MISSIONE 4
ISTRUZIONE
RICERCA

CERENKOV TELESCOPE ARRAY PLUS (CTA+)

COMPONENTE 2, INVESTIMENTO 3.1, IR0000012,
CUP: C53C22000430006

CAPITOLATO TECNICO

PER LA FORNITURA DI "STRUTTURE ELETTROMECCANICHE DI TELESCOPI SST DI CTAO, IVI INCLUSI I SOTTOSISTEMI E TUTTE LE ATTIVITÀ CORRELATE E NECESSARIE ALLA LORO MESSA IN OPERA"

STATEMENT OF WORK

FOR THE SUPPLY OF "ELECTROMECHANICAL STRUCTURES OF THE CTAO SST TELESCOPES, INCLUDING SUBSYSTEMS AND ALL ACTIVITIES RELATED TO AND NECESSARY FOR THEIR INSTALLATION"

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
INAF ISTITUTO NAZIONALE DI ASTROFISICA

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1 INTRODUCTION

1.1 Scope & Purpose

This Statement of Work (SoW) intends to address the deliverables, the organizational structure and relative activities requested by INAF (referred alternatively as “Institute” or “SST Consortium”) to the Contractor necessary for the successful completion of the work related to [AD1]. The company in charge for the execution of the work (referred to as “Contractor”) will be selected by INAF by means of a tender. Consequently, this SoW must be considered as an applicable document during the entire work execution.

In particular, it will focus on the following topics:

- INTRODUCTION
- EXECUTIVE SUMMARY
- SMALL SIZE TELESCOPES OVERVIEW
- SST TELESCOPES DESCRIPTION AND DEVELOPMENT STATUS
- MASTER SCHEDULE, PROGRAMME PHASES, STUDY LOGIC & CONTRACTUAL ACTIVITIES
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1.2 Compliance with the DNSH Principle

Regulation (EU) 2020/241 provides in art. 5, paragraph 2, that *the Facility* (editor's note: RRF - Recovery and Resilience Facility) *only supports measures respecting the principle of "do no significant harm"* (so-called DNSH), introduced by Regulation (EU) 2020/852. To guarantee compliance with the DNSH principle, this obligation is reflected in all economic operations financed by the RRF and included in the Italian National Recovery and Resilience Plan.

At a national level, compliance with the DNSH principle is regulated in the “*Guida Operativa per il rispetto del principio di non arrecare danno significativo all’ambiente (cd.DNSH)*” (Guida DNSH), attached to Circolare MEF-RGS no. 33 of 13 October 2022, available at the following link:

https://www.italiadomani.gov.it/content/dam/sogei-ng/documenti/20221021_Guida%20Operativa_MI.pdf

With reference to the DNSH, the "*Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione*" intervention, referred to in the M4C2 Investment 3.1 measure, has been assigned to Regime 2, therefore the investment must be implemented in the mere

compliance with the DNSH principle, without the burden of providing a substantial contribution to the environmental objective of climate change mitigation.

For the supply in question, since its instrumentation equipped with electronic components, only the attached Checklist no. 3 - Purchase, leasing and rental of non-medical PCs and EEE - is applicable (see Annex 6).

During the supply phase, the Economic Operator is required to sign the declaration of conformity to the DNSH principle, accompanied by the checklist relating to Sheet no. 3 filled out for the points of competence, accompanied by any supporting documentation and in which the non-applicability of any constraints is justified.

1.3 Applicable Documents

These documents, and all the documents applicable of these documents, are considered applicable for this SoW.

The Applicable Documents, with the exception of those where a link or bibliographic reference is indicated, can be downloaded at the following links:

http://www.brera.inaf.it/?page=appalti_acquisti;settore=trasparenza;showdate

and

https://inaf.ubuy.cineca.it/PortaleAppalti/it/homepage.wp

[AD1] Disciplinare Di Gara - Gara Europea A Procedura Aperta Per L'appalto Della Fornitura Di "Strutture Elettromeccaniche Di Telescopi SST Di CTAO, Ivi Inclusi I Sottosistemi E Tutte Le Attività Correlate E Necessarie Alla Loro Messa In Opera"

[AD2] SST Mechanical Structure - Subsystem Technical Requirement Specification, SST-MEC-SPE-002

[AD3] SST Mechanical Structure - Local Control Software Requirements Specification, SST-MEC-SPE-004

[AD4] SST Programme: Telescope Technical Requirements Specification, SST-PRO-SPE-001

[AD5] SST Mechanical Structure: Design Report, SST-MEC-DSR-001

[AD6] SST Programme: Programme Management Plan, SST-PRO-PLA-001

[AD7] Product Review DMA Disposition 2.0

[AD8] Product Review Panel Report V2.0

[AD9] SST Mechanical Structure: Safety System, SST-MEC-DSR-002

[AD10] SST Programme: STR/CAM I/F Control Document, SST-PRO-ICD-007

[AD11] SST Programme: Configuration & Data Management Plan, SST-PRO-PLA-002

[AD12] SST Programme: Risk Management Plan, SST-PRO-PLA-004

[AD13] SST Programme: Product Assurance & Quality Plan, SST-PRO-PLA-005

[AD14] SST Programme: Safety Management Plan, SST-PRO-PLA-006

[AD15] Power Distribution System South (PDSS) to Small Sized Telescopes (SST), ICD CTA-ICD-SEI-000000-0016

[AD16] CTAO Telescope Safety Design Specification, CTA-SPE-TEL-000000-0003
[AD17] Small Sized Telescopes (SST) to Foundation at CTAO-South ICD, CTA-ICD-TEL-405000-0001
[AD18] ASTRI Interface Control Document for M1 panels, ASTRI-INAF-ICD-7220-001
[AD19] ASTRI M2 Interface Control Document, Available at the Contractor Kick Off Meeting
[AD20] CTAO Telescope Grounding - Lightning and LEMP Protection, CTA-SPE-TEL-000000-0002
[AD21] CTA-S Rules and Regulations for Contractors on the CTA-S Site, CTA-SPE-SEI-303000-0002
[AD22] CTA-S Site Safety Manual – Available at the Contractor Kick Off Meeting
[AD23] CTAO Acceptance Process, CTA-PRO-MGT-000000-0002
[AD24] CTAO RAM Calculation Methodology Guideline, CTA-INS-SEI-000000-0001
[AD25] FMEA Procedure, CTA-PRO-SEI-000000-0002

1.4 Reference Documents

The Reference Documents, with the exception of those where a link or bibliographic reference is indicated, can be downloaded at the following links:

http://www.brera.inaf.it/?page=appalti_acquisti;settore=trasparenza;showdate

and

https://inaf.ubuy.cineca.it/PortaleAppalti/it/homepage.wp

[RD1] The ASTRI-Horn telescope validation toward the production of the ASTRI Mini-Array: a proposed pathfinder for the Cherenkov Telescope Array, Proc. SPIE. 11119
[RD2] The ASTRI mini-array at the Teide observatory, Proc. SPIE. 11822
[RD3] A Compact High Energy Camera (CHEC) for the Gamma-ray Cherenkov Telescope of the Cherenkov Telescope Array, 35th International Cosmic Ray Conference -ICRC217-10-20 July 2017
[RD4] SST Programme: Top level & trade-off analysis Report, SST-PRO-ANR-006
[RD5] Mechanical optimization of the M1 Dish for the Small-Sized Telescopes of the future Cherenkov Telescope Array, Proc. SPIE. 12188
[RD6] Vassiliev, V., et al., "Wide field aplanatic two-mirror telescopes for ground-based γ-ray astronomy", Astroparticle Physics 28, 10-27 (2007)
[RD7] Pareschi, G., "The ASTRI SST-2M prototype and mini-array for the Cherenkov Telescope Array (CTA)", proc. SPIE, vol. 9906, 99065T (2016)
[RD8] Scuderi, S., et. al, "The ASTRI Mini-Array of Cherenkov telescopes at the Observatorio del Teide", JHEA 35, 52 (2022)
[RD9] Marchiori, G., et al., "ASTRI SST-2M: the design evolution from the prototype to the array telescope", Proc. SPIE vol. 10700, 107005W (2018)
[RD10] SST Programme: Factory AIT Plan SST-PRO-PLA_011

[RD11] SST Programme: On site AIT Plan, SST-PRO-PLA-012
[RD12] SST Programme: AIV Plan, SST-PRO-PLA-013
[RD13] SST Mechanical Structure: Structural Analysis Report, SST-MEC-ANR-008
[RD14] ASTRI Mini Array drawings as built, http://www.brera.inaf.it/disegni-e-schemi-Astri1
[RD15] SST Camera: Camera Engineering Development and Verification Plan, SST-CAM-PLA_009
[RD16] SST Optics: Design Report, SST-OPT-DSR-001
[RD17] SST Camera: Design Report, SST-CAM-DSR-001
[RD18] ASTRI Mini-Array PMC and SQM Detailed Design Document, ASTRI-INAF-DES-7500-001
[RD19] SST Programme: Engineering Development and Verification Plan, SST-PRO-PLA-009
[RD20] SST Programme: Performance Analysis Report, SST-PRO-ANR-010
[RD21] SST Programme: Telescope Concept of Operations, SST-PRO-OPD-001
[RD22] SST Mechanical Structure: On-site Maintenance Plan, SST-MEC-PLA-015
[RD23] M1 Dish Optimized Step File, SST-MEC-MES-01_M1DishOP_CNRS_2206_vf.stp
[RD24] Infrastructure IKC Teams Support, CTA-INS-SIS-401000-0001_CTA-S
[RD25] CTA Architecture, CTA-DER-SEI-000000-0001

1.5 Definition of Terms and Abbreviations

1.5.1 Abbreviations and acronyms

ACADA	Array Control and Data Acquisition System
ADP	Acceptance Data Package
AD	Applicable Documents
AIT	Assembly Integration and Testing
AIV	Assembly Integration and Verification
ASTRI	Astrophysics with Italian Replicating Technology Mirrors
BKO	Bridging phase Kick-Off
CDR	Critical Design Review
CFI	Customer-Furnished Items
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
DRB	Delivery Review Board
FAR	Final Acceptance Review
FRC	France Contribution
DR	Delivery Review
DVER	Design Verification Engineering Review
e.g.	exempli gratia (“for example”)
ERIC	European Research Infrastructure Consortium
ESC	Executive Steering Committee
ESO	European Southern Observatory
FDB	Functional Block Diagram
FMECA	Failure Mode, Effects, and Criticality Analysis
i.e.	id est (“that means”)
IKC	In Kind Contribution
INAF	Istituto Nazionale di Astrofisica
INSU	Institut National des Sciences de l'Univers
KO	Kick-Off
LEMP	Lightning Electromagnetic Pulse
MPIK	Max-Planck-Institut für Kernphysik
OP	Observatoire de Paris
PA	Product Assurance
PBS	Product Breakdown Structure
PLC	programmable logic controller
PMP	Programme Management Plan
PO	Project Office
PQR	Production Qualification Review
PMC	Pointing Monitoring Camera
PR	Product Review (aka Preliminary Design Review)

PRM	Programme Manager
PSE	Programme System Engineer
QA	Quality Assurance
QM	Quality Manager
RAMS	Reliability, Availability, Maintainability & Safety
RD	Reference Documents
S-CDR	Subsystem Critical Design Review
SI3	Stellar Intensity Interferometry Instrument
SiPM	Silicon Photo Multiplier
SQM	Sky Quality Monitor
SST	Small Size Telescope
SST-TEL	SST Telescope
SST-MEC	SST Mechanical Structure
SST-OPT	SST Optics
SST-TCS	SST Telescope Control System
SST-CAM	SST Camera Cherenkov
SST-STR	SST Structure
TCS	Telescope Control Unit
TPC	Telescope Power Cabinet
TCC	Telescope Control Cabinet
TRR	Test Readiness Review
TRB	Test Review Board
WBS	Work Breakdown Structure
WP	Work Package
WPD	Work Package Description

1.5.2 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

TERM	DEFINITION
	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).
Contractor	Industry involved in the SST Programme which has a contract with an institute
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.
Hardware	Hardware is a single or an assembly of physical electronic devices which cannot be changed in its user environment.
Institutes	Research Institutes involved in the SST Programme.
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 SST+ and CTA-SST consortium.

TERM	DEFINITION
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.
Proponent	Economic operators as described in [AD1]
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).
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.
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. EXECUTIVE SUMMARY

An international consortium of institutes will provide the SST telescopes as an in-kind contribution to the Cherenkov Telescope Array Observatory (CTAO). For more information, visit the CTAO's website at https://www.cta-observatory.org to learn more.

CTAO will be based on sub-arrays with 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. The SSTs will be installed at the CTAO southern Site in the Chilean Andes (Paranal area, area under ESO's governance).

This tender deals with the design, production, assembling, shipping, on-site integration, calibration, and verification of up to 25 SST telescopes.

Each SST Telescope (SST-TEL) is composed of 4 subsystems:

- SST-MEC (electro-mechanical structure including Mount, Optical Support Structure, Electrical & Control System Cabinets, Protection System, Auxiliary Devices, Maintenance and AIT/V Tools as described in section 4.1.)
- SST-OPT (the Optics consisting in M1 and M2 mirrors)
- SST-TCS (the high-level SW that manages the telescope subsystems)
- SST-CAM (the camera Cherenkov)

In the remainder of the document, the term SST Structure (SST-STR) Project refers to the entire mechanical structure (SST-MEC), the optical assembly (SST-OPT) and the control system (TCS).

In February 2023, the SST Consortium went through a review (called Product Review) organized with CTAO. Thanks to the Product Review, the preliminary design of the telescope and its subsystems, the organization and the management plan of the consortium and the programmatic schedule were approved.

In such a context, INAF represents the main contributor and leader of the SSTs telescopes implementation effort. INAF responsibilities cover the central programme office coordination, the SST-STR project office coordination and main in-kind contributor for the production and implementation of the electro-mechanical structures, the provision in terms of in-kind contribution of the SST-OPT and SST-TCS systems and the scientific support.

This SoW specifically regards the supply and implementation in Chile of the SST electromechanical structures that will be provided under INAF's responsibilities to CTAO. It applies to all activities and deliverables throughout the various development phases of the SST Telescopes production and implementation. In the following chapters, the preliminary design of the SST Telescope and its subsystems, the status of the project, the schedule, the phases, and the tasks requested to the contractor, the organization of the team, responsibilities and Customer's rights and the document Requirements Definition will be described. In particular, the goals of this tender are:

- to consolidate the preliminary SST-MEC sub-system design [AD5][AD2][RD14] approved at the Product Review;
- to address the preliminary SST-MEC electro-mechanical design towards the S-CDR and CDR reviews till the final approved version and, in this respect, to:

  - manage all the analysis needed to finally confirm and improve a few subsystems of the design of SST-MEC, which is already at a good consolidation level but not yet completely finalized;
  - manage all the Structural Analysis of the SST-MEC and SST-TEL;
- to manage and consolidate the Internal interface between the SST-MEC and SST-CAM sub-systems;
- to manage and consolidate the Internal interface between the SST-MEC and SST-OPT sub-systems;
- to support and consolidate the Internal interface between the SST-MEC and SST-TCS sub-systems;
- to support the consolidation of the external interfaces between the SST-TEL and the CTAO infrastructure;
- to perform all the trade-offs needed to consolidate the interfaces and integration procedures;
- to realize all the SST-MEC subsystem prototypes needed to consolidate and support the design;
- to provide all the acceptance data package (ADP) needed for the various reviews;
- to provide the entire set of 3D design and construction documentation (including the definition of all the subsystems and materials to be used for the production, AIV plans, handbooks maintenance plans and documentation);
- to provide the RAMS and FMECA analysis in agreement with the CTAO requirements;
- to realize up to 25 SST-MEC including the Mount system, Optical Support Structure, the Electrical System, Telescope Protection System, Auxiliary Devices, Software and Maintenance Tool as described in section 4.1;
- to assembly, integrate and test the first SST-TEL on-factory (including the optics and the focal plane camera);
- to manage all the shipment activities related to SST-MEC and SST-OPT sub-systems;
- to assembly, calibrate and test up to 25 SST-TEL onsite (including the optics and the focal plane camera);
- to support, by operating the telescopes, the institutes in their verification activities in order to verify the scientific performance of the telescopes;
- to take responsibility for the onsite security aspects in agreement with CTAO.

All these aspects will be detailed and clarified in the following sections.

3. SMALL SIZE TELESCOPES OVERVIEW

When a VHE gamma-ray interacts with the atoms and ions in the upper levels of the atmosphere, it induces a cascade of secondary particles which propagates over many kilometres at a speed higher than the speed of light through the atmosphere. These particles emit Cherenkov light, forward-beamed with an opening angle of about one degree. A Cherenkov light event consists of a time-correlated multi-photon image with a typical timescale of ~10 ns. Cascades originate at an altitude of ~10 km above ground and create a light pool on the ground of ~120 m radius. Telescopes placed on the ground, containing large reflectors, focus the light to and imaging camera. Such Cherenkov cameras must be highly pixelated, cover a large field of view, and be able to detect UV/blue light down to the single photon levels with exposure times of approximately a billionth of a second. To provide a high imaging sensitivity over an extensive energy range, from a few tens of GeV up to a few hundreds of TeV, the Cherenkov Telescope Array Observatory (CTAO, see web page link at https://www.cta-observatory.org) will be based on sub-arrays with 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 CTAO Southern site includes LSTs, MSTs and SSTs. In particular, it currently envisages the construction and installation of 37 SSTs (25 of them are object of this SoW).

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 modified 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 and the first telescope of the ASTRI mini-array project and a Cherenkov camera based on SiPM sensors called CHEC-S. Table 3-1 reports the main properties of the Small-Sized telescope (SST).

Table 3-1 - Small-sized telescope main properties

Small-Sized telescope (SST) main properties:	
Optical Design	modified Schwarzschild-Couder
Primary reflector diameter	4.3 m
Secondary reflector diameter	1.8m
Effective mirror area (including shadowing)	>5 m^2
Focal length	2.15 m
Total weight	<17.5 t
Field of view	>8.8 deg
Number of pixels in SST Camera	2048
Pixel size (imaging)	0.16 deg
Photodetector type	SiPM
Telescope data rates (before array trigger)	>600 Hz
Telescope data rates (readout of all pixels; before array trigger)	2.6 Gb/s

Positioning time to any point in the sky (>30° elevation)	70s
Telescope Post Processing Pointing Precision	< 7 arcsecs

4. SST TELESCOPES DESCRIPTION AND DEVELOPMENT STATUS

The high-level Product Breakdown Structure (PBS) that provides the hierarchical product breakdown of the SST Telescope is reported in Figure 4-1 [AD6].

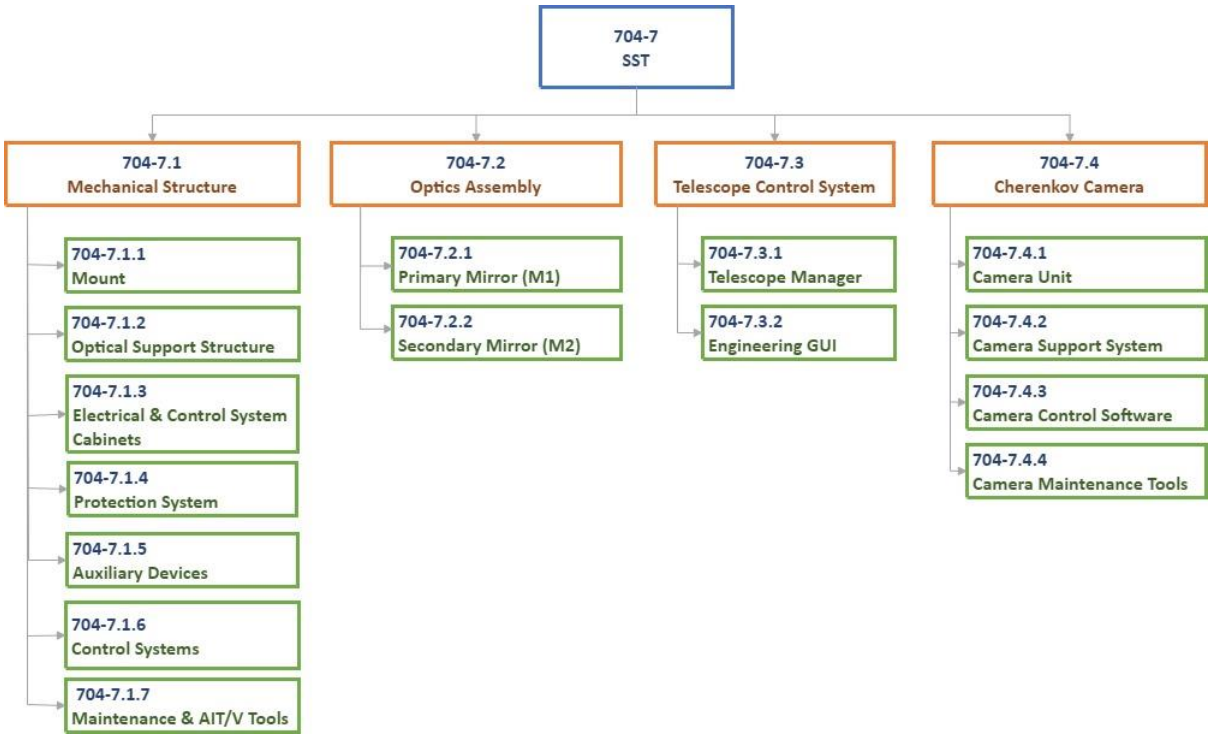

Figure 4-1: Telescope Product Breakdown Structure

The PBS includes the main elements that allocate the functions and sub-functions.

The SST Consortium responsibility is considering the levels detailed in the following bullets.

- *SST Telescope (SST-TEL):* It is the whole contribution of the SST Consortium to CTA. It consists in the provision of all the equipment necessary to perform the imaging of the Cherenkov Light, providing the whole telemetry, both scientific and engineering, and guaranteeing an autonomous managing of the telescope equipment.

- *Mechanical Structure (SST-MEC)*: The Telescope Mechanical Structure includes all the hardware, software and documentation that allows 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 SST-MEC. The SST-MEC 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 SST-MEC is fixed to the concrete foundation by means of anchor bars. The SST-MEC also includes the control hardware/software related to the SST-OPT.

- *Optics Assembly (SST-OPT):* The Optical Assembly (Optics) includes the primary and secondary mirrors.

- *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.

In the remainder of the document, the term SST Structure (SST-STR) Project refers to the entire mechanical structure (SST-MEC), the optical assembly (SST-OPT) and the control system (SST-TCS).

- *Cherenkov Camera (SST-CAM):* The SST Camera comprises all the activities related to the design development and implementation of the detection cameras, including all the related hardware and software subs-systems (with the associated documentation). The camera system of each telescope makes possible the Cherenkov signal detection, images acquisition, digitisation, trans project and pre-processing. The SST Camera system 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).

In the remainder of the document, the term SST Camera (SST-CAM) Project refers to the entire SST-CAM.

Each of these subsystems represented are described in the following sections and annexes.

4.1 Mechanical Structure

A detailed and full description of the SST-MEC actual preliminary design as approved by CTAO Product Review [AD8] is reported in [AD5].

In this paragraph, a brief overview of the SST-MEC functional decomposition that drove the actual baseline design is given.

The design chosen by the CTAO Council in June 2019 as baseline for the SST-Telescopes is based on a dual-mirror configuration. The baseline mechanical structure of the SST is a slightly modified and compact classical altitude-azimuth configuration, with a dual-mirror Schwarzschild-Couder optical design. The primary segmented mirror (M1) is composed of 18 hexagonal tiles of 85 cm size (from face-to-face) able to mimic a 4.3 m diameter monolithic mirror. The monolithic secondary mirror (M2) has a diameter of 1.8 m and is separated by a distance of about 3m form M1 [RD16]. A 3D CAD representation of the Telescope is shown in Figure 4-2. The ASTRI Mini-Array drawings as built can be found at [RD14].

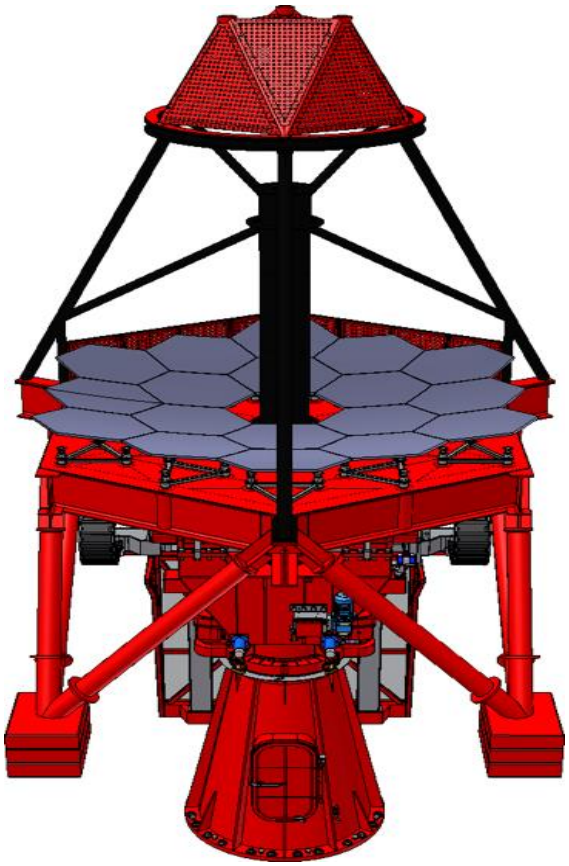

Figure 4-2: CTA-SST front view

The Telescope Mechanical Structure (SST-MEC) includes all the hardware and software subsystems that allows the telescope to point to different positions of the sky, fulfilling the required performance. All mechanical parts (structural elements, bolts, screws, bearings, gears, springs, bumpers, accessories, etc.) needed to support the telescope optics to collect light are part of the SST-MEC.

