



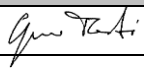

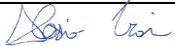
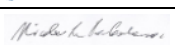
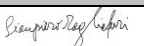
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# SST Mechanical Structure: On-site Maintenance Plan

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SST-MEC-PLA-015

Version 2b

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# 1 Introduction

## 1.1 Scope & Purpose

This document is the Maintenance Plan of the SST telescope mechanical structure.

The scope of the Maintenance Plan is to list the operations, their frequency and the associate manpower/tools, that are needed to maintain correctly and safely the SST telescope.

In particular, the present document:

- Lists all maintenance activities and their frequency.
- Describes the safe approach to the telescope and the required conditions when a maintenance activity needs to be performed.
- Lists all general and subsystem-specific warnings and cautions.
- Lists the main support equipment needed for maintenance operations.
- Lists the main consumable and expendable equipment needed for maintenance.
- Lists the spare parts used for maintenance.
- Makes reference to the step-by-step procedures or manuals needed for safe and correct maintenance.
- Makes reference to the user manual to operate the telescope manually in case of emergency.

## 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

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## 1.4 Definition of Terms and Abbreviations

### 1.4.1 Abbreviations and Acronyms

ASTRI	Astrophysics with Italian Replicating Technology Mirrors
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
DLM	Depot Level Maintenance
DR	Delivery Review
ILM	Intermediate Level Maintenance
INAF	Istituto Nazionale di Astrofisica
INSU	Institut National des Science de l'Univers
KO	Kick-Off
LRU	Line Replaceable Unit
LSA	Logistic Support Analysis
MPIK	Max-Planck-Institut für Kernphysik
OEM	Original Equipment Manufacturers
OP	Observatoire de Paris - PSL, CNRS
OLM	Organizational Level Maintenance
PA	Product Assurance
PBS	Product Breakdown Structure
PCIL	Programmed Check and Intervention List
PM	Project Manager
PR	Product Review
PMP	Programme Management Plan
PO	Project Office
PQR	Production Qualification Review
PR	Product Review
PRM	Programme Manager
PRR	Production Readiness Review
PSE	Programme System Engineer
QA	Quality Assurance
RAMS	Reliability, Availability, Maintainability & Safety
SLM	Supplier Level Maintenance
SRU	Shop Repairable Unit
SST	Small-Sized Telescope

### 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)

TERM	DEFINITION
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. <b>NOTE:</b> 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.

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## 2 Maintenance Approach

The approach to maintenance of the SST Telescope is similar both for preventive maintenance, that is maintenance that is performed on a scheduled basis, and for corrective maintenance, that is maintenance that is performed after the occurrence of a fault.

The maintenance approach is to either restore a failure or perform scheduled tasks on a SST Telescope system as quickly as possible, by means of replacement of Line Replaceable Units (LRUs) or Shop Replaceable Units (SRUs) rather than repair-in-place.

In addition, the plan is to be as independent as possible from third-part maintenance providers, by ensuring the competency of organizational personnel in all maintenance tasks.

An LRU is an item that can be replaced on-equipment, which does not require a special workshop to be replaced; it is defined as unit which can be easily exchanged (without extensive calibration, of sufficient low mass and dimension for easiness of handling, etc.) by maintenance staff of technician level. An SRU is an item that is replaced in an LRU and requires a special workshop.

Maintenance will be mainly performed at assembly and subassembly level by replacement of Line Replaceable Units (LRU's), either in case of failure or according to a schedule, and a step-by-step procedure for safe replacement of every LRU will be provided.

According to the LRU definition, and in order to ease all LRUs and SRUs maintenance operations and to assure they are performed safely, for all LRUs and SRUs, if their mass is more than 15Kg and less than 40 Kg they will be equipped with carrying handles, while if their mass is more than 40Kg they will have an integral lifting arrangement (e.g. eye-bolts).

The following preliminary list gives an indication on the equipment that can be considered as LRU:

- Azimuth encoder reading head
- Altitude encoder reading head
- Azimuth motor assembly
- Elevation actuator assembly
- Azimuth stow pin assembly
- Elevation stow pin assembly
- Azimuth limit switches
- Elevation limit switches
- Elevation Bumper
- Elevation Bearings assembly
- Azimuth and Elevation drives
- Control system Hardware
- Electrical components of the cabinets
- Filters of the cabinets
- Fans of the cabinets



- 
- Lightning Protection System components
  - Temperature sensors
  - Vibration sensors
  - Base door components
  - M1 Segment Support components
  - M2 Actuators
  - M2 Lateral Fixed Points
  - M2 Loadspreaders
  - M2 Shields

In conclusion, the maintenance tasks will be minimized and to the extent of possible be limited to LRUs and SRUs replacement and preventive maintenance tasks.

All Maintenance tasks will be defined by a Logistic Support Analysis (LSA) process.

## 2.1 Maintenance Levels

The following Maintenance Levels apply:

- **Organisational Level (O-Level or OLM):** O-Level Maintenance will be executed on-site of the SST telescope. Corrective Maintenance at O-Level is accomplished by the removal and replacement of LRU's from the telescope system equipment. In extreme cases, replacement of components such as pipes, wires etc could occur. Preventive Maintenance at O-Level is accomplished by executing the maintenance on the SST telescope equipment.
- **Intermediate Level (I-Level or ILM):** I-Level Maintenance will be executed at a support base facility close to the SST telescope site. Corrective Maintenance at I-Level is executed on equipment removed at O-Level, and is accomplished by the removal and replacement of LRU's and SRU's, as applicable. Preventive Maintenance at I-Level is accomplished by executing complex maintenance on equipment removed at O-Level.
- **Deport Level (D-Level or DLM):** D-Level Maintenance will be executed at a dedicated D-Level Repair Facility further away from the SST telescope site. Personnel from this level could also provide assistance to OLM, ILM and DLM activities when required. Corrective Maintenance at D-Level is executed on LRU's and SRU's from I-Level and is accomplished by the removal and replacement of components/software as applicable. Preventive Maintenance at D-Level is accomplished by executing the specialist maintenance on equipment removed at O-Level, and not in the capability of I-Level.
- **Supplier Level (S-Level or SLM):** S-Level Maintenance will be executed at equipment suppliers or Original Equipment Manufacturers (OEM) in factory and can be anywhere in the world. Personnel from this level would also provide assistance to OLM, ILM and DLM activities when required. Corrective Maintenance at S-Level is executed on LRU's and SRU's from OLM, ILM

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and/or DLM, and is accomplished by the removal and replacement of components/software as applicable. Preventive Maintenance at S-Level is accomplished by executing the specialist maintenance on equipment removed at O-Level (if applicable).

