SST Programme:
Factory AIT Plan

SST-AIT-PLA-011

Version 2b

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1 Introduction

1.1 Scope & Purpose

This document describes the SST AIT plan and procedures that shall be executed at the SST factory premises after the Production Phase of the SST Structures, Cameras and Optic. The scope of this activities is to demonstrate that the SST Telescope has been designed and built to satisfy the requirements of the project. After the positive conclusion of these activities the Telescope will be delivered to the CTAO Site where the SST telescope will be assembled, integrated and verified again.

The current version of the document includes the AIT plan and procedure related to the Mechanical Structure and the Optical Assembly. The next version of the document will include the full factory AIT plan.

In section 2 of the document, the factory assembly plan and procedures of the SST Telescope are illustrated.

In section 3, the factory verification and test plan is laid out.

In section 4, the disassembly of the TMS as required by the shipping strategy is described.

Finally, in section 5 safety warnings and rules to be observed during the AIV activities are reported.

1.2 Applicable Documents

[AD1]	SST-MEC-SPE-002 2b	SST Mechanical Structure: Technical Specification

1.3 Reference Documents

[RD1]	SST-MEC-DSR-001 2b	SST Mechanical Structure: Design Report
[RD2]	SST-PRO-PLA-012 2b	SST Programme: On-site AIT Plan

1.4 Definition of Terms and Abbreviations

1.4.1 Abbreviations and Acronyms

ACADA	Array Control and Data Acquisition System
AIT	Assembly Integration and Testing
AIV	Assembly Integration and Verification
AR	As Required
BKO	Bridging phase Kick-Off
CDR	Critical Design Review
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
FAR	Final Acceptance Review
FRC	France Contribution
DR	Delivery Review
DVER	Design Verification Engineering Review
ERIC	European Research Infrastructure Consortium
ESC	Executive Steering Committee
IKC	In Kind Contribution
INAF	Istituto Nazionale di Astrofisica
INSU	Institut National des Science de l'Univers
KO	Kick-Off
MPIK	Max-Planck-Institut für Kernphysik
OP	Observatoire de Paris – PSL, CNRS
PA	Product Assurance
PBS	Product Breakdown Structure
PM	Project Manager
PR	Product Review
PMP	Programme Management Plan
PO	Project Office
PQR	Production Qualification Review
PR	Product Review
PRR	Production Readiness Review
PSE	Programme System Engineer
QA	Quality Assurance
RAMS	Reliability, Availability, Maintainability & Safety
SE	System Engineer
SST	Small-Sized Telescope
TMS	Telescope Mechanical Structure
TRR	Test Readiness Review
WBS	Work Breakdown Structure
WP	Work Package
WPD	Work Package Description

1.4.2 Glossary

TERM	DEFINITION
"As Built" Configuration	The as-built configuration or applied configuration is defining the as-built status per each serial number of Configuration Item (CI) subject to formal acceptance.
"As Designed" Configuration	The as-designed configuration or Applicable configuration is defining the current design status of a Configuration Item (CI)
AIV	AIV is the Assembly Integration and Verification, which is referred to the integration activities related with the verification of the system or sub-system. In the framework of SST for briefness this term includes also the Assembly Integration and Testing which is related with the integration activities and testing to be performed during the integration at system and subsystem levels
Baseline	Set of information which describes exhaustively a situation at a given instant of time or over a given time interval.
Change	Vehicle for proposing modifications to an approved baselined data or the business agreement.
Configuration	Functional or physical Characteristics of a product defined in configuration definition documents subject to configuration baseline.
Configuration Item	Aggregation of hardware, software, processed materials, services or any of its discrete portions, that is designated for configuration management and treated as a single entity in the configuration management process. **NOTE:** A configuration item can contain other lower level configuration item(s).
Deviation	Written authorization to depart from the originally specified requirements for a product prior to its production.
Firmware	Firmware is software programmed onto an electronic device which is treated like a pure hardware.
Executive Steering Committee	The SST Executive Steering Committee (ESC) is the high-level decision-making body which will manage the strategic direction of the Programme and will be in charge of overseeing progress and facilitating global collaboration among the participating groups.
Institutes	Research Institutes involved in the SST Programme.
Contractor	Industry involved in the SST Programme which has a contract with an institute
SST-PRO	It is the team composed by Institutes and Contractors responsible, involved in the production of SST telescopes elements, which coordinate the project level activities.
Hardware	Hardware is a single or an assembly of physical electronic devices which cannot be changed in its user environment.
Item	Any part, component device, sub-unit, unit, equipment, or device that can be individually considered.
Model	Physical or abstract representation of relevant aspects of an item or process that is put forward as a basis for calculations, predictions, or further assessment useful for the preparation of SST production
Partners	are those entities taking responsibility for IKC delivery by signing IKC agreements with CTAO, plus any organisation identified by these signing entities as playing an essential role in SST delivery. The institutes are the partners of the CTA-SST consortium.
Product	A product (hardware, software, service) required in the frame of the program and included as element of the product tree having a unique identifier. A product may be deliverable or not.
Product Breakdown Structure	Hierarchical structure depicting the product orientated breakdown of the project into successive levels of detail down to the configuration items necessary to deliver the required functions. The Product Breakdown Structure (PBS) in general is influenced by Institutes/partners decisions to group certain products or by program history. It identifies products and their interfaces; it serves as the basis for the WBS
Service	Service is the result of at least one activity necessarily performed at the interface between the SST consortium and CTA and is generally intangible.
Software	Set of computer programs, procedures, documentation and their associated data.
SST-E2E	The SST end-to-end telescope, or simply SST, will consist of the SST Structure and the SST Camera (including all mechanics, mirrors, auxiliary devices and required software), integrated and commissioned on-site including all required documents. It ends at (and integrates into CTA via) the system interfaces specified by the CTA PBS.
SST Consortium	The SST Consortium then consists of the Partners and their associated Teams, where a Team is a set of individuals within a single organisation at a single location (such as a University group).
System	An entity of products assembled or working together for a well-defined specified purpose. In SST the term system can be utilised in alternative to Telescope End-to-End.
Sub-System	Like a system but a lower level. In SST the SST system is composed by the subsystem SST-MECH, SST-OPT, SST-TCS and SST-CAM.
Waiver	Written authorization to use or release a product which does not conform to the specified requirements
Work Breakdown Structure	Hierarchical representation of the activities necessary to complete a project.

2 Factory assembly plan and procedures

2.1 Introduction

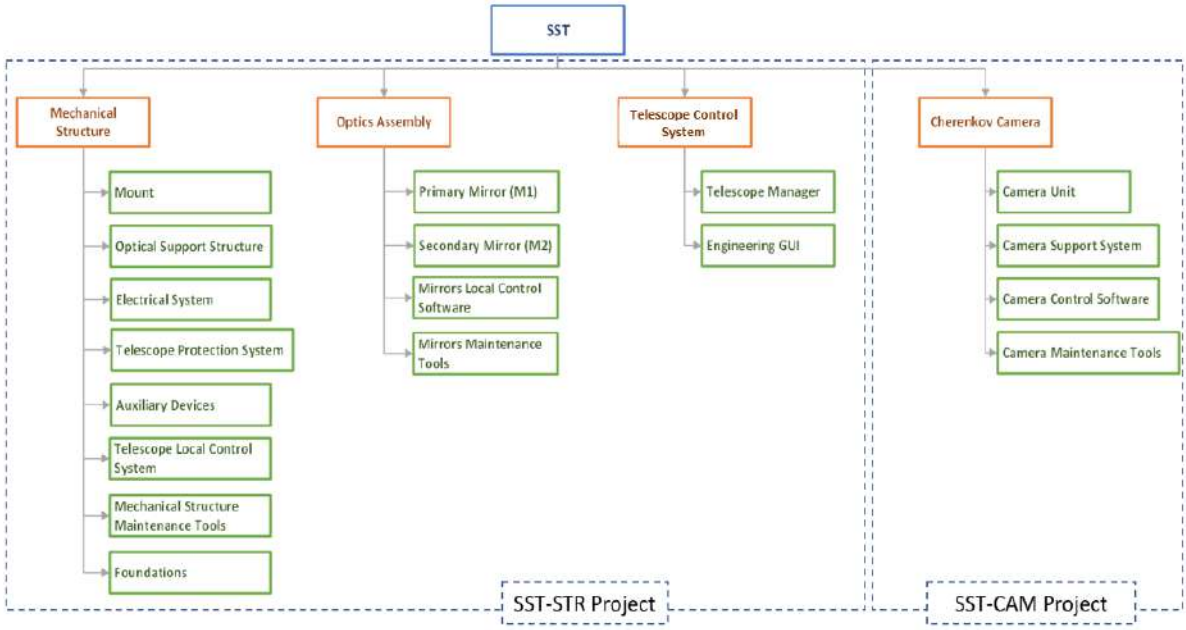
The Cherenkov Telescope Array Observatory (CTAO, see web page link at https://www.cta-observatory.org) includes three different types of telescopes: large-sized (LST, 23 m diameter), medium-sized (MST, 12 m diameter) and small-sized (SST, 4 m diameter) telescopes. They are distributed in two observing sites, the Northern one in La Palma, the Canary Islands, and the Southern one in the Chilean Andes in the Paranal area. The CTA South "Alpha Configuration" would include LSTs, MSTs and SSTs. In particular, it envisages the construction and installation of 42 SSTs (a number that could increase up to 70 in future upgrades).

The SSTs are developed by an international consortium of institutes that will provide them as an in-kind contribution to CTAO. The SSTs rely on a Schwarzschild-Couder-like dual-mirror polynomial optical design, with a primary mirror of 4 m diameter, and are equipped with a focal plane camera based on SiPM detectors covering a field of view of ~9°. They are sensitive in the band from ~0.5 TeV up to ~300 TeV, providing the Observatory with sensitivity to the highest energies. The current SST concept has been validated by developing the prototype dual-mirror ASTRI-Horn Cherenkov telescope the ASTRI mini-array and the CHEC-S Cherenkov camera.

2.1.1 SST product breakdown structure

The top-level product breakdown structure of the SST Telescope is given in the following figure:

Figure 1 Top-level Product Breakdown Structure of the SST Telescope



- *Mechanical Structure (STR-MEC)*: The Telescope Mechanical Structure (TMS) includes all the hardware and software that allow the telescope to point to different parts of the sky with the required performances. All mechanical parts (structural elements, bolts, screws, bearings, gears, springs, bumpers, accessories) needed to support the telescope optics to collect light

are part of the TMS. The TMS provides the motion capabilities that allow the Telescope to point and track over its specified range. All the electromechanical parts are provided with power and communication via dedicated supply lines. The TMS is fixed to the concrete foundation by means of anchor bars.

- *Optics Assembly (SST-OPT):* The Optical Assembly (Optics) includes the primary and secondary mirror and their control hardware.

- *Telescope Control System (SST-TCS):* The Telescope Control System (TCS) interfaces the Telescope with the CTAO facility (ACADA). The TCS includes a Telescope Engineering GUI to operate the SST Telescope in standalone mode during installation, calibration and maintenance activities.

- *Cherenkov Camera (SST-CAM):* The SST Camera comprises all the hardware, software and documentation associated with Cherenkov image detection, digitisation, trans project, and pre-processing. The SST Camera is modular, it consists of a number of subsystems These modular subsystems greatly simplify the organisation and division of activities within the production phase, and also form the basis of the international SST Camera Project (SST Camera).

2.2 Mount Assembly Procedures

Please note that Elevation angle are intended with 0deg EL as the horizon, and 90deg EL as zenith.

2.2.1 Product Breakdown Structure

The PBS of the Mount Assembly is hereunder reported to make simpler the process of identifying the parent subsystem of each telescope part that is to be assembled:

Table 1: Mount Subassembly Product Breakdown Structure

Level 1		Level 2		Level 3	
7110-000	Mount Assembly	7111-000	Base structure		
				7111-100	Base
				7111-200	AZ encoder
		7112-000	AZ bearing		
		7113-000	AZ fork	7113-100	AZ fork structure
				7113-200	EL axis bearing
				7113-300	AZ & EL Drives
				7113-400	EL encoder
				7113-500	AZ & EL switches
				7113-600	AZ & EL cable wraps
				7113-700	AZ & EL Stow pins
				7113-800	EL bumpers
7130-000	Electrical system	7131-000	Electrical Cabinets	7131-100	High Power Cabinet
				7131-200	Low Power Cabinet
		7132-000	Electrical Boxes	7132-400	Base Junction Box
		7133-000	Cabling	7133-100	Base cabling
				7133-200	AZ Fork cabling
		7134-000	LPS & Grounding	7134-100	AZ LPS

2.2.2 Factory area requirements

Floor clear area: circular with 11 m diameter

Height under ceiling: 11 m

Height under hoist: 10 m

2.2.3 Support equipment

Table 2 Mount assembly support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Overhead crane	Standard	N/A	1	
Wire rope	Standard	N/A	5	
Lifting sling	Standard	N/A	1	
Lifting point for bolting	Vario-Starpoint VRS-F-M20 with star key / RUD	7101315	3	Or similar M20 2.3t rotating eyebolts
Lifting point for bolting	Eye bolt RS-M10 / RUD	56397	2	Or similar high-strength M10 500kg eyebolts
Hoist	Standard	N/A	1	
Measuring system	Standard	N/A	1	Precision spirit gauge / Total station
Target for measuring system	Standard	N/A	AR	Typology depending on the adopted measuring system
Guide rod M20	Special	N/A	2	
Lifting point for bolting	Load ring VLBG 5t M30 with bolt / RUD	8500828	2	Or similar M30 5t pivoting eyebolts
Lifting point for bolting	Load ring VLBG 2,5t M20 with bolt / RUD	8500826	2	Or similar M20 2.5t pivoting eyebolts
Eye bolt for lifting	M12 / standard	N/A	2	
Eye bolt for lifting	Standard	N/A	AR	Different diameters, from M10 to M24
Mechanics tool set	Standard	N/A	2	
Electrical torque wrench	Standard	N/A	1	Capacity up to 500 Nm
Electrical tool set	Standard	N/A	2	
Hydraulic tensioning cylinder	Standard	N/A	1	Equipped with pump

2.2.4 Consumables

Table 3 Mount assembly consumables

NOMENCLATURE	TYPE / MANUFACTURER	QTY	REMARKS
Grease	LGEP2 / SKF	0.32 kg	For AZ Bearing
Hard blue	Standard	AR	For gear alignment
Acetone	Standard	AR	For degreasing
Cleaning paper	Standard	AR	

2.2.5 Telescope parts

Table 4 Mount assembly items

NOMENCLATURE	MANUFACTURER	PT NO.	QTY	REMARKS
Base		7111-100-00-00	1	
Base door		7111-110-00-00	1	
AZ Bearing	Rollix	N/A	1	
Pedestal		N/A	1	
Interface flange between the Pedestal and the Base		N/A	1	
AZ Fork structure		7113-100-00-00	1	
AZ stow pin	Servomech	7113-710-00-00	1	
AZ motor L	Beckhoff / Bonfiglioli	7113-711-00-00	1	
AZ motor R	Beckhoff / Bonfiglioli	7113-712-00-00	1	
Cabinets support		7113-110-00-00	1	
HPC Electrical cabinet		3131-100-00-00	1	
LPC Electrical cabinet		7113-200-00-00	1	
Cable trays	N/A	3133-250-00-00	1	
AZ Fork cable box		7113-621-00-00	1	
EL Cable wrap L box		7113-622-00-00	1	
EL Cable wrap R box		7113-623-00-00	1	
Base Cabling	N/A	3133-100-00-00	1	
AZ Fork cabling	N/A	3133-110-00-00 3133-210-00-00 3133-220-00-00	1	

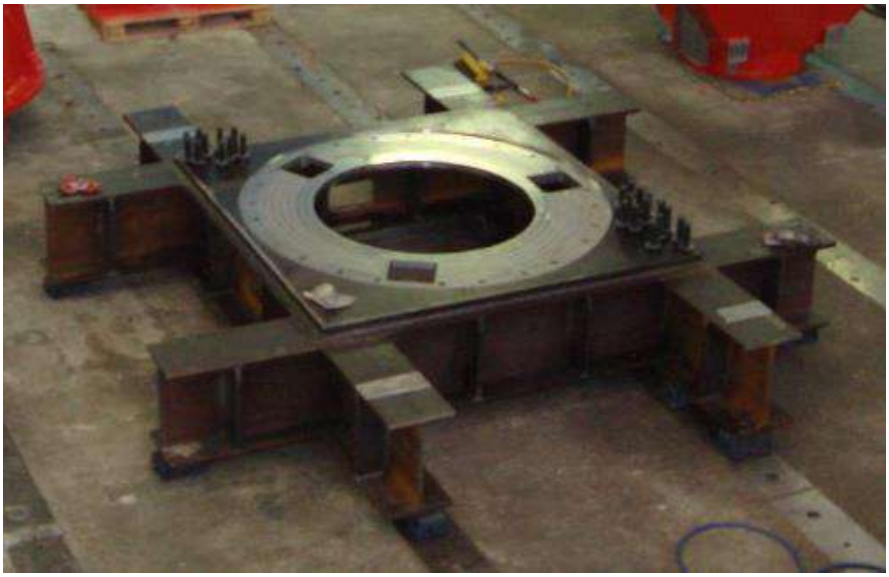
NOMENCLATURE	MANUFACTURER	PT NO.	QTY	REMARKS
		3133-230-00-00 3133-260-00-00 3133-270-00-00 3133-280-00-00		
EL Actuator	Servomech / Beckhoff	7113-320-00-00	1	Items to be previously assembled

2.2.6 Procedure Steps

NOTE

Do next steps to install the Pedestal on the floor.