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

The Mechanical Structure can be decomposed as shown in Table 4-1 and described in the following sections.

Table 4-1: SST-MEC 4th Level PBS

PBS (704 -)*	*Level 2*	*PBS*	*Level 3*	*PBS*	*Level 4*
7.1	Mechanical Structure				
		7.1.1	Mount		
				7.1.1.1	Azimuth Structure
				7.1.1.2	Elevation Structure
		7.1.2	Optical Support Structure		
				7.1.2.1	M1 Dish
				7.1.2.2	M1 segment support
				7.1.2.3	Counterweights
				7.1.2.4	OSS Upper Structure
				7.1.2.5	M2 Support Structure
				7.1.2.6	Swing-Arm for Intensity Interferometry Instrument
		7.1.3	Electrical & Control System Cabinets		
				7.1.3.1	Telescope Power Cabinet
				7.1.3.2	Telescope Control Cabinet
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		7.1.5	Auxiliary Devices		
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		7.1.6	Control Systems		
				7.1.6.1	Mount Control System
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4.1.1 Mount

The SST use an Azimuth and Elevation mount. The Mount is the SST mechanical system that supports the mirrors systems and the camera in the focal position. It allows the motion in azimuth and elevation to align the optical system axis to any permitted direction on the sky.

The Mount includes two main elements:

- The Azimuth Structure
- The Elevation Structure

4.1.1.1 The azimuth structure

The main elements of Azimuth Structure are:

- The Base Structure
- The Azimuth slewing Bearing

The Azimuth structure also includes the mechanical supports of the Azimuth main encoder, of the azimuth limit switches and of all the electrical, networking, signal cables that pass across the foundation and go to the Telescope cabinets or directly to the upper parts of the telescope.

4.1.1.1.1 The Base Structure

This term indicates the fixed part of the Mount supporting the Elevation Structure.

The Base is fixed to the foundation by means of 24 M30 anchor bolts, and shall be oriented in the North-South direction within <5'. The foundation is provided by the foundation provider and its supply is not included in this bid. The base structure is the structural interface between SST-MEC and foundation [AD17]. The Base shall be levelled within <5' in both North-South and East-West directions. The azimuth bearing is mounted over the base and its central axis define the Azimuth axis of rotation of the telescope.

The base structure has these tasks:

- to act as interface between the foundation and the Elevation Structure, distributing the loads from the last;
- to allow, by means of an access door, a safe access to the items installed inside the base, due to their sensitivity to weather agents (azimuth encoder, azimuth switches, cable wraps etc);

In the Base is installed a light to allow to work inside with good visibility.

4.1.1.1.2 Azimuth slewing bearing

The Azimuth slewing bearing is the main structural element that allows to rotate the telescope around the azimuth axis. It has an external gear-teeth where act the pinions mounted on the gearboxes of the two Azimuth motors.

It is installed on the top of the base and allow the Elevation Structure to rotate around the Azimuth Axis.

The inner face of the slewing bearing, the one fixed on the Elevation fork lower flange, is provided with a proper slot in order to allow the Azimuth encoder tape installation.

4.1.1.2 The Elevation Structure

The Elevation structure rotates around the azimuth axis and is mounted on the Azimuth slewing bearing.

The Fork (see Figure 4-3) is the main mechanical part of the Elevation structure and is directly coupled to the Azimuth bearing.

The other elements of the Elevation structure are the following subsystems:

- Elevation bearings
- Elevation ball screw jack
- Elevation Motors Supports
- Elevation Encoder Support
- Elevation Limit switches support
- Elevation Stow-pin support
- Elevation bumper
- Elevation Cable Wrap
- Azimuth Motors supports
- Azimuth Stow-pin support
- Telescope power and control cabinets support structure

The components mounted on the fork allow the movement of the telescope around the elevation and azimuth axes, as well as the safety of the telescope in survival conditions from a personnel and hardware point of view. These are the reasons that make the Elevation structure so critical for the entire telescope structure.

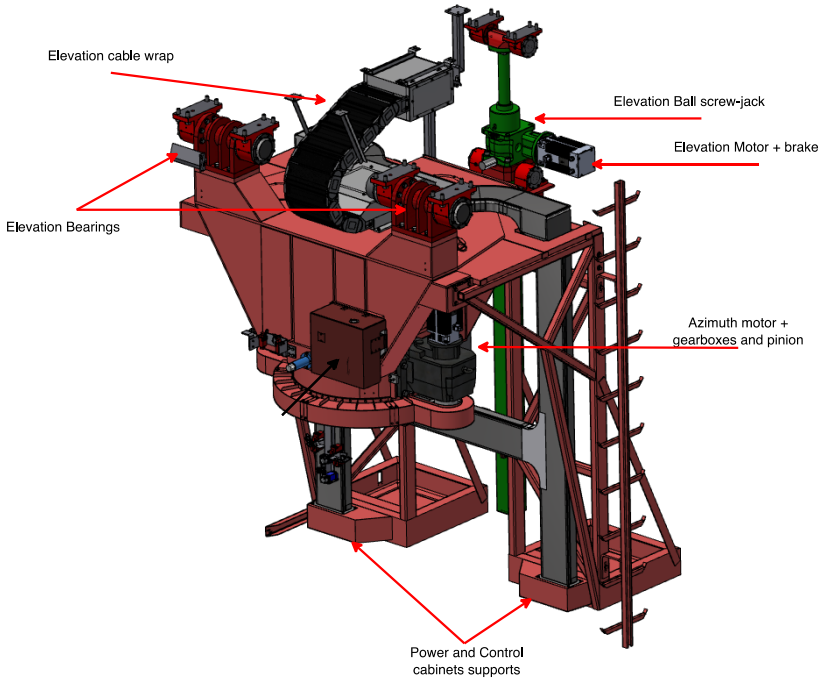

Figure 4-3: The elevation fork. Some of the elements mounted on the fork are also indicated.

4.1.1.2.1 Elevation Bearing

The two couples of conical preloaded Elevation bearings are mounted on the top of the two prongs of the fork. Their central axis defines the Elevation axis. The Optical Support Structure is mounted on the Elevation bearing so that it can rotate around the Elevation Axis.

4.1.1.2.2 Elevation ball screw jack

The motion in Elevation axis is possible with a preloaded ball screw jack. The ball screw jack is fixed to the M1 Dish by means of hinges, one located on the top of the ball screw and the other installed on the ball screw jack body. This allows to provide motion of the M1 dish and thus, all Optical support structure. The ball screw is fully deployed with Elevation angles close to horizon (0°) and completely retracted when the Elevation angles are close to the zenith position (90°). A bellow is provided to protect the ball screw from weather agents when it is deployed; since the screw is passing through the jack, a protection tube hosts it when the ball screw is fully retracted.

4.1.1.2.3 Elevation Stow Pin

In the current baseline design, the Elevation stow pin guarantees no motion during maintenance and when the telescope is in parking position. It must be mentioned that the parking position is the same of the maintenance position.

4.1.1.2.4 Elevation Bumper

The Elevation axis design imposes a certain unbalance in order to provide no backlash during operation. The unbalance introduces a torque that would move the Optical support structure spontaneously from the zenith to the horizon position. For this reason, a safety issue arises. In case the Elevation actuator (mechanical jack), for whatever reason, cannot stop the rotation of the Optical support structure from zenith to horizon, there must be a safety device able to stop without damaging this undesired motion.

4.1.1.2.5 Elevation Cable Wrap

Cableways from Cabinets to the Optical support structure are allowed by using a unique, central Elevation cable wrap. This cable wrap is standard IGUS R4.56.30.150, which ensures cable protection and the correct guide from the Azimuth fork to M1 dish. Its motion is provided passively following the Elevation axis one. More space is reserved for possible camera cooling hoses.

4.1.1.2.6 Azimuth Stow Pin

The Azimuth stow pin guarantees no motion for Azimuth axis and it is very similar to the concept of the Elevation stow pin. The loads for this unit (shear load of about 95kN), is lower than the Elevation one; for this reason, the concept has been kept in order to speed up production of parts.
Three azimuth parking positions of the telescope are foreseen for SST. In fact, the azimuth stow pin can be inserted into three separate bushings displaced at 60deg in azimuth between each other.

4.1.1.2.7 Supports for the Electrical Cabinets

The Fork provides the support structure for the Electrical cabinets.

The electrical Cabinets of the telescope are located at about 80 cm in height from the ground and are 2m tall. During factory integration, on-site commissioning, and maintenance throughout the entire lifetime of the array, they often need to be accessed, and work must be performed on them for quite some time.

A platform is therefore placed providing access to the cabinets without additional means, and a small retractable ladder is foreseen to easily climb on the platform.

The railways are bolted to the access platform, so that they can be removed in case of need.

4.1.2 Optical Support Structure

The Optical Support Structure (OSS) represents that part of the Telescope, which supports the optics. The OSS is mounted on the Elevation bearings and is also supported by the Elevation ball screw jack. The main parts of the OSS are:

- The *M1 dish*, the structure to which is anchored the OSS upper structure and the M1 mirror segment supports.

- The *counterweights* to balance the elevation structure around its axis of rotation.
- The *OSS Upper Structure*
- The *M2 Support Structure* that includes, the Pointing Monitoring Camera.

4.1.2.1 M1 Dish

It is the principal part of the subsystem; its main functions are:

- bearing the triangles carrying the 18 mirrors of M1;
- supporting the counterweights;
- supporting the OSS Upper Structure.

At the time of the release of this document, the M1 Dish design is based on a large, hexagon-shaped welded structure, where 3 principal beams (double C section) are recognizable: one vertical and the other two at 60° from the vertical one; such a structure provides support to the mast, while actuators interfaces have reinforcing ribs (organized in two concentric racks) to give stiff response and guarantee the adequate stability to keep the mirror segments in their position. An array of perforated aluminium sheets on the upper two sides of the hexagon works as a shield, protecting the mirrors from the snow when the telescope is in the parking position.

4.1.2.2 M1 segments Support

Each M1 Segment Support has allocated the following functions:

- Provide the interface between each Mirror segment and the M1 Dish ([AD18], I/F between SST-MEC and SST-OPT M1);
- Maintain the M1 Mirror segment in the correct position with respect to the M1 Optical surface;
- Allow to move (tip/tilt/piston) the M1 Mirror segment in a controlled manner;
- Allow removal of the M1 Mirror segment from the M1 Dish.

Each mirror segment is provided with three passive actuators preloaded by means of springs and fixed in their positions with tapered locking devices, which work with friction.

Handling each segment is possible by removing a single actuator per time, the locking device and the fixing screws. Each mirror segment can be detached from the actuators removing three fixing screws per pad. A sliding device is available for all three actuators, so that the segment can be slid out to permit the mirror removal.

4.1.2.3 Counterweights

The counterweights function is to properly balance the movement of the whole mechanical structure rotating around the elevation axis; they consist in two sets of steel blocks each supported by 3 beams bolted to flanges welded to the M1 Dish structure.

4.1.2.4 OSS Upper Structure

The OSS Upper Structure is the structure that supports:

- M2 Support Structure: the frame where the secondary mirror with its motors, drives and accessories, is mounted;
- the main scientific instrument of the telescope: the Cherenkov Camera
- The Optical Camera used to align the mirrors during calibration and maintenance activities.

It consists of a central mast reinforced by three pipes spread at 120 degrees to each other. Both the mast and the pipes are bolted to the M1 Dish. Furthermore, a top ring connects the end of the three pipes, to improve the structure's stiffness and to facilitate the operations of mounting/dismounting of the M2 Support Structure.

4.1.2.5 M2 Support Structure

The M2 Support Structure main functions are:

- Interface the M2 Mirror ([AD19], I/F between SST-MEC and SST-OPT M2);
- Allow to move (tip/tilt/piston) the M2 Mirror in a controlled manner.

The M2 Support system includes an active tripod that allows M2 precise positioning along the Z axis and tip-tilt (rotation around X and Y axes), and a lateral support that grants safety support and safe load transmission. The tripod consists of three load-spreaders with 3 flexures each to transmit axial loads only.

The motion is possible with a motor and a ratio gear, which permits the actuators to move with an axial stroke of ±7.5mm. Each motorized driving unit is equipped with an absolute encoder and two electrical limit switches to have full feedback on position and safety of motion. The joint between the flexures structure and the actuator consists of a double-tilting system, which allows the M2 to be tilted and displaced along the optical axis without constraints.

The M2 Support Structure also include the support plate for the flasher unit onto centre of M2 mirror [AD10].

4.1.2.6 Swing-Arm for Intensity Interferometry Instrument

The SI3 shall have a positioning arm that deploys and removes it on the focal axis in front of the Cherenkov Camera. This positioning arm shall be permanently mounted on the Optical support structure part of SST-MEC. The arm shall have its control system that shall be connected to the SST_MEC Safety System.

4.1.3 Electrical & Control system Cabinets.

The Telescope Electrical & Control system cabinets, include all the parts (cables, switchboards, cable trays, etc.) for the distribution of electrical power, networking and inside the SST Telescope. The

main components of this system are:

- Telescope Power Cabinet (TPC)
- Telescope Control Cabinet (TCC)
- Telescope Cabinets Conditioning system
- Secondary Electrical Boxes
- CTAO - SST Services Connection Cabinet
- Telescope networking devices
- Cabling

From the Site Infrastructure, the power, network, timing, safety incoming lines enter into the telescope from the Base, pass through the azimuth cable wrap up to the two cabinets on the Azimuth structure (see Figure 4-4).

Figure 4-4: the figure shows: on the left the ASTRI Mini-Array Telescope Power Cabinet and on the right the ASTRI Mini-Array Telescope Control Cabinet.

The telescope control hardware and electrical communication components are grouped following their functionality and they are contained in two electrical cabinets, supported by the Azimuth Fork:

The logical blocks of all the control, network and electrical parts mounted inside the cabinets are reported in Figure 4-5.

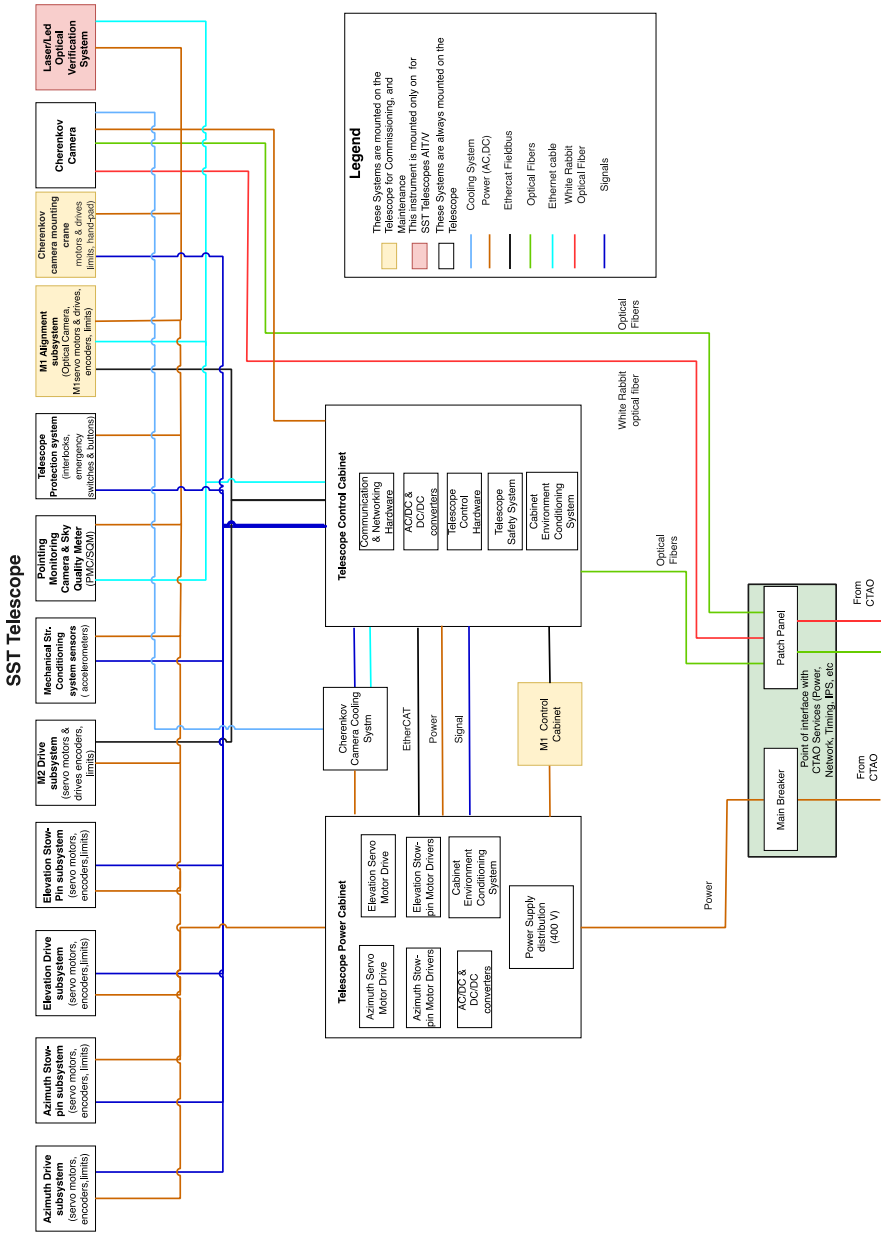

Figure 4-5: The main logical blocks of the Electrical and Control HW mounted on the SST telescope Cabinets

All the cables are routed through the azimuth (AZ) cable, considering also a spare length in order to allow the cables to follow the movement of the axis.

4.1.3.1 Telescope Power Cabinet (TPC)

This is the cabinet where all electrical breakers and protections are mounted, including fuses, connections racks, etc. Here are installed the main Az and El motors drivers and the commands and protection elements of the stow-pins motors. Fans and heaters guarantee that the cabinet environmental conditions are always within the specification ranges.

The Telescope has the following main electrical interface incoming from the site infrastructure:

- 400 V (TN-S system, 50 Hz) for normal power, UPS protected

4.1.3.2 Telescope Control Cabinet (TCC)

This is the cabinet where are mounted all the controls and networking parts: PLC, Control PC, I/O modules, AC/DC power supply, networking devices etc. Fans and heaters guarantee that the cabinet environmental conditions are always within the specification ranges.

4.1.3.3 Telescope Cabinets Conditioning System

The TPC and TCS humidity and temperature shall be monitored and controlled. The humidity and temperature values inside the cabinet shall be made available via the I/O modules connected to the Telescope Control Unit.

4.1.3.4 Secondary Electrical Boxes

See Task 5s.2a (sec.5.2.2.2).

4.1.3.5 CTAO - SST Services Connection Cabinet

This is the I/F cabinet/s where the SST telescope will be connected to the CTAO Services: power, networking, timing, safety.

4.1.3.6 Telescope networking devices

These include the main Telescope switch and all patch-panels needed to establish the Telescope internal networking system and its connection with the CTAO network.

4.1.3.7 Cabling

In the telescope’s Azimuth Structure are present these devices:

- AZ encoder;

- The AZ limits switches and Lyra (used to allow turns of more than 360 Degrees on Azimuth);
- Base door (interlock) limit switch.
- The CTAO – SST interface point for the electrical, data and safety connections.

The cables coming from these components go in a box at the top interface of the AZ cable drape (the "AZ structure cable box") which is the interface with the cable duct system: it allows the cables distribution towards the cabinets (Telescope control cabinet TCC and Telescope power cabinet TPC) and towards the elevation (EL) cable wraps. Furthermore, the cables, which serve the various devices/equipment installed in this area exit from the cable duct by means of dedicated cable glands.

The Timing and Data cables of the Cherenkov go directly form the CTAO – SST interface point to the Camera at the top of the central tube that supports the Cherenkov Camera.

In the telescope elevation structure these devices are present:

- EL encoder;
- EL rotational limit switches;
- AZ and EL rotational motors;
- AZ and EL stow pins;
- Base light.

From the EL cable wrap, by means of opportune cable conduits (external to the masts) the cables are distributed along the mast path.

The central mast is used to distribute the cable towards the Cherenkov Camera while another set continues along the mast to reach the equipment of the M2 area. These last are:

- M2 actuators (with the relevant M2 box used as electrical interfaces and disconnection point);
- M2 actuators encoders;
- Pointing Monitoring Camera (PMC) equipment (auxiliary).

The removable crane system for mounting the Cherenkov Camera (maintenance tool).

4.1.4 Protection System

Telescope Protection System (TPS) is composed of:

- Telescope Safety System
- Lightning Protection System

4.1.4.1 Telescope Safety System

The Telescope Safety System refers to all the hardware necessary to guarantee the safety of the telescope and of the people working on it during operations or maintenance activities. It includes the Telescope Safety. The TPS includes the following parts:

- Safety PLC
- Safety I/O Modules

- Interlocks safety switches
- E-Stop Buttons
- Temperature Sensors
- Software

The above listed components are described in [AD9] in compliance with [AD16]. The temperature sensors are mounted internally to the Telescope Power and Control cabinets and are connected to the Telescope Control Unit.

4.1.4.2 Lightning Protection System

The Lightning Protection System refers to all the hardware necessary to guarantee the protection against lightning and LEMP [AD20].

4.1.5 Auxiliary Devices

The auxiliary assemblies are those items that support the main function of the telescope during operations and maintenance. Only some of those items are permanently on the telescope but can be installed when needed. The Auxiliary assemblies include:

- Pointing Monitoring Camera
- The Mirror Alignment System
- Optical Camera (CFI)
- Laser/Led optical verification system

4.1.5.1 Pointing Monitoring Camera

This system is installed on the rear of the M2 support structure to obtain astrometric calibrated FoV of the region pointed by the telescope. The system is based on a FLIR Blackfly S GigE (Model: BFS-PGE-63S4M-C) with a 6.3 Mpx Monochromatic Sony IMX178 CMOS sensor. In front of the CCD Camera is mounted a Computer M7528-MPW3 lens to ensure a wide sky coverage and sampled enough to obtain an astrometric accuracy of 5 arcsec over the full sky (see Figure 4-6). The PMC will be used to implement a telescope-pointing model TPOINT-like with a grid pointing directions over the entire sky.

Figure 4-6: A picture of the PMC Camera and Lens assembled together with the metal cylinder used to anchor the camera to the main mechanical frame (left). The PMC/Lens while being mounted on the internal mechanical frame (centre and right).

4.1.5.2 Mirror Alignment System

The M1 alignment procedure consists in finding the best optical position of each M1 segment to obtain, all over the focal plane, the expected optical Point Spread Function (PSF). The PSF is measured analysing the images of a bright star taken with the Optical Camera mounted on the focal plane.

After the completion of alignment, the Optical camera and the motorized support stages of the mirror segments are removed. Three of these systems are envisaged for all SST Telescopes.

The M1 Segment alignment system consists of:

- M1 Actuators and Drivers
- M1 limit switches
- M1 Control Cabinet
- Cabling and ducts support

Three actuators are inserted inside each of the three supports on which is mounted each mirror segment. Each actuator has a step-motor and two limit switches. The three motors of each segment are connected to a three axes motion controller. In total there are 54 actuators and 18 motion controllers connected to the Telescope Control Unit through the EtherCAT fieldbus. The controllers and the power supply and all the connections shall be mounted in a standard Electrical cabinet that shall be easily mounted and dismounted on the SST telescope.

Each actuator shall allow to linearly move (piston/tip/tilt) each mirror segment of >= ±7.5mm with respect to the zero-position defined by the optical design

The M1 alignment procedure is performed only during commissioning and programmed maintenance activities. For this reason, the 54 actuators and their control electronics shall be easily mounted and dismounted from the M1 Dish.

4.1.5.3 Optical Camera

To perform the alignment procedure, the Cherenkov camera has to be removed and replaced with an Optical CCD Camera, and a motorized system has to be mounted on the rear of each M1 mirror segment support actuator to allow the tip, tilt, and piston movements of each mirror segment. The optical CCD camera is mounted on a rotary stage that is then mounted on a x-y linear stage to allow the positioning of the CCD, with right orientation, in several focal plane positions. This will allow us to verify the correct alignment of each SST telescope's optical surfaces by measuring the optical PSF of the system. The comparison of the measured PSF with that expected at the different positions on the focal plane will allow us to obtain the correct repositioning of the M1 segments acting on their motorized support stages.

The Optical Camera is a CFI.

4.1.5.4 Laser/Led optical verification system

The SST Mirrors' initial mounting and positioning on the telescope are verified through a system of Lasers mounted on the mirror segments and a led mounted at the centre of the focal surface. It consists of:

- Lasers and supports
- Focal plane Led and support
- Screen
- Cabling
- Control Software
- Analysis Software (CFI)

Conceptually, when on the led on the focal plane illuminates the M2 mirror and then by reflection the M1 mirror segments. A screen located at an appropriate distance from the M1 mirror will show the image formed by the full optical system.

4.1.5.5 Intensity Interferometry Instrument

The Stellar Intensity Interferometry Instrument (SI3) is a fast-single photon counting instrument for performing intensity interferometry observations of bright stars with the SST_TEL Array. SI3 will be designed to perform accurate measurements of single photon arrival times (1 ns) in a narrow optical window (3-8 nm) centred at a wavelength in the range 420-500 nm.

The Intensity Interferometry Instrument is a CFI.