## 2.2 Maintenance Typologies

Three main kinds of maintenance will be considered:

- Periodic preventive maintenance
- Overhaul
- On-Site Repair / Corrective maintenance

**Periodic Preventive Maintenance:** this maintenance is the planned interval maintenance, which is performed at the levels indicated in section 2.1. in order to maintain the telescope fully operational, within its specified performance parameters. This includes checking, greasing, substitution of consumables, visual inspection, etc. All maintenance operation shall be planned in the Programmed Check and Intervention List (PCIL) of the Maintenance Manual, which shall list the tools, the procedures, and the time necessary for their execution and their periodicity.

**Overhaul:** is a planned major maintenance operation, which can be performed if the necessity arises.

Periodical painting and surface protection will not be necessary more often than every 10 years and shall be planned at the time of overhaul, if necessary. Possible overhaul activities, including painting and other possible tasks, will be described in the Maintenance Manual.

**On-Site repair/Corrective Maintenance:** replacement or repair takes place only in case of failure of an item. On site repair is normally limited to the in-situ exchange of LRUs.

In addition to the main categories listed above, Monitoring Points and Test Routines will be developed and implemented.

**Monitoring points:** The status of the SST telescope parameters, which may be relevant for assessing life degradation and telescope troubleshooting (example motor and transformer temperatures, overshoots, lubrication levels etc.) will be available for monitoring and treatment by telescope Operators. These variables will be defined according to the design of the subsystems.

**Self-tests:** self-tests could be executed on switch-on or at other times at SST telescope Operators request in order to locate failures down to LRU level. Self-tests shall:

- Exercise functions
- Check initialization procedure
- Carry out test at telescope control system level

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It shall be possible to initiate the self-test routine in remote mode and from the local control panel. Suitable command(s) to execute the self-test and report status are to be defined.

## 2.3 Support Technical Publications

Support Publications will be released to provide sufficient and correct up to date information for personnel to perform specific tasks for Operation and Maintenance, and to compliment training efforts and shall be based on international best practise. The publication package will be developed for the Operators and Maintainers.

Operator publications will provide suitable information for the observer and operator to understand the SST Telescope and to effectively execute defined tasks and shall have its origin from Operator Interface Control Documents and LSA Data.

Maintainer publications will provide suitable information for the maintainer to understand the SST system and to effectively execute maintenance tasks.

The four publications that are prepared and release as a support to maintenance are:

- The Maintenance Manual
- The Operations Manual
- The Software Maintenance Manual
- The Software User Manual

### 2.3.1 Maintenance Manual

The manual will be addressed to all people responsible for the maintenance of the SST telescope.

Aim of the manual will be to give, in a quick and comprehensible way, indications, instructions and advice concerning the maintenance of the Telescope machine and its manual operation in case of emergency.

Th manual will be a consultation book used by the personnel who needs specific information on the job they are performing and must be used for the Telescope maintenance.

The manual will indicate when to perform a scheduled maintenance activity (periodic prevent or overhaul) and helps the maintenance crew during the execution of its specific work.

The observance of all the indications written in the manual will allow to perform maintenance on the Telescope and to operate some subsystems during emergencies in safe conditions.

The manual will be considered as part of the telescope and will be kept up to its final dismantlement in a visible and easily accessible place.

The maintenance manual will contain the detailed maintenance procedures with drawings, part lists and possible applicable technical publications (e.g. supplier manuals). It shall contain also the maintenance requirements and scheduling for all items included in the supplies of this contract, an example of which is given in section 4.

It shall identify all maintenance actions, and provide them in a tabular form with as a minimum:

- Type of maintenance, inspection, LRU exchange, overhaul etc;
- Dates (intervals) of maintenance;
- Procedure identification and number

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For each intervention there shall be a specific procedure with the following information as a minimum:

- Item to be maintained
- Number and qualification of maintenance personnel
- Duration of maintenance action
- Tools and equipment, including access
- Required parts
- Required consumables
- Step by step procedure, including preparation
- Safety measures
- Check after action and start up

### 2.3.2 Operations Manual

The Operations Manuals will describe in detail all the procedures needed to operate correctly and safely the SST telescope.

It shall at least:

- Describe the start-up procedures;
- Describe the shut-down procedures;
- Describe all the procedures to operate the subsystems;
- Describe all the operational errors messages for the Telescope Controller and the resulting remedial action;
- Describe all the safety procedures to operate the antenna and the subsystems,
- List all the operational limits;
- List the emergency cases, which can occur during operations;
- Describe emergency procedures;
- Make reference to any other procedure needed for safe and correct operation;
- Trouble-shooting and actions to be performed by the operator upon error conditions, fault identification;
- Includes the operations manual of the Control System

### 2.3.3 Software Maintenance Manual

The Control Software Maintenance manual shall cover:

- Programming language, the operating system and development system used;
- The internal organization of the software and files description;
- The installation procedure including the environment set-up (operating system, etc.);
- The preventative maintenance operations (file clean-up, etc.);
- Document the test procedures;

- 
- Describe the detailed procedure to install new releases and to check the installed versions.

If, in addition to custom software, any other "off-the shelf" software is used, the original documentation shall be provided.

#### 2.3.4 Software User Manual

The Software User manual shall describe as a minimum:

- Contain the design documentation;
- Software design overview, and architecture;
- Software installation and downloading procedures;
- Operating modes;
- User Interface;
- List of commands and parameters;
- List of error messages and their interpretation.

## 3 Safety precautions during maintenance

All people involved in the maintenance will be trained for the safety on site, including the knowledge of the applicable manuals. On site there will be a logbook where the daily status of the activities will record by the relevant telescope responsible. A file containing all the forms (maintenance, safety, red flag, etc.) shall be kept on site and properly filled by the personnel.

As general rule, the telescope, also if not apparently moving, shall be considered as a moving machine because remotely controlled.

A basic recommendation is the installation of closed fencing all around the telescope motion volume.

Since the Telescope is a moving machine remotely controlled, the rule to safely approach it foresees that the operator pushes the remote emergency stop, locks-out and tags-out it before moving towards the telescope for any maintenance activity. This action interlocks the movements of the telescope axes for a safe access nearby the telescope itself.

In addition, various indications and recommendations will be reported in the Maintenance Manual tasks, such as the lock-out and tag-out procedures, the switch fuse and the circuit breakers to be set to OFF position on the Electrical Cabinets, in order to prevent unexpected and uncontrolled telescope axes movements.

### 3.1 Safety Procedures

In order to guarantee a safe use, operation and maintenance of the telescope and its relevant subassemblies, a SAFETY "CHECK LIST" and a SAFETY "RED FLAG" template will be provided. This is just a suggestion on how the activities should be organized. If on site there are existing other similar procedures / forms, the last ones will be applied.

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The first form will be filled in by the person responsible for the telescope operations at the beginning of the working day/night.

The second one will be filled in by the person responsible for the telescope maintenance and it will be addressed to the Operation Responsible.