1. Set the Pedestal on the floor. Lock the Pedestal to the floor by means of mechanical jacks (3 to obtain isostatic configuration) in order to provide an adequate and suitable fastening method for the Base.



2. Install on the Pedestal the interface flange between the Pedestal and the Base.
3. Install the targets to be used for the measures. Verify the correct alignment of the Pedestal by means of the available measuring system (Total station, precision spirit gauges) , otherwise, act on mechanical jacks in order to adjust adequately planarity.

NOTES

- Do next steps to install the Base Structure (1890kg) on the Pedestal.
- The Base Structure must be previously painted.

4. Install the Base Door and all its items. Align the Base Door switch.
5. Clean and degrease with Acetone the surface of the interface flange between the Pedestal and the Base.
6. Install three lifting point for bolting VRS-F-M20 on the Base Main Structure. Use the wire ropes and a hoist to connect them to the overhead crane.
7. Lift the Base Main Structure and move it on the dedicated Pedestal.

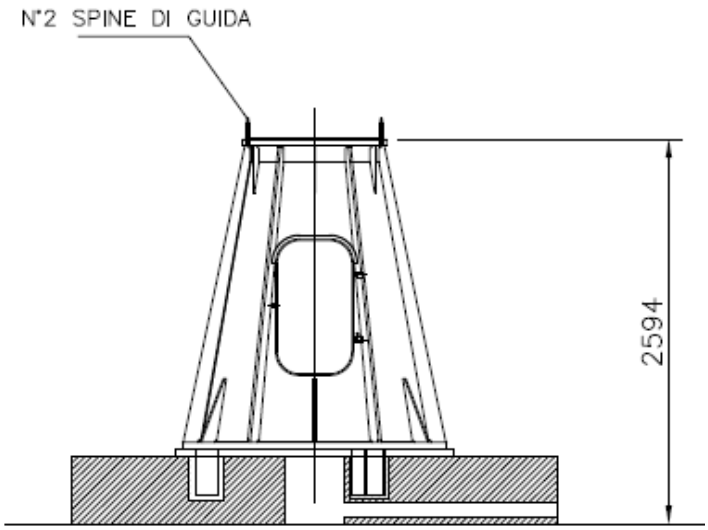
Figure 2 Base structure characteristics and lifting method

8. Install all M33 fastenings (screws and washers or alternatively end studs with washers and nuts to simulate the real fastening method of the final site) that attach the Base Main Structure to the Pedestal. Use the hydraulic tensioning cylinder to tighten and torque the fastenings with a proper procedure (crossed rows, starting from half torque).
9. Use precision spirit gauge level for the alignment measures. Verify the correct alignment of the Base Main Structure.

NOTE

- Do next steps to install the AZ Bearing.

10. Install two guide rods M20 on the Base Main Structure.



11. Install two eye bolts RS-M10 on the AZ Bearing. Use the wire ropes to connect them to the overhead crane.
12. Lift the AZ Bearing and move it on the Base Main Structure.

Figure 3 AZ bearing installed and lifting method

13. Install all M22 fastenings that attach the AZ Bearing to the Base Main Structure. Tighten and torque the fastenings with a proper procedure (crossed rows, starting from half torque) up to 320 Nm.
14. Grease the AZ Bearing if not already performed, with the grease indicated in section 2.2.4.

NOTES

- Do next steps to install the AZ Fork main structure (1350 kg).
- The AZ Fork main structure must be previously painted.

15. Install four lifting points for bolting (two load ring VLBG 5t M30 and two load ring VLBG 2,5t) on the AZ Fork main structure. Use the wire ropes and a hoist to connect them to the overhead crane.
16. Lift the AZ Fork main structure. Install two guide rods M20 on the AZ Fork main structure lower flange.

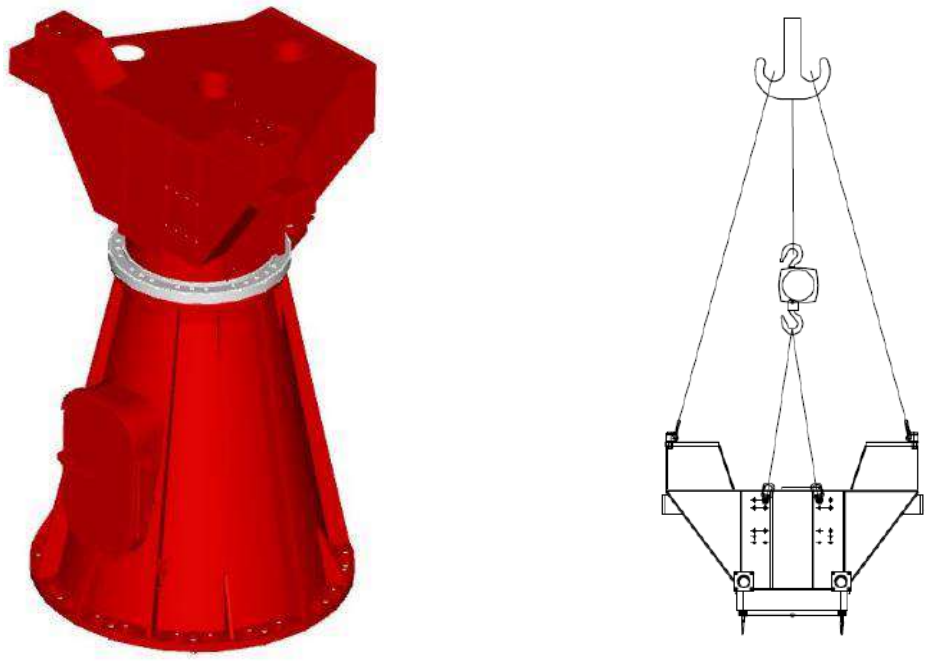


Figure 4 AZ fork main structure installed and lifting method

17. Move the AZ Fork main structure on the AZ Bearing.
18. Install all fastenings that attach the AZ Fork main structure to the AZ Bearing. Tighten and torque the fastenings with a proper procedure (crossed rows, starting from half torque and finally with full torque) up to 320 Nm.

NOTE

- Do next steps to install and adjust both the AZ Motor L and the AZ Motor R.

19. Install the lifting eyebolts on the ratio motor gear. Use the AZ motor handling device to lift the ratio-gear and move it until correct position.
20. Install the two AZ motor shims on the ratio motor gear.
21. Lift the ratio-motor and set it to the correct position on the AZ Fork main structure. Install all M20 fastenings that fix the ratio motor gear to the AZ Fork main structure without tighten them with torque wrench.
22. Install the AZ Motor Pinion and apply the hard blue on 3-4 gear teeth to check alignment.

23. Disengage the brake by means of hand release.
24. Adjust the ratio-motor position running by hand the azimuth axis clockwise and counter-clockwise in order to guarantee proper gear/rack contact by means of visual inspection of the blue contact pattern.
25. Fix the AZ Motor position by means of torque wrench.

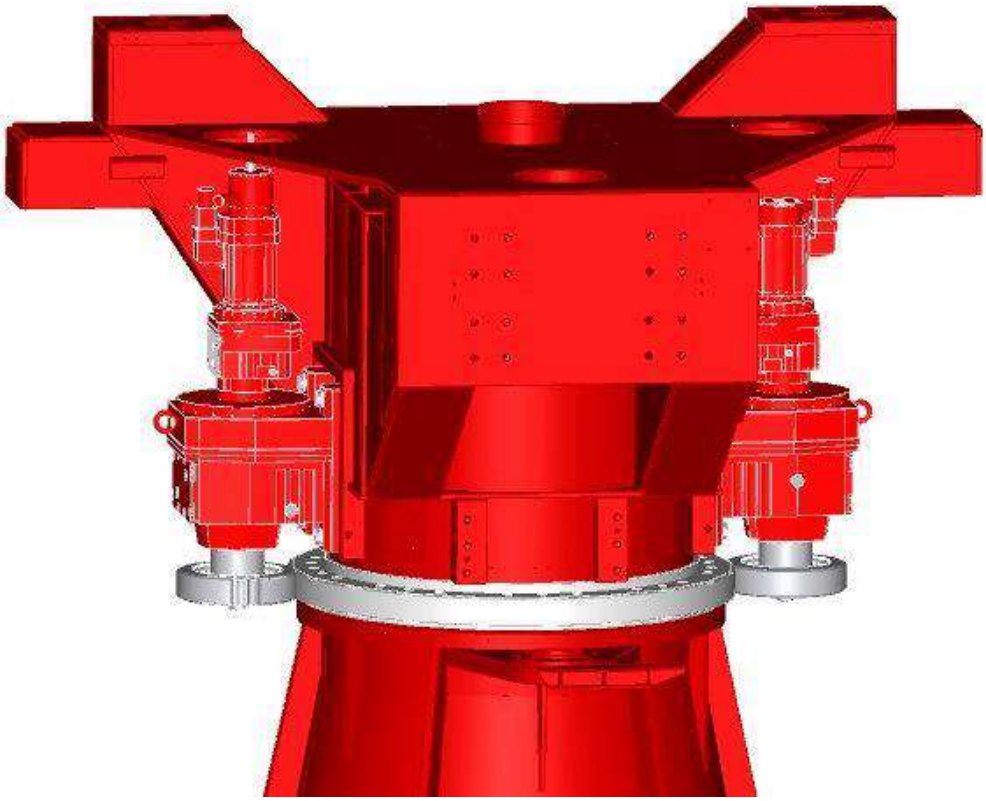


Figure 5 AZ motors installed

NOTE
• Do next step to install the Cabinets Support and the two Electrical Cabinets.

26. Install the Cabinets Support on the AZ Fork main structure.
27. Install the lifting eyebolts on the Electrical Cabinets.
28. Lift the Electrical Cabinets with a lifting means and set them to the correct position on the Cabinets Support. Install all fastenings that attach the Electrical Cabinets to the Cabinets Support.

Figure 6 Cabinets support and Cabinets installed

NOTE
• Do next steps for the EL Bumpers on AZ Fork.

29. Install the EL Bumpers on the AZ Fork.

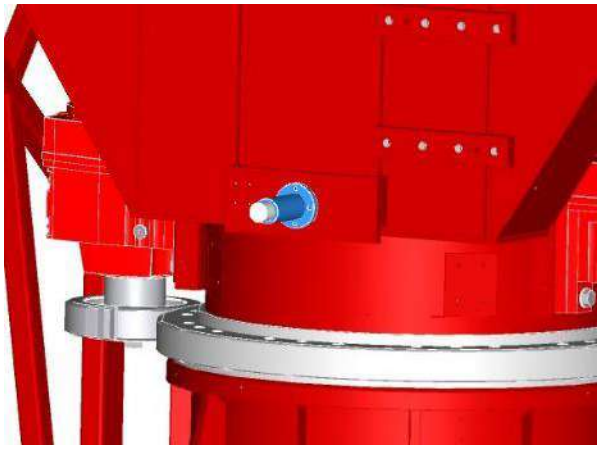


Figure 7 EL bumper installed

NOTES
• Do next steps to install the AZ Stow Pin and EL Stow Pin on the AZ Fork. • The AZ & EL Stow Pins must be previously assembled. • The AZ & EL Stow Pins assembly and functionality must be previously verified on the bench.

30. Install two lifting eyebolts M12 on the AZ Stow Pin. Use the AZ motor handling device to lift the AZ stow pin until correct position (for EL Stow Pin procedure is equivalent).
31. Install all fastenings that attach the AZ Stow Pin (EL Stow Pin) to the AZ Fork main structure.
32. Install all other items and the centering switch of the AZ Stow Pin (EL Stow Pin).

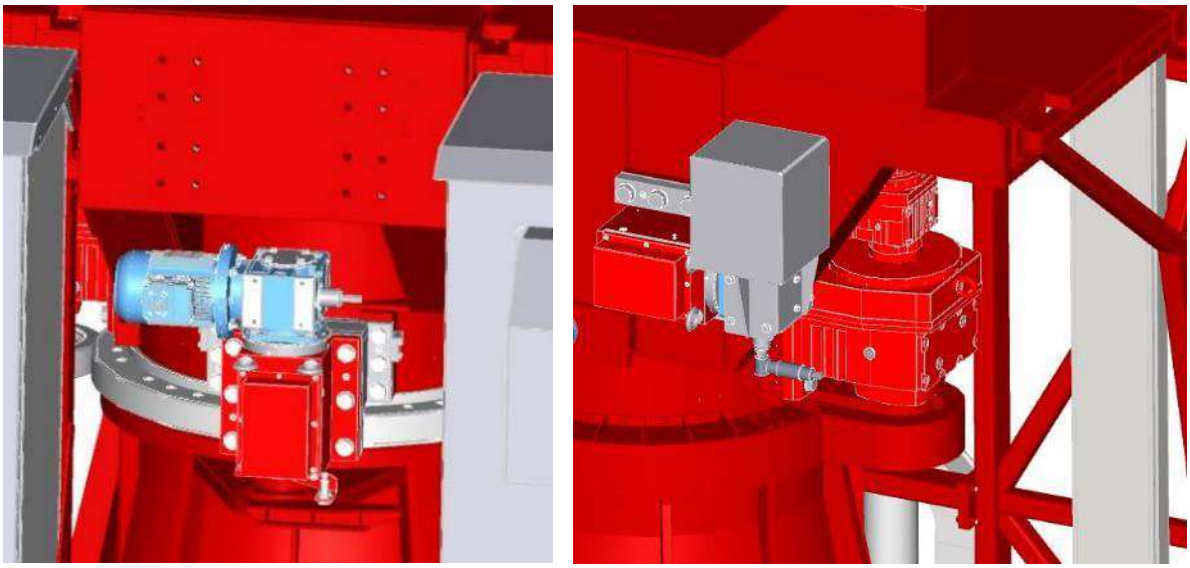


Figure 8 AZ and EL stow pins installed

NOTES
• Do next step to pre-assemble the EL Actuator on the bench. • The pre-assembled EL Actuator must be painted before installation on the telescope.

33. Assemble the ELA Upper Hinge, the ELA Lower Hinge and the Motor to the mechanical screw jack.

NOTE
• Do next steps to install the EL Actuator.

34. Install the lifting point for bolting VRS-F-M20 on the ELA Bracket.
35. Lift the ELA Bracket with a lifting means and set it to the correct position on the AZ Fork main structure. Install all fastenings that attach the ELA Bracket to the AZ Fork main structure without tightening them completely.

Figure 9 EL actuator bracket

36. Install two lifting points for bolting VRS-F-M20 on the ELA Lower Hinge Shaft of the EL Actuator.
37. Lift the EL Actuator with a lifting means and set it to the correct position on the AZ Fork main structure. Tighten and torque all M20 fastenings that attach the ELA Lower Hinge to ELA Bracket, with a proper tightening procedure.