4.1.6 Control Systems

The Mechanical Structure Control Systems includes:

- Mount Control System
- Mirrors Control System
- Telescope Condition Monitoring system

- Power Management System
- Engineering-AIT/V GUI Software
- Telescope Local Panel
- Telescope Hand-Pad

The main blocks of the Mechanical Control System are reported in Figure 4-7.

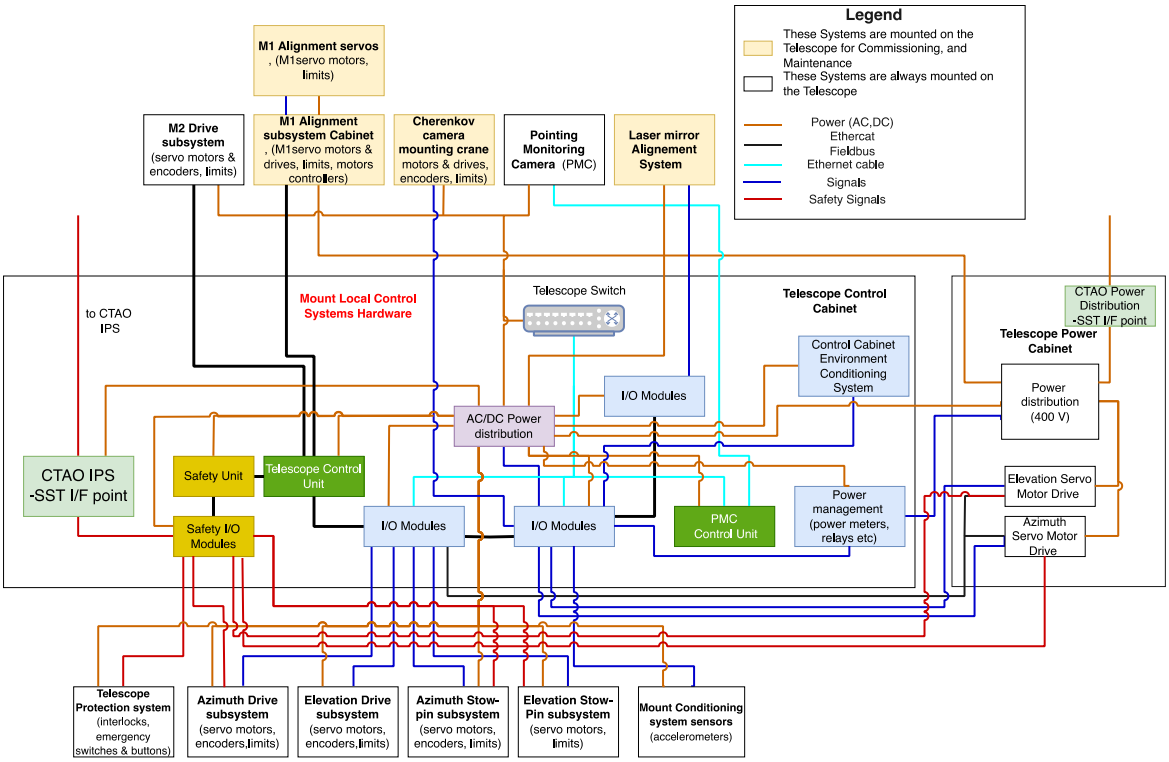

Figure 4-7: Main Blocks of the Mechanical Structure control System

4.1.6.1 Mount Control System

The Mount control software is described and specified in [AD5], this document gives also a general overview of the Architectural concepts to be followed in developing Control system to be delivered to CTAO. It consists of:

- Azimuth Actuators and Drivers
- Azimuth Encoder
- Azimuth Limit switches
- Elevation Actuators and Drivers
- Elevation Encoder
- Elevation Limit switches
- Azimuth Stow-Pin Actuator and driver
- Elevation Stow-Pin Actuator and driver
- Telescope Control Unit
- I/O Modules
- Fieldbus

- Mount Control Software
- Telescope OPC-UA Server software

4.1.6.1.1 Azimuth Actuators and Drivers

The Azimuth axis motion is powered by two servo (brushless) motors fixed to the Fork and located at 180 degrees respect to each other along the circumference of the azimuth slewing bearing. Each motor shall be provided with reduction stages that transmit motion to the Azimuth mechanical axis through a pinion mounted on the last reduction gearbox that is coupled to the Azimuth slewing-bearing.

The two servo motors shall work together in a master-slave configuration, controlled in differential torque mode, to eliminate backlash and guarantee good motion accuracy under all operational conditions.

The master motor shall be equipped with a fail-safe brake.

The master motor shall use a multiturn absolute encoder in case the main azimuth encoder fails to reach a safe position.

The Drivers of the motors are mounted on the Telescope Power Cabinet and are part of the Mount Control System. The Azimuth Drivers implement the Safe Torque Off Safety function. The driver's STO Inputs are connected to the Telescope Safety PLC which is part of the Mount control system.

4.1.6.1.2 Azimuth Encoder

In the ASTRI Mini-Array the azimuth encoder is an optical Sin-Cos incremental tape encoder with absolute reference marks. The encoder thus requires an initialization process before being able to work. The Azimuth axis encoder shall provide a resolution of <2.5". It is glued on a machined circular surface in the upper part of the internal wall of the Base.

4.1.6.1.3 Azimuth limits Switches

The Azimuth switches are mounted inside the Base and are in a proper bracket which offers interface for 7 switches. One of this is the lyra (it shall be inserted in the interlock chain) used to get the information on the CW or CCW azimuth rotation. The lyra shall be mounted in correspondence of the WEST point.

4.1.6.1.4 Elevation Actuators and Drivers

The Elevation axis motion is provided by a high efficiency preloaded ball screw jack driven by a brushless motor. The servo motor is equipped with a brake to provide safe operations and avoid accidents to people and hardware)

The Driver of the Elevation motor is mounted on the Telescope Power Cabinet and is part of the Mount Control system. The Elevation Driver implements the Safe Torque Off Safety function. The Elevation driver STO Input is connected to the Telescope Safety PLC that is part of the Mount control system.

4.1.6.1.5 Elevation Encoder

The Elevation axis encoder is mounted on the Elevation Axis and shall be the Heidenhain RCN2580 absolute encoder, providing a resolution of ± 2.5".

4.1.6.1.6 Elevation Switches

The Elevation switches are mounted on the Fork and are located in a proper blade support, which offers interface for 6 switches.

4.1.6.2 Telescope Control Unit

The Telescope Control Unit is the Control Unit of all SST controls. It shall be a Beckhoff PC C6920-0080 (8 cores TC380). All the software controls running on the TCU shall be developed using the PLC Structured Text (ST) or Functional Block Diagram (FBD) language, following the IEC 61131-3 standard. It shall run under Beckhoff TwinCAT 3 (The Windows Control and Automation Technology) runtime environment.

4.1.6.3 I/O Modules

The I/O Modules include all modules capable of manage digital or analog signals produced by any sensors installed on the SST-MEC. All modules shall be selected among those compatible with EtherCAT fieldbus with a preference for Beckhoff I/O modules.

4.1.6.4 Fieldbus

The Fieldbus used in the SST-MEC shall be the EtherCAT for controls and Safety over EtherCAT (FSoE) for functional Safety.

4.1.6.5 Mount Control Software

The Mount Local Control software running on the TCU shall monitor and control all the main functionalities of the telescope structure, including those needed for maintenance, testing and calibration activities.

4.1.6.6 Telescope OPC-UA Server software

The open, Ethernet-based communication standard OPC UA (Open Platform Communications Unified Architecture) shall be used by all Controls system of SST-MEC to communicate with the Supervisors of each Local Control system. The Telescope Control Unit shall integrate the Beckhoff TwinCAT OPC-UA server.

4.1.6.7 Mirrors Control System

The main components of the Mirror local control systems are:

- M2 Actuators & Drivers
- M2 Encoders
- M2 limit switches
- M2 Motion Controller
- Laser/Led optical verification controller
- Fieldbus
- Control Software

The Analysis software of the data provided by the Mirror alignment and control system will be provided by the INAF to the Contractor.

4.1.6.8 The Telescope Conditioning Monitor System

This system consists of accelerometers mounted on the telescope drive system. The data provided by these sensors combined with the motor currents, voltage and speed will allow condition-based maintenance to limit system downtime and spare part stocks. The output signals of these sensors are read by dedicated I/O modules connected to the Telescope Control Unit.

4.1.6.9 Power Management System

The Power managements system consists of:

- Power, Voltage, frequency, Current meters
- Relays
- I/O Module
- Control Software
- switches and circuit breakers

These devices are used to monitor the power status and consumption of the telescope and to switch on/off all the Telescope subsystems (e.g. PMC, M2 and M1 Actuators and Controllers etc.).

4.1.6.10 Engineering-AIT/V GUI Software

The Engineering AIT/V GUI software allows to operate the integrated telescope Structure during AIT/V phase both at the factory and on-site. The hierarchy of GUIs of the Telescope Structure Subsystems is sketched in Figure 4-8.

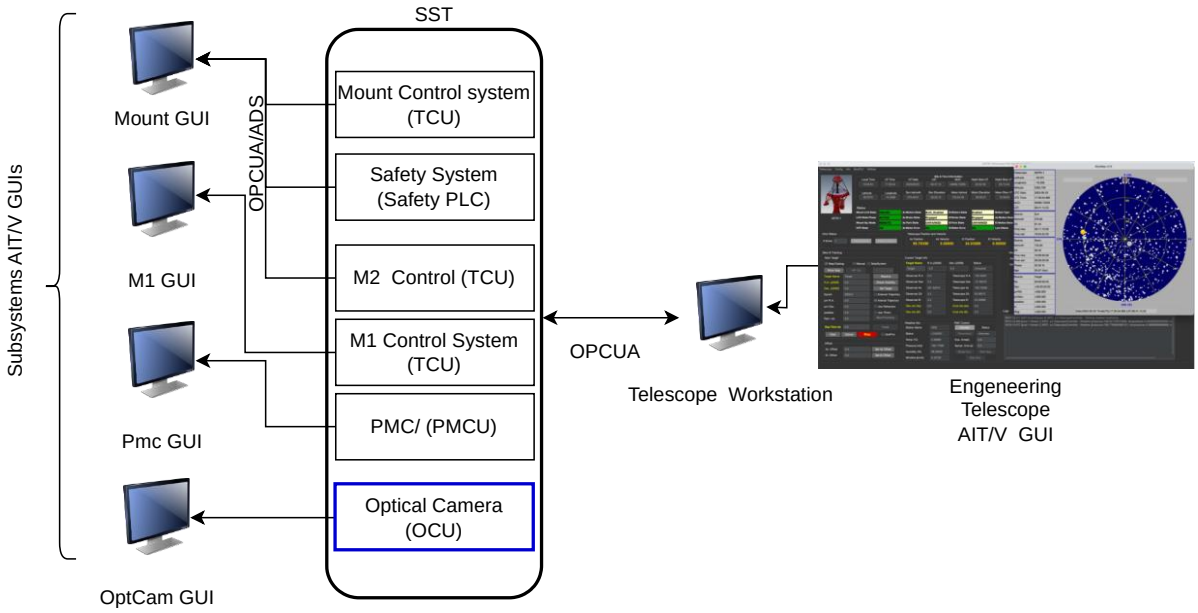

Figure 4-8 Hierarchy of the SST Structure control GUIs.

4.1.6.11 Telescope AIT/V Workstation

The telescope AIT/V workstation is the engineering workstation running all the software packages needed to operate the single or integrated SST Structure subsystems. The workstation shall have high graphical performance. The workstation will be used only during the AIT/V phase in the factory and at the site.

4.1.6.12 Telescope Control Panel

As for CTAO telescope Safety Design Specification [AD16] a local control panel shall be provided for local control and command of the structure rotation axes. The location of this panel shall be chosen under ergonomic and safety considerations, whereby the visual observation of the movement may be necessary. An emergency stop shall be included at the panel.

4.1.6.13 Telescope Hand-pad

As for CTAO telescope Safety Design Specification [AD16] a portable control unit shall be provided for use of maintenance personnel servicing the telescope structure. This shall provide at least velocity

control loop in both Altitude and Azimuth axes, only when the control has been put in Local. The portable control unit shall be equipped with an emergency stop, velocity control setting adjustment, and provide the encoder reading on a display.

4.1.7 Maintenance and AIT/V Tools

Maintenance tools for the Mechanical Structure include:

- Camera Handling Tools
- Handling and Moving equipments
- Maintenance Tools
- M1 Mirrors Maintenance Tools
- M2 Mirrors Maintenance Tools

4.1.7.1 Camera Handling Tool

The function of this system is to allow the installation and the removal of the Cherenkov camera in a safely manner on the SST Telescope mount.

4.1.7.2 Handling and Moving equipments

This includes all the equipment necessary to move, lift, assembly, handling and integrated the various part during AIT/V phase.

4.1.7.3 Maintenance Tools

This includes all custom tools developed specifically to support maintenance of some components of the SST-MEC like for example mounting/dismounting AZ and EL motors.

4.1.7.4 M1 Mirrors Tools

This includes all custom tools needed to mount and dismount the M1 segments and performs any other maintenance activity. In particular, the tools should allow to mount/dismount the single segment without any interference with the surrounding ones.

4.1.7.5 M2 Mirrors Tools

This includes all custom tools needed to mount and dismount the M2 mirror on its support structure and performs any other maintenance activity related to it.

4.2 Optics

The SST Telescope Optical Design is fully described in [RD16] and summarized in Annex 3.

4.3 Cherenkov Camera

The SST Cherenkov Camera Design is fully described in [RD17] and summarized in Annex 4.

4.4 Telescope Control System

The SST Telescope Control System is summarized in Annex 5.

4.5 SST Interfaces

A full description of the CTAO Context in which the SST telescope will operate is given in [RD25] and represented in Figure 4-9. A more detailed external I/Fs description will be provided at the Contractor Kick Off Meeting.

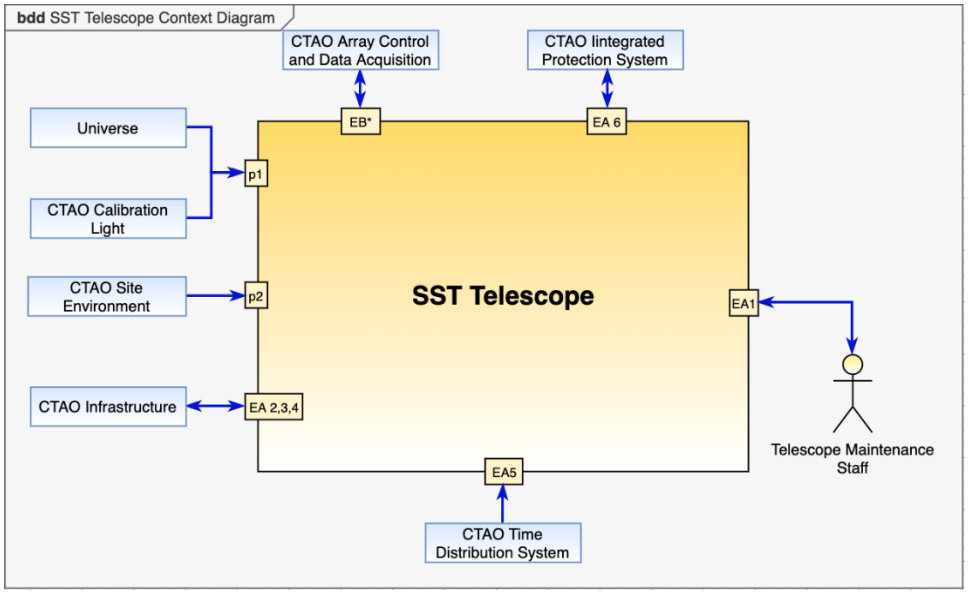

Figure 4-9: Telescope Context Diagram

The SST Telescope interfaces with the CTAO infrastructure, which provides:

- access safe pedestrian and vehicle access to each SST Telescope and its local subsystems (e.g. electrical cabinets etc.);
- underground utility distribution systems;
- connection to the site electrical power distribution and emergency backup systems;
- communications infrastructure (Optical fiber) distribution system ;
- areas for the final assembly and integration of the telescope;
- spaces for service, repair, and maintenance;

- storage areas for material handling equipment (e.g. cherry-picker, lifts, ….)
- spaces to store spare parts for maintenance and repair key SST Telescope subsystems (e.g., Mirrors).

CTAO provides to the SST Telescope information about environmental conditions, including weather (temperature, wind, humidity, pressure, precipitation, dust levels, and clouds), atmospheric conditions and seismic activity.

The SST Telescope interfaces and provides information to the CTAO Integrated Protection System (IPS) which globally monitors the safety of the observatory. Internally the SST Telescope provides the software and hardware components necessary to ensure its safe operation. Safeguards are identified by the hazard analysis provided for each SST Telescope subsystem. The SST Telescope area is protected by a fence to keep persons and equipment safe.

The SST Telescope is operated through its interface with CTAO ACADA. ACADA provides efficient observatory operation, which includes scheduling of observations, sequencing of commands to SST Telescope to execute observations and supervision, science and telemetry data acquisition, and quality Monitoring. Also, ACADA provides to the SST Telescope core services: the log service (history of events), alarm service (history of warnings and alarm conditions), telemetry service (monitored data values), configuration service (properties and settings), and system supervisor service (coordinate, monitor and manage software and hardware health).

The SST telescope is connected to the CTAO Time Distribution System which provides the reference time signal to assign a timestamp to each detected light event.

An overview, as approved by the Product Review [AD8][AD9] is given in Figure 4-10 and Figure 4-11.

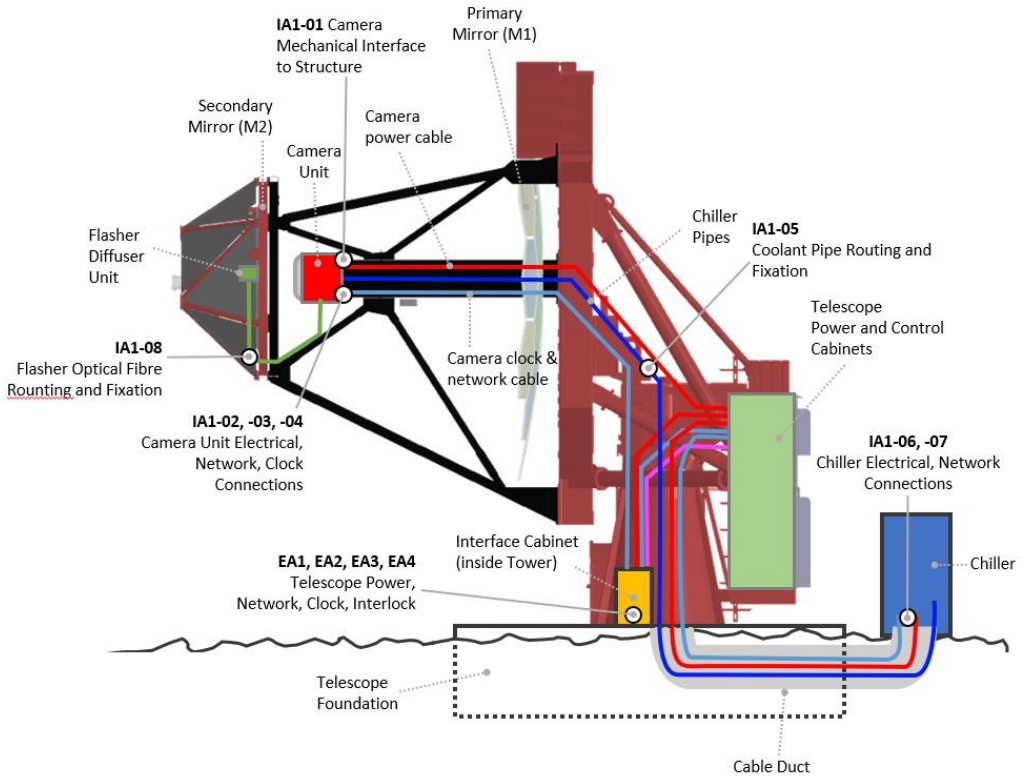

Figure 4-10: Overview of the Telescope Interfaces

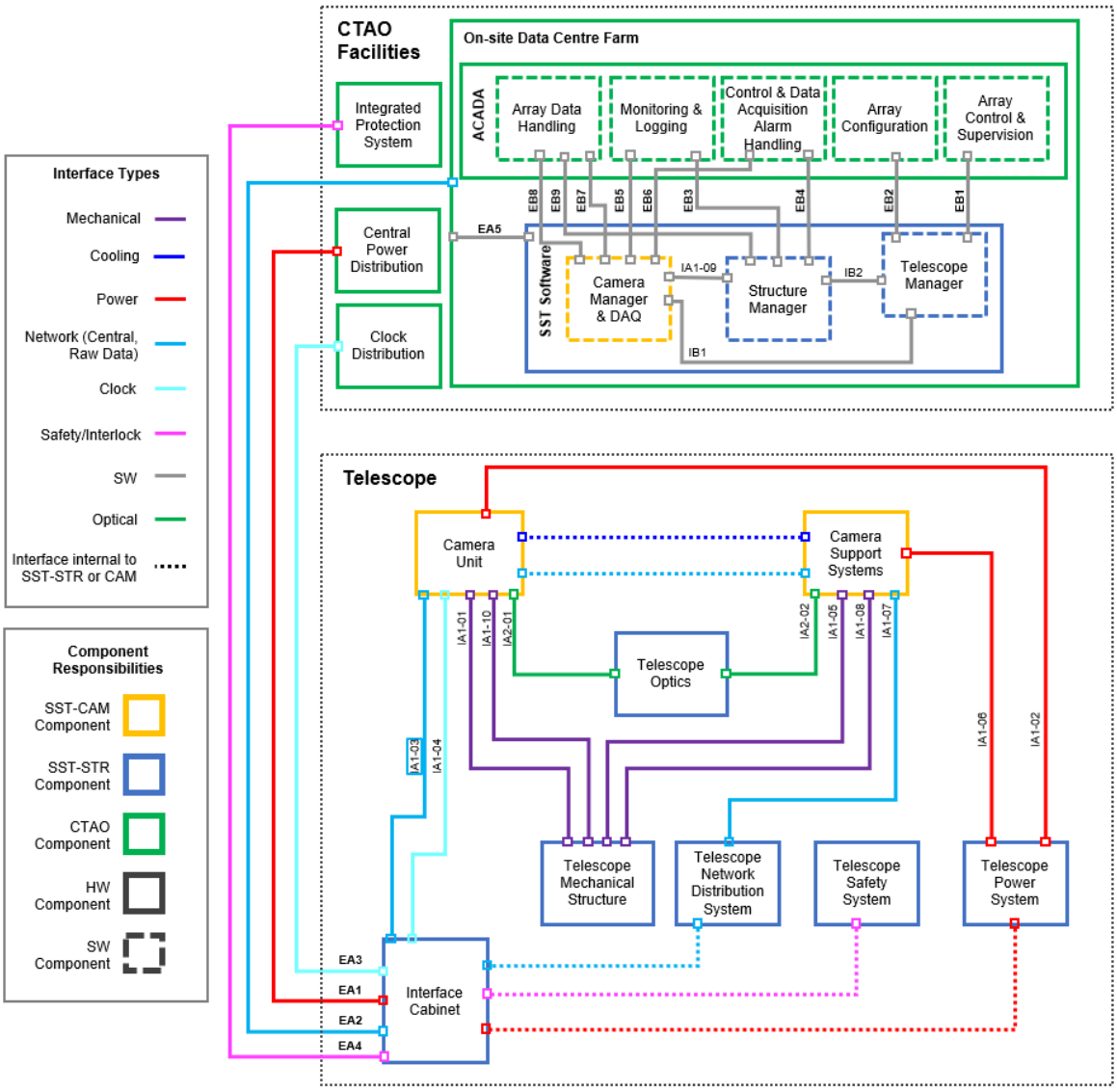

Figure 4-11: Overview of the Telescope Interfaces

4.6 SST Telescope Development Status

This section reports the development status of the SST project and its subsystems [RD19].

All the activities carried out so far have led to a preliminary design of the telescope and all its subsystems.

This preliminary design was presented in February 2023 at the Product Review (or more properly a Preliminary Design Review) and it has been endorsed by CTAO as suitable for being developed to the CDR level of design.

4.6.1 Verification Strategy

The Telescope verification strategy uses prototypes for the main subsystems, engineering, and qualification models.

Therefore, the first produced item of each SST-MEC, SST-OPT, SST-TCS, and SST-CAM subsystem will be integrated on the first telescope to be used as a qualification model.

The verification strategy of the SST Telescope has been designed to confirm (through demonstration) that the equipment (design) is compatible with the requirements of the CTAO project.

The AIT/V campaign is to demonstrate that:

- the Telescope design, at the subsystem level, is qualified with respect to the environmental condition;
- the overall Telescope (including software, procedures, and resources) can fulfil the project requirements, providing all the performances requirements as specified in [AD4];
- the structure verified in conjunction with the camera works properly;
- the Final Models are delivered in due time, within the agreed schedule;
- In addition to the AIT/V campaign goals, the Telescope Design and Production must be organized considering the following master drivers:
  - the operational period;
  - a structural design to allow easy accessibility for maintenance, alignment and testing;
  - to privilege the use of standard or recurrent equipment;
  - to privilege the use of well-known and already proven technologies.