**SAFETY PROCEDURE - FORM no.1**  
**ANALYSIS OF THE SYSTEM'S SAFETY CONDITIONS**

**SUBASSEMBLY NAME:**.....

	<u>Y</u>	<u>N</u>
a) Any mechanical job in progress?	<input type="checkbox"/>	<input type="checkbox"/>
b) Any electrical job in progress?	<input type="checkbox"/>	<input type="checkbox"/>
c) Any adjustment in progress?	<input type="checkbox"/>	<input type="checkbox"/>
d) Safety devices are operative?	<input type="checkbox"/>	<input type="checkbox"/>
	<u>Y</u>	<u>N</u>
- Functional stop?	<input type="checkbox"/>	<input type="checkbox"/>
- Motion stop?	<input type="checkbox"/>	<input type="checkbox"/>
- Smoke sensors?	<input type="checkbox"/>	<input type="checkbox"/>
- Interlocks?	<input type="checkbox"/>	<input type="checkbox"/>
- Barriers?	<input type="checkbox"/>	<input type="checkbox"/>
- Others?	<input type="checkbox"/>	<input type="checkbox"/>
e) Use limitation due to external activities?	<input type="checkbox"/>	<input type="checkbox"/>
f) The safety conditions are valid at ALL levels (Local/ACU)?	<input type="checkbox"/>	<input type="checkbox"/>
g) New safety/operational issues?	<input type="checkbox"/>	<input type="checkbox"/>
h) Any extra safety procedure needed?	<input type="checkbox"/>	<input type="checkbox"/>

DATE: .....

NAME: ..... SIGNATURE: .....

---

**SAFETY PROCEDURE - FORM no.2**

**RED FLAG FOR OPERATORS AND USERS RELATED TO OPERATION AND SAFETY CONDITIONS**

**DEVICE/SUBASSEMBLY NAME:.....**

	<u>Y</u>	<u>N</u>	<u>Note</u>
a) Mechanical job in progress	<input type="checkbox"/>	<input type="checkbox"/>	.....
b) Electrical job in progress	<input type="checkbox"/>	<input type="checkbox"/>	.....
c) Adjustment in progress	<input type="checkbox"/>	<input type="checkbox"/>	.....
d) Safety devices	<input type="checkbox"/>	<input type="checkbox"/>	.....

	<u>Y</u>	<u>N</u>	<u>Note</u>
- Functional stop?	<input type="checkbox"/>	<input type="checkbox"/>	.....
- Motion stop?	<input type="checkbox"/>	<input type="checkbox"/>	.....
- Smoke sensors?	<input type="checkbox"/>	<input type="checkbox"/>	.....
- Interlocks?	<input type="checkbox"/>	<input type="checkbox"/>	.....
- Barriers?	<input type="checkbox"/>	<input type="checkbox"/>	.....
- Others?	<input type="checkbox"/>	<input type="checkbox"/>	.....

	<u>Y</u>	<u>N</u>	<u>Note</u>
e) Use limitation due to external activities	<input type="checkbox"/>	<input type="checkbox"/>	.....
f) Other	<input type="checkbox"/>	<input type="checkbox"/>	.....

DATE: .....

FROM: ..... SIGNATURE: .....

FROM: ..... SIGNATURE: .....

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## 3.2 Circuit breakers and disconnectors lock-out and tag-out

This section with its figures shows the general procedure of Lock-out and Tag-out (LO/TO) on electrical switches.

All telescope devices (main axes drives, stow pins, etc.) feature switches that are lockable. Those are located inside the electrical cabinets. Each time when maintenance is to be performed on a given device, the LO/TO procedure shall be applied on the switch powering the device.

In the maintenance manual, all procedures that require LO/TO of switches shall report the relevant instructions to locate and lock the switch inside the cabinet.

The following figures shows the sequence of the blocking system insertion. This locking system can be applied to any circuit breaker of any number of phases.



Fig. 1: Device inserted into the circuit breaker



Fig. 2: The device blocks the circuit breaker open position





Fig. 3: First padlock inserted



Fig. 4: First padlock blocked

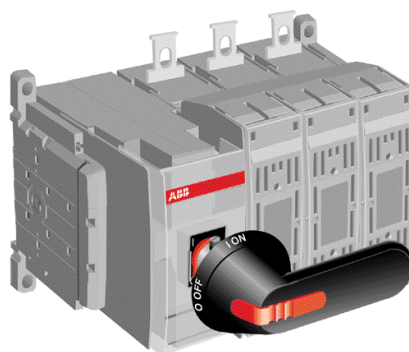


*Fig. 1: A second locking device is inserted*

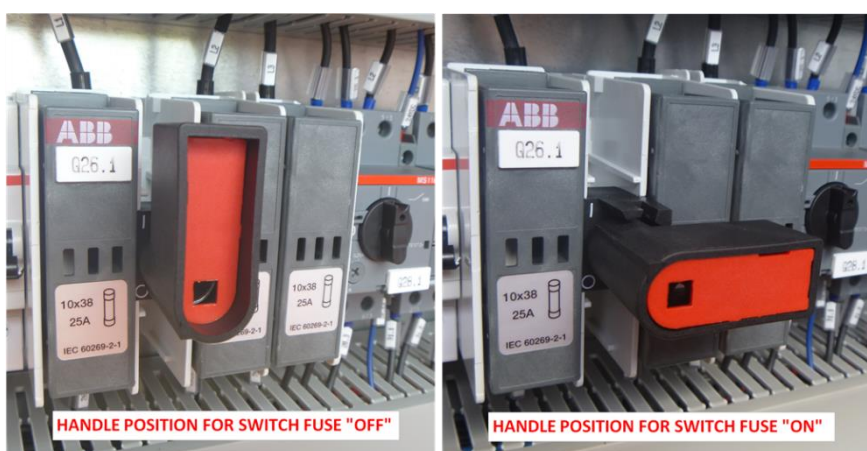


*Fig. 2: Every pole of the circuit breaker is padlocked*

The figures below are relative to a typical switch fuse (the first one) and to the Telescope Drives switch fuse (the second one), both located inside the Electrical Cabinets. The safety procedure foresees to set the handle of these switch fuses to OFF position. Also, in this case the padlock can be inserted in the relevant padlock handle of the switch fuse when it is in OFF position.



*Fig. 3: Typical switch fuse*



*Fig. 4: Telescope Drives switch fuse, handle positions detail*

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## 3.3 Telescope confined spaces

Confined space are those spaces that could be unsafe for human occupancy. Because of oxygen deficiency, physical and electrical hazards, personnel entering these spaces may be asphyxiated or seriously injured.

The Base has been identified as Confined Space volume in the Telescope.

In case of access inside this mentioned volume, it must be adopted all the measures foreseen and enforced at the site for such kind of activity.

In particular:

- The confined space must be ventilated by leaving the Base access door open and locked in this position;
- Be careful that at least one standby person (possibly equipped with a two-way radio) must be stationed just outside the access opening of any confined space while it is occupied.