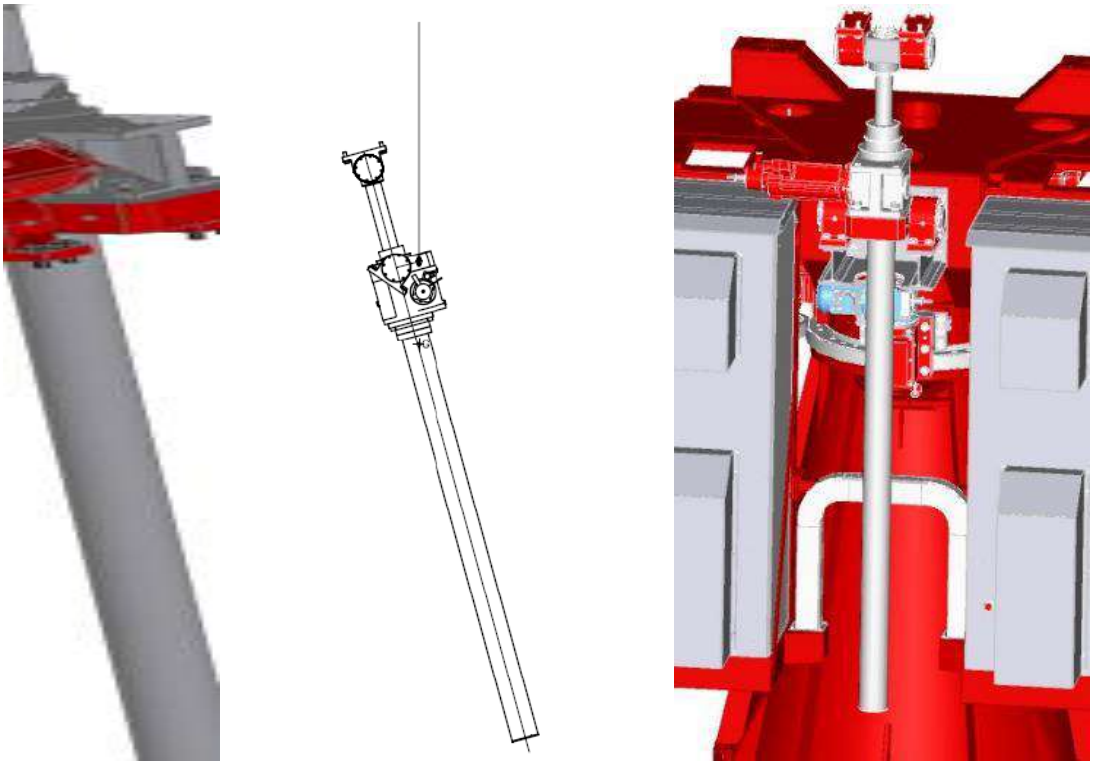


Figure 10 EL actuator installed and lifting method

NOTE
• Do next steps to install the Cabinets Tray and some EL Cable Wrap items.

38. Install the AZ Fork Cable box.

39. Install the EL Cable Wrap Trays between the Electrical Cabinets and the AZ Fork Cable box.
40. Install the EL Cable Wrap in order to check the mechanical interfaces. After check, remove the item.

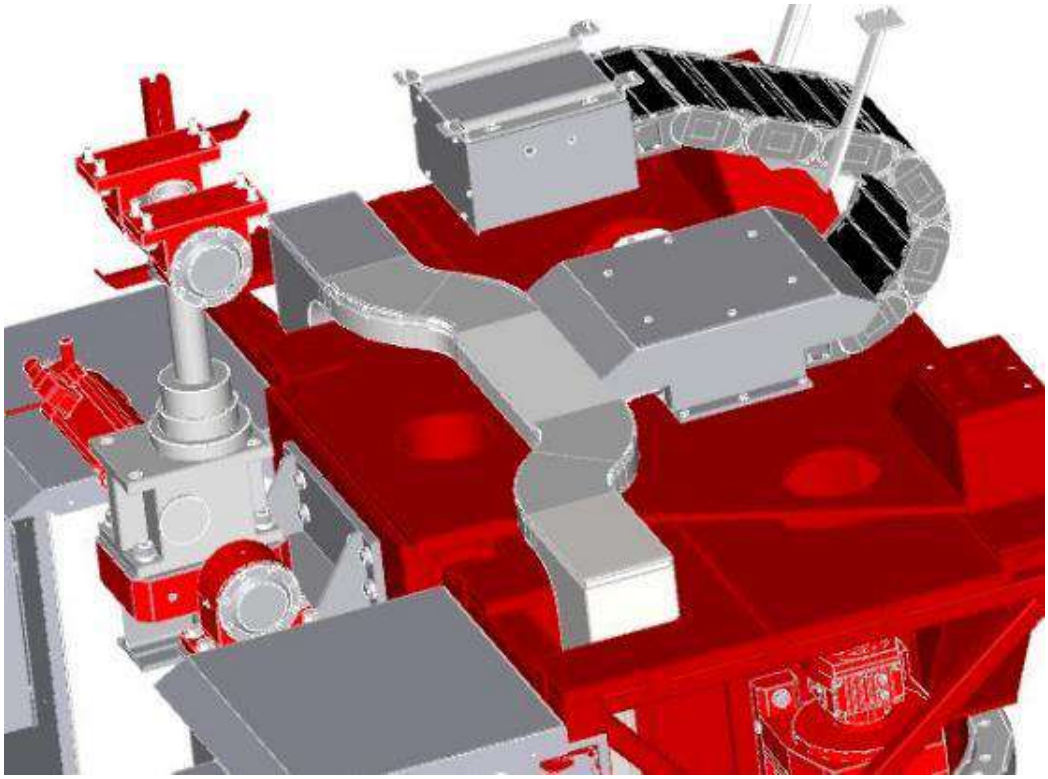


Figure 11 EL cable wrap installed

NOTE
• Do next steps for the electrical installations and LPS of the Mount Assembly.

41. Install the AZ Cable Wrap items.
42. Install the LPS boxes inside the Base.
43. Install all the electrical and signal cables from the Base to the Electrical Cabinets passing through the AZ Cable Wrap.
44. Connect electrically the subsystems already installed on the AZ Fork and on the Base (Base Door switch, AZ Drives, AZ Stow Pin motor and switches, EL Actuator motor).
45. Lay the AZ Encoder scanning heads cables from the Electrical Cabinet to the fixed point inside the Base passing through the AZ Cable Wrap.
46. Install the items of the LPS on the Mount Assembly (ring on the Base, down conductors on the AZ Fork, supports for the brushes).

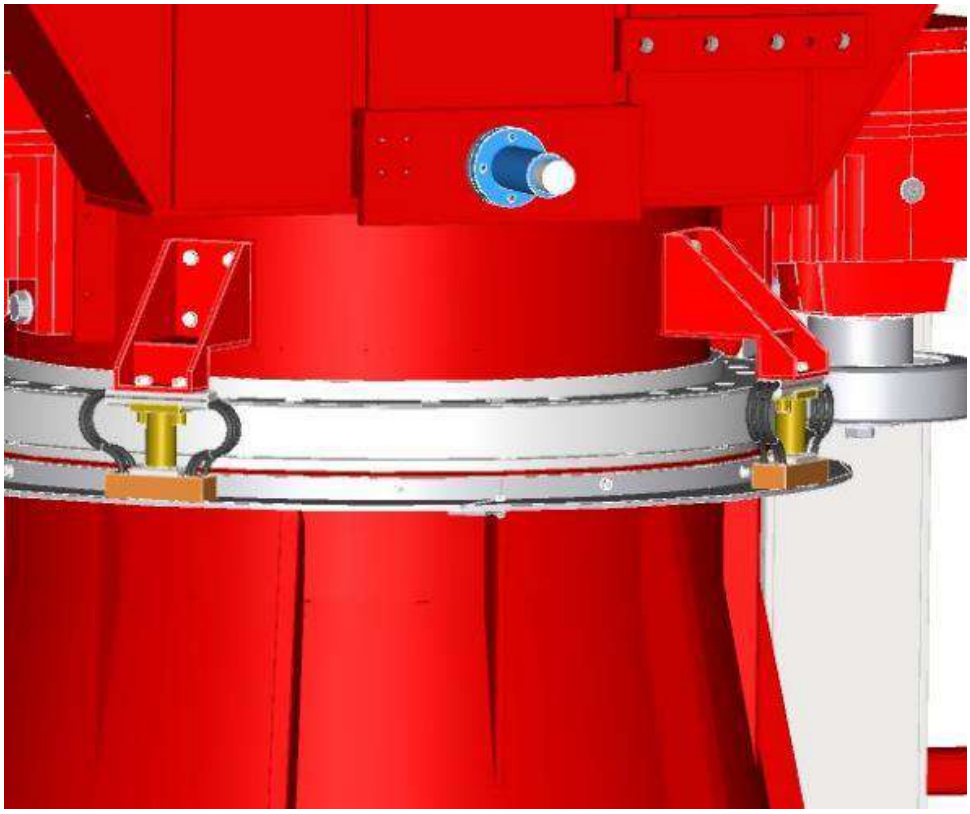


Figure 12 AZ LPS brushes installed

2.3 Optical Support Structure Assembly Procedures

Please note that Elevation angle are intended with 0deg EL as the horizon, and 90deg EL as zenith.

2.3.1 Product Breakdown Structure

The PBS of the Optical Support Structure is hereunder reported to make simpler the process of identifying the parent subsystem of each telescope part that is to be assembled:

Table 5: Optical Support Structure Product Breakdown Structure

Level 1		Level 2		Level 3	
7120-000	Optical Support Structure	7121-000	M1 dish	7121-100	M1 Shields
		7122-000	Counterweights		
		7123-000	OSS Upper Structure	7123-100	Mast
				7123-200	Central Tube
				7123-300	Top ring
		7124-000	M2 Support Structure	7124-100	Optical Baffle & M2 Shield
		7125-000	M1 Segment Support Subassembly	7125-100	M1 segment support
				7125-200	M1 segment calibration
				7125-300	M1 segment handling
		7126-000	M2 Support	7126-100	M2 Actuator
				7126-200	M2 actuator driving unit
7130-000	Electrical System	7132-000	Electrical Boxes	7132-200	M2 Box
		7133-000	Cabling	7133-300	M1 Dish cabling
				7133-400	Mast cabling
		7134-000	LPS & Grounding	7134-200	EL LPS

2.3.2 Factory area requirements

Floor clear area: circular with 11 m diameter

Height under ceiling: 11 m

Height under hoist: 10 m

2.3.3 Required conditions

Table 6: OSS assembly requirements

REQUIRED CONDITIONS
M1 Dish (Left and Right Structures) assembled, locked by pins, machined and painted.
EL Axis Bearing Left assembled (Encoder Group, R Group and Base)
EL Axis Bearing Right assembled (L Group, R Group and Base)
M1 Dish Cable Wrap box assembled
Populated M2 Back Up Structure with actuators, loadspreaders, lateral fixed points, M2 and junction box

2.3.4 Support equipment

Table 7: OSS Assembly support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Support pedestal for M1 dish		N/A	3	For optical support structure pre-assembly.
Overhead crane	Standard	N/A	2	
Wire rope	Standard	N/A	AR	
Fender		N/A	4	For M1 Dish edges protection. Custom made on factory.
Measuring system	Standard	N/A	1	Precision spirit gauges or total station
Target for measuring system	Standard	N/A	1	
Lifting point for bolting	Load ring VLBG 5t M30 with bolt / RUD	8500828	4	Or similar M30 5t pivoting eyebolts
Mechanics tool set	Standard	N/A	2	
Electrical torque wrench	Standard	N/A	1	Up to 500 Nm torque
Electrical tool set	Standard	N/A	2	
Wood plate	Standard	N/A	3	
Support leg	Special /	N/A	4	To support the M2 support structure
Lifting point for bolting	Load ring VLBG 4t M24 with bolt / RUD	8500827	3	Or similar M24 4t pivoting eyebolts
Hoist	Standard	N/A	1	
Eye bolt for lifting	M12 / Standard	N/A	2	
Electrical drill	Standard	N/A	1	
Adaptor ∅ 14mm	Special /	7113-310-03-00	1	To connect the drill to the secondary shaft of the EL Actuator motor
Manlift	Standard	N/A	1	Articulating boom type Genie Z-30/20N or similar (maximum platform dimensions 120x80 cm)
Set of dedicated measuring tools to check the main		N/A	1	

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
geometrical characteristics of the encoder groove				
Blank steel tape	Heidenhain	N/A	1	Part of the AZ encoder supply
Dummy scanning head	Special /	7111-210-05-00	1	
Small dedicated protected magnet	Heidenhain	N/A	AR	Part of the AZ encoder supply
Portion of scale tape for test	Heidenhain	N/A	1	Part of the AZ encoder supply
Signal analyzer	Heidenhain	N/A	1	PWM9 or similar

2.3.5 Consumables

Table 8: OSS assembly consumables

NOMENCLATURE	TYPE / MANUFACTURER	QTY	REMARKS
Glue	UHU plus endfest 300	AR	For AZ Encoder tape
Acetone	Standard	AR	For degreasing
Cleaning paper	Standard	AR	

2.3.6 Items

Table 9: OSS assembly items

NOMENCLATURE	SUPPLIER	PT NO.	QTY	REMARKS
M1 dish		7121-000-00-00	1	
Central tube		7123-000-01-00	1	
Mast		7123-000-02/09-00	1	
M2 Back up structure		7124-000-00-00	1	
M2 shield		7124-000-00-00	1	
EL axis bearing left		7113-210-00-00	1	
EL axis bearing right		7113-220-00-00	1	
M1 junction box		3133-300-00-00	11	

NOMENCLATURE	SUPPLIER	PT NO.	QTY	REMARKS
EL cable wrap support		7121-000-04-00	2	
M1 dish cable wrap box		7113-624-00-00	1	
Conduit	Teaflex	L15N	151m	
M2 Loadspreader assembly		7126-000-00-00	1	
M2 junction box	ILME	APV19	1	
Camera SPD junction box	ILME	APV14	2	
Conduit	Teaflex	L27N	35m	
Scale tape	Heidenhain	ERA 7400C	1	
AZ encoder head group	Hedeinhain /	7111-210-00-00	4	
AZ switches	Telemecanique, Pepperl+Fuchs	7113-510-00-00	1	
EL switches	Telemecanique, Pepperl+Fuchs	7113-520-00-00	1	
EL stow pin	Servomech	7113-720-00-00	1	Already assembled
LPS & Grounding	N/A	3134-000-00-00	1	
AZ Fork cabling	N/A	3133-210-00-00 3133-220-00-00	1	
M2 Backup Structure cabling	N/A	3133-500-00-00	1	

2.3.7 Procedure Steps

NOTES

- Do next steps to assemble the M1 Dish (3400 kg) with EL bearings and EL cable wrap box.
- The M1 Dish L and R Structures must be machined together, joined by pins.
- The procedure is not affected by which half of the Dish (left and right) is handled first.

47. Join the M1 dish halves by means of pins used for the machining.
48. Set the M1 dish (both halves) upside down onto three temporary supports (screw jacks with flat head) with a height of about 700mm (located in correspondence of the edges of the M1 Dish).

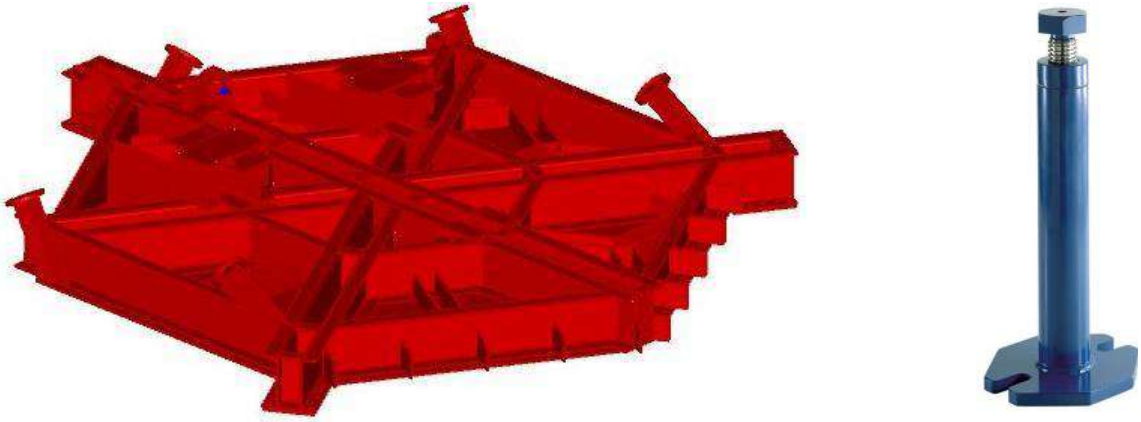


Figure 13 M1 Dish halves assembled and screw jacks with flat head

49. While the M1 Dish is supported by screw jacks install the EL axis bearings (left and right) with pins and loose bolts.

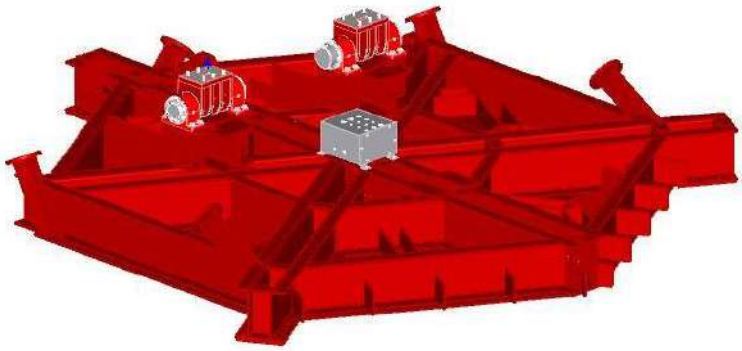


Figure 14 EL bearings and EL cable wrap box installation on M1 dish

50. Install the EL cable wrap box in order to ease cable wrap installation during installation of the Mount assembly.
51. Install all Conduits for the electrical cables from the M1 Dish Cable Wrap box to the interfaces with the Conduits installed along the Mast.