Based on the SST Team experience, the “best fit” of those drivers can be met by means of the following models:

- SST-MEC subsystems prototypes (i.e. M1 Actuators, M2 Actuators, PMC, etc.);
- Engineering Models of the subsystems for functional (HW & SW) and electrical validation at the subsystems level;
- Qualification Models of the Optics for physical and performance validation;
- one Qualification Model of the Telescope to verify interfaces, functions, and performance, and to verify the AIT/V process on factory and on-site;
- 24 Telescope Final units to compose, together with the telescope used as a qualification model, the entire set of 25 Telescopes on the CTAO southern site foreseen by this SoW;
- Subsystem Spares to provide AIT/V and maintenance activities.

At the moment of writing this document, the development status achieved by the SST program is based on the following prototypes:

- an SST Structure prototype, ASTRI-Horn Cherenkov telescope, has been produced and tested extensively in Catania, Serra La Nave, during the years 2014-2020. [RD1];
- The first ASTRI-1 Structure prototype of the ASTRI Mini-Array is being tested in Tenerife, Teide observatory [RD2];
- a Camera Unit prototype (CHEC-S SiPM) [RD3];
- a trade-Offs analysis performed during the bridging phase [RD4].

4.6.2 Structure development status

The current structure baseline selected for the SST-STR is the outcome of a project initiated in 2011 as a "flagship project" funded by the Italian Ministry of University and Scientific Research (MUR). This project is named ASTRI and is led by INAF. It started with developing, in the context of the SST–CTAO project in its early phase, a prototype Cherenkov telescope of the 4-m class. This telescope relies on an innovative dual-mirror optical configuration based on a polynomial-modified Schwarzschild - Couder design previously proposed by Vassiliev et al., [RD6]. In 2014 it was installed on the Mount Etna volcano, at the M.G. Fracastoro astronomical station operated by INAF–Osservatorio Astrofisico di Catania (see Figure 4-12, left panel, and [RD7]). This prototype has been named ASTRI-Horn after Guido Horn D'Arturo and is now available as a test bench for implementing hardware and software developed by the SST team.

Figure 4-12: Left: The ASTRI-Horn telescope prototype on the Mount Etna station; Right: the first ASTRI Mini-Array telescope

Following the successful realization of the ASTRI-Horn prototype, the ASTRI team moved toward implementing the ASTRI Mini-Array with 9 telescopes. The ASTRI Mini-Array has been designed based on the high-level SST requirements.

Taking advantage of the lessons learned during the development and operations of the ASTRI-Horn prototype, the design of the ASTRI Mini-Array electro-mechanical structure has been further optimized. For a detailed description of these improvements see [RD8], [RD9]. The ASTRI Mini-Array drawings as built can be found at [RD14]. The electromechanical structure of the first ASTRI Mini-Array telescope has now been constructed, shipped to Tenerife (Canary Islands) and integrated at the Teide Astronomical Observatory see Figure 4-12 right panel.

In Autumn 2020, CTAO defined this to be the SST structure baseline configuration.

The main differences between the SST current baseline and the ASTRI Mini-Array telescopes are:

- *the design of the M1 Dish (see next sections);*
- *the power and data INFRA-TEL interface located inside the base structure (see below);*
- *the SST Camera I/Fs;*
- *the presence of the SST Camera Chiller with the cooling pipes going through the SST structure.*

4.6.2.1 Trade-offs during Bridging Phase and Structure Technology Roadmap

During the Bridging Phase, several trade-offs were performed to improve the SST design [RD4]. The most relevant trade-off for the scope of this SoW was the optimization of the M1 dish design [RD5]. An Observatoire de Paris - PSL/CNRS team led these studies within the SST consortium, using an optimized design process based on structural optimization tools. This optimization focused on the redefinition of the beam layout of the M1 dish.

The combined use of topology and topography optimizations, shape optimization, and post-processing of these results allowed to obtain a different beam layout, as shown in Figure 4-13.

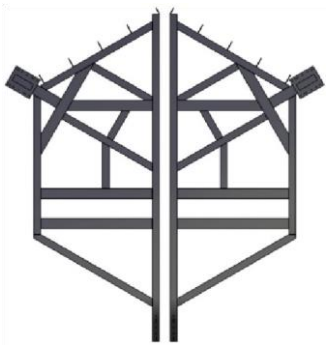

Figure 4-13: Main beam layout of the alternative design.

A second step of the work consisted in defining the geometry of the sections of these beams. The choice was to adopt standard U and I profiles for the beams, to make easier the fabrication process. The resulting 3D design is shown in Figure 4-14.

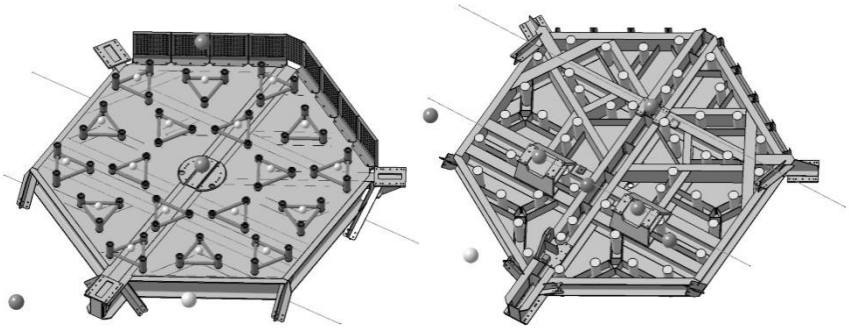

Figure 4-14: Alternative conceptual design of the M1 Dish.

Based on the structural analysis results [RD13] and the trade-off analysis [RD4], the M1 Dish Optimization [RD23] has been integrated into the baseline configuration [AD5].

4.6.3 Cherenkov Camera development status

For the SST Cherenkov Camera development status and technology roadmap refers to [RD15].

5. MASTER SCHEDULE, PROGRAMME PHASES, STUDY LOGIC & CONTRACTUAL ACTIVITIES

5.1 Master Schedule

The master timeline of SST is shown in Figure 5-1 and Figure 5-2.

To meet the plan and schedule, the Contractor in the full production phase will have to produce at least two mechanical structures and to perform on-site AIT/V of two telescopes every month.

The schedule assumes that the CTAO South site will be available for AIT/V activities from June 2025. In the event of a delay, the Contractor shall be able to store the first 5 SST-STR, to continue the production and to reschedule the AIT/V activities later accordingly and in agreement with the site availability.

The Contractor shall consider the schedule reported as reference; the Contractor can propose a schedule based on different assumptions (e.g. concentrating the production and/or the AIT of the SST-MEC in some particular periods) but always meeting the review dates and within the end date of the main activities as:

- ***SST-MEC CDR ADP Available for RIXs (T0+6months)***
- ***SST-TEL CDR (T0+9months)***
- ***SST-TEL TRB/OF-PQR (T0+16 months)***
- ***SST-MEC #1 Production and AIT/V (T0+13 months)***
- ***SST-MEC #1-#5 set ready for delivery (T0+18 months)***
- ***SST-MEC #6-9 Production (T0+21 months)***
- ***SST-MEC #10-14 Production (T0+26 months)***
- ***SST-MEC #15-19 Production (T0+31 months)***
- ***SST-MEC #20-25 Production (T0+37 months)***
- ***SST-TEL AIT/V #1-5 (T0+30 months)***
- ***SST-TEL AIT/V #6-9 (T0+33 months)***
- ***SST-TEL AIT/V #10-14 (T0+37 months)***
- ***SST-TEL AIT/V #15-19 (T0+40 months)***
- ***SST-TEL AIT/V #20-25 (T0+44 months)***

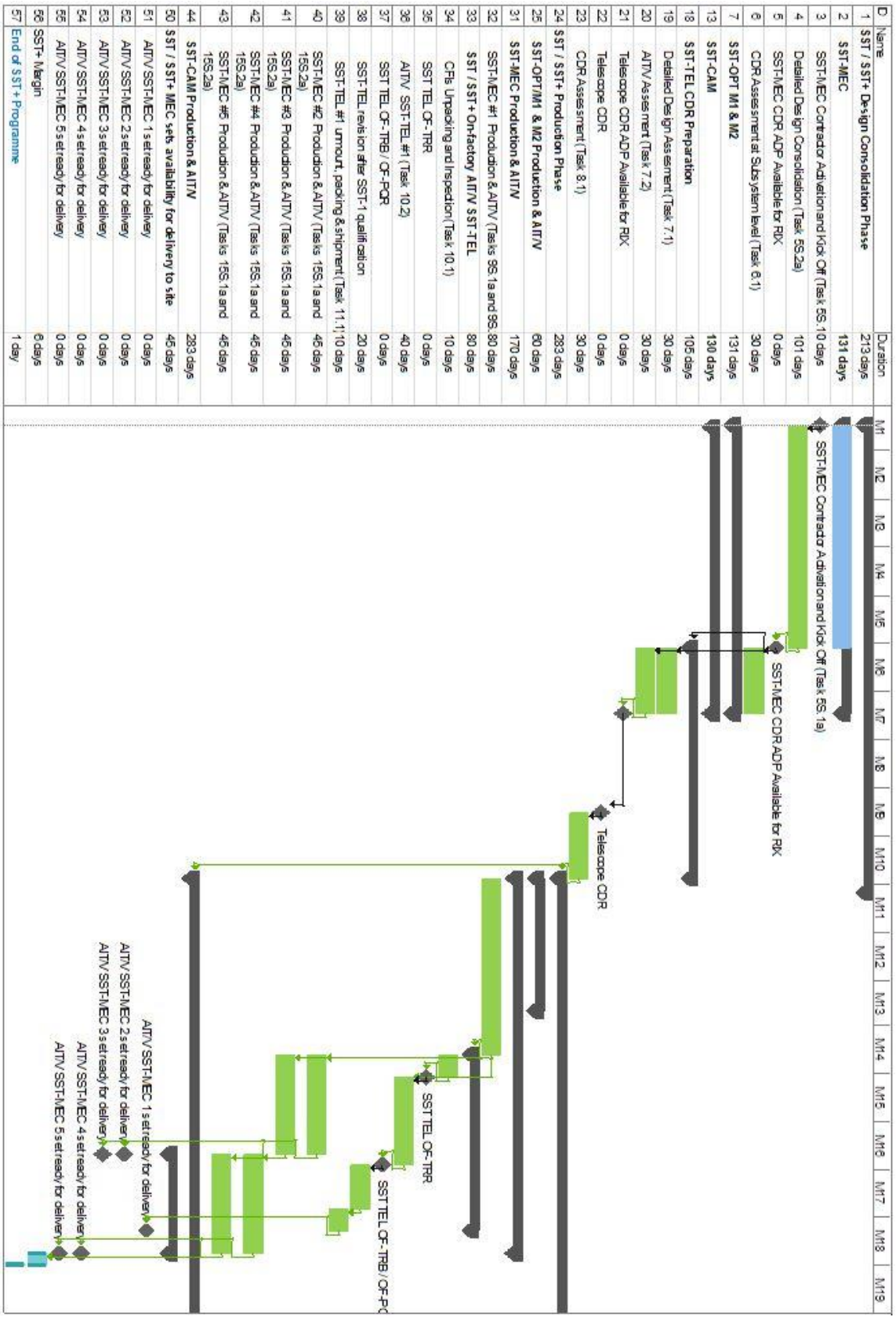

Figure 5-1: The SST/SST+ Programme Master Schedule (Telescopes #1/5)

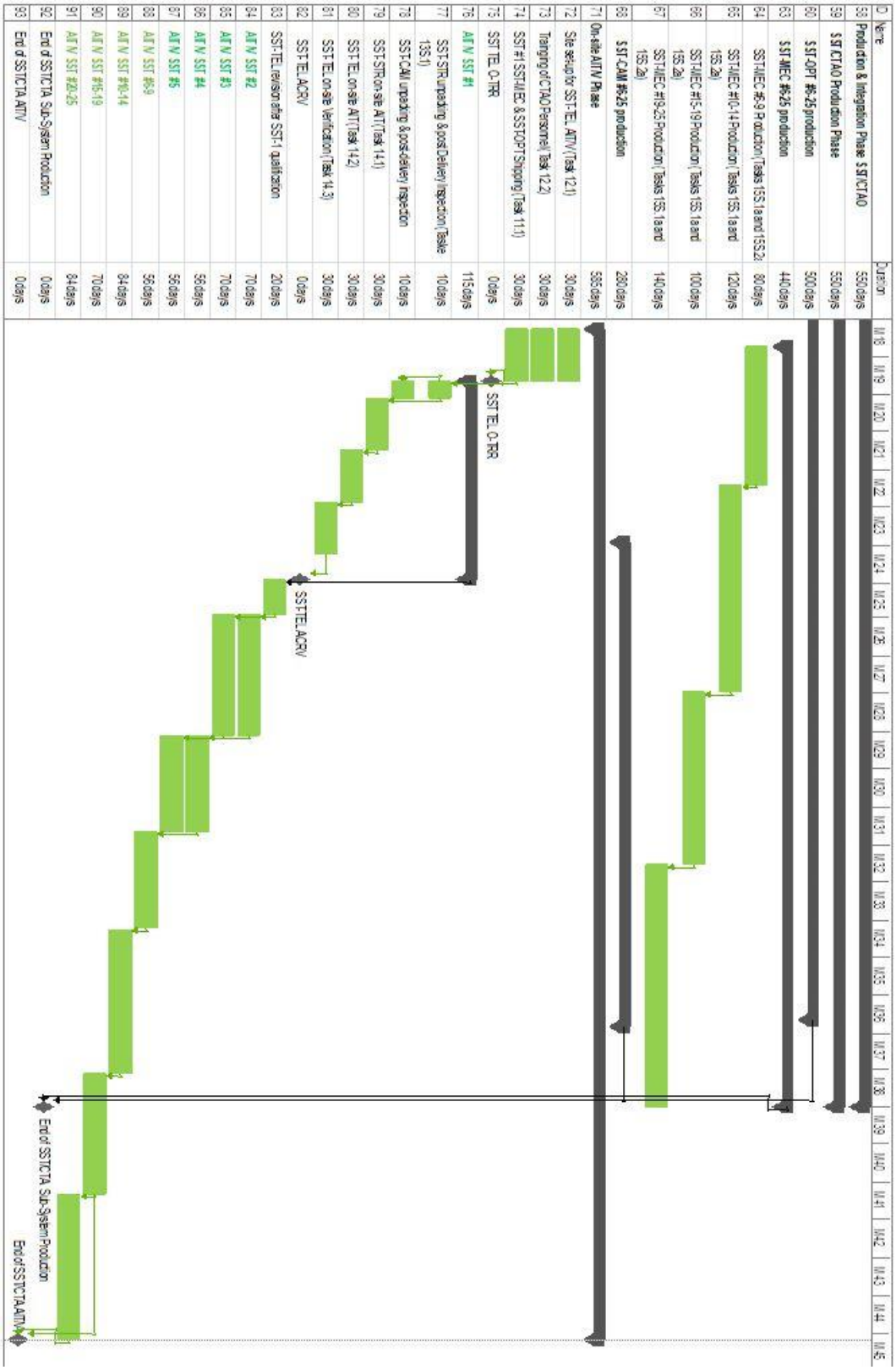

Figure 5-2: The SST Programme Master Schedule – Production (Tel #6/25) and AIT/V Phases (Tel #1/25)

5.2 Programme Phases, Study Logic and Contractual Activities

The SST Programme timeline is divided into four phases:

- Bridging (*Closed*),
- Design Consolidation (*Current Phase*),
- Production,
- On-Site AIT/V

Details of tasks to be performed and completed in each Phase is specified hereafter.

5.2.1 Bridging Phase (Closed)

The Bridging Phase has been closed by the Product Review, held in February 2023, in which the preliminary design of the SST Telescopes has been presented and approved by a board composed of external experts and endorsed by CTAO. Actions have been assigned with closure at the CDR [AD7][AD8].

5.2.2 Consolidation Phase (Current)

The outcoming of this phase is the final SST design, optimised for simplicity, maintainability, and cost. This phase also sees the realisation of the plans and documentation for the Production and AIV Phases. It is expected that the Design Consolidation Phase will conclude upon passing the Telescope CDR.

Starting from the Consolidation Phase KO (occurred on June 7, 2023) and until the Telescope CDR the preliminary design of the Telescope and its subsystem, approved by the Product Review, will be consolidated and finalized. All the analysis and simulations to confirm the chosen design will be carried out. All HW models needed to confirm the chosen design will be produced and tested.

During this consolidation phase the industrial contract based on this SoW will be assigned.

Figure 5-3 reports the activities that will be carried out during this phase. ***The green boxes represent the tasks and reviews in which the contractor is involved.***

Design Consolidation Phase

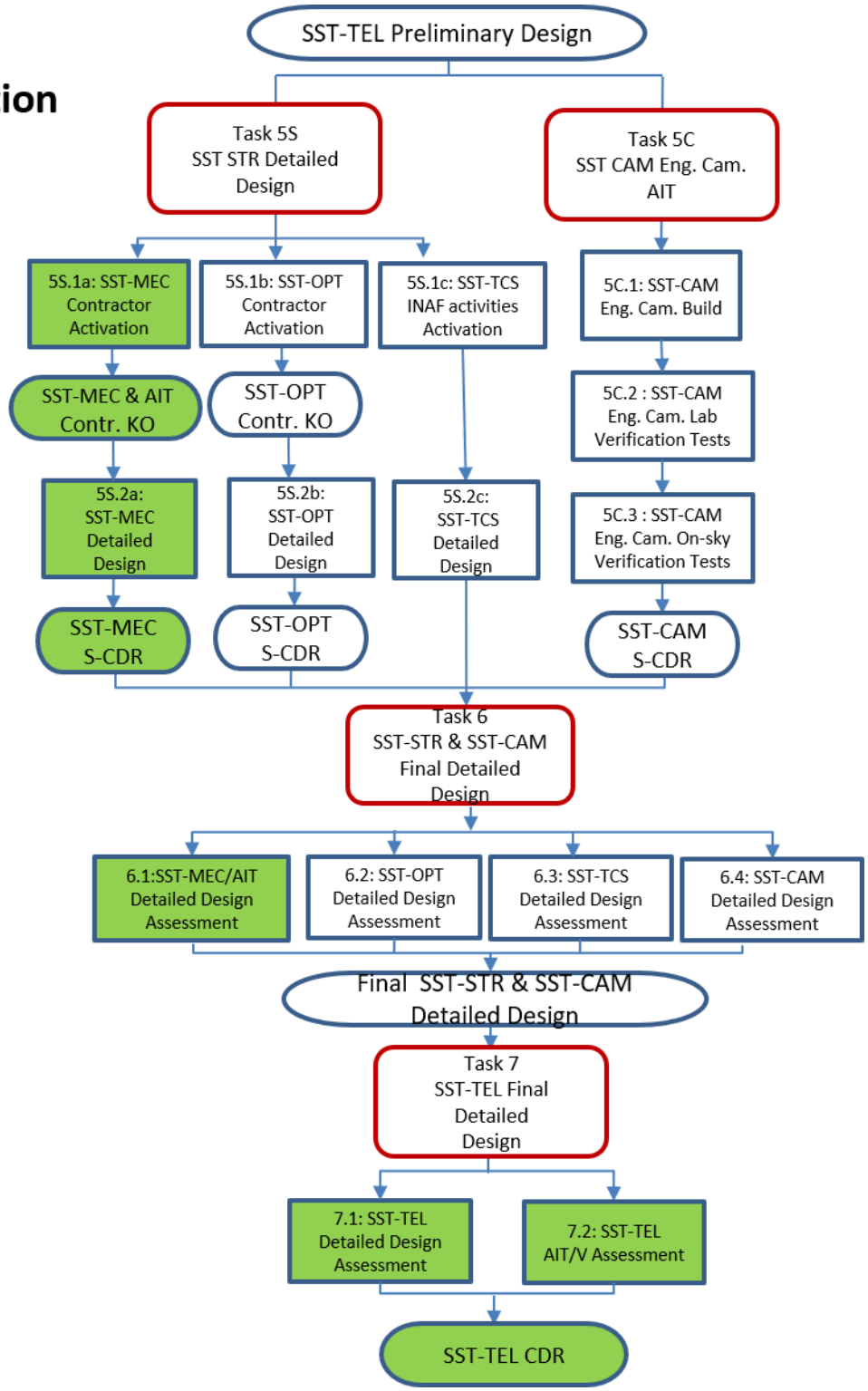

Figure 5-3: SST-PRO Design Consolidation Phase from KO to CDR flow-char. The green boxes involve the Contractor.

The following sections details the activities requested to the Contractor.

5.2.2.1 Task 5s.1a Contractor Activation (T0)

Input:

- Statement of Work (this document);
- SST Preliminary Design [AD5][AD2][RD14];
- Applicable Documents (par 1.3);
- Reference Documents (par 1.4), within the use and limits clarified within the SoW.

Description:

- the Contractor shall provide the documents requested for the Kick Off Meeting as reported in Annex 1;

Output:

- Documents reported in Annex 1.

5.2.2.2 Task 5s.2a SST-MEC Detailed Design (T0-T0+5)

Input:

- Statement of Work (this document);
- SST Preliminary Design [AD5][AD2][RD14];
- Applicable Documents (par 1.3);
- Reference Documents (par 1.4), within the use and limits clarified within the SoW.

Description:

- After the Contract Kick Off, the contractor shall start the management of the activities following the standard project management practice (i.e. scheduling and reporting, risk register, etc.);
- After the Contract Kick Off, the contractor shall consolidate the proposed design of the SST-MEC;
- If requested by INAF, the contractor shall perform all the tradeoff analysis to finalize the design. The contractor proposes to INAF the trade-offs list. The trade-offs are authorized by INAF after approval of the proposed tradeoffs;
- The contractor shall perform all the tradeoff analysis to support the integration procedures (i.e. SST-MEC and SST-CAM);
- **With Respect the SST-MEC preliminary design described in section 4, the Contractor shall perform at least the following tradeoff analysis:**

    - With reference to the Base Structure (sec. 4.1.1.1.1), the Contractor shall propose a design for the CTAO-SST Electrical, Networking, Timing and Safety Interface point to be installed inside the Base and for the cabling from this point to the Telescope Cabinets and the/or the other part of the Telescope. The design shall consider that the connection of the telescope to the CTAO electrical, networking and safety distribution system will be via cables passing through the foundation and entering in the telescope from the Base floor.
    - With reference to the Azimuth slewing Bearing (sec. 4.1.1.1.2), the contractor shall propose a design for the replacement of the azimuth axis main tape

encoder with a closed absolute encoder, having the same resolution, mounted directly on the azimuth axis. The design shall consider all possible changes induced by this deviation from the baseline design, on the Base and on the electrical and data cabling. Also, the impact on the Mount Control System shall be considered.

- With reference to the Mount (sec. 4.1.1), the Contractor shall study, design and build an automatized lubrication system for the maintenance of the mount subsystems as gears, bearings, and in general of all transmission elements of the telescope.
- With reference to the Elevation ball screw jack (sec.4.1.1.2.2), the Contractor shall study the optimization of the kinematics of the Elevation axis of the telescope. The Contractor shall perform a trade-off analysis regarding all aspects impacted by the axis kinematics, such as, but not limited to, the following:
  - Manufacturing complexity;
  - Assembly complexity;
  - Electrical power demand (peak and mean);
  - Elevation motor sizing;
  - Elevation screw jack sizing;
  - Transmission ratio constancy over the range 20-90°;
  - Control loop accuracy;
  - The output of the study shall be an optimized set of parameters for the Elevation axis kinematics, which respects all existing design constraints and improves the overall functionality and performance of the telescope.
- With Reference to the M2 Support Structure (sec. 4.1.2.5), the Contractor shall design and build the support plate for the flasher unit onto centre of M2 mirror [AD10].
- With reference to the Swing-Arm for intensity Interferometry Instrument positioning arm (sec. 4.1.2.6), the Contractor shall design and build the positioning arm including its control system (HW & SW) and electric, network control, safety and timing interfaces with SST-MEC Components. The specific information about the SI3 instrument that shall be mounted on the arm will be provided by INAF within 3 months from the KO.
- With reference to the Telescope Power Cabinet (sec. 4.1.3.1), the Contractor shall design and implement the CTAO – SST Telescope Electrical Power interface described in the applicable document [AD15].
- With reference to the Telescope Cabinets Conditioning System (sec. 4.1.3.3), the Contractor shall design and implement the Cabinet conditioning system.
- With reference to the Secondary Electrical Boxes (sec. 4.1.3.4), the Contractor shall design and implement the Cabinet conditioning system if needed.
- With reference to the CTAO - SST Services Connection Cabinet (sec. 4.1.3.5), the contractor shall design and provide all the components needed to implement the SST Telescope interface with the CTAO power, networking, timing, safety services on the basis of the dedicated Interface Control Document provided by CTAO.