### 3.3.1 Maintenance operations precautions

Inside the maintenance manual there will be several notes, cautions and warnings in order to assure the maintenance crew attention over the various maintenance operations and possible associated problems or residual risks. Therefore, the manual and all the associated applicable documentation must be deeply studied by the maintenance crew, in order to assure a correct and safe maintenance and a prompt reaction in case of troubles.

### 3.3.2 Precautions for sensitive components

In case of intervention on the telescope, both for use, debugging, scheduled maintenance, LRU exchange, etc. it is recommended to take particular care of the cabinet closure. It is commonly understood that each equipment and component need to be known by the maintenance crew on the basis of overall telescope technical documentations.

On the telescope, the most sensitive devices are:

- Electronics in general, with emphasis to all control boards;
- AZ encoder system;
- M1 segments;
- M1 supports;
- M2 mirror;
- M2 loadspreader assembly.

It is therefore recommended to have an adequate training activity over all these devices with relevant installation and maintenance procedures, in which all the important information and warnings have been introduced.

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## 4 Maintenance Plan

### 4.1 Support Equipment List, Consumable and Spare parts

The maintenance manual, to allow the correct maintenance operations, will contain a chapter dedicated to the following elements:

- Support equipment list.
- List of consumables.
- Spare part List.

The lists will be detailed and will report in particular whether equipment, consumables or spare parts are standard or specific for SST Telescope.

Below is the template that will be used for each list.



NOMENCLATURE	TYPE / MANUFACTURE R	PT NO.	QTY	REMARKS	FIGURE (indicative only)
Hydraulic tensioning cylinder	STS2-M33B1 / Hi-Force		1	Equipped with pump. Or similar.	
Mobile crane	Standard		1	Lifting load 2000 kg	

Figure 1: Example of Support Equipment List

---

NOMENCLATURE	TYPE / MANUFACTURER	PT. NO	QTY	REMARKS
Adhesive	Loctite 406		AR	See MTDS and MSDS at chapter <a href="#">2.3</a>
Grease	LGEP2 / SKF		180 g (for AZ Bearing) + AR g (for AZ Bearing Spur Gear)	See MTDS and MSDS at chapter <a href="#">2.3</a>

Figure 2: Example of Consumables

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Seal rings	DIN 3760 type AS		8	Qty 4 for each gearbox.
Filter	Class G3 standard / RITTAL	3173.100	5 pieces pack	

Figure 3: Example of Spare Part List

## 4.2 Preventive and Corrective Intervention Plan

The manual will identify all maintenance actions and provide them in a tabular form, with the following indications:

- procedure identification and number.
- type of maintenance: scheduled inspection, greasing, LRU exchange, removal procedure, installation procedure etc.

- frequency of the maintenance task (for scheduled inspections and preventive maintenance only).
- duration of the maintenance action.

#### 4.2.1 Preventive maintenance

Preventive maintenance plan contains any variety of scheduled interval maintenance to a system, subsystem or item of equipment, which must be performed in order to maintain the Telescope operational and within its specified performance and to evaluate the conditions of the components that are not expected to survive for the entire lifetime.

This includes checks, greasing, substitution of consumables, visual inspections, etc.

The elapsed time and manhours are calculated based on the employment of two operators for each activity.

The calculated time for each activity does not include preparation and access to the telescope; it however includes close-up.

Table 1: Preventive Maintenance Plan

TASK NAME		INTERVAL									DURATION		NOTES
ITEM	MAINTENANCE TYPE	3M	6M	1Y	2Y	3Y	5Y	8Y	10Y	OTHER	ELAPSED TIME (min)	MAN HOURS	
Base	Scheduled inspection					X					55	1.85	
AZ Encoder	Scheduled inspection			X							20	0.65	
AZ Bearing Spur Gear	Greasing		X								90	3	
AZ Bearing	Greasing		X								70	2.35	
AZ Bearing Seals	Scheduled inspection		X								55	1.85	
AZ Bearing Screws	Scheduled inspection			X							55	1.85	

TASK NAME		INTERVAL									DURATION		NOTES
ITEM	MAINTENANCE TYPE	3M	6M	1Y	2Y	3Y	5Y	8Y	10Y	OTHER	ELAPSED TIME (min)	MAN HOURS	
AZ Fork Structure	Visual examination					X					30	1	
EL Axis Bearing	Greasing					X					15	0.5	All four bearing supports
EL Axis Bearing	Scheduled inspection			X							25	0.85	
AZ Motor	Scheduled inspection		X								20	0.65	
AZ Motor	Change of oil						X				90	3	For two motors
ELA Upper and Lower Hinges	Greasing					X					20	0.65	All four ELA Hinge Supports
EL Actuator	Greasing and Scheduled inspection			X							60	2	
AZ and EL Limit Switches	Manual test		X								30	1	
AZ Stow Pin	Greasing					X					30	1	
AZ Stow Pin	Scheduled inspection			X							30	1	
AZ Stow Pin Gearmotor	Change of oil							X			45	1.5	
EL Stow Pin	Greasing					X					35	1.15	
EL Stow Pin	Scheduled inspection			X							40	1.35	
EL Stow Pin Gearmotor	Change of oil							X			45	1.5	

TASK NAME		INTERVAL									DURATION		NOTES
ITEM	MAINTENANCE TYPE	3M	6M	1Y	2Y	3Y	5Y	8Y	10Y	OTHER	ELAPSED TIME (min)	MAN HOURS	
Optical Support Steel Structure and Electrical Conduits	Scheduled inspection					X					120	4	
M2 Loadspreader Assembly	Scheduled inspection			X							45	1.5	Cherry picker
M2 Loadspreader	Lubrication		X								10	0.15	Cherry picker
M2 Loadspreader	Greasing								X		120	4	Cherry picker
Electrical Cabinets	Scheduled inspection		X								45	1.5	
Electrical Cabinets, Filters	Change		X								10	0.3	
LPS & Grounding	Scheduled inspection			X						Every time a lightning struck the Telescope	45	1.5	Cherry picker
M1 Mirrors	Scheduled inspection		X								120	4	Cherry picker
M2 Mirror	Scheduled inspection		X								45	1.5	Cherry picker

#### 4.2.2 Condition-based and corrective maintenance

The **Condition-Based Maintenance** is performed when need arises, after one or more indicators show that equipment is going to fail or that equipment performance is deteriorating. It is therefore based on the use of unscheduled inspections and real-time data. As the result of a checking or of an inspection, the maintenance manual will include the activities, such as cleaning, that are required occasionally as consequence (on condition) of the inspection itself, but not



at specific intervals. Observing the state of the system, it is known as Condition Monitoring. Such a system determines the equipment's health and acts only when maintenance is actually necessary.

The **Corrective Maintenance** will be carried out after failure detection by the telescope Local Control Software, and it is aimed at restoring an asset to a condition in which the item, subsystem, machine can perform its intended function. Therefore, it will consider the replacement or repair actions which take place only in case of failure of an item. On site repair is normally limited to the in-situ exchange of LRUs, but not only.