NOTES
• Do next steps to assemble the M1 Dish on the Mount Assembly

52. By means of two chains equipped with hooks, lift the upside down M1 dish from the upper corner in order to have it hanged vertically. In this way, the EL bearings interface will be oriented by gravity towards down.
53. Approach the Mount assembly in order to permit the installation of the EL bearings in the correct position by means of the aligning keys located on the EL bearings interfaces of the Mount assembly.

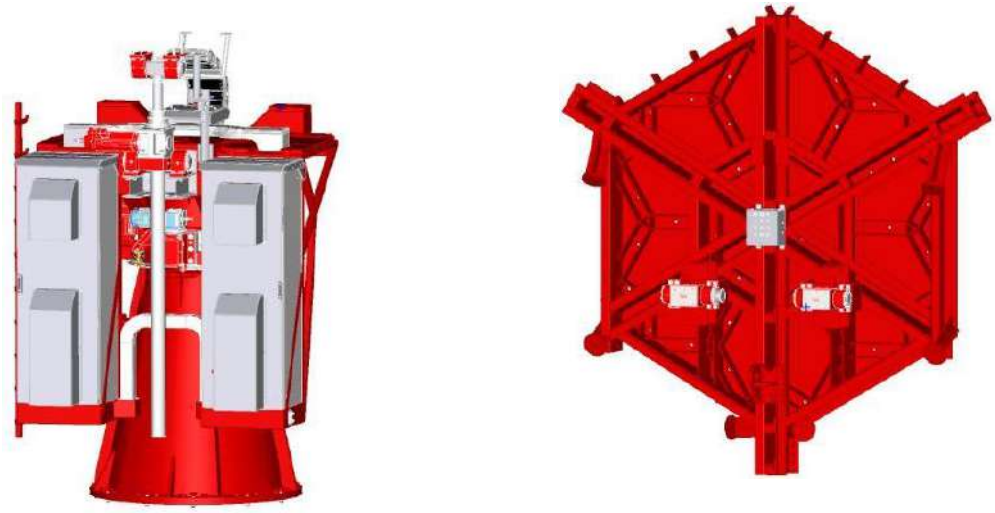


Figure 15 M1 Dish installation on Mount assembly

54. While the M1 Dish is still hanged by the crane, tighten all the M20 bolts of the EL bearings in order to fix the interfaces of M1 Dish and the Mount Assembly.

CAUTION
BE CAREFUL TO KEEP THE M1 DISH CONNECTED TO THE OVERHEAD CRANE BECAUSE THE STRUCTURE IS NOT BALANCED YET.

55. After bolt tightening to 400 Nm, gently rotate the M1 Dish towards the 90° EL position in order to engage the ELA Upper Hinge of the EL Actuator with the M1 Dish interface. Install all M20 fastenings that attach the ELA Upper Hinge to the M1 Dish without tighten the bolts firmly to the M1 Dish interface.
56. Complete a motion of the M1 dish from 90° to 0° operating manually the EL Actuator. In this way, it will align spontaneously as the ELA Upper Hinge will set its axis horizontally during motion.

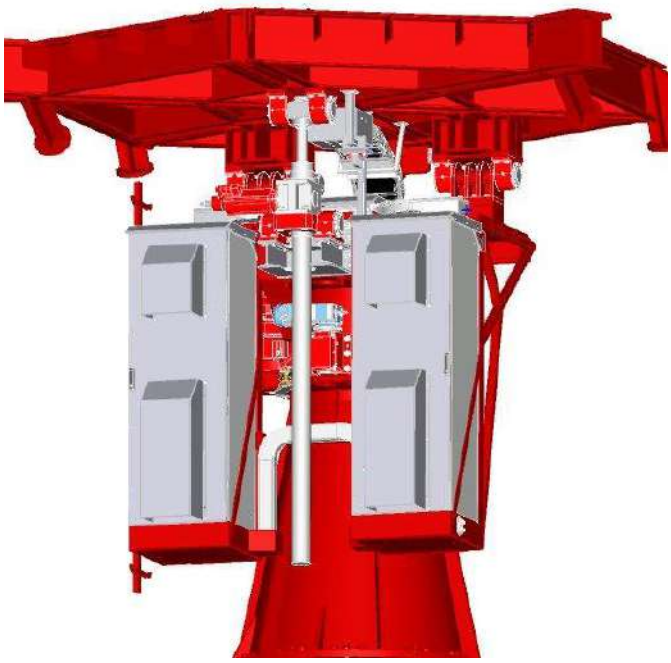


Figure 16 M1 dish installed on Mount Subassembly

57. At this point, even though the Elevation axis is not balanced yet, the M1 Dish can be disconnected form the bridge crane, as the elevation screw jack is keeping it fix.

CAUTION
BE CAREFUL TO MANUALLY BRAKE THE ELEVATION SCREW JACK MOTOR AXIS BECAUSE THE STRUCTURE IS NOT BALANCED YET.

58. Clamp the elevation screw jack motor axis, so that unbalance of the elevation does not induce reverse motion of the screw.

NOTE
• Do next step to install the LPS & Grounding System on the Optical Support Structure.

59. Install the LPS & Grounding System all around the M1 Dish, along the Mast and on the M2 Back Up Structure.

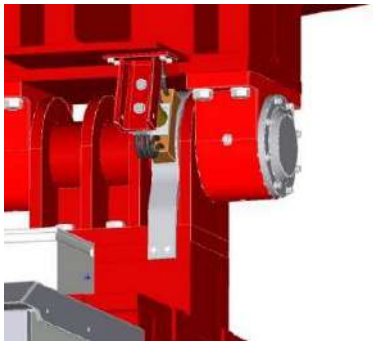


Figure 17 EL LPS brushes installation

NOTE
• Do next steps to complete the OSS on the telescope.

60. Install the Central Tube on the upper side of the M1 Dish by means of the specific alignment pins.
61. Install the M2 BUS in the M2 Mounting Template.
62. Install the M2 Mounting template with the M2 BUS on the Central Tube interface.

Figure 18 OSS during completion

63. Lock by specific 12mm pins the top ring to M2 BUS position in order to guarantee repeatability of assembly.
64. Install the Mast on the M1 Dish and on the Central Tube.

65. Lock by 12mm pins the positions between the M1 Dish, the Central Tube and the Mast and between the M2 Back Up Structure and the Mast.

NOTE
• Do next step to assemble and populate the M2 BUS

66. Remove the M2 BUS from the top ring.
67. Assemble each M2 Actuator and Loadspreader.
68. Turn upside down the M2 Back Up Structure and set it on the floor.

Figure 19 M2 BUS positioned upside down

69. Install the M2 Loadspreader Assembly on the M2 Back Up Structure.

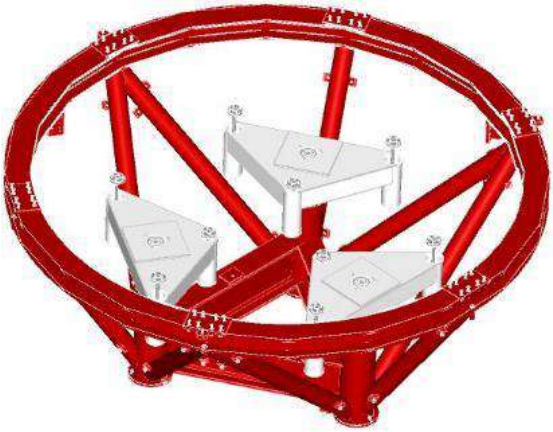


Figure 20 Populated M2 BUS

70. Lift and turn upside down the M2 Back Up Structure with the M2 Loadspreaders Assembly.
71. Bring the Top ring and position it on the ground.
72. Lift the M2 Back Up Structure with the overhead crane in order to install it on the Top Ring.
73. Connect the electrical and signal cables of the M2 Loadspreaders to the M2 Junction Box.
74. Connect the M2 Junction Box to the control system through a temporary cable routing.

75. Verify that all M2 Loadspreaders have been connected correctly; this means that they move along the same direction.
76. Position the M2 on the M2 handling cart.

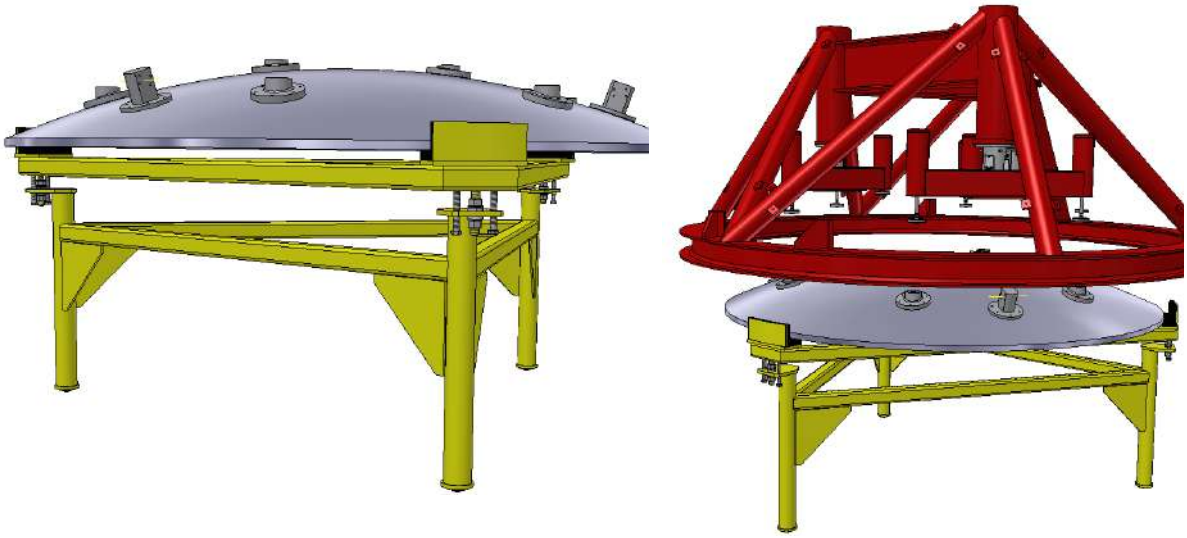


Figure 21 M2 placed on the M2 handling cart and M2 BUS lowering

77. Lift the M2 BUS with the Top Ring and bring it coaxial with the M2 on its handling cart.
78. Lower the M2 BUS down on three screw jacks with flat head.
79. Install the M2 Mirror on M2 Loadspreader Assembly and connect the Lateral fixed points to the M2 Back Up Structure.
80. Install the Shields on the M2 Back Up Structure by means of M8 screws.

NOTE
Do next steps to verify the interfaces of the M1 Segment Supports.

81. Install all the M1 Segment Supports on the M1 Dish in order to verify the correct interface between the items by means of M6 screws.

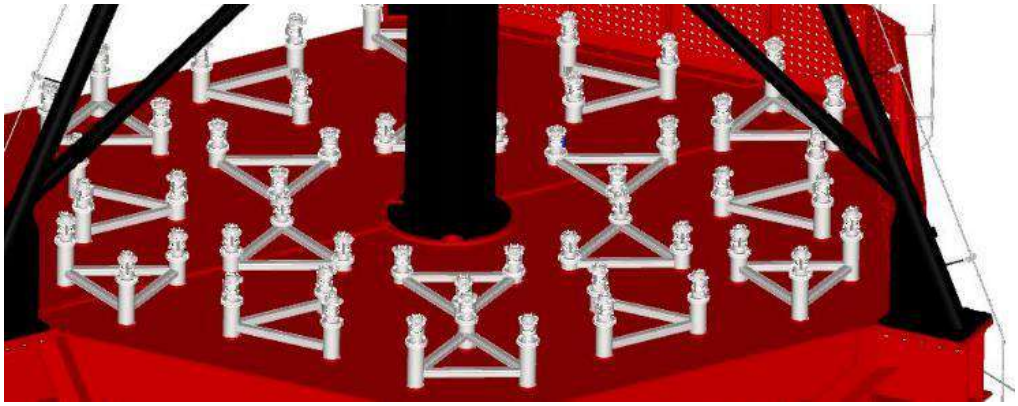


Figure 22 M1 Segments supports installation

NOTE
Do next step to install the LPS & Grounding System on the Optical Support Structure.

82. Install the LPS & Grounding System all around the M1 Dish, along the Mast and on the M2 Back Up Structure.

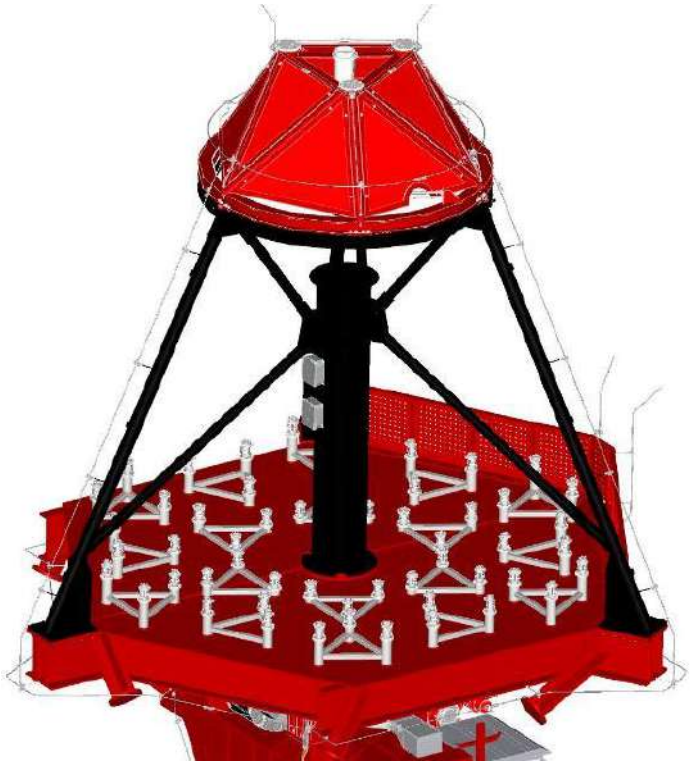


Figure 23 Lightning Protection System rods installation

NOTE
• Do next steps to connect electrically the EL Encoder and to install the AZ and EL Switches.

83. Connect the EL Encoder with a temporary cable routing.
84. Install and connect the EL Switches. Operate manually the EL Switches in order to check their functionality and to verify the correct communication and output on the THCU.
85. Adjust the EL Stow Pin position and lock it with the installation of the centering pins. Align the EL Stow Pin switches (proximity, end stokes, centering).
86. Connect all the electrical cables of the EL Stow Pin.
87. Install and connect all AZ Switches. Operate manually the AZ Switches in order to check their functionality and to verify the correct communication and output on the THCU.

NOTE
• Do next steps to install counterweights on the telescope.

88. Install all the counterweights beams on both sides of the bottom interfaces of the M1 Dish.
89. Pre-assemble on the ground both counterweight masses.
90. Install the counterweight masses by means of the overhead crane. At this point the Elevation axis is balanced, and no unwanted motion of the axis can occur.

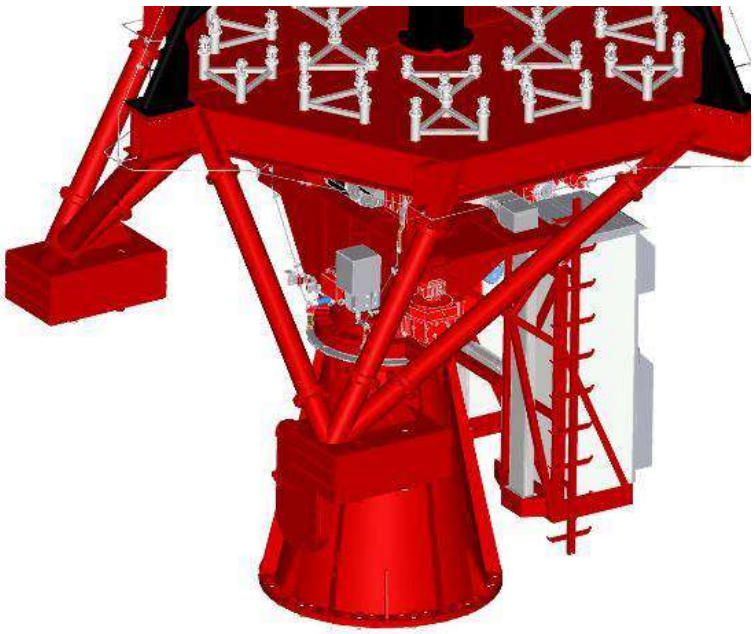


Figure 24 Counterweights installed

NOTE
• Do next steps to install the AZ Encoder scale tape.