- With reference to the Telescope networking devices (sec. 4.1.3.6), the Contractor shall design and provide all the components needed to implement the SST Telescope internal networking system.
- With reference to the Cabling (sec. 4.1.3.7), the Contractor shall design and provide all the components needed to implement the SST Telescope cabling system including the cabling of the system that are temporary mounted on the Telescope as the M1 Alignments actuators.
- With reference to the Protection System (sec. 4.1.4), the Contractor shall design and provide all the components needed to implement the SST Telescope Protection System including the implementation of its interface with the CTA IPS system on the basis of an Interface Control Documents that is, at this time, under consolidation by CTAO and will be provided by the SST Team when it will be released.
- With reference to the Pointing Monitoring Camera (sec. 4.1.5.1), the Contractor shall procure and realize the Mechanical, electrical and control parts of the Point Monitor Camera starting from the one realized for the ASTRI-Mini Array telescope described in [RD18], considering that the SQM device described in [RD18] will be not present in the SST Telescope, the PMC mechanical structure shall be consequently simplified. The PMC control and astrometric software will be provided by the SST Team.
- With reference to the Mirror Alignment System (sec. 4.1.5.2), The Contractor shall improve or propose a new design and realize the M1 Alignment system (HW and SW). The Control software shall run on the Telescope Control Unit in the Beckhoff TwinCAT3 environment. The EtherCAT fieldbus shall be used to connect the M1 segments motor controllers and absolute encodes to the TCU using the EtherCAT Fast Hot Connect technology.
- With reference to the Optical Camera (sec. 4.1.5.3), the Contractor shall integrate the Optical Camera (HW and SW) in the SST Telescope on the basis of Interface Control Documents. The Optical camera and its Control software will be provided by INAF to the Contractor.
- With reference to the Laser/Led optical verification system (sec. 4.1.5.4), the system shall be defined by INAF in collaboration with the Contractor during the Consolidation phase up to the CDR.
- With reference to the Azimuth Limits Switches (sec. 4.1.6.1.3), the Contractor shall consider a new arrangement for the Azimuth switches and for the Lyra in designing the new azimuth absolute encoder arrangement.
- With reference to the Elevation Actuators and Drivers (sec. 4.1.6.1.4), the Contractor shall study and propose a design considering the presence of a secondary motor on the elevation axis to be operated in case of fault of the primary motor. The design shall also consider the impact on cabling and on the Mount Control System.
- With reference to the Telescope Conditioning Monitor System (sec. 4.1.6.8), the Contractor shall also provide the Data Analysis software in order to define the predictive maintenance procedure based on the data collected by this subsystem.
- With reference to the Maintenance and AIT/V Tools (sec. 4.1.7), the Contractor shall design the tools (except the Camera Handling Tool) based on the final SST design and on the Maintenance procedures needed to maintain the SST performances compliant with the requirements.

  - With reference to the Camera Handling Tool (sec. 4.1.7.1), the Contractor shall perform all the tradeoff analysis in order to support the mounting/dismounting procedures of the SST-CAM.

- The Contractor shall perform all activities/analyses necessary to demonstrate that the design will meet all requirements;
- The Contractor shall perform at least the SST-MEC RAMS [AD24], FMECA [AD25], Structural and Thermal analysis;
- The Contractor shall perform Structural and Thermal analysis at SST-TEL level;
- The Contractor shall satisfy the recommendation #1, #2 and #6 reported in the Product Review Final Disposition [AD7] and [AD8];
- In the first part of the consolidation phase (<T0+3months), the Contractor shall identify the long lead items (>20 weeks);
- In agreement with INAF, the Contractor shall start - if needed - the procurement of the long lead items for the SST-MEC Qualification Model [AD1];
- The Contractor shall manage and consolidate the Internal interface between the SST-MEC and SST-CAM starting from [AD10];
- The Contractor shall manage and consolidate the Internal interface between the SST-MEC and SST-OPT starting from [AD18] and [AD19];
- The Contractor shall consolidate the Internal interface between the SST-MEC and SST-TCS managed by INAF. First Draft of the ICD will be provided for the Contractor KO by INAF;
- The Contractor shall consolidate the external interfaces between the SST-TEL and the CTAO infrastructure (i.e. power, data, timing, safety, foundation, etc.) in agreement with INAF and CTAO;
- The contractor shall be responsible of the SST-MEC AIT/V and SST-TEL AIT. During this phase, the contractor shall consolidate all the documents related to the SST-MEC AIT/V and SST-TEL AIT on factory (only for the first Telescope) and on site [RD10][RD11]. The contractor will be supported with the necessary documentation of the subsystems not under its responsibility (i.e. Camera/SW/Optics integration procedures, etc.);
- The Contractor shall support and work with INAF for the consolidation of the SST-TEL on site Verification Plan ([RD12], about scientific requirements and scientific performance);
- The Contractor shall provide the ADP for the S-CDR review as indicated in Annex 1;
- The Contractor shall go through the S-CDR review (see sec. 6.3 for details).

Output:

- This task will end with the S-CDR in which the Contractor shall provide the Acceptance Data Package reported in Annex 1. The ADP will then be evaluated by a panel of SST Consortium personnel.

5.2.2.3 Task 6.1 SST-MEC & AIT Detailed Design Assessment (T0+6-T0+7)

Input:

- S-CDR result and recommendations/actions;

Description:

- After the S-CDR, the contractor shall implement all the actions requested and update all the documentation;
- Start prototypes activity if necessary to prove subsystem design (i.e. M1 actuators, etc.).

Output:

- The contractor shall provide updated documents following the S-CDR result and recommendations/actions;
- The contractor shall perform all the analysis and simulations requested by the panel involved for the S-CDR (see sec. 6.3).

5.2.2.4 Task 7.1 SST-TEL Detailed Design Assessment (T0+7 - T0+9)

Input:

- S-CDR result and recommendations/actions.

Description:

- The Contractor shall work and coordinate with the Programme Office in order to consolidate the Telescope Design for the SST-TEL CDR;
- The Contractor shall provide the CDR - ADP for the review as indicate in Annex 1;
- The Contractor shall participate with an active role to the review.

Output:

- The Contractor shall provide all the documents at telescope level related to the activities requested in the Task 6.1. The list is reported in Annex 1.

5.2.2.5 Task 7.2 SST-TEL Onsite AIT-V Assessment (T0+7 - T0+9)

Input:

- S-CDR result and recommendations/actions.

Description:

- The contractor shall work and coordinate with the Programme Office in order to consolidate the Telescope On Factory and On-Site AIT/V plans for the SST-TEL CDR;
- The contractor shall provide the ADP for the review;
- The contractor shall participate with an active role to the SST-TEL CDR review.

Output:

- The contractor shall provide all the documents at telescope level needed for the SST-TEL CDR. The list is given in Annex 1. INAF will provide to the Contractor all documents and information necessary for the subsystems not under his responsibility (SST-OPT, SST-CAM and SST-TCS);
- This task will end with the TEL-CDR in which the Contractor shall provide the Acceptance Data Package reported in Annex 1. The ADP will then be evaluated by a review board appointed by CTAO and will consist of a combination of CTAO and non-CTAO participants. CTAO will act as the decision-making authority (see sec. 6.3.1.2).

5.2.3 Production Phase

In the **Production Phase** the SST-STR (including SST-MEC, SST-OPT and SST-TCS) and Cameras will be produced by the SST Partners and the Industrial Contractors and delivered to the CTA southern site following the plans developed and approved in the Design Consolidation Phase. The Production Phase begins with the first Camera and Structure. As indicated in section 4.1, the first model of the Telescope is considered the Qualification Model. It will be completely integrated and tested in the factory. Then, after a formal qualification process, it will be shipped on-site, where it will be integrated and fully tested again. It will be used on the factory to verify interfaces, functions, and performance, and the AIT/V process before moving it on-site.

The Contractor shall be responsible for the production of the SST-MECs, and their transportation on-site and integration.

The Contractor shall be responsible for the entire AIT/V process of the SST-MEC and SST-TEL as described hereafter.

The Contractor shall grant proper access to production facilities to INAF, to the SST consortium people and to CTAO personnel.

5.2.3.1 Telescope 1 - Qualification Model

The first Telescope, considered the ***Qualification Model***, is integrated and verified at the premises of the Contractor.

Figure 5-4 and Figure 5-5 report the work logic and activities flow of the first telescope, nominally called the Qualification Model, from the production until the verification onsite. ***The green boxes are the tasks and reviews in which the contractor is involved.***

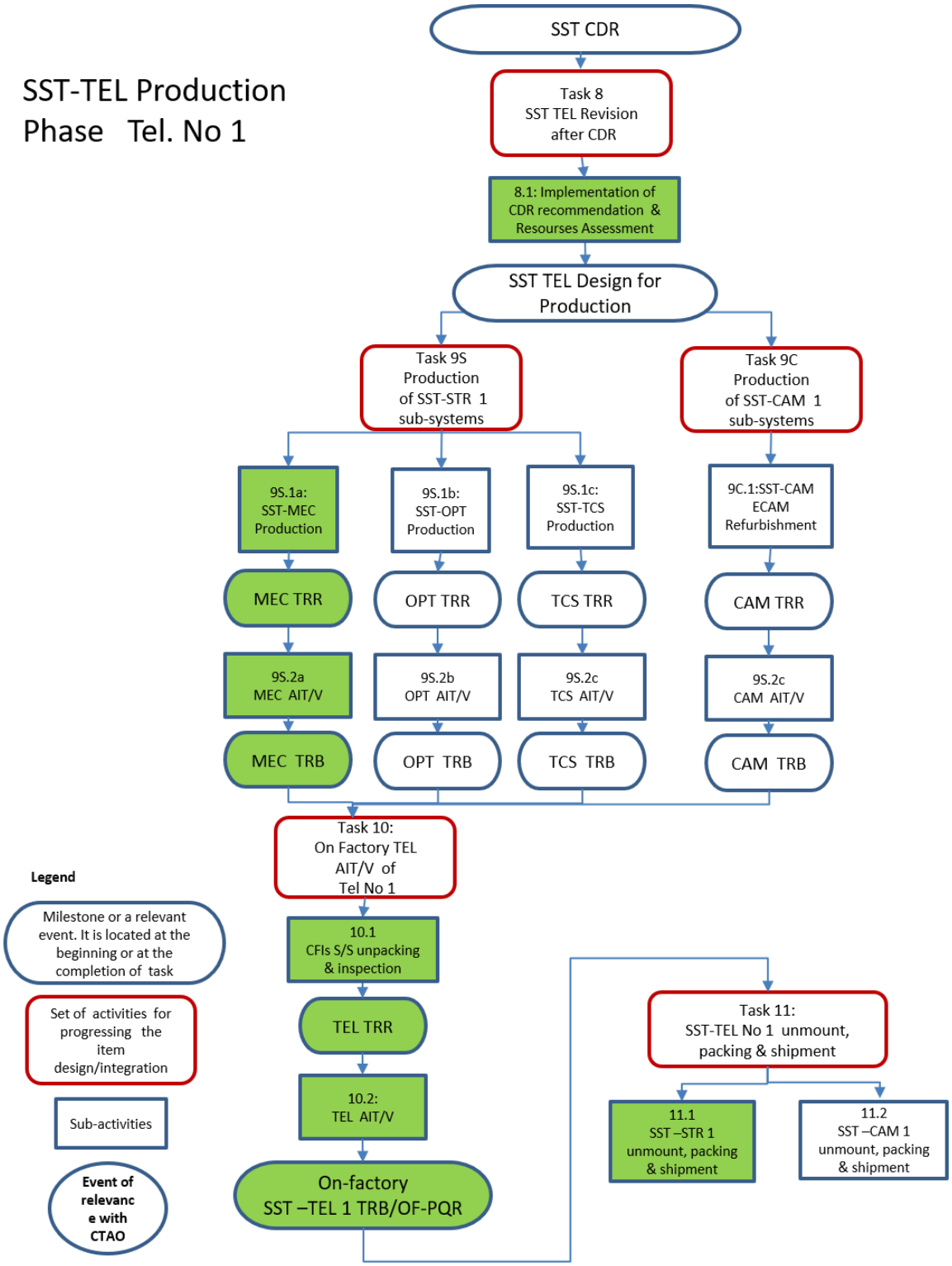

Figure 5-4 : SST-PRO TEL 1 Production and on factory AIT/V flow-chart

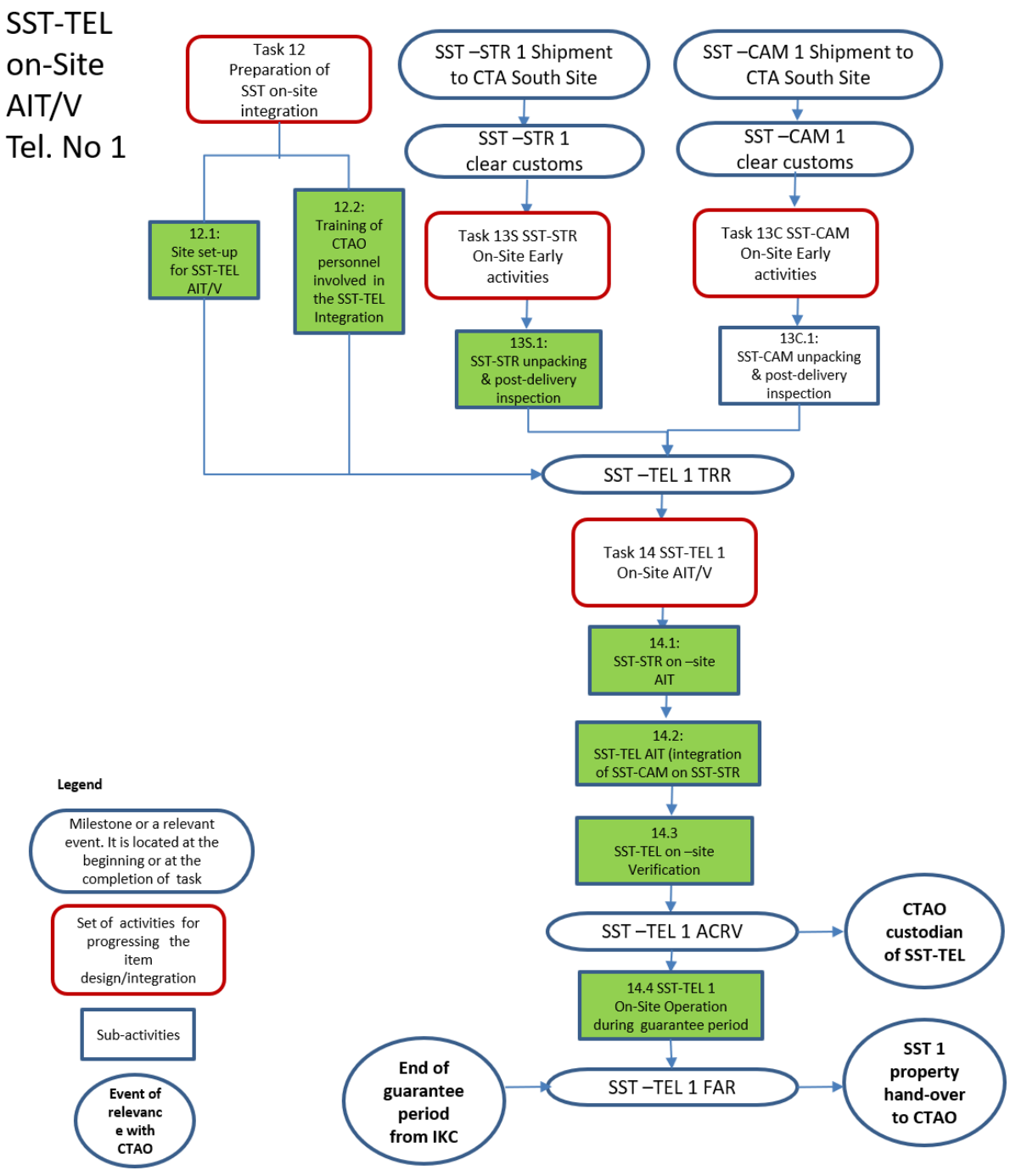

Figure 5-5: SST-PRO TEL 1 On site AIT/V

The following sections details the activities requested to the Contractor.

5.2.3.1.1 Task 8.1 Implementation of CDR recommendation and Resources Assessment (T0+9-T0+10)

Input:

- TEL-CDR result and recommendations/actions.

Description:

- After the Telescope CDR, the recommendation of the board shall be implemented, and the design updated coherently. The Contractor shall apply the recommendations related to the SST-MEC, Telescope AIT and all the documents under its responsibility;
- After the Telescope CDR, the contractor shall assess the resources needed to accomplish the production phase;
- After the Telescope CDR, the contractor shall assess all plans needed to accomplish with the production phase.
- The contractor shall provide all the documents updated following the TEL-CDR result and recommendations/actions to finalize the design for production;
- The contractor shall perform all the analysis and simulations requested by the review board involved for the TEL-CDR (see sec. 6.3 for more details) to finalize the design for the production.

Output:

- CDR ADP Updated.

5.2.3.1.2 Task 9S.1 SST-MEC Production (T0+10 - T0+11)

Input:

- Documents updated after the CDR.

Description:

- After the Design for production assessment (task 8.1), once the SST-TEL Design is assessed, the Contractor shall start the procurement of the parts, materials, support equipment's and tools in order to support the production to complete the procurement of the long lead items (see task 5S-2a);
- The contractor shall finalize all the set-up needed to produce the SST-MEC;
- The contractor shall procure and manufacture all SST-MEC parts, materials, auxiliary equipment and tools in order to produce 1 SST-MEC.

Output:

- 1 SST-MEC including parts, materials, support equipment's and tools ready for the AIT/V process;
- With reference to the Auxiliary Devices (par 4.1.5):
  - 1 Pointing Monitoring Camera;
  - 1 Mirror Alignment System;
  - 1 Laser/Led Optical Verification System.

- With reference to the Maintenance and AIT/V Tools (par 4.1.6):
  - All the tools, general facilities and vehicles needed to perform the AIT/V of the first Telescope On Factory and On-Site.

5.2.3.1.3 Task 9S.2 SST-MEC AIT/V (T0+11 - T0+13)

Input:

- Output of the task 9S.1.

Description:

- The Contractor shall assembly all the subsystem of the SST-MEC;
- The contractor shall integrate all the subsystem in order to compose the SST-MEC;
- The Contractor shall provide test plan and test procedures;
- The contractor shall test the SST-MEC;
- The contractor shall verify the SST-MEC requirements;
- The contractor shall organise and manage a TRR before the test activities and a TRB (see sec. 6.3 for TRR and TRB definition). after the end of verification. The decision authority for the reviews will be the contract provider.

Output:

- Test Results/Report/Procedures/plans and all documentation as indicated in Annex 1.
- SST-MEC integrated.

5.2.3.1.4 Task 10.1 CFIs Sub-systems unpacking and inspection (T0+13 - T0+14)

Input:

- SST-OPT (CFI);
- SST-CAM (CFI);
- SST-TCS (CFI);
- Optical Camera (CFI).

Description:

- The Contractor shall unpack and Inspect the Optics (CFI);
- The Contractor shall unpack and Inspect the Camera (CFI);
- The Contractor shall inspect the TCS Software (CFI);
- The Contractor shall unpack and Inspect the Optical Camera (CFI);

Output:

- Subsystems ready for integration;
- Formal Acceptance of the CFIs.

5.2.3.1.5 Task 10.2 On Factory TEL AIT/V of Tel No 1 (T0+14 - T0+16)

Input:

- The output of task 10.1

Description:

- The Contractor shall integrate and test the telescope at the factory to qualify it.
- The Contractor shall provide test plan and test procedures for the AIT/V process.
- The Contractor shall integrate SST-MEC and SST-OPT.
- The Contractor shall integrate SST-MEC and the PMC.
- The Contractor shall integrate SST-TCS with SST-MEC/SST-OPT to compose SST-STR.
- The contractor shall perform the alignment activities between SST-MEC and SST-OPT at the presence of the SST Consortium.
- The Contractor shall integrate SST-STR and SST-CAM to compose SST-TEL.
- The contractor shall verify the alignment performance of the SST-TEL, before the installation of the SST-CAM, using the Mirror Alignment System (sec. 4.1.5).
- The contractor shall test the SST-TEL with reference to the SST-MEC Functional and Performance requirements (i.e. movement of the SST-TEL using the SST-TCS).
- The contractor, operating the Telescope, shall support the verification of the SST-TEL requirements [AD4] performed by INAF;
- The contractor shall support the SST-TEL a TRR before the test activities and a TRB after the end of verification providing the documentation indicated in Annex 1. The making decision authority for the reviews will be CTAO and the provider of the contract. The TRB will be considered an On Factory Qualification Review and will authorize to start the production of the next SST-MECs (see sec. 6.3 for details about the reviews).

Output:

- Telescope fully tested.
- Test Results/Report and others documents as specified in Annex 1.

5.2.3.1.6 Task 11.1 SST-STR No 1 unmount, packing and shipment (T0+16 - T0+17)

Input:

- Output of the task 10.2.

Description:

- The contractor shall disassemble the telescope;
- The contractor shall unmount the SST-OPT (M1 & M2);
- The contractor shall unmount the SST-CAM;
- The contractor shall pack the subsystems;
- The contractor shall participate to the DRB (described in sec. 6.3);
- After DRB authorization, the Contractor shall ship the SST-MEC and SST-OPT including all the related AIT tools and Optical Camera to the CTAO Southern Site located in Chile.

Output:

- Test Results/Report and all the documents needed for the DRB as defined in Annex 1;
- SST subsystems tested at telescope level, packed and shipped.

5.2.3.1.7 Task 12.1 and Task 12.2 - Preparation of SST on-site integration (T0+17 - T0+18)

Input:

- Output of the task 8.1;
- Output of the task 10.2;
- Output of the DRB.

Description:

- The contractor shall set-up the site for the SST-TEL AIT/V;
- The contractor shall manage all the onsite safety responsibilities related to the SST-TEL AIT/V in liaison with the CTAO Safety Officer [AD21][AD22];
- The contractor shall train the CTAO personnel involved in the SST-TEL integration.

Output:

- Test Plan/Documents needed for the on-site SST-TEL 1 TRR as defined in Annex 1;
- SST on-site training.

5.2.3.1.8 Task 13s.1- On site early activities (T0+17 - T0+18)

Input:

- Output of the task 10.

Description:

- The contractor shall manage all the shipment and clear customs activities related to the SST-MEC and SST-OPT;
- The contractor shall manage all preliminaries activities related to SST-MEC and SST-OPT deliveries;
- The contractor shall manage all the incoming activities related to SST-MEC and SST-OPT deliveries;
- The contractor shall manage all the unpacking activities related to SST-MEC and SST-OPT deliveries;
- The contractor shall manage all the inspection activities related to SST-MEC and SST-OPT deliveries.

Output:

- SST-MEC and SST-OPT ready for the On-site integration.

5.2.3.1.9 Task 14.1, 14.2, 14.3 and 14.4 – SST-TEL 1 On –Site AIT/V (T0+18- T0+23)

Input:

- Output of the task 13s.1;
- SST-CAM (CFI) already unpacked, inspected and tested.

Description:

- The Contractor shall integrate and test the telescope on site;
- The Contractor shall provide test plan and test procedures for the on-site AIT/V process;
- The Contractor shall integrate SST-MEC and SST-OPT;
- The contractor shall verify the SST-MEC requirements;
- The Contractor shall verify the interfaces between SST-TCS and SST-MEC/SST-OPT at the presence of INAF;
- The contractor shall manage and perform the alignment activities between SST-MEC, SST-OPT and the Optical Camera at the presence of INAF. The SST Consortium will provide the scientific software to evaluate the alignment;
- The Contractor shall integrate SST-STR and SST-CAM to compose SST-TEL;
- The contractor shall verify the alignment performance of the SST-TEL, before the installation of the SST-CAM, using the Mirror Alignment System (sec. 4.1.5);
- The contractor shall test the SST-TEL with reference to the SST-MEC Functional and Performance requirements (i.e. movement of the SST-TEL using the SST-TCS);
- The contractor, operating the Telescope, shall support the verification of the SST-TEL requirements [AD4] performed by INAF;
- The contractor shall support the SST-TEL a O-TRR before the test activities and an O-TRB after the end of verification providing the documentation indicated in Annex 1. The making decision authority for the reviews will be CTAO and the provider of the contract.
- The Contractor shall support-perform all tasks needed for the ACRV process, including providing documentation as defined in Annex 1;
- After the ACRV, the contractor shall provide the necessary support during the warranty period.

Output:

- Telescope fully tested and verified;
- Test Results/Reports/documents as indicated in Annex 1.