This table lists also the removal and installations procedures of items that must be performed as required preliminary action to allow subsequent workshop activities on the item itself.

Table 2: Condition based and corrective maintenance list

TASK NAME		DURATION		NOTES
ITEM	MAINTENANCE TYPE	ELAPSED TIME (min)	MAN HOURS	
Steel Structures	Clean and apply surface protection	Variable with the surface to be painted.	Variable with the surface to be painted.	
Door Switch	Change	15	0,5	
AZ Encoder Scale Tape	Dry	10	0,3	After rainy weather and/or high humidity, before the Telescope operation.
AZ Encoder Scanning Head	Change	45	1,5	For one scanning head
Bumper	Change	10	0,3	
EL Encoder	Change	30	1	
AZ Motor	Emergency operation	30	1	
AZ Motor	Clean and apply surface protection	Variable with the surface to be painted.	Variable with the surface to be painted.	To be added 3,5 MH for motor removal and installation in case of complete re-coating.
AZ Motor	Remove procedure	45	1,5	For one motor

TASK NAME		DURATION		NOTES
ITEM	MAINTENANCE TYPE	ELAPSED TIME (min)	MAN HOURS	
AZ Motor	Install procedure	60	2	For one motor
EL Actuator	Emergency operation	10	0,3	
EL Actuator Motor	Change	40	1,3	
AZ Limit Switches	Change	15	0,5	For one limit switch
EL Limit Switches	Change	15	0,5	For one limit switch
AZ Stow Pin	Emergency operation	15	0,5	
AZ Stow Pin Limit Switches	Change	30	1	For one limit switch
AZ Stow Pin Gearmotor	Clean and apply surface protection	Variable with the surface to be painted.	Variable with the surface to be painted.	To be added 2,8 MH for gearmotor removal and installation in case of over-coating.
AZ Stow Pin Gearmotor	Remove procedure	30	1	
AZ Stow Pin Gearmotor	Install procedure	40	1,4	
EL Stow Pin	Emergency operation	15	0,5	
EL Stow Pin Limit Switches	Change	30	1	For one limit switch
EL Stow Pin Gearmotor	Clean and apply surface protection	Variable with the surface to be painted.	Variable with the surface to be painted.	To be added 2,65 MH for gearmotor removal and installation in case of over-coating.
EL Stow Pin Gearmotor	Remove procedure	35	1,15	
EL Stow Pin Gearmotor	Install procedure	45	1,5	
M1 Segments	Remove procedure	35	1,75	Time for one M1 Segment. To be added 40 min (1,3 MH) for required conditions.

TASK NAME		DURATION		NOTES
ITEM	MAINTENANCE TYPE	ELAPSED TIME (min)	MAN HOURS	
M1 Segments	Install procedure	45	2,25	Time for one M1 Segment. To be added 60 min (2 MH) for close-up procedures.
M1 Axial Actuator Gearmotor	Change	20	0,65	
M2 Loadspreader Assembly	Disassemble procedure	150	7,5	
M2 Loadspreader Assembly	Assemble procedure	180	9	
M2 Loadspreader Gearmotor and Encoder	Change	60	2	On a single M2 Loadspreader
Electrical Cabinets	Clean and apply surface protection	Variable with the surface to be painted.	Variable with the surface to be painted.	
UPS Battery Cartridge	Change	30	1	Estimated lifetime 3-5 years

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## 5 Spare Parts

The range, quantity and location of spares and consumables shall have its origin from LSA data and simulation/modelling.

Replenishment of LRU's and SRU's will be based on an exchange principle, i.e. a serviceable item shall be provided on the receipt of an unserviceable item.

O-Level Supply Support will provide LRU's that have a high probability of failure and/or critical items, as well as required consumables. All items defined as spares at O-Level shall be interchangeable with no calibration, tuning or alignment.

I-Level Supply Support will provide LRU's that have a lower probability of failure and selected SRU's, as well as required Consumables. I-Level Supply Support shall also provide a replenishing function for O-Level. Interchangeable items shall require a minimum of tuning, calibration, aligning or other actions. Where alignment, calibration or tuning is required, a deterministic procedure for such actions shall be contained in the support publications.

D-Level Supply Support will provide long-lead LRU's, SRU's and components only. D-Level Supply Support could also provide a replenishing function for I-Level.

S-Level Supply Support will provide selected critical components only.

### 5.1 Spare Parts List

The Spare part list will be provided, and it shall contain all the information related to the spare parts necessary to operate and maintain the telescopes for 30 years. This shall include as a minimum:

- Recommended number / quantity
- Manufacturer/supplier
- Name
- Type designation
- Dimensions
- Specification
- Delivery times
- Expected lifetime on the shelf
- Special storage provisions
- Storage conditions
- Consumables

In the Spare Part List special indications will be integrated for the following categories:

- Fragile and/or critical parts
- Components or parts with very long delivery time or which are custom-made
- Off-the-shelf / custom-made products
- End-of-life COTS which may be unavailable later in the future

An example of a spare parts list is reported in the following table:

Table 3: Example of spare parts list

NOMENCLATURE	QTY	REMARKS
Plain bearing Iglidur®	4	
Plain bearing Iglidur®	2	
Door gasket	~ 2,8 m	
Seal ring	1	For R97
Seal ring	1	For R57
Seal rings	8	Qty 4 for each gearbox.
Filter	5 pieces pack	
Gearbox	1	
Stepper motor	1	
Hollow shaft encoder	1	
Ratio Gear	1	
Stepper motor	1	
Encoder scanning head	1	
Angle encoder with integral bearing	1	
Limit switch	1	Base Door limit switch
Limit switch	12	Stow Pins end stroke limit switches + AZ power-off limit switches + AZ directional limit switches+ EL power-off limit switches + EL directional limit switches
Inductive sensor	6	Stow Pins proximity sensor + AZ proximity sensors + EL proximity sensors
Limit switch	2	Stow Pins enable limit switch
Limit switch	1	AZ Rotation Iyra switch
Bumper	2	
Motor	1	
Battery Cartridge	1	

## 5.2 Spare Parts Packaging, Handling, Storage, Transportation

All SST telescope LRU's and SRU's with a mass of more than 15 kg and less than 40 kg will be designed with carry handles.

All SST telescope LRU's and SRU's with a mass of more than 40 kg will be designed with integral lifting eyes or other provision for handling.

All serviceable LRU's and SRU's will be preserved in such a way that they can be stored in covered facilities, in all applicable weather conditions, for a period of at least 2 years, without incurring any damage.

All unserviceable LRU's and SRU's will be preserved in such a way that they can be stored in covered facilities, in all applicable weather conditions, for a period of at least 6 months, without incurring any damage.

All LRU's will be stored under conditions as defined in "Class 1.1: Weather protected, partly temperature-controlled storage locations" of the ETSI EN 300 019-1-2 standard.

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All LRU's will be packaged in such a way that they can be transported under conditions as defined in "Class 2.2: careful transportation" of the ETSI EN 300 019-1-2 standard without incurring any damage.