91. Rotate the telescope manually through the EL Actuator around its EL axis from 0° to 90°.
92. Inspect visually the scale tape slot for any dirt.
93. Check the main geometrical characteristics of the encoder groove on the AZ Bearing with the set of dedicated measuring tools.
94. Clean with Acetone the scale tape slot.
95. Install the dedicated blank steel tape in order to measure of the length of the tape slot (jump to 93 if there is no blank).

Figure 25 Encoder blank tape installation

96. Remove the blank steel tape.
97. Install the supports of the scanning heads.
98. Install the dedicated scanning head dummies (one after the other) on the scanning head supports.
99. Align the scanning head supports with the use of the scanning head dummies.

Figure 26 Scanning head dummy before installation on scanning head support

100. Remove the scanning head dummies.
101. Clean again with Acetone the tape slot and the AZ bearing in the surface above the tape slot.

102. Lay preliminarily the encoder scale tape on the internal surface of the AZ bearing in the surface above the tape slot and lock it with the dedicated protected magnets.

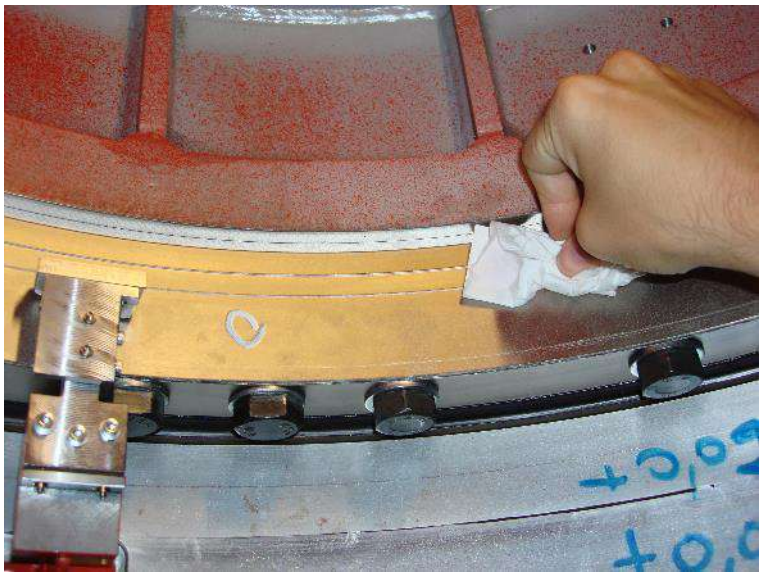


Figure 27 Encoder tape slot cleaning before glueing

103. Clean again the tape slot with Acetone.

104. Put the glue on the tape slot.

105. Set the tape to the correct position inside the slot, as shown in figure 2-27.

Figure 28 Encoder tape positioned and glued on its slot

NOTE
• Do next steps to install the AZ Encoder scanning heads.

106. Clean the scale tape with Isopropyl Alcohol.

107. Install the AZ Encoder Head Plate Uppers on the scanning head supports.

108. Install the real scanning head on the AZ Encoder Head Plate Upper and connect it to the signal analyzer.

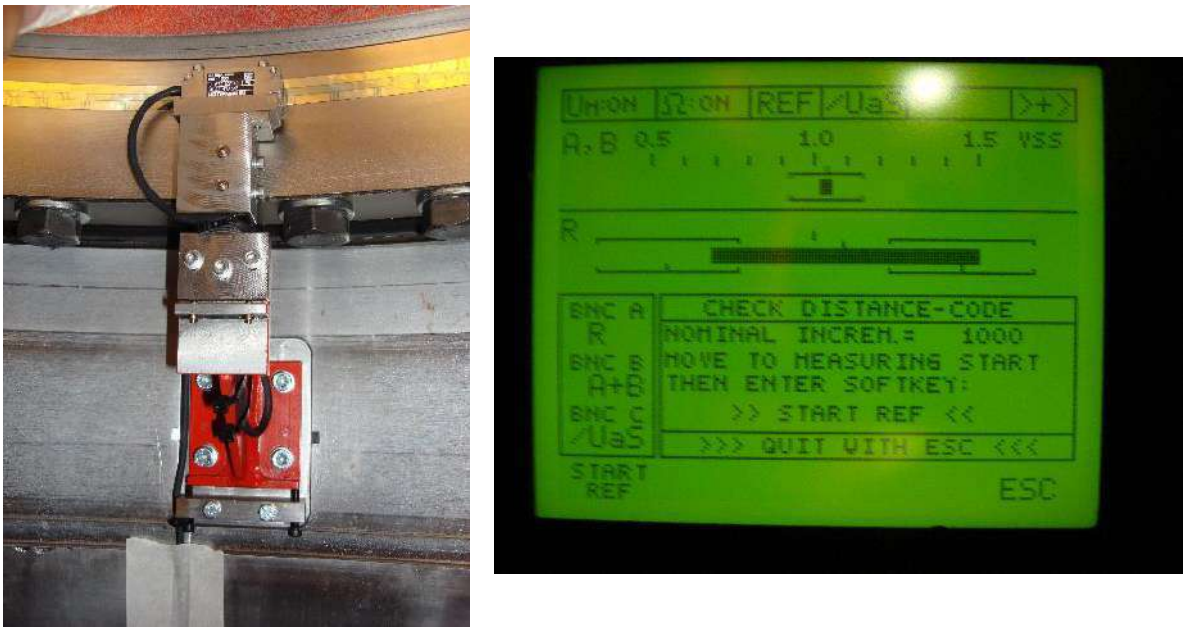


Figure 29 Encoder reading head during calibration and screen of the quality signal

109. Install one scanning head with the spacer foil on a support near the scale tape junction.

110. Rotate the telescope to check the signal in correspondence of the junction (no reading errors with 3 passes over the junction). Do also some complete rotations to verify that the signals are correct along the entire circumference of the AZ bearing.

111. Act on the scanning head eccentric nut in order to fine adjust the scanning head position, if necessary.

112. Complete the glue curing process (12 hours at constant temperature).

113. Check again the signals coming out from the same reading head previously installed.

114. Install all remaining scanning heads.

115. Analyze the output signals of all the scanning heads. Do the scanning head fine adjustment if necessary

NOTE
• Do next steps to perform the alignment of the AZ Switches and of the AZ Stow Pin.

116. Align the AZ Switches.

117. Adjust the AZ Stow Pin position and lock it with the installation of the centering pins.

118. Align the AZ Stow Pin switches (proximity, end stokes, centering).

NOTE
• Do next steps to install Camera on the telescope.

119. Install the jib crane on the top ring at E 0°.

120. Lift the camera and to move it to its correct position.

121. Install the camera on the Central tube.

NOTE
• Do next steps to fine adjust balancing of the EL axis.

122. Install one load ring VLBG 5t M30 on the top corner of M1 Dish Structure. Use a lifting cable, with dynamometer to connect it to the overhead crane.

123. Tension the lifting wire and disconnect the ELA Upper Hinge of the EL Actuator from the M1 Dish.

124. Calculate the unbalance value of the EL axis. If it is different from the reference value of 1545 Nm by more than 20%, it is necessary to install or remove some counterweight plates accordingly, and repeat the step.

125. Re-connect the EL Actuator. If it is necessary to remove/install counterweights, come back to 0° EL.

126. Repeat the unbalance verification.

127. Once verified at 0° EL, move the telescope until 90° and repeat the unbalance verification with one load ring VLBG 5t M30 installed on the bottom corner (at the base of the central lower mast) of the M1 Dish and releasing the ELA Upper Hinge.

128. After this final verification, fix the ELA Upper Hinge to its M1 Dish interface without tighten.

129. Proceed to 0° in EL in order to allow usual ELA Upper Hinge self-alignment before tightening with torque wrench.

130.

NOTE
• Do next steps to install primary mirror segments.

131. Bring the telescope to 0deg EL, as shown in figure 2-29, in order to be able to install the primary mirror segments.

132. The order of installation must be the following:

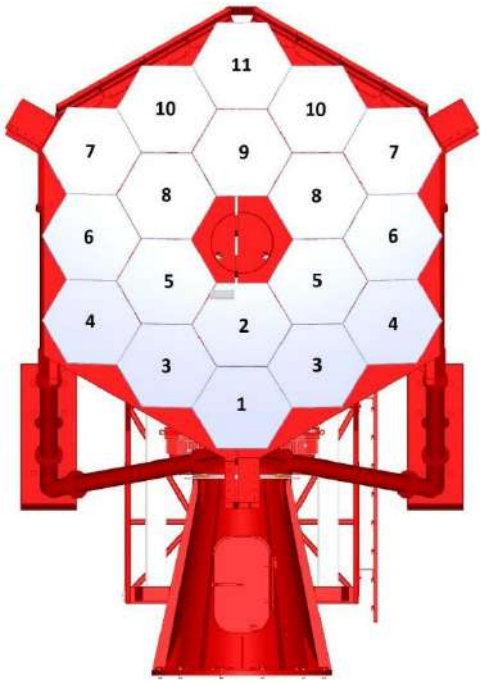


Figure 30 Sequence of M1 segments installation

133. Install the sliding devices in (from the rear of the cell) in the Segment support in order to slide it out of about 200mm in order to receive the mirror.

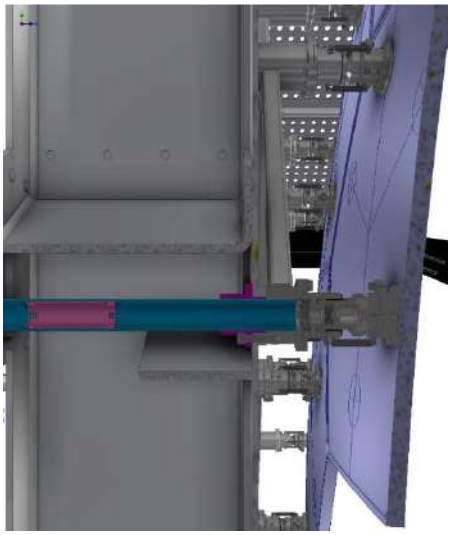


Figure 31 Sliding device for M1 segment support

134. With a cherry picker, approach the interface on the segment support with the mirror segment ready to be installed. The mirror segment shall be store safely in the cherry picker platform. Do not remove the plastic protective film from the mirror surface.

135. Fix the M6 bolts (3 per each support) on the interfaces between mirror segment and supports.

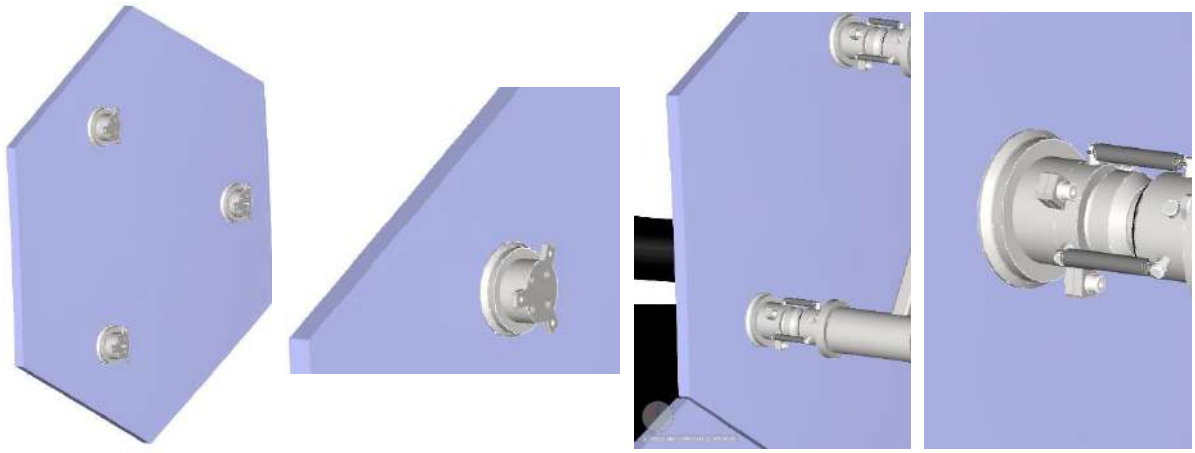


Figure 32 Mirror segment details before and after installation

136. Retract the sliding devices in order to be able to fix the supports on the M1 dish.

137. Tighten the bolts accordingly (by hand only, not with the electric wrench).

3 Verification & Test plan and procedures

3.1 Sub-system Level Verifications

3.1.1 AZ Bearing, Axial Stiffness Test

TASK CODE: SST-7112-000-00-356A-A
REQUIREMENT TO BE MET: Azimuth bearing axial stiffness > 400 E6 Nm
PRELIMINARY REQUIREMENTS

REQUIRED CONDITIONS
Base installed on the pedestal.
AZ bearing and AZ fork installed on the Base.
Four dial gauges between the AZ bearing and the AZ fork installed. Do the zeroing of the dial gauges.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.2 M2 Loadspreader, Survival Push Force Test

TASK CODE: SST-7127-100-00-340A-C
REQUIREMENT TO BE MET: Maximum survival push force on the actuator 2150 N
PRELIMINARY REQUIREMENTS

REQUIRED CONDITIONS
M2 loadspreader assembled without springs and support triangle.
Support for the M2 Loadspreader installed on one fixed surface.
M2 loadspreader installed on the dedicated support.
Load cell and the screw jack between the M2 loadspreader installed in the second fixed surface.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.3 M2 Loadspreader, Survival Pull Force Test

TASK CODE: SST-7127-100-00-340B-C
REQUIREMENT TO BE MET: Maximum survival pull force on the actuator 2650 N
PRELIMINARY REQUIREMENTS

REQUIRED CONDITIONS
M2 loadspreader assembled without springs and support triangle.
Eye bolt VRS-F-M10 installated on the M2 loadspreader.
Support for the M2 Loadspreader installed on one fixed surface.
M2 loadspreader installated on the dedicated support.
Dynamometer and the ratchet lever hoist between the M2 loadspreader installed on second fixed surface.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.4 M2 Loadspreader, Function Test

TASK CODE: SST-7127-100-00-340C-C
REQUIREMENT TO BE MET: Correct functionality of each M2 Loadspreader
PRELIMINARY REQUIREMENTS

REQUIRED CONDITIONS
M2 Loadspreader assembled without springs and support triangle.
Limit switches installed and adjusted.
Limit switches and stepper motor powered and connected to the Beckhoff control system.
Support for the M2 Loadspreader installed on the test bench.
M2 loadspreader installed on the dedicated support.
Lock the rotation of the Triangle Frame Interface (without preventing the axial movement) with the anti-rotation device.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.5 M2 Loadspreader, Axial Stiffness Test

TASK CODE: SST-7127-100-00-356A-C
REQUIREMENT TO BE MET: Axial actuator stiffness 30 N/micron

PRELIMINARY REQUIREMENTS

REQUIRED CONDITIONS
M2 Loadspreader assembled.
Support for the M2 Loadspreader installed on one fixed surface.
M2 Loadspreader installed on the dedicated support.
Load cell and the screw jack between the M2 loadspreader installed on the second fixed surface.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.6 M2 Lateral Fixed Point, Max Survival Load Test

TASK CODE: SST-7127-400-00-350A-C

REQUIREMENT TO BE MET:

Max survival load on lateral fixed points 2900 N

Yielding of the sacrificial pins with axial force on the lateral fixed points 2000 < F < 2900 N.

PRELIMINARY REQUIREMENTS

REQUIRED CONDITIONS
M2 Lateral Fixed Point assembled without the Right and Left Rods.
M2 Lateral Fixed Point on the test bench.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.7 EL Actuator Test

Task code

SST-7113-320-00-320A-C

Requirement to be met

Torque necessary for motion without load needs to be less than 3.8Nm (worst condition 7.7-3.9Nm assuming actuator efficiency equal to 1).

Required conditions

EL actuator system assembled with motor on a bench.

Drive needs to be available along with its cable to connect to the motor.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Laptop	Special	N/A	1	
Commissioning SW	Special / Drive manufacturer	N/A	1	
Drive/Laptop USB interface cable	Special / Drive manufacturer	N/A	1	Depends on the interface

Procedure

1. Connect the power supply to the drive.
2. Connect the motor and the drives with the dedicated cables.
3. Supply electrical power to drive.
4. Connect the Laptop with cable USB interface.
5. Using the commissioning software, upload parameters and command motion to the actuator for 5 to 10s.
6. During motion, evaluate the torque output, form the commissioning software in both directions.
7. Power off the electrical power and disconnect all the cables.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.8 M2 actuator range

Task code

SST-7126-000-00-340A-C

Requirement to be met

M2 support actuator axial stroke of at least ±7.5mm.