5.2.3.2 Telescope 2 to n – Mass Production

Figure 5-6 reports the work logic and activities flow for the telescopes 2/n. ***The green boxes represent the task and reviews in which the contractor is involved.***

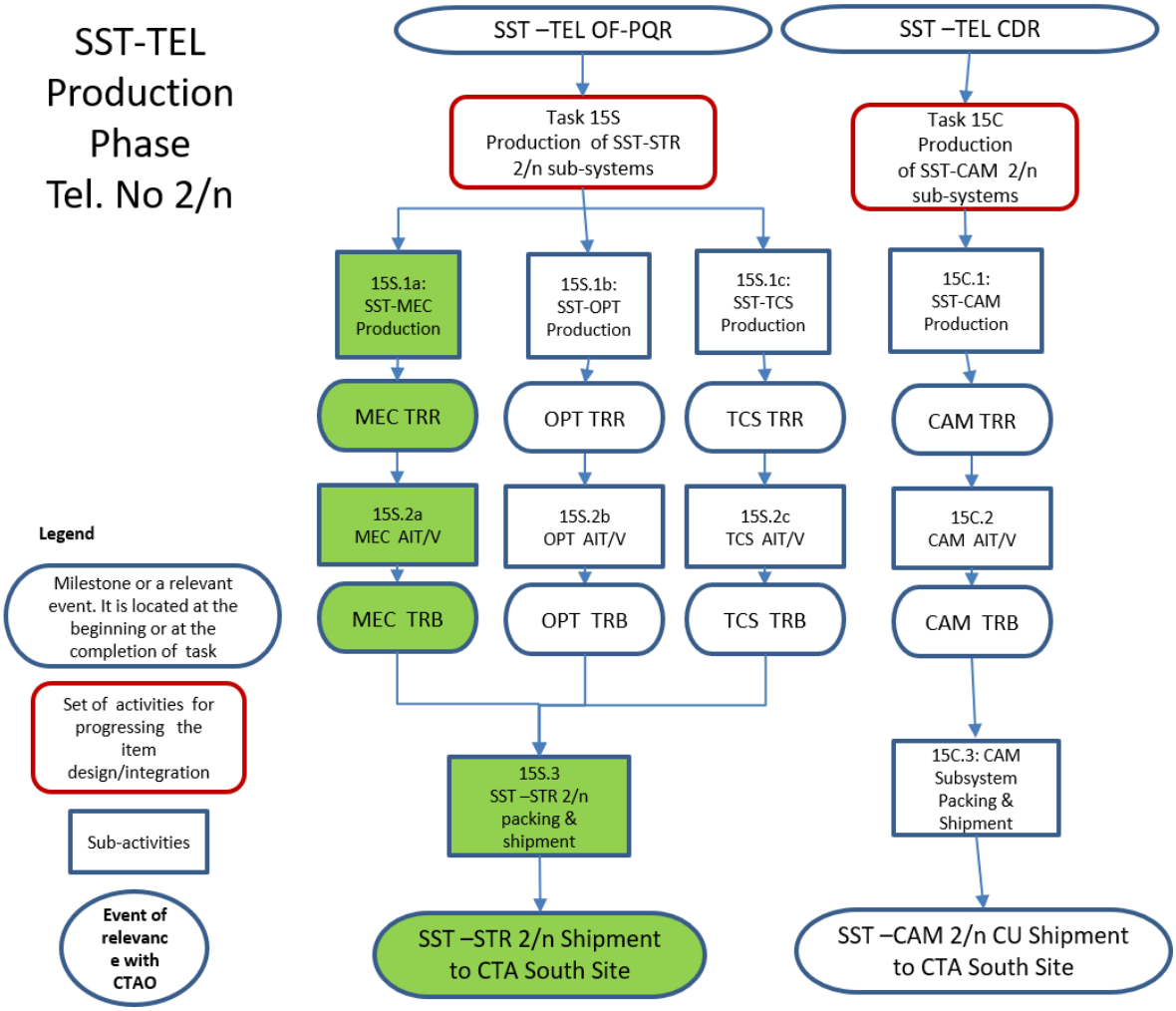

Figure 5-6 : SST-PRO TEL 2 to N Production

5.2.3.2.1 Task 15S.1 SST-MEC Production 2/n (T0+13- T0+35)

Input:

- Documents updated after the CDR;
- Results and documentation of task 11.1.

Description:

- The contractor shall start the procurement of the parts, material, support equipment's and tools in order to support the production to complete the procurement of the long lead items (see task 5S-2a);
- The Contractor shall procure and manufacture all SST-MEC parts, materials, auxiliary equipment and tools in order to produce 24 SST-MEC.

Output:

- 24 SST-MEC including parts, material, support equipment's and tools ready for the AIT/V process;
- SST-MEC Spare Parts as result of the RAMS analysis and maintenance plan;
- With reference to the Auxiliary Devices (par 4.1.5):
  - 24 Pointing Monitoring Camera;
  - 2 Mirror Alignment System;
  - 1 Laser/Led Optical Verification System.
- With reference to the Maintenance and AIT/V Tools (par 4.1.6):
  - All the tools, general facilities and vehicles needed to perform the AIT/V of at least two telescopes on site in parallel.

5.2.3.2.2 Task 15S.2 SST-MEC AIT/V 2/n (T0+13- T0+35)

Input:

- Output of the task 15S.1.

Description:

- The Contractor shall provide test plan and test procedures;
- The Contractor shall assembly all the subsystems of the SST-MEC;
- The Contractor shall test the SST-MEC subsystems;
- The Contractor shall integrate and test all the subsystems in order to compose the SST-MEC (at least the SST-MEC #2);
- The contractor shall organise and manage a TRR before the test activities and a TRB after the end of verification.

Output:

- Test Results/Report;
- SST-MEC integrated.

5.2.3.2.3 Task 15s.3 SST-STR packing and shipment 2/n (T0+17- T0+37)

Input:

- Output of the task 15S.2;
- SST-OPT (CFI).

Description:

- The contractor shall pack SST-MEC and SST-OPT;
- The contractor shall participate and support the DRB (described in sec. 6.3);
- The contractor shall ship the SST-MEC and SST-OPT including all the related AIT tools and Optical Camera to the CTAO Southern Site located in Chile.

Output:

- Test Results/Report and all the documents needed for the DRB as defined in annex 1;
- SST-MEC tested and Verified;
- Packing and Shipment.

5.2.4 On site AIT/V Phase

The AIT/V Phase will start with the first telescope (Qualification Model) as described in 6.2.3.1.

This section applies to the AIT/V of the Telescope 2 and following.

During the **AIT/V Phase** of the programme, Structures and Cameras are received on site, installed, integrated, commissioned and handed over to CTAO following the plans developed and approved in the Design Consolidation Phase. The AIV Phase begins in anticipation of receipt of the first Camera, Optics and Structure with on-site preparation (task 12.1 and task 12.2).

Due to the large number of units, Telescope Production and AIV will run in parallel. AIV phase will end with the acceptance of the final SST by CTAO and the removal of any temporary equipment and personnel on-site.

The SST Programme will take an incremental approach for the acceptance as indicated by CTAO [AD23] in:

- **Step 1 Pre-Shipment Provisional Acceptance (DRB):** Done at the sub-system level prior to shipment to CTAO Southern Site. Repeated for every unit, or batch of units shipped.
- **Step 2 On-site Provisional Acceptance (ACRV):** Done for every SST, or batch of SSTs, following onsite AIV.
- **Step 3 On-site Final Acceptance (FAR):** Done once the warranty period has expired and when all obligations of the provider have been fulfilled. It can be done in a single stage, or in a multiple-stage program (e.g., per SST or batch, as the warranty expires).

The Contractor shall be responsible for the entire AIT/V process of the SST-MEC and SST-TEL.

The Contractor shall be responsible for all the safety aspect during the AIT/V phase.

The Contractor shall appoint an On-Site AIT Coordinator who shall be responsible for the coordination of the SST-TEL AIT/V phase activities.

The Contractor shall appoint an On-Site Safety Manager who shall be responsible for all safety aspects during SST-TEL AIT/V phase. The On-Site Safety Manager shall be a separate person from the On-Site AIT Coordinator.

The Contractor shall refer to the CTAO rules for the operations on site [AD21] and safety [AD22].

The schedule assumes that the CTAO South site will be available for AIT/V activities from June 2025. In the event of a delay, the Contractor shall be able to store the first 5 SST-STR, to continue the production and to reschedule the AIT/V activities later accordingly and in agreement with the site availability.

The contractor shall have to provide all the necessary facilities during the integration and testing phase (e.g. toilets, changing rooms, any containers to be used as control rooms, etc.) taking into account what CTAO will provide to the IKCs and its contractors [RD24].

Besides its own personnel, the contractor must provide access to these facilities also to the INAF personnel, bearing in mind that we estimate a team of INAF staff of up to 6 persons that may be present at the same time.

Contractor shall grant proper access to the AIT/V facilities to the SST consortium people and to CTAO personnel as requested by INAF. CTAO personnel will have no authority to supervise contractor activities on site, except for safety aspects as documented in [AD22].

The Figure 5-7 reports the activities that will be carried out during this phase. ***The green boxes represent the task and reviews in which the contractor is involved.***

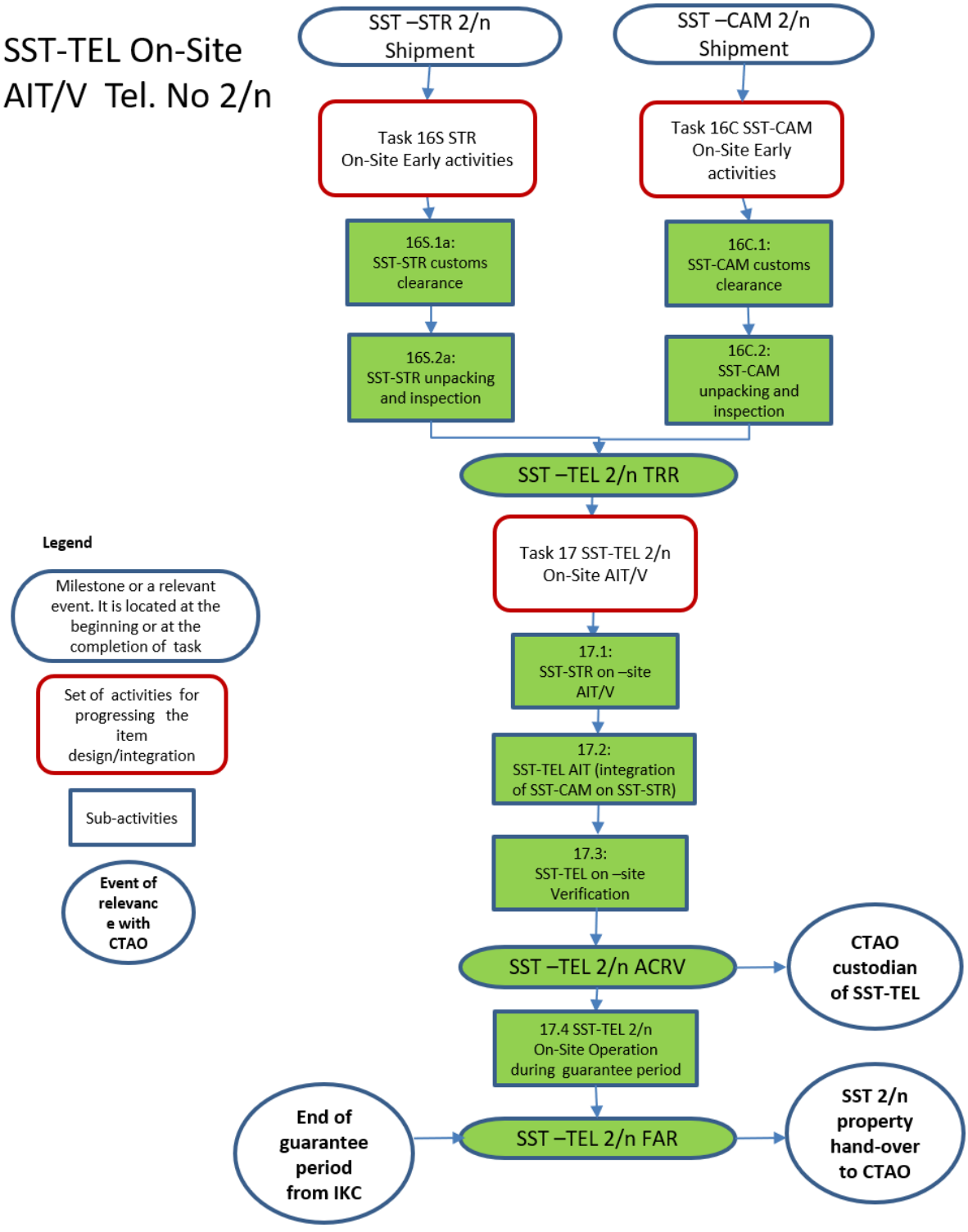

Figure 5-7: SST-PRO TEL 2/n Production Phase flow-chart

The following sections details the activities requested to the Contractor.

5.2.4.1.1 Task 16s.1 – SST-STR 2/n Custom Clearance (T0+17 - T0+37)

Input:

- Output of the task 15S.3

Description:

- The contractor shall manage all the shipment delivery and clear customs activities related to the SST-MEC and SST-OPT;

Output:

- SST-MEC and SST-OPT cleared

5.2.4.1.2 Task 16s.2 – SST-STR 2/n Unpacking and Inspection (T0+17 - T0+37)

Input:

- Output of the task 16S.1

Description:

- The contractor shall manage all the incoming activities related to SST-MEC and SST-OPT deliveries;
- The contractor shall manage all the unpacking activities related to SST-MEC and SST-OPT deliveries;
- The contractor shall manage all the inspection activities related to SST-MEC and SST-OPT deliveries.

Output:

- SST-MEC and SST-OPT ready for the On-site integration

5.2.4.1.3 Task 17.1, 17.2, 17.3 and 17.4 – SST-TEL 2/n On Site AIT/V (T0+24 - T0+44)

Input:

- Output of the task 13s.1
- SST-CAM (CFI) already unpacked, inspected and tested

Description:

The Contractor shall integrate and test the telescope on site

- The Contractor shall provide test plan and test procedures for the on-site AIT/V process
- The Contractor shall integrate SST-MEC and SST-OPT
- The Contractor shall verify the SST-MEC requirements;
- The Contractor shall integrate SST-TCS with SST-MEC/SST-OPT to compose SST-STR
- The contractor shall perform the alignment activities between SST-MEC and SST-OPT;
- The Contractor shall integrate SST-STR and SST-CAM to compose SST-TEL
- The contractor shall verify the alignment performance of the SST-TEL, before the installation of the SST-CAM, using the Mirror Alignment System (sec. 4.1.5).
- The contractor shall test the SST-TEL with reference to the SST-MEC Functional and Performance requirements (i.e. movement of the SST-TEL using the SST-TCS).
- The contractor, operating the Telescope, shall support the verification of the SST-TEL requirements [AD4] performed by INAF;
- The contractor shall support the SST-TEL a TRR before the test activities and a TRB after the end of verification providing the documentation indicated in Annex 1. The decision-making authority for the reviews will be CTAO and the contract provider.
- The contractor shall participate in and support the ACVR process

Output:

- Telescope fully tested and verified
- Test Results/Reports and all the documents list given in Annex 1

6. SST CONSORTIUM AND CONTRACTOR ORGANISATION

The SST Consortium Organisation is fully described in [AD6] as well all the internal interfaces and external interfaces with CTAO.

The work breakdown structure of the SST project is reported in Figure 6-1.

Figure 6-1 SST Work Breakdown Structure

The SST Programme Office (ID 1000) manages all the SST Project. The SST Structure (ID 2000) controls and manages the realization of all the activities related to the SST-MEC (ID 3000), SST-OPT (ID 4000) and SST-TCS (ID 5000).

6.1 Contractor Organisation

The organization of the contractor activities (SST-MEC ID 3000) as reported in the Figure 6-1 has to be considered as an indication.

The Contractor shall be responsible to explicitly identify the project organization providing at least the followings figures with the described expertise:

a. Project Manager: the Contractor shall assign an experienced professional Project Manager to manage the Work throughout all Phases of the Work (see section 5). The Project Manager shall have authority to control the Work to meet technical, cost, and schedule requirements.

The Project Manager shall be the principal point of contact with INAF for all managerial and contractual matters.

b. System Engineer: the Contractor shall identify a professional engineer with extensive experience in the design of highly complex systems. The System Engineer will be responsible for overseeing the development of the technical design, relative technical documentation and its up-to-date configuration and will ensure compliance with the technical requirements and interfaces. The System Engineer shall be the principal point of contact with INAF for all technical matters.
c. Contract Manager: the Contractor shall identify a Contract Manager who works as Authority to make contract changes, approve change orders and amendments in agreement with Project management.
d. Safety Manager: The Contractor shall appoint a Safety Manager who shall be responsible for the Contractor's Safety Plan, and for overseeing all safety aspects of the SST during the various phases, with particular emphasis on the AIT/V phase.
e. Product Assurance Manager: The Contractor shall identify a Product Assurance Manager who has the responsibility for the Contractor's Product Assurance Plan, and for overseeing all quality and product assurance aspects and documents of the SST. The PA Manager shall be the principal point of contact with INAF for all PA and quality matters.
f. AIT Manager: The Contractor shall assign an AIT Manager in charge of developing the activities and the documentation relative to Assembly Inspection and Test activities.
g. On-Site AIT Coordinator: The Contractor shall assign an On-Site AIT Coordinator in charge to coordinate the Telescope AIT activities on-site.
h. On-Site Safety Manager: The Contractor shall appoint an On-Site Safety Manager who shall be responsible for all safety aspects of the SST during the AIT/V phase. The On-Site Safety Manager shall be the main point of contact for all safety matters during the AIT/V phase. The On-Site Safety Manager shall be a separate person from the On-Site AIT Coordinator.
i. Project Control Manager: in charge of keeping configuration of product and associated requirements, including documents, drawings, models, databases, hardware, software, and support equipment.
j. Engineering disciplines key personnel: The Contractor shall provide the key personnel in charge for SST (i.e. Structure, Mechanisms, Electrical systems, Plant systems, Motion control systems, SW, RAMS).

6.2 Meetings

The Contractor shall perform the following reporting and reviews throughout the duration of this effort. Where designs or other information are proprietary, all INAF and SST Contractor participants will execute non-disclosure agreements with the Contractor as required to support information transfer. Each review requires delivery of both a written report and an actual presentation (in English).

6.2.1 Weekly meetings

The Contractor shall provide informal progress updates to INAF at least weekly via telephone or call conference. Formal presentations of overall program status are not required, but the Contractor shall be prepared to discuss schedule status, technical issues, critical risks and resolutions, and manpower.

The objective of these updates is to keep INAF informed of progress and problems and to enable interactive efforts toward arriving at effective engineering designs and issue resolutions.

In summary:

- The Contractor shall organize the meeting
- Normally held remotely.
- The Contractor shall send the agenda 2 days in advance.
- The Contractor shall produce presentations if deemed necessary.
- The Contractor shall manage, discuss, collect and share the action Item status.
- The Contractor shall prepare the minutes.
- Minutes shall be agreed and signed at the end of the meeting.

6.2.2 Monthly meetings

During the development of the entire work, the Contractor shall organize formal progress updates which shall take place normally at Contractor's premises unless INAF decides differently. During the production phase, these meetings may be held where the parts are in fabrication to allow direct inspection.

In summary:

- Normally held at Contractor's facilities every month (unless otherwise requested by the Customer).
- The Contractor shall send Agenda 5 working days in advance.
- The Contractor shall produce presentations and present the content of the Monthly Progress Report.
- The Contractor shall manage, discuss, collect and share the action Item status.
- The Contractor shall prepare the minutes.
- Minutes shall be agreed and signed at the end of meeting.

6.3 *Reviews, KOs meeting and decision points*

In this section the main SST Programme event are presented, consisting of reviews, meetings and decision points that form the boundaries between programme phases.

The SST Programme events is summarized in Figure 6-2 and detailed below.

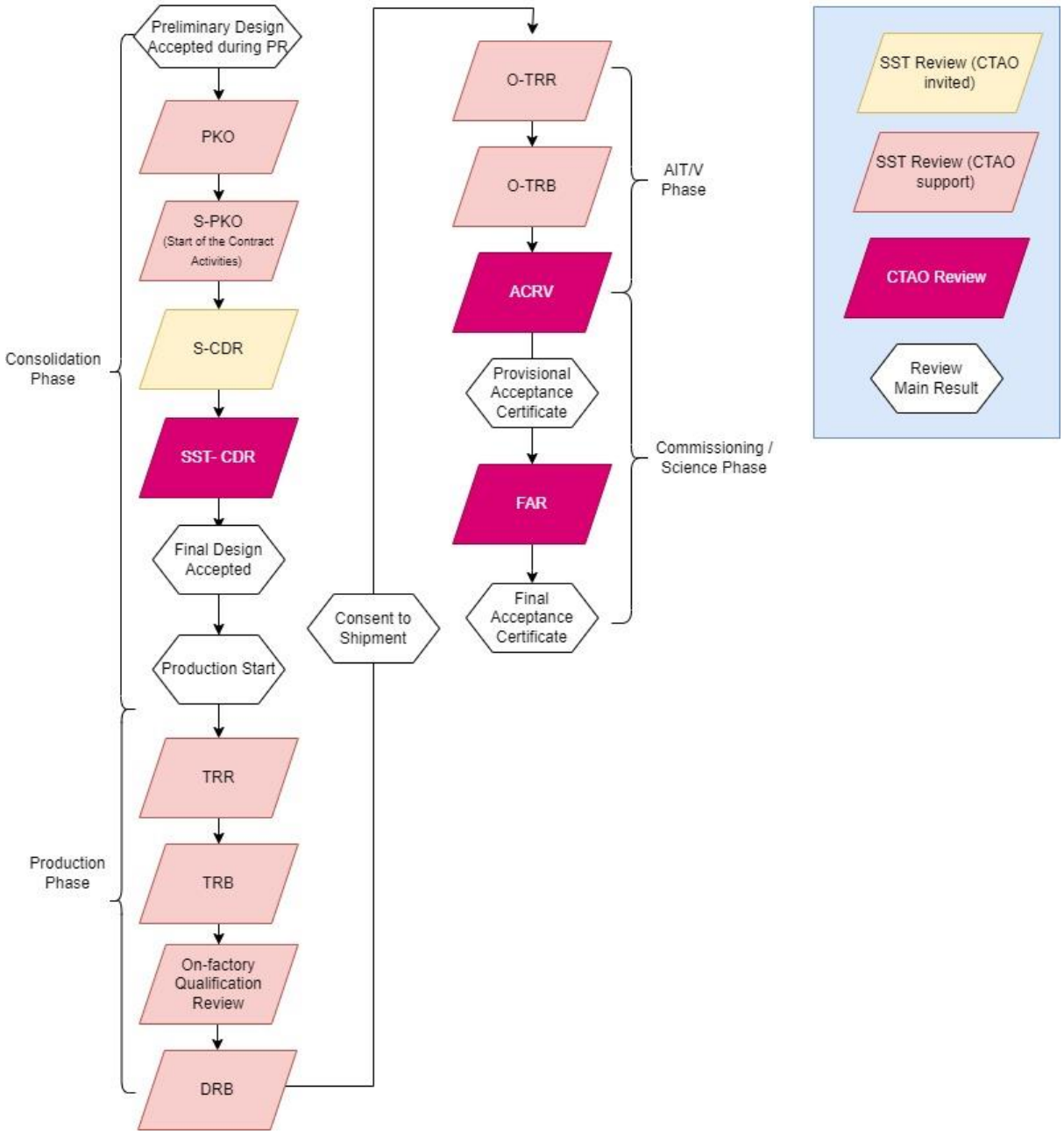

Figure 6-2: SST Events flow-down

Each Review is accompanied by a documentation / data pack.

A summary of the Reviews and Main Meeting is provided in Table 6-1.

The reviews and meetings in which the Contractor is involved are highlighted in green.

Table 6-1 - Summary of SST Programme Events

Event		Type	Participants	Frequency	Note
Bridging Phase					
BKO	Bridging Phase Kick-Off	Kick-Off	CTAO, SST-PRO, SST-STR & CAM	Once	- Closed
PR	Product Review	Review	CTAO, SST-PRO, SST-STR & CAM	Once	- Closed
Design-Consolidation					
PKO	Programme Kick-Off	Kick-Off	CTAO, SST-PRO, SST-STR & CAM	Once	- Closed
S-PKO	Sub-system KO	Kick-Offs	SST-PRO, SST-Subsystem, Industrial Partners *(as applicable)*	Once	T0 Contract (expected in January 2024)
S-CDR	Sub-System Critical Design Reviews	Review	CTAO, SST-PRO, SST-Subsystem Industrial Partners *(as applicable)*	Once	T0+6 months
CDR	Critical Design Review	Review	CTAO, SST-PRO, SST-STR & CAM	Once	T0+9 months
Series-Production Phase					
TRR	Test Readiness Review	Review	CTAO, SST-PRO, SST-STR, SST-CAM	Once (*delta* if procedures change)	T0+14 months
TRB	Test Review board	Review	CTAO, SST-PRO, SST-STR, SST-CAM	Per item tested	T0+17 months
OF-PQR	On Factory Production Qualification review	Review	SST-PRO, SST-STR, SST-CAM, CTAO	Once	T0+17 months
DRB	Delivery Review Board	Review	CTAO, SST-PRO, SST-STR, SST-CAM Industrial Partners *(as applicable)*	Per batch shipped	T0+18 months
On-Site AIV Phase					
O-TRR	Onsite Test Readiness Review	Review	CTAO, SST-PRO, SST-STR, SST-CAM Industrial Partners *(as applicable)*	Once (*delta* if procedures change)	T0+20 months
O-TRB	Onsite Test Review Board	Review	CTAO, SST-PRO, SST-STR, SST-CAM Industrial Partners *(as applicable)*	Per item tested (*delta* if NCRs occur)	T0+23 months
ACRV	Provisional Acceptance Review	Review	CTAO, SST-PRO, SST-STR, SST-CAM Industrial Partners *(as applicable)*	Per batch verified	T0+25 months (First Telescope)
FAR	Final Acceptance Review	Review	CTAO, SST-PRO, SST-STR, SST-CAM	Once (or per batch as warranty expires)	

6.3.1 Consolidation Phase

6.3.1.1 Programme (& Sub-System) Kick-Offs (PKOs)

The PKO event indicates the formal start of the Design Consolidation Phase and was successfully held on June 7, 2023. The main input for this phase is the preliminary design approved during the Product Review [AD7][AD8].

It was attended by representatives of the SST Programme, all SST Projects and CTAO. The SST team presented the project status, the product review results, the consolidation of the WBS and PBS, the updated schedule and the documents plan.

The S-PKO formally authorises the start of work by industrial contractor.

The S-PKO shall be organised by the INAF with participation of the industrial contractor.

6.3.1.2 SST (& Sub-System) Critical Design Reviews (CDRs)

The SST CDR will be organised jointly by the SST Programme and CTAO. The review is external to the SST Programme, in that CTAO will act as the decision-making authority and appoint the review panel, which will consist of a combination of CTAO and non-CTAO participants. The CDR will assess if the proposed SST design, and interfaces to CTAO, have been sufficiently verified and are fit-for-purpose for use in the observatory. All design documentation will be submitted, along with preliminary series-production plans. Passing the CDR indicates acceptance of the SST design by CTAO. Following the CDR, the SST design will be under CTAO configuration control.