All LRU's and SRU's that are frequently transported will be packaged in CLIP-LOK containers.

Packaged LRU's and SRU's where one or more dimension is larger than 1.5m, will be ISO standard sizes.

Packaged LRU's and SRU's that require periodic maintenance during storage will be packaged in red-coloured containers.

Packaging for LRU's and SRU's will be provided by the supplier of the LRU's and SRU's.

Packaged LRU's and SRU's will have the following markings securely attached on the outside of the packaging container:

- "Fragile" label
- Mode of transport "careful transportation" or "very careful transportation"
- "This side up" label
- "Fork lift here" label, where applicable
- Centre of gravity marking, where applicable
- Packaged Item Identification plate, with identification data completed
- Where applicable, tamper proof labels for "wrong way up" and "excessive acceleration"

Packaged LRUs and SRUs that are frequently transported will have the following Item Identification plate securely attached on the outside of the packaging container:

- Label heading "SST telescope Component"
- LRU/SRU Description
- LRU/SRU Identifier
- LRU/SRU Version
- LRU/SRU serial number
- LRU/SRU supplier Description
- LRU/SRU supplier Identifier
- Bar Code
- Packaged weight
- Container stack ability (where applicable)
- Preservation date (where applicable)
- Shelf life (where applicable)

## 6 Support Equipment

All Support and Test Equipment, especially if special, necessary to maintain and operate the SST telescope will be provided and guarantee to be at the right place at the right time.

Requirements for Support and Test Equipment to be supplied at the various maintenance levels will be determined and motivated by the outputs of the LSA process and simulation/modelling.

Standardization of Support and Test Equipment at various maintenance levels will be maximized.

Industrialized Test Jigs used during development will be utilized as far as possible.


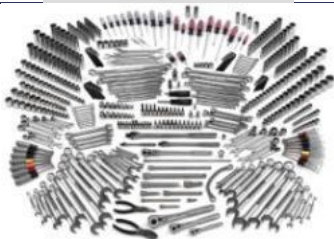



All Support and Test Equipment will be compliant with the requirements of the Machinery Directive, and they will be suitable to operate in the environment of the proposed applicable maintenance level.

It shall not be required to calibrate any test and support equipment in periods shorter than 12 months.

## 6.1 Support equipment list



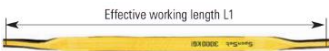





In the following, a preliminary list of support equipment needed to perform maintenance on the SST telescope system is reported:



Table 4: Preliminary support equipment list

ITEM	QTY	REMARKS	FIGURE (indicative only)
Hydraulic tensioning cylinder	1	Equipped with pump. Or similar.	
Mechanics tool set	2		
Ladder	2		
Scraper	2	To be used only if needed.	
Electrical tool set	2		



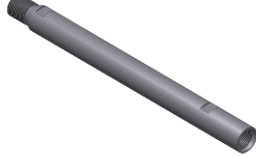
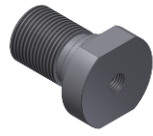

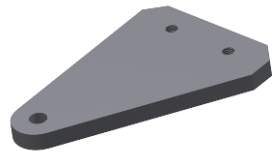


ITEM	QTY	REMARKS	FIGURE (indicative only)
Portable air compressor	1		
Flashlight	2		
Small stepladder	2		
Torque wrench	2	Up to 1420 Nm	
Grease gun	2		
Drip tray	1		
Brush	2	For cleaning	
Feeler gauge set	1		
Piece of cylindrical tube	AR		
Plastic hammer	2		













ITEM	QTY	REMARKS	FIGURE (indicative only)
Puller	1		
Circlips pliers	1	For retaining ring removal	
Eye and eye flat sling	2	Or similar	
Ratchet lever hoist	1	Or similar	
Cherry picker	2		
Mobile crane	1	Lifting load 2000 kg	
Shackle	1	Load 1 ton	
Rope	1		

ITEM	QTY	REMARKS	FIGURE (indicative only)
Electrical drill	1		
Adaptor Ø 14 mm	1		
Adaptor Ø 19 mm	1		
Adaptor Ø 19 mm	1		
Chronometer	1		
90° angular adaptor for drill	1		
Adaptor Ø 19 mm			
Inspection mirror	1		
Vacuum cleaner	1		

ITEM	QTY	REMARKS	FIGURE (indicative only)
ESD Bracelet	2		
File	2	Suitable to remove traces of oxidation from earthing bus-bar joints and relative connections.	
Calibre	1		
Wire rope	3		
Lifting point for bolting	3	Or similar	
Mechanical jack	4	Minimum stroke 100mm	
Support leg	4		

ITEM	QTY	REMARKS	FIGURE (indicative only)
M2 handling cart	1	Special	
Camera handling tool	1	Special	
Probe	1		
Pipe guide 1	2		
Pipe guide 2	2		
Guide plug	2		
Eye Plate 7	1	Mobile part of the lifting bracket. To be used for Mirror A, B, D, H, I, L, M.	
Lift Plate 8	1	Mobile part of the lifting bracket. To be used for Mirror C, E, F, G.	
Bracket 9	1	Mobile part of the lifting bracket. To be used for Mirror N, O, P, Q, R, S, T.	
M1 Mirror Lifting Bracket	1	Special handling and lifting device for Mirror position Q.	

ITEM	QTY	REMARKS	FIGURE (indicative only)
Support Frame 11	1	Easel for segment rotation. To be used for Mirror N, O, P, Q, R, S, T.	
Support Frame 12	1	Easel for segment rotation. To be used for Mirror A, B, C, D, E, F, G, H, I, L, M.	
Compact tensioner	1	Or similar	
Suction pad	2		
Signal analyzer	1	Or similar	
Paint brushes	AR		
Paint spray gun	1		
Electrical heater	1		

ITEM	QTY	REMARKS	FIGURE (indicative only)
Round sling	1	500 kg	
Hard work clamp	1	Suitable for 100 kg load. Maximum height 35 cm.	

## 6.2. Consumables materials and expendable equipment list

In the following, a preliminary list of consumables and expendables that are needed to perform maintenance on the SST telescope system is reported.

Consumable shall respect the applicable safety regulations on the CTAO for chemical products (grease, solvents, etc.). Safety data sheets will accompany each product and adequate labelling will be put on the exterior of the consumable.