Required conditions

Loadspreaders installed on M2 BUS.

Drives needs to be available along with its cable to connect to the motor.

Limit switches installed and adjusted.

M2 mirror may or may not be installed. If installed, M2 lateral fixed point shall be removed, so to prevent damages on those items.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Laptop	Standard /	N/A	1	
Commissioning SW	Special / Drive manufacturer	N/A	1	
Drive/Laptop USB interface cable	Special / Drive manufacturer	N/A	1	Depends on the interface
Limit switch engagement monitoring system.	Standard /	N/A	1	Cables, battery and lamp for low voltage (5V)
Caliper	Standard /	N/A	1	

Procedure

1. Connect the power supply to the drive.
2. Connect the motor and the drives with the dedicated cables.
3. Connect the limit switch to the engagement monitoring system.
4. Supply the power to the drive.
5. Command a movement of the M2 Loadspreader till the engagement of the upper limit switch (when lamp of the engagement monitoring system is turning off).
6. Measure the height with the gauge.
7. Command a movement of the M2 Loadspreader till the engagement of the lower limit switch (when lamp of the engagement monitoring system is turning off).
8. Measure the height with the gauge.
9. Verify that the measured axial stroke is 15 mm. If that is not verified, adjust limit switches positions in order to increase the range, coming back to step n°5.
10. Repeat all steps for the second and the third M2 Loadspreader actuators.
11. M2 actuator speed

RESULT

DATE	OPERATOR	SIGNATURE

3.1.9 M2 actuator stroke

Task code

SST-7126-000-00-340B-C

Requirement to be met

M2 support actuator axial stroke of at least 0.75mm/s.

Required conditions

Loadspreaders installed on M2 BUS.

Drives needs to be available along with its cable to connect to the motor.

Limit switches installed and adjusted.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Laptop	Standard /	N/A	1	
Commissioning SW	Special / Drive manufacturer	N/A	1	
Drive/Laptop USB interface cable	Special / Drive manufacturer	N/A	1	Depends on the interface
Limit switch engagement monitoring system.	Standard /	N/A	1	Cables, battery and lamp for low voltage (5V)
Caliber	Standard /	N/A	1	
Chronograph	Standard /	N/A	1	

Procedure

1. Connect the power supply to the drive.
2. Connect the motor and the drives with the dedicated cables.
3. Connect the limit switch to the engagement monitoring system.
4. Supply the power to the drive.
5. Command a movement of the M2 Loadspreader till the engagement of the upper limit switch (when lamp of the engagement monitoring system is turning off).
6. Prepare the chronograph in order to start simultaneously with command of step n°7 and stop at the lower limit switch reaching.
7. Command a movement of the M2 Loadspreader till the engagement of the lower limit switch (when lamp of the engagement monitoring system is turning off).
8. Record the elapsed time for the entire stroke and calculate the speed.
9. Repeat all steps for the second and the third M2 Loadspreader actuators.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.10 M2 actuator accuracy

Task code

SST-7126-000-00-340C-C

Requirement to be met

M2 support actuator axial accuracy must be lower than ±0.02mm.

Required conditions

Loadspreaders installed on M2 BUS.

Drives needs to be available along with its cable to connect to the motor.

Limit switches installed and adjusted.

M2 mirror may or may not be installed. If installed, M2 lateral fixed point shall be removed, so to prevent damages on those items.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Laptop	Standard /	N/A	1	
Commissioning SW	Special / Drive manufacturer	N/A	1	
Drive/Laptop USB interface cable	Special / Drive manufacturer	N/A	1	Depends on the interface
Limit switch engagement monitoring system.	Standard /	N/A	1	Cables, battery and lamp for low voltage (5V)
Caliper	Standard /	N/A	1	
Micrometric dial gauge	Standard /	N/A	1	Calibrated, with 0.001 mm accuracy

Procedure

1. Connect the power supply to the drive.
2. Connect the motor and the drives with the dedicated cables.
3. Connect the limit switch to the engagement monitoring system.
4. Supply the power to the drive.
5. Command a movement of the M2 Loadspreader till the engagement of the upper limit switch (when lamp of the engagement monitoring system is turning off).
6. Command a step movement of 1mm to the M2 Loadspreader actuator towards lower limit switch.
7. Measure the height with the gauge.
8. Repeat step n°5 till the engagement of the upper limit switch (when lamp of the engagement monitoring system is turning off).
9. Measure the height with the gauge.
10. Verify that the measured axial stroke is 15 mm. If that is not verified, adjust limit switches positions in order to increase the range, coming back to step n°5.
11. Repeat all steps for the second and the third M2 Loadspreader actuators.

RESULT

DATE	OPERATOR	SIGNATURE

3.1.11 M2 support position adjustment

Task code

SST-7126-000-00-340D-C

Requirement to be met

M2 support must guarantee to adjust position within the range of ±4mm and guarantee a tilt of ±0.35° (2.95mm on 484mm of radius).

Required conditions

Loadspreaders installed on M2 BUS.

Drives need to be available along with its cable to connect to the motor.

Limit switches installed and adjusted.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Industrial PC	Standard /	N/A	1	
Final SW for M2 control	Special / Drive manufacturer	N/A	1	
Dial gauge with magnetic positioning base	Standard /	N/A	3	
M2 handling cart		7124-200-00-00		

Procedure

1. Connect the power supply to the industrial PC.
2. Connect the power supply to the drive.
3. Connect the motor and the drives with the dedicated cables.
4. Connect the limit switch to the I/O card.
5. Supply the power.
6. Command a movement of all the M2 Loadspreaders to their mean position.
7. Set the magnet supports of the three gauges at 120° respect to. The gauges must touch the rear surface of the Mirror.
8. Command a movement of 4 mm in both the directions to the M2 Loadspreaders contemporaneously (piston movement) and record the values indicated by the three gauges.
9. Command a movement of all the M2 Loadspreaders to their mean position.
10. Command a movement of 3 mm in one the direction to one M2 Loadspreaders actuator (tilt movement) and record the values indicated by the three gauges.

11. Repeat command sequentially for the remaining M2 support actuators taking care to record the dial gauges measurement between the actuator motion.
12. Command a movement of 3 mm in the opposite direction of step n°10 to one M2 Loadspreaders actuator (tilt movement) and record the values indicated by the three gauges.
13. Repeat command sequentially for the remaining M2 support actuators taking care to record the dial gauges measurement between the actuator motion.

RESULT

DATE	OPERATOR	SIGNATURE

3.2 Factory Tests

3.2.1 Sub-Systems Tests

3.2.1.1 Stow pins tests

Task code

SST-7100-000-00-000A-C

Requirement to be met

None. Functionality only.

Required conditions

Stow pin completely assembled.

Support equipment

None.

Procedure

1. Connect the power supply cable to the motor electrical box.
2. Supply electrical power to motor in order to move it in both directions (either inverting the cabling or with a selector).

RESULT

DATE	OPERATOR	SIGNATURE

3.2.1.2 M2 Positioning system

See section 3.1.8-11.

3.2.2 System Inspection & Tests

3.2.2.1 Rain, Snow, Ice and Hail

Task code

SST-7100-000-00-310A-A

Requirement to be met

Protection from environmental damages or contamination.

Required conditions

Telescope entirely assembled and balanced.

A check list needs to be prepared for the purpose.

Support equipment

None.

Procedure

1. The check list needs to be verified point by point successfully with a photo for each verification.
2. The check list will include:

- Door seal.
- AZ bearing cover.
- Electrical cabinet door sealing.
- Electrical cabinet roof.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.2 Dust and sand

Task code

SST-7100-000-00-310B-A

Requirement to be met

Protection from dust and sand contamination.

Required conditions

Telescope entirely assembled and balanced.

A check list needs to be prepared for the purpose.

Support equipment

None.

Procedure

1. Checklist need to be verified point by point successfully with a photo for each verification.
2. The checklist will include:
    - Door seal.
    - AZ bearing cover.
    - Electrical cabinet door sealing.
    - Electrical cabinet air inlet filters.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.3 Azimuth range

Task code

SST-7113-310-00-320A-A

Requirement to be met

The telescope must have a minimum range of 540deg (±270deg).

Required conditions

AZ motors installed and adequately connected to power line and to telescope control system.

AZ encoder system installed and operative

AZ limit switches installed and operative

Control system for AZ drive adequately connected.

Support equipment

None.

Procedure

CAUTION
BE CAREFUL TO PERFORM THE MOTION TEST AT REDUCED SPEED (1/10 MAX SPEED) AND ACCELERATION.

NOTES
• AZ 0° refers to East direction. • This test is done to check the communication between the AZ Motors and the Control System and the correct functionality of the AZ Drives.

1. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope to ± 20°. Verify the correct communication of the Drive system and the congruent motion.
2. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope to ± 90°. Verify the correct communication of the Drive system and the congruent motion.
3. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope to ± 180°. Verify the correct communication of the Drive system and the congruent motion.
4. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope to ± 255°. Verify the correct communication of the Drive system and the congruent motion.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.4 Azimuth encoder initialization

Task code

SST-7111-200-00-342A-A

Requirement to be met

Verify the proper AZ encoder initialization. This is preparatory to permit the measure of entire AZ stroke.

Required conditions

Telescope completely assembled and balanced.

Telescope EL axis at 0° position.

Control system implemented and operational.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
SW procedure	Special /	N/A	1	

Procedure

1. Start initialization procedure from AZ stow pin position.
2. Move Telescope in AZ for an arbitrary angle either clockwise or counter-clockwise.
3. Set the TwinCAT to “Config” mode to delete all the variables
4. Activate the SW project again
5. Initialize the AZ encoder again.
6. Bring the telescope to AZ stow pin position.
7. Verify repeatability.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.5 AZ drive torque bias

Task code

SST-7113-310-00-342A-A

Requirement to be met

Torque bias needs to be at least equal to 654Nm.

Required conditions

AZ drive system assembled.

Control system for AZ drive connected.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Control system for AZ drive	Special /	N/A	1	
SW procedure	Special /	N/A	1	

Procedure

NOTE
This test is needed to check the torque bias between the master and the slave motors. The bias is important to exclude the backlash of the rack gear interface within Operation conditions.

1. Command the axis with a velocity of about 0.1°/s for 30 seconds (JOG Mode).
2. The slave has to be commanded automatically from the control SW with a torque algebraically different of 1308Nm with respect to the master (e.g. master = 2000Nm → slave = 692Nm, master = 1000Nm → slave = -308Nm, master = 308Nm → slave = -1000Nm, etc.).
3. The torques (current absorptions) of each motor have to be acquired.
4. Analyze offline the data.
5. Repeat the test commanding the axis with a maximum velocity of 4.5°/s with the highest acceleration (1°/s^2) and move with the maximum velocity for 90° (ABSOLUTE Mode).

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.6 Elevation range for observations

Task code

SST-7113-320-00-340A-A

Requirement to be met

The observation range in EL is between 20 to 91deg.

Required conditions

OSS completely assembled

EL encoder installed and operative.

EL Limit switches installed and operative.

Control system for EL drive connected and operative.

Support equipment

None.

Procedure

CAUTION
BE CAREFUL TO PERFORM THE MOTION TEST AT REDUCED SPEED (1/10 MAX SPEED) AND ACCELERATION.

NOTE
This test is done to check the communication between the Motor of the EL Actuator and the Control System and the correct functionality of the EL Drive.

1. Rotate the Telescope around the EL axis from 90° to 91° operating manually on the secondary shaft of the EL gearmotor (Drive) in order to check the correct functionality of the EL Limit Switches.
2. Move the telescope around its EL axis from 91° to 0° operating manually on the secondary shaft of the EL gearmotor (Drive) in order to check the correct functionality of the EL Limit Switches.
3. Move the telescope around its EL axis from 0° to -3° operating manually on the secondary shaft of the EL gearmotor (Drive) in order to reach the EL Bumpers position.
4. Come back to 0° EL operating manually on the secondary shaft of the EL gearmotor (Drive).
5. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope from 0° to +25°. Verify the correct communication of the Drive system and the congruent motion.
6. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope till +50°. Verify the correct communication of the Drive system and the congruent motion.
7. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope till +91°. Verify the correct communication of the Drive system and the congruent motion.
8. Give the dedicated commands with the telescope control system (ABSOLUTE Mode) to move the telescope back to +0°. Verify the correct communication of the Drive system and the congruent motion.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.7 Repositioning time

The repositioning time needs to be lower than 70s from a random telescope position to any other one. This requirement is specialized for both the main axes.

3.2.2.7.1 Azimuth speed and acceleration

Task code

SST-7113-310-00-342A-A

Requirement to be met

AZ speed shall reach at least 4.7deg/s.

Required conditions

Telescope completely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Software procedure	Special /	N/A	1	

Procedure

NOTE
AZ 0° refers to East direction.

1. Verify the effective maximum AZ speed commanding the motors using the mount control software (ABSOLUTE Mode) or the motor software tools and measuring the velocity with the AZ axis encoder.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.7.2 Elevation speed and acceleration

Task code

SST-7113-310-00-342A-A

Requirement to be met

EL speed shall reach at least 1.1deg/s.

Required conditions

Telescope completely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Software procedure	Special /	N/A	1	

Procedure

1. Verify the effective maximum EL speed commanding the motors using the mount control software (ABSOLUTE Mode) or the motor software tools and measuring the velocity with the EL axis encoder.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.8 Braking

Task code

SST-7113-300-00-340A-A

Requirement to be met

AZ braking angle shall be less than 2deg.

EL braking angle shall be less than 1deg.

M2 shall be subjected, during braking, to a deceleration equal or less than 1.5g.

Required conditions

Telescope completely assembled and balanced.

Elevation axis at 0deg (horizon pointing).

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Software procedure	Special	N/A	1	

Procedure

1. Set the EL axis at 0deg, if not already at this position.
2. Move the AZ axis at the maximum velocity using the mount control software in ABSOLUTE Mode

3. Push an emergency button.
4. Save the data and verify the braking time and the braking angular displacement.
5. Repeat the test both in CW and in CCW directions.
6. Move the EL axis at the maximum velocity using the mount control software in ABSOLUTE Mode
7. Push an emergency button.
8. Save the data and verify the braking time and the braking angular displacement.
9. Repeat the test both in Up and in Down directions.
10. Calculate the acceleration at M2 considering its distance from the EL axis of about 4m.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.9 Main axes Eingenfrequencies

Task code

SST-7113-300-00-342A-A

Requirement to be met

Telescope AZ and EL axes shall have an eigenfrequency higher than 2.5Hz.

Required conditions

Telescope completely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
SW procedure	Special	N/A	1	

Procedure

1. Record telescope response (position) to a white noise stimulus generated at Azimuth drive level as a sequence of torque commands.
2. The stimulus has adequate amplitude to avoid servo saturation (which generates non linear behavior).
3. The closed loop transfer functions is calculated offline from the recorded data (input and output position).
4. Record telescope response (position) to a white noise stimulus generated at Elevation drive level as a sequence of torque commands.
5. The test has to be repeated with the EL axis in three different positions: 0°, 30°, 60°, 90°.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.10 Position closed loop bandwidth

Task code

SST-7113-300-00-342B-A

Requirement to be met

Telescope AZ and EL axes shall have a position loop bandwidth greater than 1Hz.

Required conditions

Telescope completely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
SW procedure	Special /	N/A	1	

Procedure

1. Execute an AZ position step of 0.5 degrees, and calculate rise time, overshoot and bandwidth of the position closed loop.
2. Execute an EL position step of 0.5 degrees, and calculate rise time, overshoot and bandwidth of the position closed loop.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.11 Regular performance monitoring

3.2.2.11.1 Power consumption test

Task code

SST-3130-000-00-342A-A

Requirement to be met

Telescope power consumption requires to be retrieved.

Required conditions

Telescope completely assembled and balanced.

Power off/disconnection at cabinet level of all the loads not related to the drive motors:

- Resistors/fans of the +HPC and +LPC cabinets (switch off -Q25.1 and –Q34.1 respectively);
- Cherenkov Camera;
- PMC;
- M2 box;

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Software procedure	Special /	N/A	1	

Procedure

1. Record the wind speed from the weather station.
2. Move the azimuth and the elevation axis in their mean position (ABSOLUTE Mode).
3. Command positioning of the azimuth and of the elevation axis at their respective maximum speed (AZ 4.5°/s and EL 2°/s). AZ motion will be tested in clockwise and counter-clockwise direction. Moreover, EL axis motion will be tested in both directions.
4. Record the power consumption for all combinations of AZ/EL motions with the dedicated Beckhoff module.
5. Calculate the mean power consumption for the two axes.
6. Repeat steps from 3 to 5 tracking a source for 15 min on the sky.