The SST CDR may be preceded by internal (to the SST Programme) sub-system CDRs (S-CDRs) as appropriate. Each S-CDR would be organised by the SST Programme Office. S-CDRs would take place on draft documentation to then be revised, as needed, and submitted to the SST CDR.

The SST-MEC Contractor shall go through the S-CDR review managed by INAF.

The SST-MEC ADP, as resulted of the SST-MEC S-CDR, shall go through the SST CDR managed by CTAO.

6.3.2 Production Phase

6.3.2.1 Test Readiness Review (TRR)

A TRR shall be held before the start of the test activity to verify that all conditions allow to proceed with the test. A TRR is an operative review, generally held by a teleconference, with complete focus on pre-shipment test plans and procedures. The objective of this review is to declare the readiness for the test authorising the start of the test.

The TRR(s) may be done singularly for the SST (i.e. for the first integrated telescope on factory), and/or separately for any sub-system (e.g., STR, CAM, OPT, MEC) as appropriate (i.e., depending on timeframe and industrial contracts).

The TRR(s) will be done once, prior to the testing the first produced item under test (i.e. before the AIT/V of the first camera). Following any changes to the test plans / procedures a delta TRR may be needed before further tests are performed.

The TRR will be composed by System Engineers, AIV Managers, Quality Control Responsible and CTAO representatives.

Once the TRR has been successfully completed, it is possible to proceed with the tests.

The Contractor, for the first Telescope integrated on Factory, shall organise and manage a TRR before the test activities. The making decision authority for the reviews will be INAF and CTAO.

6.3.2.2 Test Review Board (TRB) – Production Phase

A TRB shall be held to review all results and conclude on the test completeness and achievement of objectives. A TRB is an operative review, generally held by a teleconference, with complete focus on test results and NCRs. In case of NCRs, further testing and a delta-TRB may be needed.

The TRB will be composed by System Engineers, AIV Managers, Quality Control Responsible and CTAO representatives.

Once the TRB has been declared successfully completed, it is possible to proceed with the delivery review board.

The Contractor, for the first Telescope integrated on Factory, shall organise and manage a TRB after the end of verification. The making decision authority for the reviews will be INAF and CTAO.

6.3.2.2.1 On-factory Production Qualification Review

The first Telescope, considered the Qualification Model, is integrated and verified in the premises of the factory responsible for the AIT. After this qualification SST-TEL#1 is dismounted and ready for delivery to South site. The On-factory Production Qualification Review is an internal review organised by SST Programme with the CTAO support. The success of the OF-PQR authorizes the Contractor to start the mass production of the SST-MEC.

The TRB will be considered as On Factory Qualification Review.

6.3.2.3 Delivery Review Board (DRB) – Production Phase

Following completion of a successful TRB (or on-factory QR), a given sub-system will undergo the DRB. A DRB will then be organised to assess the test results and authorise a sub-system for

shipment to CTAO South Site. The DRB then forms the first step in the CTAO Provisional Acceptance process.

Unlike the TRR, the DRB will be repeated for each unit (or batch of units) shipped to CTAO south Site. The review is fairly light-weight consisting of remote review of documentation. *The DRB(s) will be organized by the SST Programme Office with formal participation of CTAO-PO members and industrial partners (as appropriate).*

The Contractor shall contribute to the DRB process providing the documents list given in Annex 1. The Contractor is in charge for the Shipment after DRB approval.

6.3.3 Onsite AIT/V Phase

6.3.3.1 Onsite Test Readiness Review (O-TRR)

A second test readiness step is needed to accompany the incremental acceptance approach adopted by the SST Programme. The objective of the O-TRR is to ensure that AIT/V plans, procedures and related facilities are fit to assemble and test the first SST, and that all required items have been delivered and are available onsite. The O-TRR is done once and covers all SST subsystems. If necessary, the O-TRR may be split into two parts: done prior to the build of the first SST, and then iterated prior to the final verification testing of the first SST (this may be needed if, for example, verification test procedures change due to lessons-learnt in commissioning the first SST). If any changes to the AIT/V procedures are made during SST production, a delta-O-TRR will be performed. The O-TRR will be organized by the SST Programme with formal participation of CTAO-PO members and industrial partners (as appropriate). Authorisation to start on-site AIT/V will come from the the CTAO Director (or be delegated appropriately).

The Contractor, for the first Telescope integrated On-Site, shall participate to the O-TRR before the test activities. The making decision authority for the reviews will be INAF and CTAO.

6.3.3.2 Onsite Test Review Board (O-TRB) – Production Phase

The O-TRB shall be held to review all results and conclude on the test completeness and achievement of objectives. A TRB is an operative review with complete focus on test results and NCRs. In case of NCRs, further testing and a delta-TRB may be needed.

The O-TRB will be organized by the SST Programme with formal participation of CTAO-PO members and industrial partners (as appropriate).

Once the TRB has been declared successfully completed, it is possible to proceed with the Provisional Acceptance Review.

The Contractor shall participate to the TRB after the end of the verification phase. The making decision authority for the reviews will be INAF and CTAO.

Successful completion of the review represents formal acceptance of the telescope by INAF.

6.3.3.3 Provisional Acceptance Review (ACRV)

An ACRV will be performed for every SST, or batch of SSTs, delivered to CTAO. Successful completion of the ACRV for a given SST will result in *Provisional Acceptance* of that deliverable by CTAO. *Provisional Acceptance* is the formal recognition by CTAO that the INAF deliverable item subject to the acceptance process is compliant with the relevant requirements and interface specifications, and with safety regulations (if applicable).

If no major issues have been identified during the ACRV, "Provisional Acceptance" of a deliverable can be granted to INAF by the CTAO Director. This implies that equipment, or a software application, can be used, operated and/or integrated into the system at the target site, and responsibilities related to safety (if applicable), operations, and maintenance (except warranty work) are transferred from the supplier to the CTAO, and the warranty period would begin.

If during the Acceptance Review a set of remedial actions is identified that needs further attention, and if the acceptance team considers that none of these issues blocks the safe use of the deliverable, "Provisional Acceptance with Reservations" could be recommended, i.e., provisional acceptance would be conditional on resolving first the pending action items. In this case integration activities and/or use of the deliverable could proceed, but a Provisional Acceptance Certificate should not yet be issued. Once all remedial work is completed the reservations can be removed.

The Contractor shall contribute to the ACRV process providing the documents list given in Annex 1.

The ACRV activates the guarantee period provided by the contractor to INAF.

6.3.3.4 Final Acceptance Review (FAR)

Once the warranty period for an SST has expired and when all obligations of the SST IKC have been fulfilled, including the implementation of remedial actions as well as responses to warranty claims made during the warranty period, the FAR can take place and "Final Acceptance" can be granted by the CTAO Director. A corresponding "Final Acceptance Certificate" is then issued by CTAO and signed. The FAR may be done once for all SSTs, or in stages as the warranty of each delivered batch expires.

The contractor shall contribute to the FAR process providing the documents list given in Annex 1.

6.3.4 Review process

The Contractor shall host specific meetings and reviews throughout the duration of this effort as described below and identified by the Contractor in their Project Plan. These meetings shall provide to INAF the ability to review and approve Contractor plans and results to ensure work compliance and to enable payment. Where necessary, INAF will provide written approval of the completion of activities for payment.

Specific requirements for Milestone completion, payment application, and purchaser review are provided in the contract document. The Contractor is encouraged to integrate multiple topics (where plausible) to minimize the number of in-person meetings.

In summary:

- All Review dates shall be decided at KOM (possible date changes will be discussed at each Review).
- Minutes shall be agreed and signed at the end of the meeting.
- Review process:
  - The Contractor shall send the review documents 2 weeks in advance with respect to the meeting date.
  - INAF will send RIXs 1 week in advance with respect to the meeting date.
  - The Contractor shall send the agenda 1 day after receiving the RIXs.
  - The Contractor shall send presentations to address agenda topics 1 day in advance with respect to review meeting dates.
  - Conduct the review meeting as agreed at KOM (with minute signed at the end).
  - After review meeting, all open points shall be closed by the Contractor within 2 weeks, unless otherwise specified and mutually agreed.
  - INAF will send the milestone closure through an official note.

6.4 Documentation

6.4.1 Configuration and Data Management

The contractor shall establish and maintain a Configuration and Data Management (CADM) plan in agreement with [AD11].

The CADM program, applied during the different project phases, includes rules and procedures for:

- Identification revision and control of the Project documentation
- Systematic management of Project data and control of documents distribution and delivery
- Progressive review and release of all drawings and Project documentation in accordance with the Project Requirements and established baseline
- Change control and processing of the change documentation
- Maintenance, throughout the Project life cycle, of the configuration status accounting for each Configuration Item and all configured parts.
- Support for document preparation, identification and control
- Data and document receipt and registration
- Data maintenance, storage, retrieval distribution and exchange.

The CADM includes procedures and standards for:

- Classification of documents
- Document numbering and identification
- Document approval

- Document format

6.4.2 Document Management

6.4.2.1 Document Delivery List

Document delivery list identifying documentation agreed with each SST partner is reported in Annex 1.

Any addition, deletion or revision of the Document Delivery List shall be agreed with INAF.

6.4.2.2 Document Control, Distribution and Retrieval

All controlled documents will be subject to the configuration management requirements as defined in [AD11].

INAF reserves the right to distribute the documentation to their consultant and CTAO as deemed necessary for the proper follow-up of the contract.

INAF will prepare project documentation to an agreed standard format and structure.

INAF will inform any recipient in a timely manner of the existence of any document needed during project execution.

6.5 Schedule

6.5.1 Schedule Technique

The Contractor shall report the main activities and milestones. A coherent set of schedule techniques will be used to allow easy transferring and integration of schedule files in the overall project bar chart and ensure common control, analysis methodology and reporting.

The Precedence Diagram Method (PDM) will be used for all networks.

The project schedule breakdown is organized into hierarchical level:

- Master/summary schedule
- Major constituent schedule (link to PBS/WBS)
- Detailed schedule

Activity numbers will not be reused in the event of deletion or change to the description or nature of an activity.

The same time units will be used for all schedules and the same schedule status date is used for all Detailed Schedules to be integrated into a Master Schedule.

The common set of calendars will be used for all schedules and they will consider all periods where activities cannot take place.

The rules applied to build the project network are:

- Proper logic and sequences of activities
- Coherent set of scheduling techniques at all levels of the SST Consortium
- Coherence between network activities and WBS tasks
- Program key events used as schedule milestones
- Representation of critical path

6.5.2 Schedule reporting

The SST-MEC Contractor schedule status is reported to INAF on a regular basis.

Updated schedule documentation will be included in the progress report and complemented by the following information:

- Updated Milestones List
- Activity progress status based on the bar charts, showing
  - activities status progress with actual dates of starting and completion and, in case of shifting, new date of completion and recovery actions
  - activities impacted by any other change as change of logic links, change of durations, start and end dates evolution
- Summary list of deliverable items reporting the status (nominal delivery date, new delivery date, final delivery date)

For all the activities that are affected by a schedule change during the reporting period a concise description of their status will be provided, indicating possible impacts and/or other significant implications.

7. INVENTORY AND PROPERTY CONTROL

Property Control is the instrument for handling, storing, accounting and final disposing of the SST property items. SST-PRO will ensure property control performance of the contract/agreement, including any other third party who acts on his behalf or to whom it entrusts CTAO final property.

The inventory control function will provide full accountability of SST owned items during the term of the contract. To serve this purpose, these items will be uniquely identified, marked, segregated, and maintained.

Upon completion of the deliveries the SST-PRO partners will dispose of all items acquired in accordance with agreed instructions (To be defined). To guarantee the correct implementation of the property control, SST-PRO will define inventory control procedures subject to CTA approval.

7.1 Treatment of Property

All property items subject to inventory control will be uniquely identified and changes to such items affecting their configuration, quality, reliability, performance, value or usefulness to the CTAO, as their physical location will be traced and recorded.

7.2 Ownership

INAF will have the intellectual property of all documents, drawings including all detailed plans in digital appropriate format, SW source code, third parts SW licences and models produced and paid during the development of this Contract [AD1].

In particular, starting from the CDR, INAF is authorized to use and modify and distribute the documents, drawings, SW source code, third parts SW licences, models and their content.

7.3 Product Assurance records

INAF shall have unrestricted access to PA records, certificates, incoming inspection protocols, etc., which if not to be delivered as part of the planned data packages, shall be available for review and audits as deemed by INAF. The audits can be conducted at Contractor's and/or Sub-contractor's promises, at INAF discretion. At the end of the work, the entire quality books data base shall be handed over to INAF.

7.4 Facilities access

The Contractor shall provide general site access to their facility and CTAO South Site where SST activity is specifically occurring for INAF individuals identified and pre-authorized by both parties during normal business hours and operations. INAF individuals will comply with all Contractor safety rules and facility policies.
The Contractor shall provide INAF with facility phone and internet capabilities adequate to support technical interactions as necessary and access to observe testing as required.

8. ANNEX 1: DOCUMENT REQUIREMENTS DEFINITION

8.1 Documents Matrix Vs Reviews

In Table 8-1 are listed the minimum set of documents to be provided by the Contractor through all the various phases of the project and reviews. The contents of the documents are reported in sections 8.2-8.8.

Table 8-1: Documents Matrix Vs Reviews

Document Name [Protocol]	S-PKO	S-CDR	CDR	TRR	TRB	OF-PQR	DRB	O-TRR	O-TRB	ACRV	FAR
Project Management Plan [SST-MEC-PLA-001]	X	X	X								
Configuration & Data Management Plan [SST-MEC-PLA-002]	X	X	X								
Risk Management Plan [SST-MEC-PLA-004]	X	X	X								
Risk Analysis Report [SST-MEC-REP-001]		X	X	X	X	X	X	X	X	X	X
Master Schedule Report [SST-MEC-REP-003]	X	X	X	X	X	X	X	X	X	X	X
Progress Report [SST-MEC- PRR-XXX]	X	X	X	X	X	X	X	X	X	X	X
Product Assurance & Quality Plan [SST-MEC-PLA-005]	X	X	X								
Safety Management Plan [SST-MEC-PLA-006]	X	X	X								
Audit Plan [SST-MEC-PLA-007]		X	X								
Key and Mandatory Inspection Points Plan [SST-MEC-PLA-008]		X	X								
Failure-Modes, Effects and Criticality Analysis [SST-MEC-ANR-001]		X	X								
Worst Case Circuit Analysis (WCA) [SST-MEC-ANR-002]		X	X								
Part Stress Analysis and de-rating analysis [SST-MEC-ANR-003]		X	X								
RAM Analysis Report [SST-MEC-ANR-004]		X	X								
Safety Assessment Report [SST-MEC-ANR-005]		X	X								
Declared Item List (DIL) [SST-MEC-LIS-001]		X	X				X				
Declared Material List (DML) [SST-MEC-LIS-002]		X	X				X				
Declared Process List (DPL) [SST-MEC-LIS-003]		X	X				X				
No Conformance Report [SST-MEC-NCR-XXX]		X	X	X	X	X	X	X	X	X	X
Request for Deviation / RFD [SST-MEC-RFD-XXX]		X	X	X	X	X	X	X	X	X	X
Request for Waivers / RFW [SST-MEC-RFW-XXX]		X	X	X	X	X	X	X	X	X	X
Engineering Development and on Factory Verification Plan [SST-MEC-PLA-009]	X	X	X								
Software Development and Verification Plan [SST-MEC-PLA-010]	X	X	X								
Factory AIT Plan [SST-MEC-PLA-011]		X	X								
On site AIT Plan [SST-MEC-PLA-012]		X	X				X				
On-site Maintenance Plan [SST-MEC-PLA-015]		X	X				X				
Logistic Plan [SST-MEC-PLA-016]		X	X				X				

Document Name [Protocol]	S-PKO	S-CDR	CDR	TRR	TRB	OF-PQR	DRB	O-TRR	O-TRB	ACRV	FAR
Subsystem Technical Requirement Specification [SST-MEC-SPE-002]		X	X								
Local Control Software Requirements Specification [SST-MEC-SPE-004]		X	X								
Design Report [SST-MEC-DSR-001]		X	X								
Software Architecture Description Report [SST-MEC-DSR-003]		X	X								
Software Detailed Design Description Report [SST-MEC-DSR-004]		X	X								
Technical Budgets Report [SST-MEC-TRE-004]		X	X								
Test Specifications [SST-MEC-SPE-004]		X	X								
MEC/OPT I/F Control Document [SST-MEC-ICD-005]		X	X								
SW I/F Control Document (SICD) [SST-MEC-ICD-006]		X	X								
MEC/CAM I/F Control Document [SST-MEC-ICD-007]		X	X								
SST Operational Concept Document [SST-MEC-OPD-007]		X	X								
Drawings and Diagrams [SST-MEC-DWD-001]		X	X				X				
Configuration Item Data List (CIDL) [SST-MEC-ADC-001]		X	X				X				
Verification Matrix [SST-MEC-VER-001]		X	X				X			X	X
Thermal Analysis Report [SST-MEC-ANR-007]		X	X								
Structural Analysis Report [SST-MEC-ANR-008]		X	X								
Storing, Transport and Handling Procedures [SST-MEC-PRC-001]		X	X	X			X				
AIT/V Procedures [SST-MEC-PRC-002]		X	X	X							
On-Factory AIT/V Procedures [SST-MEC-PRC-003]		X	X	X							
On-Site AIT Procedures [SST-MEC-PRC-004]		X	X	X				X			
Test Procedures [SST-MEC-PRC-006]		X	X	X				X			
Test Procedures "as done" [SST-MEC-PAD-XXX]					X				X		
Acceptance Test Report [SST-MEC-ATR-XXX]					X				X		
On-Site Test and Verification Reports [SST-PRO-OTR-XXX]									X		
Telescope/Subsystem User Manual [SST-MEC-MAN-001]			X	X			X			X	
SST Subsystem logbooks [SST-MEC-LGS-XXX]							X				
SST Telescope logbooks [SST-MEC-LGT-XXX]							X			X	
As Built Configuration Document (ABCD) [SST-MEC-ABC-XXX]							X				
Packing List [SST-MEC-PAL-XXX]							X				
Inventory List [SST-MEC-INL-XXX]							X			X	
Request For Waivers / Request For Deviations (RFW / RFD) list [SST-MEC-DWL-XXX]							X			X	
Certificate of Conformance [SST-MEC-COC-XXX]							X			X	
CAD model [SST-MEC-MAT-001]		X	X			X	X				
Structural Mathematical Model (SMM) [SST-MEC-MAT-002]		X	X			X	X				

Thermal Mathematical Model (TMM) [SST-MEC-MAT-003]		x	x			x	x				

8.2 Project Management & Reporting

Document Name [Protocol]	*Content Description*
Project Management Plan [SST-MEC-PLA-001]	The document shall address the following minimum set of information: • Organizational breakdown with organogram and responsibilities, key personnel (key roles and WP roles). • Tools and processes for project control, coordination and monitoring. • Main Suppliers foreseen and their management. • System Engineering related topics: • Requirements and how to grant their compliance (analyses, means and tools used to design and produce HW and SW etc.). • Interfaces and how to guarantee successful communication between parties. Moreover, Project plan should provide the link to the followings: • Development plan • Product Assurance plan • Procurement plan • Risk management plan The Document shall comply with the Statement of Work.
Configuration & Data Management Plan [SST-MEC-PLA-002]	This document establishes the overall Configuration and Data Management (CADM) rules and procedures to achieve an effective control over the design and finally over the products as built status and relevant supporting data. It defines rules and procedure for documentation release and control to be undertaken by SST Consortium. This plan defines the how and when the CADM rules and procedures are applied to ensure that: • Each Configuration Item (CI) and related documentation are uniquely identified. • The design standard of the CI is defined, traceable and retrievable at each point in time. • Effective change control is established and maintained, • Reports are timely established and released to support program activities. • Design and product inspections are performed to verify the current configuration status. • Applicable CM process is monitored to verify correct application of CADM requirements. • Program documentation is received, reviewed, released and recorded in an orderly and consistent manner. The Document shall comply with the [AD11].

Risk Management Plan [SST-MEC-PLA-004]	The document shall contain the following minimum set of information: • Project objectives (in terms of cost schedule in order to assess the scoring scheme). • Risk scoring scheme (severity and likelihood). • Risk index definition (based on the risk scoring scheme). • Mitigation actions (based on Risk index). • Risk acceptance criteria. • Risk comparison methods (to assign risk priorities). • Risk monitoring (risk assessment and risk register). The Document shall comply with the [AD12].
Risk Analysis Report [SST-MEC-REP-001]	This document reports all the risks identified during the execution of the contract according to the methodology presented in the RMP [AD12]. The identified risks are summarized in the Risk Register. The Risk register shall list in a tabular format as a minimum: • A unique risk identification reference. • Risk source originator (e.g. Progress Meeting Review, etc.) • Risk identification date. • Description of the risk. • The risk owner. • Risk index (assessed as indicated in Risk management plan). • Status (e.g. open, mitigated, occurred, retired). • The current prevention/mitigation actions identified. • The due date for the implementation of prevention/mitigation action foreseen. • Mitigated risk index. This document shall be available on demand starting from the Contractor KO.
Master Schedule Report [SST-MEC-REP-003]	The document shall contain the Master Schedule of the project which includes the activities/tasks in Gantt Chart form with: • The dependencies between activities • An up to date status of the Project and the critical path highlighted • The percentage of task completion • The buffer time explicitly stated • The identification of normal working conditions (working and non-working periods)
Progress Report [SST-MEC- PRR-XXX]	This document provides a summary of the activities performed during the reporting period. Includes project status, meeting planning, action status, documentation status, NC status, identification of critical areas. For SST-MEC, It will be issued monthly starting from Contractor Kick Off.

8.3 PA, QA and RAMS

Document Name [Protocol]	*Content Description*
Product Assurance & Quality Plan [SST-MEC-PLA-005]	This document describes the general quality requirements, activities, methods and required resources applicable to all the Work Packages (WPs) of the projects, with the aim to meet the quality objectives and to assure the expected performance and reliability. This quality plan will provide assurance that: • The items in all their parts are compliant with the specifications. • The risks are identified, assessed and controlled. • The traceability and quality of deliverables are accessible at all times. • Non-conformities (NCs) are identified and addressed. This document shall comply with [AD13].
Safety Management Plan [SST-MEC-PLA-006]	The document provides the following information: • The safety management approach and methodology to be used throughout the entire duration of the project, with specific chapter for the integration of the telescope and its verification. • The safety organization structure indicating the structure of the different levels of responsibilities and authorities involved in project safety (including Contractor activities). • Safety management, reporting, planning and control. • Hazard identification and tracking principles. • Safety monitoring process (e.g. audits with sub-contractors, hazard analysis report, accident report etc.). • Training of the personnel. This Document shall comply with the [AD14].
Audit Plan [SST-MEC-PLA-007]	This document reports the PA/QA audits planned to verify the implementation and effectiveness of the PA/QA plan and asses the capability of the contractor and sub-contractors to perform the required tasks This document includes a dedicated checklist to be used when performing the audits. The checklist will cover all the PA requirements applicable. The Audit plan will be updated after CDR when necessary. This document shall comply with [AD13].

Key and Mandatory Inspection Points (KIP/MIP) Plan [SST-MEC-PLA-008]	This document reports the KIP MIP planned according to the PA/QA plan. This document shall comply with [AD13].
Failure-Modes, Effects and Criticality Analysis (FMECA/S-FMECA) [SST-MEC-ANR-001]	This document reports the Failure-Modes, Effects and Criticality Analysis (FMECA/S-FMECA) results. It includes Single Point Failure List (SPF).
Worst Case Circuit Analysis (WCA) [SST-MEC-ANR-002]	This document provides the results of the Worst-Case Circuit Analysis (WCA).
Part Stress Analysis and de-rating analysis (PSA) [SST-MEC-ANR-003]	This document provides the results of the Part Stress Analysis and de-rating analysis (PSA).

RAM Analysis Report [SST-MEC-ANR-004]	This document shall contain as a minimum: • Description of the System under examination and decomposition in LRU. • Reliability analysis using, if existing, the SST templates, CTA tools and software • Methodology used to perform the analysis in line with CTA RAM requirements and needs. • Reliability data sources including the product / items data sheets given by the suppliers. • Prediction of Reliability and Availability based on failure rates data. • Preventive replacement time for components in a repairable System. • Spare parts requirements and production rate, spare parts list. • Mean Time Between Failures (MTBF) computation. • Down time of the Product and its availability considering the MTBF, Mean Time To Repair (MTTR) and the Time for Preventive Maintenance. • The BILL of Material (BOM) used for the RAMS Analysis. The use of a specific tool (as reliasoft) can be requested for the RAM Analysis. Furthermore, the report shall contain or refer to the following: • Failure-Modes, Effects and Criticality Analysis (FMECA/S-FMECA) • Fault Tree Analysis (FTA). • Reliability Block Diagrams (RBD).

Safety Assessment Report [SST-MEC-ANR-005]	The safety assessment report summarizes the status of safety activities and highlights safety issues requiring special attention during the project phases (from design consolidation to final acceptance). For each project phase, activity and review, the content of the report shall be adapted.
	For each review, the safety approval authority will provide an indication of the expected content to be provided.
	