Table 5: Consumable and expendable materials list

NOMENCLATURE	TYPE / MANUFACTURER	QTY
Grease	Standard	AR
Isopropyl alcohol	Standard	AR
Adhesive	Loctite 406	AR
Clean cloth	Standard	AR
White spirit	Standard	AR
Lint-free cloth	Standard	AR
Grease	Special	180 g (for AZ Bearing) + AR g (for AZ Bearing Spur Gear)
Grease	Mobilux EP 2 / ExxonMobil	55 g (for each of the four EL bearing supports) + 22 g (for each of the four ELA hinge supports) + 305 ml (or 285 g) for AZ Stow Pin + 305 ml (or 285 g) for EL Stow Pin + AR g (for M2 Loadspreaders)
Hexagon head screw	M20x120 Cl 10.9 ISO 898 galvanized	AR
Oil	Glygoyle 220 / Mobil	13,4 l + 13,4 l (for R97 gear units) 2 l + 2 l (for R57 gear unit)
Grease	Mobiltemp SHC 100	1 g (for each gear unit)
Flange sealant	Loctite 574	2 ml + 2 ml
Oil	SHELL Tivela S 320	0,8 l + 0,8 l
Liquid threadlocker	Loctite 222 / Henkel	AR
Lubricant	Standard	AR

NOMENCLATURE	TYPE / MANUFACTURER	QTY
Grease	Thermoplex ALN 1001 / LUBCON	250 g
Oil	BLASIA S 220 / AGIP	AR
Emery cloth	Standard	AR
Water	Standard	AR
Powder free latex gloves	Standard	AR
Rust remover	Standard	AR
Tie rap	Standard	AR
Epoxy-polyamide rust-preventive	PRIMOZIN Series 0770 RAL 7035 / Franchi&Kim	AR
Epox catalyst	Series 0918 / Franchi&Kim	AR
Satin finish polyurethane enamel	ISO 90 SATIN Series 0413 RAL 3016 / Franchi&Kim	AR
Polyurethane catalyst	Series 0929 / Franchi&Kim	AR
Matte polyurethane enamel	ISO 90 OPACO Series 1230 RAL 9011 / Franchi&Kim	AR
Sandpaper	Standard	AR
Bi-component polyurethane primer	Standard	AR
Bi-component polyurethane finish enamel RAL 9005	Standard	AR
Paper tape	Standard	AR
Bi-component epoxy enamel RAL 5010	Standard	AR
Spray enamel RAL 5010	Standard	AR
Nitro spray enamel RAL 7035	Standard	AR
Marker	Standard	1

## 6.2 Support Facilities

All Support Facilities necessary to execute identified tasks for Operation and Maintenance at various levels of maintenance will be studied and provided.

Detailed requirements for facilities at all levels of maintenance will be identified during the LSA process and simulation/modelling.

Maintenance Facilities at O-Level will be the installed equipment as it is not foreseen that workshops are required at this Maintenance Level.

A base station close to the installation site shall be the O-Level Facilities for on-site equipment maintenance.

Workshop facilities shall be available at a support base located further away from the site, to execute I-Level Maintenance.

Workshop facilities shall be available at the D-Level to execute D-Level maintenance.

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These are existing supplier facilities and are currently considered to be sufficient as most of the equipment will be manufactured at S-Level.

## 6.3 Support Personnel

The Manpower and Personnel Concept is defined, in order to have the correct people at the correct place with suitable skills to perform specific tasks for Maintenance.

The identification of Personnel will be an input to the Logistic Support Analysis (LSA) process.

The following personnel categories will be taken into account during the development of the Maintenance tasks and procedures:

**Observer:** an Observer is normally an Astronomer or an Engineer who wants to do a specific science experiment or some engineering observation.

The Observer is highly skilled and will have received SST Telescope Observer training, and is concerned with the science experiments or engineering observations.

The Observer is not at all involved with the maintenance of the SST Telescope.

An Observer selects what observation task has to be performed and defines the task parameters and produces as a task instruction set. Once the Observer is satisfied that the task is properly defined, the task instruction set is provided to the Operator, requesting the execution of the task.

During task execution, the Observer may monitor the system health status, though this is normally the duty of the Operator.

**Operator:** an Operator is normally a Staff Astronomer or an Engineer that controls the SST Telescope during science experiments or engineering observations.

The Operator is highly skilled and will have received SST Telescope Operator training, and is concerned with controlling the SST Telescope and could possibly be involved in O-Level maintenance.

An Operator schedules and executes the tasks requested by one or more Observer. The Operator carries out the task by executing the task instruction set and monitoring signal, system and health state displays. Upon completion of the task, the Operator provides the task data product to the Observer. In addition, an Operator is usually involved in the Safety of Personnel and Equipment as well as Diagnostic Procedures.

**Maintainer:** a Maintainer is a technical person that is skilled and qualified and will have received SST telescope technical training and is responsible for Corrective and Preventive Maintenance of the telescope. In addition, Maintainers shall be responsible to operate infrastructure equipment such as cranes, vehicles, power generators, etc.

The Maintainer is also involved during Telescope task execution. The maintainer monitors the Telescope health status regularly during task execution and, when required, is allowed to obtain manual control of resources for the purposes of testing.



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## 7 Maintenance Tasks

This section contains an example of a maintenance task. All the maintenance tasks will contain the following information:

- Task Code.
- Production Management with operation duration for the task development.
- Require conditions for the telescope or subsystems.
- Required persons.
- Support equipment.
- Consumables, materials and expendables equipment.
- Spares.
- Safety Conditions with identification of special safety warning for the specific task.
- Procedure steps.
- Close-up procedures.

### 7.1 Maintenance Task examples

#### 7.1.1 Elevation Encoder Replacement

Here follows an example of maintenance task:

**TASK CODE:** Elevation Encoder Replacement

#### **PRELIMINARY REQUIREMENTS**

##### **Production management data**

OPERATION DURATION		
	ELAPSED TIME (MIN)	MAN HOURS (MH)
MAINTENANCE PROCEDURE	30	1

##### **Required conditions**

REQUIRED CONDITION
Telescope at -90° AZ and 0° EL.
On the HPC Electrical Cabinet, switch fuse of the Telescope Drives set to OFF position.
On the LPC Electrical Cabinet, switch off the 24Vdc auxiliary circuit breaker (THCU power supply).

##### **Required personnel**

PERSON	CATEGORY	REQUIRED CERTIFICATION/LICENSE	ESTIMATED WORKING TIME FOR COMPETENCE (MIN)
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A	Electrician	Work-at-height Electrical authorization	30
B	Mechanic	Work-at-height Cherry Picker driving license	30

#### Support equipment

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Cherry picker	Standard		1	
Ladder	Standard		1	
Mechanics tool set	Standard		1	

#### Consumables, materials and expendables equipment


NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Spring washer	Standard	DIN 7980 - 12	6	
Spring washer	Standard	DIN 7980 - 3	4	
Spring washer	Standard	DIN 7980 - 4	4	

#### Spares

NOMENCLATURE	TYPE / MANUFACTURER	PT NO.	QTY	REMARKS
Angle encoder with integral bearing	RCN 2580 / Heidenhain		1	

#### Safety Conditions

**WARNINGS**



BE CAREFUL YOU MUST READ AND UNDERSTAND ALL GENERAL WARNINGS AND CAUTIONS BEFORE PERFORMING MAINTENANCE OPERATIONS ON THE TELESCOPE.

2.