Close-up procedures

Power on/connection at cabinet level of all the loads not related to the drive motors:

- Resistors/fans of the +HPC and +LPC cabinets (switch on -Q25.1 and –Q34.1 respectively);
- Cherenkov Camera;
- PMC;
- M2 box;

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.12 Mount payloads and interfaces

Task code

SST-7100-000-00-310C-A

Requirement to be met

Presence of interfaces for telescope payloads.

Required conditions

Telescope entirely assembled and balanced.

A check list of the interfaces needs to be prepared for this purpose, with reference to documents and drawings related to the single interfaces.

Support equipment

None.

Procedure

1. Check list need to be verified point by point successfully with a photo for each verification.
2. The check list will include:
    - Primary mirror segments.
    - Secondary mirror.
    - Camera.
    - PMC system.
    - Electrical connections (power and communication).

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.13 Maintenance/access points

Task code

SST-7100-000-00-310D-A

Requirement to be met

Presence of access points and handling equipment.

Required conditions

Telescope entirely assembled and balanced.

A check list needs to be prepared for the purpose related to the built-in access means of the telescope and handling equipment.

Support equipment

None.

Procedure

1. Check list need to be verified point by point successfully with a photo for each verification.
2. The check list will include:
    - Base door.

- Cabinet doors.
- Ladder to reach AZ fork upper surface.
- Camera handling device.
- AZ Motors handling device.
- Battery drill and adapters.
- M1 handling devices.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.14 Telescope maintenance

SST-7100-000-00-320B-A

Requirement to be met

Presence of the interfaces necessary to connect the handling equipment.

Required conditions

Telescope entirely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
AZ Motors handling device	Special /	7113-310-03-00	1	
M1 Segments handling devices	Special /	7125-300-00-00	1	
M2 handling cart	Special /	7124-200-00-00	1	
Camera handling device	Special /	7128-000-00-00	1	

Procedure

1. Check the time required for the execution of the following maintenance activity:
   - AZ motor removal and installation.
   - AZ stow pin removal and installation.
   - EL stow pin removal and installation.
   - M1 segment removal and installation.
   - Camera removal and installation.
   - Secondary mirror removal and installation.
2. Confirm elapsed time with the one foreseen in the maintenance manual.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.15 EL axis emergency manual motion

Task code

SST-7111-200-00-341A-A

Requirement to be met

Verify the capability of the telescope to be move the elevation axis of the telescope manually.

Required conditions

Telescope completely assembled and balanced.

Telescope EL axis at 90 deg.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Electrical battery drill	Standard	N/A	1	
Adaptor ∅ 14mm	Special /	7113-310-03-00	1	To connect the drill to the secondary shaft of the AZ motor L and EL Actuator motor
Ladder	Standard	N/A	1	

Procedure

1. Use a ladder positioned in front of the Low-Power electrical cabinet to gain access to the secondary shaft of the Elevation Actuator.
2. Open the High-Power cabinet and manually release the EL brake by keeping pushed the relevant contactor.
3. Operate for a defined time the EL Actuator secondary shaft with a drill to rotate manually the telescope about the EL axis. The secondary shaft rotates opposite to the primary shaft: a CW rotation retracts the actuator (EL axis moves towards zenith), while a CCW rotation deploys the actuator (EL axis moves towards horizon).
4. Acquire by the encoder the initial and final EL positions of the telescope and calculate the emergency movement angular speed. Verify the emergency movement angular speed fulfills the requirement of 1.1 deg/s.
5. Move the EL axis until the parking position is reached.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.16 Flood protection

Task code

SST-7100-000-00-310E-A

Requirement to be met

Protection of the product from flood.

Required conditions

Telescope entirely assembled and balanced.

A check list needs to be prepared for the purpose.

Support equipment

None.

Procedure

1. The check list needs to be verified point by point successfully with a photo for each verification.
2. The check list will include:
    - Door seal.
    - Electrical cabinet door sealing.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.17 Entrance control

Task code

SST-7111-000-00-310A-A

Requirement to be met

Entrance control device must not impede the exit.

Required conditions

Base completely assembled.

Support equipment

None.

Procedure

1. Verify the aperture of the base door from outside and inside of the base. Photo of the system is required.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.18 Safety signaling

Task code

SST-7100-000-00-310F-A

Requirement to be met

Presence of safety signals on the telescope where necessary.

Required conditions

Telescope entirely assembled and balanced.

A check list need to be prepared for the purpose.

Support equipment

None.

Procedure

1. The check list needs to be verified point by point successfully with a photo for each verification.
2. The check list will include:
    - Safety signals in proximity with remote control socket.
    - Verify presence of siren.
    - Presence of signs in proximity of motion system that can be possibly moved manually.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.19 Drive control safety

Task code

SST-7100-000-00-320A-A

Requirement to be met

§ 5.4.22

Required conditions

Telescope completely assembled and balanced.

Support equipment

None.

Procedure

1. Verify on the Mount Control System (changes in Boolean status of THCU variables) the input and output signals (with telescope not operative) of:
    a. AZ clockwise operation limit (AZLCW1)
    b. AZ clockwise emergency limit (AZLCW2)
    c. AZ counterclockwise operation limit (AZLCCW1)
    d. AZ counterclockwise emergency limit (AZLCCW2)

e. EL low operation limit (ELOLOW)
f. EL low emergency limit (ELELOW)
g. EL high operation limit (ELOHIGH)
h. EL high emergency limit (ELEHIGH)
i. Cabinet door switch (DOORCAB)
j. Remote emergency stop button (EMERG)
k. Cabinet door emergency stop button (EMERGENCYSTOP)
l. Base door switch (DOOR)
m. Emergency stop button of mobile push buttons panel (EMSTOP)
n. AZ stow pin inserted switch (AZSTOIN)
o. AZ stow pin extracted switch (AZSTOEX)
p. EL stow pin inserted switch (ELSTOIN)
q. EL stow pin extracted switch (ELSTOEX)

2. Verify the correct functionality of the switches with the telescope operative:
   a. AZ clockwise operation limit (AZLCW1) → *movement stopped, motors still active*
   b. AZ clockwise emergency limit (AZLCW2) → *the axis is stopped and STO function is activated*
   c. AZ counterclockwise operation limit (AZLCCW1) → *movement stopped, motors still active*
   d. AZ counterclockwise emergency limit (AZLCCW2) → *the axis is stopped and STO function is activated*
   e. EL low operation limit (ELOLOW) → *movement stopped, motors still active*
   f. EL low emergency limit (ELELOW) → *the axis is stopped and STO function is activated*
   g. EL high operation limit (ELOHIGH) → *movement stopped, motors still active*
   h. EL high emergency limit (ELEHIGH)→ *the axis is stopped and STO function is activated*
   i. Cabinet door switch (DOORCAB) → *no movements, STO functions activated*
   j. Remote emergency stop button (EMERG) →*the axis is stopped and SS1 function is activated*
   k. Emergency stop on cabinet door (EMERGENCYSTOP) → *the axis is stopped and STO function is activated*
   l. Base door switch (DOOR) → *no movements, STO functions activated*
   m. Emergency stop of mobile push buttons panel (EMSTOP) → *the axis is stopped and STO function is activated*
   n. AZ stow pin inserted switch (AZSTOIN) → *AZ motor power off and brake engaged*
   o. AZ stow pin extracted switch (AZSTOEX) → *AZ motor power on possible*
   p. EL stow pin inserted switch (ELSTOIN) → *EL motor power off and brake engaged*
   q. EL stow pin extracted switch (ELSTOEX) → *EL motor power on possible*

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.20 Main axes range limits

Task code

SST-7113-500-00-340A-A

Requirement to be met

Telescope main axes set of switches functionality during motion

Required conditions

Telescope completely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Electrical drill	Special /	N/A	1	
Adaptor ∅ 14mm	Special /	7113-310-03-00	1	To connect the drill to the secondary shaft of the AZ motor L and EL Actuator motor

Procedure

NOTES
• AZ 0° refers to East direction. • The actual hardware configuration of the limit switches does not allow to test the emergency limit using a control SW command because torque is not available. So, it has to be used the drill connected to the secondary shaft of the motor to move the axis until the emergency limit is engaged. The drives in this case must be powered off.

1. Move the azimuth axis in the negative direction up to the intervention of the negative limit switches (JOG Mode):
   - pre-limit (AZLCCW0)
   - operation limit (AZLCCW1)
   - override procedure (switching off the drives and moving by drill)
   - emergency limit (AZLCCW2).
2. Verify the correct angular position of the limit switches engagement reading the position on the control software:
   - pre-limit (AZLCCW0): -260°
   - operation limit (AZLCCW1): -270°
   - emergency limit (AZLCCW2): -272,5°
3. Move the azimuth axis in the positive direction up to the intervention of the positive limit switches (JOG Mode):
   - pre-limit (AZLCW0)
   - operation limit (AZLCW1)
   - override procedure (switching off the drives and moving by drill)
   - emergency limit (AZLCW2).
4. Verify the correct angular position of the limit switches engagement reading the position on the control software:
   - pre-limit (AZLCW0): +260°
   - operation limit (AZLCW1): +270°

- emergency limit (AZLCW2): +272,5°

5. Verify that the angular range of the azimuth axis is ± 270°
6. Move the elevation axis in the low direction up to the intervention of the negative limit switches (JOG Mode):
   - pre-limit (ELPLOW)
   - operation limit (ELOLOW)
   - override procedure (switching off the drives and moving by drill)
   - emergency limit (ELELOW).
7. Verify the correct angular position of the limit switches engagement:
   - pre-limit (ELPLOW): +5°
   - operation limit (ELOLOW): +0°
   - emergency limit (ELELOW): -1°
8. Move the azimuth axis in the high direction up to the intervention of the positive limit switches (JOG Mode):
   - pre-limit (ELPHIGH)
   - operation limit (ELOHIGH)
   - override procedure (switching off the drives and moving by drill)
   - emergency limit (ELEHIGH).
9. Verify the correct angular position of the limit switches engagement:
   - pre-limit (ELPHIGH): +86°
   - operation limit (ELOHIGH): +91°
   - emergency limit (ELEHIGH): +92°
10. Verify that the EL angular range is at least 91°.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.21 Emergency stop test

Please refer to section 3.2.2.19.

3.2.2.22 Electrical safety

Task code

SST-3130-000-00-310A-A

Requirement to be met

Presence of safety signals in correspondence of potentially dangerous electrical equipment.

Required conditions

Telescope entirely assembled and balanced.

A check list needs to be prepared for the purpose.

Support equipment

None.

Procedure

1. The check list needs to be verified point by point successfully with a photo for each verification.
2. The check list will include:
    - Safety signals in proximity of HPC cabinet.
    - Safety signals in proximity of LPC cabinet.
    - Safety signals in proximity of M2 box.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.23 Electrical elements

Task code

SST-3130-000-00-315A-A

Requirement to be met

Protection of personnel and hardware from defects due to assembly or cabling issues.

Required conditions

Telescope entirely assembled and balanced.

Quality book of the electrical equipment.

Support equipment

None.

Procedure

1. Review of the quality documentation related to electrical cabling and electrical equipment in general.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.24 Observation pointing safety

Task code

SST-7113-700-00-341A-A

Requirement to be met

Telescope main axes set of switches functionality during motion.

Required conditions

Telescope completely assembled and balanced.

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Shell script	Special /	N/A	1	
Electrical drill	Standard	N/A	1	
Adaptor ∅ 19mm	Special /	7113-310-03-00	1	To connect the drill to the secondary shaft of the Stow Pin motor
Right-angle attachment for electrical drill	Standard	N/A	1	

Procedure

NOTE

AZ 0° refers to East direction.

1. Move the AZ axis in its mean position
2. Move the AZ axis toward the stow pin position and verify all steps until the completion of the AZ Stow Pin insertion:
    - AZ stow pin pre-limit switch (AZSTOWPRE) engaged at ±12° (only in case the stow function is active) and speed slowed down with a ramp.
    - AZ stow pin enabling encoder position (-90 ±0.088°)
    - AZ stow pin inserted switch (AZSTOIN) triggered.
3. Extract the stow pin and verify the AZ stow pin extracted switch (AZSTOEX) is triggered.

CAUTION

BE CAREFUL NOT TO EXCEED THE ALLOWED STROKE WHEN INSERTING/EXTRACTING MANUALLY THE STOW PIN.

NOTE

Do next step to verify the emergency operation of the AZ Stow Pin.

1. Operate the AZ Stow Pin motor secondary shaft with a drill to insert and retract manually the pin.

2. Move the EL axis in its mean position
3. Move the EL axis toward the lower stow pin position and verify all steps until the completion of the EL Stow Pin insertion:
    - EL stow pin pre-limit switch (ELSTOWPRE) engaged at +5° (only in case the stow function is active) and speed slowed down with a ramp.
    - EL stow pin enabling encoder position (0±0.127°)
    - EL stow pin inserted switch (ELSTOIN) triggered.
4. Extract the stow pin and verify the EL stow pin extracted switch (ELSTOEX) is triggered.
5. Move the EL axis toward the upper stow pin position and verify all steps until the completion of the EL Stow Pin insertion:
    - EL stow pin pre-limit switch (ELSTOWPRE) engaged at +85° (only in case the stow function is active) and speed slowed down with a ramp.
    - EL stow pin enable switch (ELSTOWEN) triggered at +90.4±0.127°
    - EL stow pin inserted switch (ELSTOIN) triggered.
6. Extract the stow pin and verify the EL stow pin extracted (ELSTOEX) switch is triggered.

CAUTION
BE CAREFUL NOT TO EXCEED THE ALLOWED STROKE WHEN INSERTING/EXTRACTING MANUALLY THE STOW PIN.

NOTE
Do next step to verify the emergency operation of the EL Stow Pin.

1. Remove the EL Stow pin cover to gain access to the EL Stow Pin motor secondary shaft.
2. Operate the EL Stow Pin motor secondary shaft with a drill equipped with the right-angle attachment to insert and retract manually the pin.

NOTE: Stow position at 90° can be implemented later via software (bullet 8). This does not jeopardize the verification of the system functionality.

RESULT

DATE	OPERATOR	SIGNATURE

3.2.2.25 Tracking precision

Task code

SST-7100-000-00-340A-A

Requirement to be met

Telescope tracking error of the main axes shall be lower than 6 arcmin RMS

Tracking error is measured compared to main axes encoders, which feature an accuracy of 2.5 arcsec RMS (1/144 of the requirement)

Required conditions

Telescope completely assembled and balanced.

Wind speed lower than 36 km/h (as artificial disturbance)

Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Software procedure	Special	N/A	1	

Procedure

1. Inject artificial wind as a software disturbance into the main axis control loop.
2. Move the azimuth axis and the elevation axis in their mean position (ABSOLUTE Mode)
3. Track a source in the sky with the telescope axes for 15 minutes (TRACKING Mode).
4. Acquire and store the trajectory received, the position commands generated by the control system SW and the encoder reading during all the tracking for both the axes.
5. Calculate the RMS of the tracking differences between the commanded position and the encoder position of the two axes.
6. Repeat steps from 3 to 5 for other five to ten sources (one of them must be at EL angle > 75°).

RESULT

DATE	OPERATOR	SIGNATURE

4 Disassembly Plan and Procedures

4.1 Required conditions

REQUIRED CONDITIONS
Fully assembled telescope.

4.2 Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
M1 dish transport device	Special	7121-100-00-00	1	
Interface device base-truck	Special	N/A	1	
Overhead crane	Standard	N/A	1	
Wire rope	Standard	N/A	AR	
Lifting point for bolting	Vario-Starpoint VRS-F-M20 with star key / RUD	7101315	2	Or similar
Hoist	Standard	N/A	2	
Lifting point for bolting	Load ring VLBG 5t M30 with bolt / RUD	8500828	2	Or similar
Lifting point for bolting	Load ring VLBG 2,5t M20 with bolt / RUD	8500826	2	Or similar
Mechanics tool set	Standard	N/A	2	
Electrical torque wrench	Standard	N/A	1	
Electrical tool set	Standard	N/A	2	

4.3 Consumables

NOMENCLATURE	TYPE / MANUFACTURER	QTY	REMARKS
Tectyl	N/A	AR	

4.4 Procedure Steps

CAUTION

BE CAREFUL TO PROTECT ALL MACHINED SURFACES NOT PAINTED WITH A TEMPORARY ANTI-RUST PROTECTIVE PAINT THAT CAN BE EASILY REMOVED WITH NO SOLVENTS.

