89	ESO	242	MS vendor	380	ESO
90	ESO	243	ESO MS vendor	381	ESO



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91	ESO	245	MS vendor	384	ESO
92	ESO	246	ESO	385	ESO
93	ESO	249	ESO	386	ESO
518	ESO	250	ESO	387	ESO
94	ESO	253	ESO	389	ESO
96	ESO	254	ESO	390	ESO
100	ESO	499	ESO	391	ESO
102	ESO	257	ESO	394	ESO
103	ESO	258	ESO	395	ESO
106	ESO	261	ESO MS vendor	396	ESO
107	ESO	262	ESO MS vendor	398	ESO
109	ESO	263	ESO MS vendor	399	ESO
110	ESO	264	ESO MS vendor	400	ESO
115	ESO	265	ESO MS vendor	401	ESO
117	ESO	266	ESO MS vendor	403	ESO
118	ESO	267	ESO MS vendor	404	ESO
119	ESO	268	ESO MS vendor	405	ESO
120	ESO	269	ESO MS vendor	406	ESO
123	ESO	270	ESO MS vendor	407	ESO
125	ESO	271	ESO MS vendor	408	ESO
127	ESO	272	ESO MS vendor	409	ESO
129	ESO	273	ESO MS vendor	410	ESO
132	ESO	274	ESO MS vendor	411	ESO



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134	ESO	275	ESO MS vendor	414	ESO
136	ESO	276	ESO MS vendor	415	ESO
137	ESO	277	ESO MS vendor	416	ESO
138	ESO	278	ESO MS vendor	418	ESO
146	ESO	279	ESO MS vendor	419	ESO
150	ESO	280	ESO MS vendor	420	ESO
151	ESO	281	ESO MS vendor	424	ESO
153	ESO	282	ESO MS vendor	425	ESO
154	ESO	283	ESO MS vendor	426	ESO
155	ESO	284	ESO MS vendor	427	ESO
156	ESO	285	ESO MS vendor	428	ESO
157	ESO	286	ESO MS vendor	429	ESO
159	ESO	287	ESO MS vendor	430	ESO
160	ESO	288	ESO MS vendor	431	ESO
161	ESO	289	ESO MS vendor	432	ESO
163	ESO	290	ESO MS vendor	437	ESO
500	ESO	291	ESO MS vendor	438	ESO
501	ESO	292	ESO MS vendor	439	ESO
502	ESO	293	ESO MS vendor	440	ESO



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503	ESO	294	ESO MS vendor	442	ESO
170	ESO	295	ESO MS vendor	443	ESO
171	ESO	296	ESO MS vendor	445	ESO
173	ESO	297	ESO MS vendor	446	ESO
174	ESO	298	ESO MS vendor	447	ESO
504	ESO	300	ESO MS vendor	448	ESO
505	ESO	301	ESO	449	ESO
506	ESO	302	ESO	451	ESO
510	ESO	303	ESO MS vendor	452	ESO
511	ESO	304	ESO	453	ESO
512	ESO	305	MS vendor	454	ESO
176	ESO	309	ESO	455	ESO
177	ESO	312	ESO MS vendor	457	ESO
178	ESO	314	ESO MS vendor	458	ESO
181	ESO	316	ESO MS vendor	459	ESO
182	ESO	318	ESO MS vendor	460	ESO
183	ESO	321	MS vendor	461	ESO
184	ESO	322	ESO	464	ESO
185	ESO	325	MS vendor	465	ESO
186	ESO	326	MS vendor	466	ESO
514	ESO	327	MS vendor	467	ESO
515	ESO	328	MS vendor	468	ESO MS vendor
517	ESO MS vendor	330	ESO	469	ESO



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200	ESO	332	MS vendor	471	ESO
201	ESO	335	MS vendor	473	ESO
203	ESO	338	MS vendor	474	ESO
207	MS vendor	340	MS vendor	476	ESO
209	ESO MS vendor	341	ESO	477	ESO MS vendor
212	ESO	342	ESO MS vendor	480	ESO
213	ESO	345	ESO	481	ESO
214	ESO	346	ESO	482	ESO
215	ESO	348	MS vendor	483	ESO
216	ESO	350	ESO	484	ESO
217	ESO	351	ESO	485	ESO
219	ESO	352	ESO	487	MS vendor
220	ESO	353	MS vendor	488	ESO MS vendor
221	ESO	354	MS vendor		