3. ALL SAFETY PRECAUTIONS MUST BE FOLLOWED BEFORE, DURING AND AFTER ALL MAINTENANCE ACTIVITIES. NON COMPLIANCE WITH THESE SAFETY RULES COULD RESULT IN POTENTIALLY GRIEVOUS INJURIES OF THE OPERATORS AND/OR DAMAGE TO THE SYSTEM.



BE CAREFUL THAT AT LEAST TWO OPERATORS MUST BE PRESENT DURING ALL MAINTENANCE 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.



DO NOT OPERATE WITHOUT PROPER PERSONAL PROTECTIVE EQUIPMENT.



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



DRIVE SYSTEM LOCK-OUT AND TAG-OUT MUST BE PERFORMED DURING MAINTENANCE OR REPAIR OPERATIONS.



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



THE ITEM IS LOCATED AT A CERTAIN HEIGHT FROM THE GROUND. HENCE, THE RISK OF OPERATORS FALL EXISTS. THEREFORE, THE OPERATORS SHALL 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 ITEM AREA.

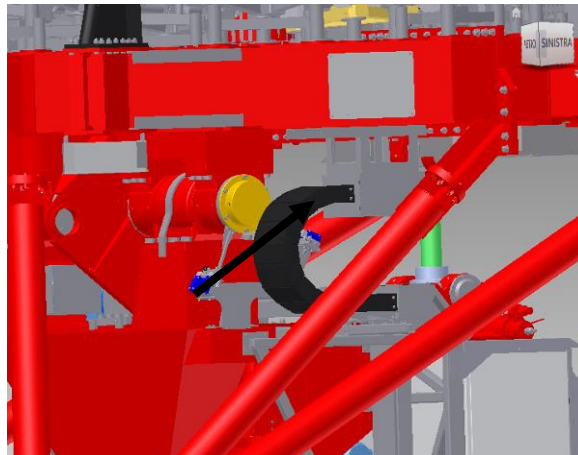


WHEN THE USE OF A MANLIFT IS REQUIRED, IT MUST BE OPERATED ONLY BY TRAINED AND QUALIFIED PERSONNEL. ALL OTHER OPERATORS MUST TAKE CARE TO REMAIN WELL OUT OF THE PATH OF THIS MEAN WHEN IT IS USED.

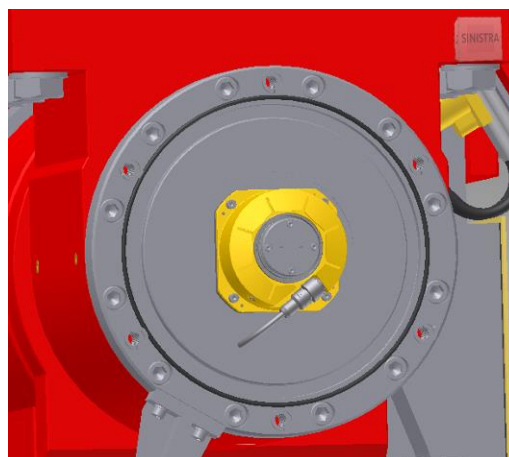
WHEN USING A MANLIFT, THE WIND SPEED MUST BE IN ACCORDANCE WITH THE LOCAL RULES.

### PROCEDURE STEPS

1. Reach the EL Bearing Encoder Group installed on the Telescope left side. Use the cherry picker or the ladder as most appropriate for the activity being performed.



2. Loosen the cable gland of the encoder cable on the Encoder Cover.
3. Remove all fastenings that attach the Encoder Cover to the EL Bearing L Ring. Move the Encoder Cover as much as necessary to get access to the encoder cable connector. Discard the spring washers.



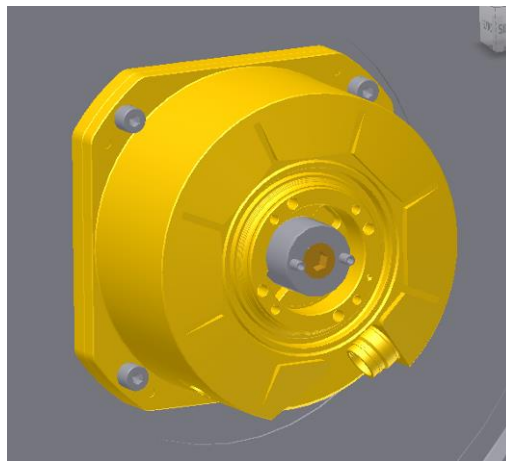
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4. Disconnect the Encoder cable connector from the Encoder.

**CAUTION**

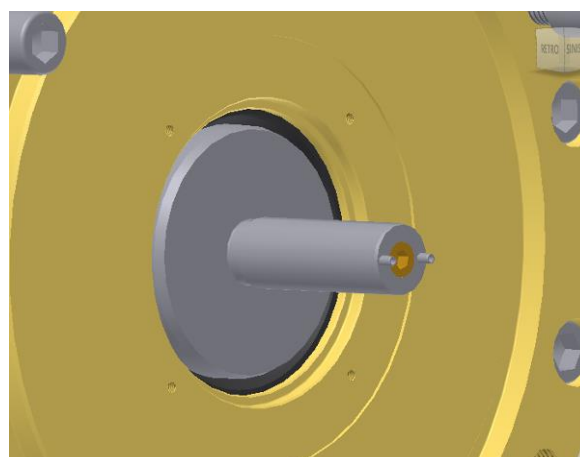


**BE CAREFUL NOT TO LOSE THE TWO PINS INSTALLED BETWEEN THE EL ENCODER CENTERING AND THE EL BEARING L SHAFT.**

5. Remove all fastenings that attach the EL Encoder Centering to the Encoder and disengage it from the EL Bearing L Shaft. Remove the EL Encoder Centering and the EL Encoder Centering Shim. Discard the spring washers.



6. Remove all fastenings that attach the Encoder to the EL Bearing L Ring. Remove the Encoder from the EL Bearing L Ring. Discard the spring washers.



7. Install the two pins on the EL Bearing L Shaft, if necessary.

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8. Set the new Encoder to the correct position on the EL Bearing L Ring. Install all fastenings that attach the Encoder to the EL Bearing L Ring.
  9. Set the EL Encoder Centering Shim to its correct position on the Encoder. Engage the EL Encoder Centering with the EL Bearing L Shaft. Install all fastenings that attach the EL Encoder Centering to the Encoder.
  10. Connect the Encoder cable connector to the Encoder.
  11. Set the Encoder Cover to the correct position on the EL Bearing L Ring. Install all fastenings that attach the Encoder Cover to the EL Bearing L Ring.
  12. Tighten the cable gland of the encoder cable.
  13. Leave the EL Bearing Encoder Group.

**Close-up procedures**

CLOSE-UP ACTIONS	
On the LPC Electrical Cabinet, switch on the 24Vdc auxiliary circuit breaker (THCU power supply).	
On the HPC Electrical Cabinet, switch fuse of the Telescope Drives set to ON position.	

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