1. Remove all M1 segments with the reverse procedure seen in section 2.3.7 (with telescope at 0° in elevation).
2. Position the telescope at 90° in its EL axis.
3. Attach the M2 Support Structure to the crane by means of its three eyebolts.
4. Remove the M2 Support Structure from the Mast taking good care to detach electrical and LPS connections.
5. Attached the Top Ring to the crane by means of three eyebolts.
6. Remove the Top ring and Mast from the M1 Dish and from the Central Tube taking care to detach the LPS connection with the M1 Dish.
7. Attach the Central Tube to the crane by mean of three eyebolts screwed on the top flange.
8. Remove the Central Tube from the M1 Dish.
9. Remove the LPS bar from the M1 Dish and leave only the supports installed on the M1 Dish.
10. Install two eyebolts VLBG 5t M30 on the M1 Dish. Use the slings/chains to connect them to the overhead crane.
11. Remove all fastenings that attach the ELA Upper Hinge to the M1 Dish and retract the actuator.
12. Remove all fastenings that attach the EL Axis Bearings to the AZ Fork main structure.
13. Lift the M1 Dish from the AZ Fork with overhead crane and lower the M1 Dish on the floor on wooden pieces in order to avoid contact with the ground by means of three supports per each half of the M1 Dish.
14. Set two woods with thickness of 400mm on the side of M1 Dish L Structure.
15. Detach the Conduits of the M1 Dish L Structure from the Conduits of the M1 Dish R Structure.
16. Remove all fastenings that attach the M1 Dish R Structure to the M1 Dish L Structure. Disengage the M1 Dish R Structure from the M1 Dish L Structure.
17. Lift the M1 Dish L Structure with overhead crane and rotate it vertically with its side with wooden pieces facing down in order to lower it down onto them.
18. Set thin wooden pieces on M1 Dish halves interface of the M1 Dish R Structure.
19. Lift the M1 Dish R Structure with overhead crane and rotate it vertically with its side with wooden pieces facing down in order to lower it down onto them. Both halves needs to be positioned inside an open top container in this configuration close to each other in order to secure them to each other and to the container.
20. Remove the AZ encoder scanning head groups from the Base.
21. Remove all fastenings that attach the Base to the Pedestal.
22. Remove the fans air scopes from the electrical cabinets.

4.5 Disassembly level

The fully integrated SST telescope is disassembled in the factory only as far as it's needed for transportation inside shipping containers.

The level of disassembly needed for transportation results in the following items:

1. Mount Subassembly (fully integrated)
2. M1 Dish
3. OSS Upper Structure
4. Counterweights
5. M2 Structure (fully integrated with M2 mirror)
6. M1 segments
7. M1 adjusters
8. Camera
9. Optical Support Structure cabling

The main items are shown in the following pictures:

Figure 33: Mount Subassembly for packing (left), fully integrated M2 structure for packing (right)

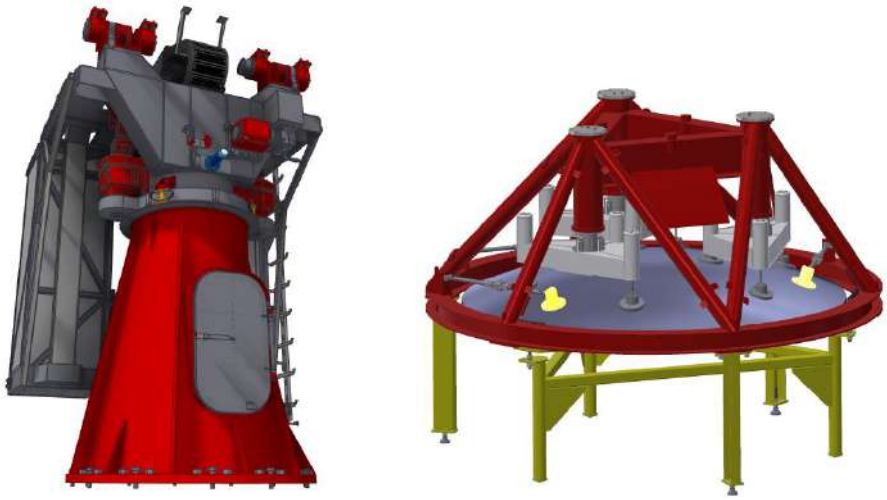
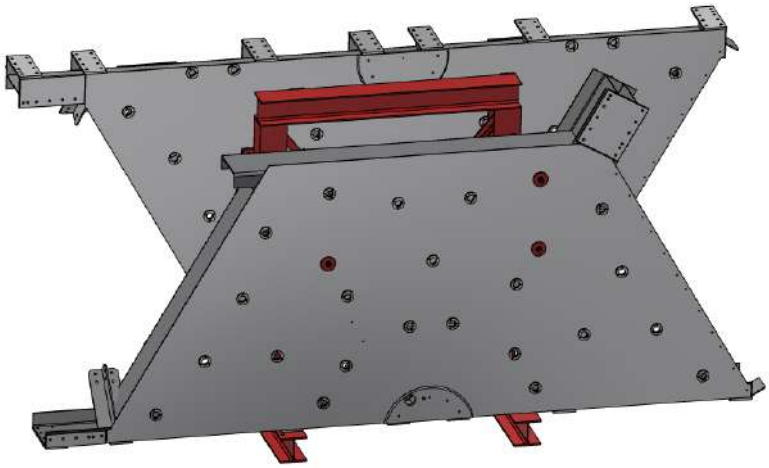


Figure 34: M1 Dish disassembled for packing



5 Safety

5.1 Safety for Assembly & Integration

WARNINGS

- YOU MUST READ AND UNDERSTAND THE INSTALLATION AND TEST PROCEDURES BEFORE PERFORMING THE WORK.
- ALL WORKERS INVOLVED ON INSTALLATION AND TEST ACTIVITIES MUST HAVE IN-DEPTH KNOWLEDGE OF THE SAFETY MANUAL. NON COMPLIANCE WITH THESE SAFETY RULES MAY RESULT IN POTENTIALLY GRIEVOUS INJURIES OF THE WORKERS AND/OR DAMAGE TO THE TELESCOPE COMPONENTS.
- THE SAFETY PRECAUTIONS DESCRIBED IN THE FOLLOWING SECTIONS MUST BE ALWAYS FOLLOWED DURING ALL INSTALLATION AND TEST ACTIVITIES. NON COMPLIANCE WITH THESE SAFETY RULES MAY RESULT IN POTENTIALLY GRIEVOUS INJURIES OF THE OPERATORS AND/OR DAMAGE TO THE SYSTEM.

BE CAREFUL THAT THE WORKING AREA IS ADEQUATELY SIGNALLED (SAFETY CONES, SAFETY TAPE, SAFETY FENCES) TO AVOID ACCESS TO UNAUTHORIZED PERSONNEL.

DO NOT WORK WITHOUT PROPER PERSONAL PROTECTIVE EQUIPMENT. WEAR HARD HAT, PROTECTIVE CLOTHING, FOOT PROTECTION, SAFETY GLOVES AND EYE PROTECTIONS.

BE CAREFUL THAT AT LEAST TWO WORKERS MUST BE PRESENT DURING ALL INSTALLATION AND TEST OPERATIONS ON THE ITEM OR SUBSYSTEM: ONE PERFORMING THE OPERATIONS, THE OTHER ONE MONITORING AND KEEPING READY FOR HELP/RESCUE AND FOR RAISE AN EMERGENCY CALL IN CASE OF NEED.

BE CAREFUL THAT THE RISK OF MECHANICAL SCHOCKS BETWEEN MOBILE MASSIVE SUBSYSTEMS THAT CAN ROTATE AT IMPORTANT SPEEDS AND NEARBY OPERATORS AND / OR ITS TOOLING AND ACCESS MEANS EXISTS. THEREFORE, IT MUST BE THE OPERATORS CARE TO POWER THE DRIVE SYSTEM OFF BEFORE TRYING TO ACCESS THE ITEM.

- WHEN THE USE OF SPECIFIC LIFTING AND HANDLING MEANS (FORKLIFTS, CRANES) IS REQUIRED, THEY MUST BE OPERATED ONLY BY TRAINED AND QUALIFIED PERSONNEL. ALL OTHER OPERATORS MUST TAKE CARE TO REMAIN WELL OUT OF THE PATH OF THESE MEANS WHEN THEY ARE USED.
- BE CAREFUL THAT DURING INSTALLATION OPERATIONS VERY HEAVY ITEMS WILL NEED TO BE LIFTED AND MOVED AROUND. THE OPERATORS MUST PAY ATTENTION NOT TO BE CRUSHED BETWEEN MOVABLE PARTS DURING THE VARIOUS LIFTING, HANDLING AND TRANSPORTING OPERATIONS.
- BE CAREFUL THAT WHEN HEAVY PARTS ARE LIFTED, IT IS STRICTLY FORBIDDEN TO STAY BELOW A LOAD. OPERATORS NEAR THE LIFTING OPERATION MUST TAKE CARE NOT TO BE IN DANGEROUS SITUATIONS.
- THE WIND SPEED DURING LIFTING ACTIVITIES MUST BE IN ACCORDANCE WITH THE LOCAL RULES.

- WHEN THE USE OF A MANLIFT IS REQUIRED, IT MUST BE OPERATED ONLY BY TRAINED AND QUALIFIED PERSONNEL. ALL OTHER OPERATORS MUST TAKE CARE TO REMAIN WELL OUT OF THE PATH OF THIS MEAN WHEN IT IS USED.
- WHEN USING A MANLIFT, THE WIND SPEED MUST BE IN ACCORDANCE WITH THE LOCAL RULES.

BE CAREFUL THAT TOOLS AND EQUIPMENT ARE IN CORRECT AND SAFE CONDITION. IF YOU FIND DEFECTS OR ANY SUSPECT CONDITION THAT YOU CANNOT REMOVE IMMEDIATELY, REPORT TO YOUR SUPERIOR. NEVER USE FAULTY AND UNSAFE EQUIPMENT.

HEAVY OBJECT. TO AVOID BACK INJURY, TWO OPERATORS AND/OR THE USE OF LIFTING AIDS AND PROPER LIFTING TECHNIQUES ARE REQUIRED WHEN MOVING IT.

	BE CAREFUL TO RESPECT THE SAFETY DATA SHEET OF CHEMICAL PRODUCTS.
	THE WORKING AREA IS LOCATED AT A CERTAIN HEIGHT FROM THE GROUND. HENCE, THE RISK OF WORKERS FALL EXISTS. THEREFORE, THE WORKERS MUST USE FALL-PREVENTION EQUIPMENT (SAFETY HARNESS) LINKED TO SAFE AND STABLE PIECES OF EQUIPMENT WITHSTANDING THEIR WEIGHT (SECURITY ANCHOR POINTS OF A MANLIFT FOR INSTANCE) BEFORE ACCESSING THE WORKING AREA.
	BE CAREFUL THAT WALKING AND/OR WORKING CLOSE TO EDGES MUST BE DONE WITH EXTREME CARE AND LIMITED TO A MINIMUM. A SAFETY HARNESS MUST BE USED TO AVOID FALLING DOWN.
	BE CAREFUL THAT DUE TO THE ENVIRONMENTAL CONDITIONS THE SURFACE CAN BE DUSTY, GRITTY, ICY. WALKING ON THE SLIPPERY SURFACES MUST BE DONE WITH CARE TO AVOID ANY SLIDE AND POTENTIAL FALL OF THE OPERATORS. RUNNING IS STRICTLY FORBIDDEN.
	BE CAREFUL NOT TO TRIP ON THE VARIOUS OBSTACLES WHEN WALKING.
	• BE CAREFUL TO RESPECT ALL GENERAL WARNING NOTES OF HEIDENHAIN - MOUNTING INSTRUCTIONS FOR SCANNING HEAD. • BEFORE TO PLUG OR UNPLUG EVERY CONNECTORS, THE POWER SUPPLY AND ALL THE DEVICES CONNECTED TO THE ENCODER COMPONENTS (HEADS, BOARDS, SIGNAL ANALYZER) MUST BE TURNED OFF AND THE POWER SOURCE MUST BE CUT.
	BE CAREFUL THAT SOME ITEM ARE ELECTRICALLY POWERED. HENCE, RISK OF ELECTRICAL SHOCKS BY CONTACT BETWEEN AN OPERATOR AND ELECTRICAL PARTS EXISTS. THEREFORE, IT MUST BE THE OPERATOR'S CARE TO POWER THE ITEM OFF BEFORE WORKING ON IT.

BE CAREFUL THAT THE UPS VOLTAGE CAN BE PRESENT IN SOME ITEMS WHEN NORMAL POWER IS OFF. CONTACT COULD CAUSE ELECTRICAL SHOCK OR BURN. BEFORE SERVICING, VERIFY THAT ALSO THE CIRCUIT BREAKER PROTECTING THE UPS SUPPLY OF THE ITEM IS DISCONNECTED, OR THAT NO VOLTAGE IS PRESENT.

CAUTION

BE CAREFUL NOT TO PINCH OR TEAR OUT THE CABLES DURING INSTALLATION OPERATIONS.

5.2 Safety for Testing

WARNINGS

- YOU MUST READ AND UNDERSTAND THE INSTALLATION AND TEST PROCEDURES BEFORE PERFORMING THE WORK.
- ALL WORKERS INVOLVED ON INSTALLATION AND TEST ACTIVITIES MUST HAVE IN-DEPTH KNOWLEDGE OF THE SAFETY MANUAL. NON COMPLIANCE WITH THESE SAFETY RULES MAY RESULT IN POTENTIALLY GRIEVOUS INJURIES OF THE WORKERS AND/OR DAMAGE TO THE TELESCOPE COMPONENTS.
- THE SAFETY PRECAUTIONS DESCRIBED IN THE FOLLOWING SECTIONS MUST BE ALWAYS FOLLOWED DURING ALL INSTALLATION AND TEST ACTIVITIES. NON COMPLIANCE WITH THESE SAFETY RULES MAY RESULT IN POTENTIALLY GRIEVOUS INJURIES OF THE OPERATORS AND/OR DAMAGE TO THE SYSTEM.

BE CAREFAUL THAT THE WORKING AREA IS ADEQUATELY SIGNALLED (SAFETY CONES, SAFETY TAPE, SAFETY FENCES) TO AVOID ACCESS TO UNAUTHORIZED PERSONNEL.

NOT WORK WITHOUT PROPER PERSONAL PROTECTIVE EQUIPMENT. WEAR HARD HAT, PROTECTIVE CLOTHING, FOOT PROTECTION, SAFETY GLOVES AND EYE PROTECTIONS.

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BE CAREFUL THAT WALKING AND/OR WORKING CLOSE TO EDGES MUST BE DONE WITH EXTREME CARE AND LIMITED TO A MINIMUM. A SAFETY HARNESS MUST BE USED TO AVOID FALLING DOWN.

BE CAREFUL THAT DUE TO THE ENVIRONMENTAL CONDITIONS THE SURFACE CAN BE DUSTY, GRITTY, ICY. WALKING ON THE SLIPPERY SURFACES MUST BE DONE WITH CARE TO AVOID ANY SLIDE AND POTENTIAL FALL OF THE OPERATORS. RUNNING IS STRICTLY FORBIDDEN.

	BE CAREFUL NOT TO TRIP ON THE VARIOUS OBSTACLES WHEN WALKING.
	• BE CAREFUL TO RESPECT ALL GENERAL WARNING NOTES OF HEIDENHAIN - MOUNTING INSTRUCTIONS FOR SCANNING HEAD. • BEFORE TO PLUG OR UNPLUG EVERY CONNECTORS, THE POWER SUPPLY AND ALL THE DEVICES CONNECTED TO THE ENCODER COMPONENTS (HEADS, BOARDS, SIGNAL ANALYZER) MUST BE TURNED OFF AND THE POWER SOURCE MUST BE CUT.
	BE CAREFUL THAT SOME ITEM ARE ELECTRICALLY POWERED. HENCE, RISK OF ELECTRICAL SHOCKS BY CONTACT BETWEEN AN OPERATOR AND ELECTRICAL PARTS EXISTS. THEREFORE, IT MUST BE THE OPERATOR'S CARE TO POWER THE ITEM OFF BEFORE WORKING ON IT.
	BE CAREFUL THAT THE UPS VOLTAGE CAN BE PRESENT IN SOME ITEMS WHEN NORMAL POWER IS OFF. CONTACT COULD CAUSE ELECTRICAL SHOCK OR BURN. BEFORE SERVICING, VERIFY THAT ALSO THE CIRCUIT BREAKER PROTECTING THE UPS SUPPLY OF THE ITEM IS DISCONNECTED, OR THAT NO VOLTAGE IS PRESENT.

End of the document