	This document includes without limitation the Hazard Analysis providing the following minimum set of information:
	• Description of the Subsystem/activity.
	• Hazards list subdivided in categories such related to:
	  ○ adopted design,
	  ○ activities before telescope use,
	  ○ lifetime operation and maintenance.
	• Assessment of the Hazard Priority Numbers including severity of the effect, likelihood of occurrence and ability of detection.
	• Explanation of the Hazard reduction measures adopted including input to operation and/or maintenance Procedures.
	• Prove that residual hazards are acceptable.
	• Existing analysis should be continued and updated

Declared Item List (DIL) [SST-MEC-LIS-001]	This document provides a detailed record of all the items. This document Includes as a minimum: • Long Lead Item List • Built Part List @ DR/PAR • Components Data Sheets
Declared Material List (DML) [SST-MEC-LIS-002]	This document provides a detailed record of all the materials used to produce the products. The data in the DML allow to assess whether the materials are suitable for a specific application, at the supplier and the customer levels (in the approval status column). The DML is prepared for each “Configuration item” DML is linked to the Declared Process List (DPL).
Declared Process List (DPL) [SST-MEC-LIS-003]	This document provides a detailed record of all the processes used to produce the products. The data in the DPL make possible to assess whether the processes are suitable for a specific application, at the supplier and customer levels (in the approval status column). The DPL is prepared for each “Configuration item” DPL is linked to the Declared Material List (DML).

No Conformance Report [SST-MEC-NCR-XXX]	The Non-Conformance Report shall include in a schematic, simplified template a set of information equivalent to the one listed here below: • Initiator and date of detection. • The reference of the requirement, document or item (CI and serial number if applicable). • The description and reason of the NCR observed. • Analysis of the root cause and if it is recurring. • Effect description. • Decision about how to address the non-conformance (action, rejection, implementation of RFD, RFW or CRE). • Approval (e.g. by SST PM) of the decision proposed. • Verification of the effectiveness of actions by PA. • Closure. NCRs are issued if and when necessary. XXX in the protocol name is a three digits progressive number.
Request for Deviation / RFD [SST-MEC-RFD-XXX]	RFD is related with an NC emerged before production. During the project development the Contractor may submit a Request for Deviation prior to the manufacture of an item seeking a planned variance from specified requirements. The minimum set of details is equivalent to the one outlined in RFW section; in RFD case the corrective action is not foreseen as the deviation is not submitted after manufacturing. RFDs are issued if and when necessary. XXX in the protocol name is a three digits progressive number.

Request for Waivers / RFW [SST-MEC-RFW-XXX]	RFW is related with an NC emerged during the production/integration phases. During the project development the Contractor may submit a Request for Waiver to accept an item which, during manufacture or after inspection, was found to depart from specified requirements, but is considered suitable for use as is or after rework by an approved method. Neither waiver shall be allowed until reviewed and granted from the INAF. An RFW shall include in a schematic, simplified template the following information as a minimum: • Initiator information. • Configuration Item (CI) to be covered by the waiver. • Serial number of the affected instances or batch number, etc. • The affected Documents/Drawings/Requirements. • The description and reason of the RFW. • Impacts on: o technical aspects such as feasibility, function, performance, reliability, maintainability or interfaces. o Schedule of key milestones (including detailed schedule of the change implication). o Costs (giving detailed information on the manpower, material, cost etc. and reflecting the differential cost for changes in work packages). o Safety of the system. • The corrective action taken by the Contractor. • The price concession proposed by the Contractor. • Additional documents as needed to justify the RFW (e.g. NCR). RFWs are issued if and when necessary. XXX in the protocol name is a three digits progressive number.

8.4 System Engineering Plan Documentation

Document Name [Protocol]	*Content Description*

Engineering Development and on Factory Verification Plan [SST-MEC-PLA-009]	This document presents the development logic and model philosophy of Mechanical Structure. This plan is only relative to the activities to be performed before the delivery to site. This document includes the verification on factory plan.
Software Development and Verification Plan [SST-MEC-PLA-010]	This document presents the development logic and model philosophy of Telescope Control Software. It includes the description of the tests to be performed before and after HW/SW integration.
Factory AIT Plan [SST-MEC-PLA-011]	This document describes the SST-TEL AIT plan and procedures that shall be executed at the SST factory premise after the Production Phase of the SST-MEC, SST-OPT, SST-TCS and SST-CAM. This document is related only to the first Telescope. The scope of this activities is to demonstrate that the SST Telescope has been designed and built to satisfy the requirements of the project. The Factory AIT Plan shall: • document the on Factory AIT activities and associated planning. • include test matrix(ces) that link the various tests with the test specifications, test procedures, test blocks and hardware model. • Assembly, integration and test including inspections, should be detailed through dedicated activity sheets. • Activity sheets shall include descriptions of the activity including the tools to be used, the expected duration of the activity, and the relevant safety or operational constraints. • The sequencing of activities should be presented as flow charts. • describe the on Factory AIT documents to be produced and their content. The SST-MEC team is the leader of on factory SST-TEL AIT.
On site AIT Plan [SST-MEC-PLA-012]	The plan describes the process of the SST-TEL AIT that will be performed on site. The on-site AIT Plan shall: • document the On-site AIT activities and associated planning. • include test matrix(ces) that link the various tests with the test specifications, test procedures, test blocks and hardware model. • Assembly, integration and test including inspections, should be detailed through dedicated activity sheets. • Activity sheets shall include descriptions of the activity including the tools to be used, the expected duration of the activity, and the relevant safety or operational constraints. • The sequencing of activities should be presented as flow charts. • describe the on-site AIT documents to be produced and their content. This document includes the description of the H/W & S/W integrated test. The SST-MEC team is the leader of on-site SST-TEL AIT.

On-site Maintenance Plan [SST-MEC-PLA-015]	The On-site Maintenance Plan describes the SST maintenance during the activities at CTAO south site. This document provides the detailed maintenance procedures with drawings. It shall contain the maintenance requirements and scheduling for all items included in the supplies of the contract. All the following types of maintenance shall be considered and the related maintenance actions shall be provided in a tabular format reporting: • Preventive maintenance (routine and running). • Corrective maintenance (deferred and urgent). • Predictive maintenance (condition monitoring based). Each intervention shall be described with the following information, as a minimum: • Item(s) to be maintained (product tree reference). • Qualification and quantity of personnel required for the maintenance activity. • Total time needed to perform the maintenance activity. • Supporting tools and equipment (including access). • Step by step procedure, including detection, preparation, location and isolation, disassembly (gaining access), repair or removal, re-assembly, realignment/re-adjustment etc., checkout (proof of fault elimination). • Required parts, consumable. • Safety implications and measures.
Logistic Plan [SST-MEC-PLA-016]	This document describes the logistic activities related to the transfer of the telescopes elements from Europe to Chile. The objective of the Logistic plan is to • Ensure a consistent/coherent identification and management of the logistic activities; • Establish roles, responsibilities and authority related to the logistic function; • Ensure conditions enabling roles and responsibilities to be undertaken in a dynamic and interactive way.

8.5 Design Definition documents

Document Name [Protocol]	*Content Description*

Subsystem Technical Requirement Specification [SST-MEC-SPE-002]	This document specifies the functional and performance requirement for the design, the development, the verification and the delivery of the telescope subsystems. This document provides the Level D requirements. Each requirement shall be uniquely identified. Traceability information of each requirement derived from higher level requirement shall be provided.
Local Control Software Requirements Specification [SST-MEC-SPE-004]	This document provides the Level E requirements about the Local Control Software. Each requirement shall be uniquely identified. Traceability information of each requirement derived from higher level requirement shall be provided. This document describes the purpose of the product, the functional and non-functional requirements applicable to the Local Control Software. This document specifies: • Functional requirements • Performance requirements • Interface requirements • Operational requirements • Resources requirements • Design requirements and implementation constraints • Security and privacy requirements • Portability requirements • Software reliability requirements The SRS shall describe, per each uniquely identified requirement, the validation approach. A validation matrix (requirements to validation approach correlation table) shall be utilized to describe the validation approach applicable to each requirement.

Design Report [SST-MEC-DSR-001]	This document shall describe all the design aspects of all items and disciplines subject of the work. The effective way to do so, is to address each requirement reported in the technical specifications and as applicable to the item/discipline subject of the Design Report. The Design report shall contain, as a minimum: • the scope, establishing the boundaries of application of the document and stating explicitly what is covered and not covered. • Applicable and reference documents in order of mention throughout the report. • The assumptions like: design requirements (e.g. environmental), maintenance requirements (if applicable), access requirements (if applicable), all calculations methods (if applicable), etc. • The materials and coating used in the design, their physical, mechanical and chemical properties when required. • The Design description addressing explicitly every requirement specified in the technical specifications. Every time a requirement is satisfied by the descriptions, it shall be essential to explicitly state “compliant to req. n°…”. • Reference to specific analysis report to support every design solution. • Calculations supporting the design, others than those included in the analysis reports. • Trade-off supporting the design, • Non-conformities. • Description of the support equipment for integration and tests
Software Architecture Description Report [SST-MEC-DSR-003]	This document provides a description of the concept, design and functional architecture of the SST telescope control software.
Software Detailed Design Description Report [SST-MEC-DSR-004]	This document shall provide the detailed description of the design for the software, with traceability between software requirements and their implementation. It shall include, as minimum, the following information: • A detailed description of the software structure (design trees) and blocks partitioning. • Data flow diagram. • Software control flow diagram. • Descriptions of data and control interfaces between software blocks and between software and hardware. • Description of algorithms.

Technical Budgets Report [SST-MEC-TRE-004]	This document provides the technical budget including (i.e. mass, power, alignment, volume, data rate, CPU time, mass memory, etc.).
Test Specifications [SST-MEC-SPE-004]	The test specification describes in detail the test requirements applicable to the test activity. It defines the purpose of the test, the test approach, the item under test and the set-up, the required support equipment, test tools, test instrumentation and measurement uncertainties, test conditions with tolerances, test sequence, test facility, pass/fail criteria, required documentation, participants and test schedule. Cleanliness and contamination control for test shall conform to the Contamination Control Plan This document is the starting point for the preparation of the test procedure.
MEC/OPT I/F Control Document [SST- MEC-ICD-005]	The purpose of the MEC/OPT I/F Control Document is to define the design of the interface(s) ensuring compatibility among involved interface ends by documenting form, fit, and function. The document presents the main I/F description between SST-MEC and SST-OPT. This document includes: • Mechanical I/F drawings.
SW I/F Control Document (SICD) [SST-MEC-ICD-006]	The purpose of the SICD is to define the design of the interface(s) ensuring compatibility among involved interface ends by documenting form, fit, and function.
MEC/CAM I/F Control Document [SST- MEC-ICD-007]	The purpose of the MEC/CAM I/F Control Document is to define the design of the interface(s) ensuring compatibility among involved interface ends by documenting form, fit, and function. The document presents the main I/F description between SST-MEC and SST-CAM. This document includes: • Electrical I/F drawings. • Mechanical & Thermal I/F drawings. This document includes the I/F between SST-CAM and SST-OPT M2.
SST Operational Concept Document [SST-MEC-OPD-007]	This document provides a description of the operational concept across all the various phases: Verification Phase, Commissioning Phase and Science Phase in compliance with the CTA Operational concept.

Drawings and Diagrams [SST-MEC-DWD-001]	This document includes: • Drawing Tree. • Mechanical Drawings as built (in pdf and Dxf format). • Electrical diagrams. • SW UML diagrams • Manufacturing drawings (includes PCB). • Cabling.
Configuration Item Data List (CIDL) [SST-MEC-ADC-001]	The Configuration Item Data List (CIDL) shall list all the up to date applicable documents relative to a specific CI at one moment in time of the project. It shall contain as a minimum: • CI identification (part number and serial number - where appropriate). • List of the technical specifications. • List of the ICDs. • List of the design/analysis reports. • List of the drawings. • Bill of Material (BoM). • List of plans. • List of procedures. • List of manuals. • Quality logbooks. • List of software. • List of NCRs and already approved RFDs/RFWs, CREs. All documents shall be recorded in the CIDL as a minimum with their code, issue, title and release date. This document must be updated when necessary.
Verification Matrix [SST-MEC-VER-001]	This document contains, for each requirement to be verified, the methods, levels and stages of product verification.

8.6 Design Justification documents

Document Name [Protocol]	*Content Description*

Thermal Analysis Report [SST-MEC-ANR-007]	This document provides calculations which support the design. It shall contain the following information, as a minimum: • The scope, identifying against which issue of the specification and/or design or manufacturing configuration the Analysis has been performed. • The assumptions • Model used in the Analysis shall be described in detail Plots and sketches illustrating the model shall be included to allow the model reproduction. • Results obtained from the analysis by means of plots and numerical values shall be processed to be directly comparable with the verification items. • Non-conformities.
Structural Analysis Report [SST-MEC-ANR-008]	This document provides calculations which support the design. It shall contain the following information, as a minimum: • The scope, identifying against which issue of the specification and/or design or manufacturing configuration the Analysis has been performed. • The assumptions • Model used in the Analysis shall be described in detail Plots and sketches illustrating the model shall be included to allow the model reproduction. • Results obtained from the analysis by means of plots and numerical values shall be processed to be directly comparable with the verification items. • Non-conformities. In particular this document includes the FE modelling and structural analysis thermo-elastics, strength and stiffness analysis results description.
Storing, Transport and Handling Procedures [SST-MEC-PRC-001]	The document provides the step-by-step procedures to ensure safe handling, storage and transportation of SST hardware.

AIT/V Procedures [SST-MEC-PRC-002]	This document describes the step-by-step AIT/V procedures at S/S level describing in detail the AIT activities and the associated planning. This document is intended only for test at S/S level.
	
	The document shall include:
	• the sequence of the S/S assembly and integration activities.
	• The detailed description of all the steps of the S/S assembly and integration (assembly, integration, alignment, inspections, checks, stating explicitly all critical operations performed during the assembly process.)
	• The description of:
	  ○ Handling equipment.
	  ○ Standard tools and machines.
	  ○ Special assembly tools.
	  ○ Measuring and alignment equipment.
	• The Detailed test procedures contain the following set of information, as a minimum:
	  ○ Unique dentification label.
	  ○ Description and objectives.
	  ○ step-by-step activities
	  ○ Inputs, outputs.
	  ○ pass/fail criteria
	  ○ Authority performing the test
	• The Detailed verification procedures.

On-Factory AIT/V Procedures [SST-MEC-PRC-003]	This document describes the step-by-step On-Factory SST-TEL AIT/V Procedures. On-Factory AIT/V Procedures are applied to the Qualification Telescope (first model).
	
	The document shall include:
	• the sequence of the assembly and integration activities.
	• The detailed description of all the steps of the telescope assembly and integration (assembly, integration, alignment, inspections, checks, stating explicitly all critical operations performed during the assembly process.)
	• The description of:
	  ○ Handling equipment.
	  ○ Standard tools and machines.
	  ○ Special assembly tools.
	  ○ Measuring and alignment equipment.
	• The Detailed test procedures contain the following set of information, as a minimum:
	  ○ Unique dentification label.
	  ○ Description and objectives.
	  ○ step-by-step activities
	  ○ Inputs, outputs.
	  ○ pass/fail criteria
	  ○ Authority performing the test
	• The Detailed verification procedures. The verification will be related to a subset of Level C requirements.
	SST-CAM, SST-OPT and SST-TCS contributions shall be included in this document.

On-Site AIT Procedures [SST-MEC-PRC-004]	This document describes the step-by-step SST-TEL On-Site AIT Procedures. The procedures are derived from the approach presented on the SST-TEL On-Site AIT plan.
	
	The document shall include:
	• The sequence of the assembly and integration activities.
	• The detailed description of all the steps of the telescope assembly and integration (assembly, integration, alignment, inspections, checks, stating explicitly all critical operations performed during the assembly process.)
	• The Description of:
	  ○ Handling equipment.
	  ○ Standard tools and machines.
	  ○ Special assembly tools.
	  ○ Measuring and alignment equipment.
	• The Detailed test procedures contain the following set of information, as a minimum:
	  ○ Unique dentification label.
	  ○ Description and objectives.
	  ○ step-by-step activities
	  ○ Inputs, outputs.
	  ○ pass/fail criteria
	  ○ Authority performing the test
	SST-CAM, SST-OPT and SST-TCS contributions shall be included in this document.

Test Procedures [SST-MEC-PRC-006]	This document is derived from the Test specification providing the operative step by step instructions in agreement with the test requirements. This document shall provide: • the activity objectives, • the applicable documents, • the references to the relevant test specification and • test set-up • the participants required • list and description of items under test and related tools • the step-by-step activities including expected results, with tolerances, pass/fail criteria, and identification of specific steps to be witnessed by QA personnel. Moreover, it shall: • include mapping matrix to the TSPE giving traceability towards the test requirement • identify special, safety and hazard conditions, operational constraints, rules for test management relating to changes in procedure, failures, reporting and signing off procedure • describe QA and PA aspects applicable to the test.

8.7 Product reference model

Document Name [Protocol]	*Content Description*
Test Procedures "as done" [SST-MEC-PAD-XXX]	This document shall be available at the completion of each test and provides the as-run test procedures: it is prepared starting from the original test procedure with the changes made during the test highlighted (red-marked copy). XXX in the protocol name is a three digits progressive number.
Acceptance Test Report [SST-MEC-ATR-XXX]	This document describes test execution, results and conclusions in the light of the test requirements. This document contains as minimum: • the test description • test results • test data (Test measurements and the environmental conditions), • the compliance evaluation report with emphasis on the close-out of the relevant verification requirements including any deviation. Any failure or anomaly during testing shall be recorded. This document Is linked to the document Test Procedures "as done". XXX in the protocol name is a three digits progressive number.

On-Site Test and Verification Reports [SST-PRO-OTR-XXX]	This document provides the results of the test and verification activities performed On-Site according to the procedures specified in the documents: On-Site AIT Procedures and "On-Site Verification Procedures" (PRC-004). This document shall include as a minimum the following information: • Test and unique label and title. • Test and verification conditions (e.g. environmental conditions, dedicated tools, calibration certificates, etc.). • Test results processed in such a way that they will be directly comparable with the verification items verified. • A comparative table shall resume the actuals versus the nominal ones required. • In case of non-compliances, the reference to the related NCRs shall be provided. • Personnel involved for execution and approval • Appendix: list of attachments of raw data (if applicable). XXX in the protocol name is a three digits progressive number.
Telescope/Subsystem User Manual [SST-MEC-MAN-001]	The Telescope/Subsystem User Manuals shall describe in detail all the procedures needed to operate correctly and safely the telescope and its subsystem. It shall contain, as a minimum: • A description of the start-up and shut-down procedures. • A description of all the procedures to operate the system and sub-systems. • A description of all the operational errors messages for the control units and their solution action. • A description of all the safety procedures to operate the system and sub-systems. • A list of all the operational boundaries. • A list of the emergency cases, which can occur during operations and the associated emergency procedures. • The reference to any other procedure needed for safe and correct operation trouble-shooting and actions to be performed by the operator upon error conditions. • The operations manuals of the Control System to provide the steps for executing the software, the expected output and the measures to be taken if error messages appear. Furthermore, it shall also describe, as a minimum: o Software design overview and architecture. o Software installation. o Operating modes. o User interface. o List of commands and parameters.

SST Subsystem logbooks [SST-MEC-LGS-XXX]	The logbook is the document in which the data related to the integration and testing of a configuration item are recorded in chronological order to provide the necessary events traceability at any time during the program life cycle, beginning with the first qualification or acceptance test. It is part of the EIDP The SST Subsystem logbooks must be maintained until the subsystem is formally provided to the user. XXX in the protocol name is a three digits progressive number.
SST Telescope logbooks [SST-MEC-LGT-XXX]	This document shall contain historical information, which is significant for operation of the item, including non-conformances, deviations and open tasks. XXX in the protocol name is a three digits progressive number.
As Built Configuration Document (ABCD) [SST-MEC-ABC-XXX]	The objective of the As Built Configuration Document is to provide a reporting instrument defining the as-built status per each serial number of configuration item subject to formal acceptance. This document provides the as-built configuration list. The as-built configuration list shall list all discrepancies between the as-designed configuration documented in the configuration item data list and the as-built configuration documented by nonconformance reports or waivers. The ABCD configuration item breakdown section, obtained from the equivalent configuration item data list section, shall be completed by adding the following information: • serial number identification; • lot or batch number identification; • reference(s) of applicable nonconformance report(s) or request for waiver(s). This document shall be updated when necessary. XXX in the protocol name is a three digits progressive number.

Packing List
[SST-MEC-PAL-XXX]
	This document provides the list for packing and shipping prepared according to the Storing, Transport and Handling Procedures and the related check list.
	
	The packing list shall contain as minimum the following information:
	• Packaging procedure
	• Container control:
	  • Protections
	  • Shock detectors
	  • Specific labelling on container
	  • Venting for Air transport
	  • Specific monitoring
	  • Dimensions
	  • Weight
	  • Labelling for handling and Container marking
	• Constraint for Carrier
	• Name of Carrier
	• Unpacking procedure
	
	This document shall be updated when necessary.
	XXX in the protocol name is a three digits progressive number.

Inventory List [SST-MEC-INL-XXX]	This document shall contain all the following information: • id label • Consumables with associated quantities, item name and vendor(s) name and contact details. • For COTS and OEM items, additional specifications not retrievable by their identification label. • Recommended amount of spare parts considering the findings of the RAM Analysis and the information provided in the Maintenance Manual. • Overall dimensions. • Storage conditions and special storage prescription (power up, no direct sun-light, etc.). • Material certificates. For parts and material for spare and maintenance: • Delivery times. • Expected lifetime on the shelf. XXX in the protocol name is a three digits progressive number.

Major Request of Waivers / Request for Deviations (RFW / RFD) list [SST-MEC-DWL-XXX]	This document provides the list of RFW/RFD, to be included in the EIDP of each delivered telescope. Telescope level document links the set at subsystem levels, integrated with NC and RFW emerged after telescope integration. XXX in the protocol name is a three digits progressive number.
Certificate of Conformance [SST-MEC-COC-XXX]	This document declares the conformance of an end item in all respect with the applicable specification(s), drawing(s) and requirements. The goal of this document is to provide the assurance that the deliverable item has been designed, manufactured and tested in accordance with the technical and quality requirements. The CoC shall contain the following elements: • Title including references to identify the product and the relevant applicable documents; • Document no. in accordance with project configuration control rules; • EIDP reference number; • Intended use, specifying the item objective • Reference of conformity • Statement of conformity • List of waivers or deviations or other remarks XXX in the protocol name is a three digits progressive number.

8.8 Mathematical Models

Document Name [Protocol]	*Content Description*
CAD model [SST-MEC-MAT-001]	This document provides the 3D CAD model of the SST-TEL. The 3D CAD model shall be produced considering the followings: • Each item should be modelled adequately, representing its volume and functionality aspects by means of CAD system. • The sub-assemblies shall be produced including the full set of items foreseen as if they are mounted in their final configuration. Motion between parts shall be possible to assess potential issues. Preliminary assembly models shall consider volume of items that are not defined yet. • All those items or systems that cannot be modelled, partially or completely, to describe their functionality through volumes will be provided in agreement through drawings and/or schematics or diagrams. The 3D CAD Model shall be provided as annex of this document both in a native format (i.e. CATIA or SolidWorks or any CAD software native format) and in a STEP file format.
Structural Mathematical Model (SMM) [SST-MEC-MAT-002]	This document describes the Structural Mathematical Model (SMM) of the SST-TEL. It is linked to structural analysis report and to the mechanical analysis model. The structural Mathematical Model as well shall be provided as annex of this document both in a native format (ANSYS, NASTRAN or any FE software native format) and in a neutral format.
Thermal Mathematical Model (TMM) [SST-MEC-MAT-003]	This document describes the Thermal Mathematical Model (TMM) of the SST-TEL. It Is linked to thermal analysis report. The thermal Mathematical Model as well shall be provided as annex of this document both in a native format (ANSYS, NASTRAN or any thermal software native format) and in a neutral format.

9. ANNEX 2: CUSTOMER-FURNISHED ITEMS (CFI)

The Customer Furnished items (CFI) for activities to be done at the company integration site and at CTAO southern Site are listed in Table 9-1 - CFIs List.

Table 9-1 - CFIs List

Item	*Description*	*N°*	*Date*
SST-TCS	All the software necessary to control and monitor the telescope	1	Before SST-TEL Qualification Model AIT/V
SST-OPT	Including all the Optics products as reported in the PBS (sect. 4) and relative documentation and mathematical models	Up to 25	Starting from the SST-TEL Qualification Model AIT/V until the end of the AIT on-site. Mathematical Models for the Contractor KO.
SST-CAM	Including all the Camera products as reported in the PBS (sect. 4, except for the SW) and relative documentation and mathematical models	Up to 25	Starting from the SST-TEL Qualification Model AIT/V until the end of the AIT on-site. Mathematical Models for the Contractor KO.
Optical Camera	Including optical camera and relative documentation and models	2 (TBC)	Before SST-TEL Qualification Model AIT/V
PMC SW	PMC control software and astrometric software	1	Before SST-TEL Qualification Model AIT/V

10. ANNEX 3: SST OPTICS DESCRIPTION

The SST Telescope Optical Design is fully described in [RD16].

The Optical Assembly includes the primary and secondary mirror. The primary mirror is decomposed in three coronas (corona 1, corona2, corona 3), the secondary mirror, Mirror Local Control System and maintenance tools.

10.1 The Telescope Optical Design

The optical system is a Schwarzschild-Couder configuration with a focal ratio F# of 0.5, (see Figure 10-1) The design has a plate scale of 37.5 mm/°, the Cherenkov pixel is approximately 0.16°, over an equivalent focal length of 2155 mm. This delivers a usable field of view up to 9.6° in diameter.

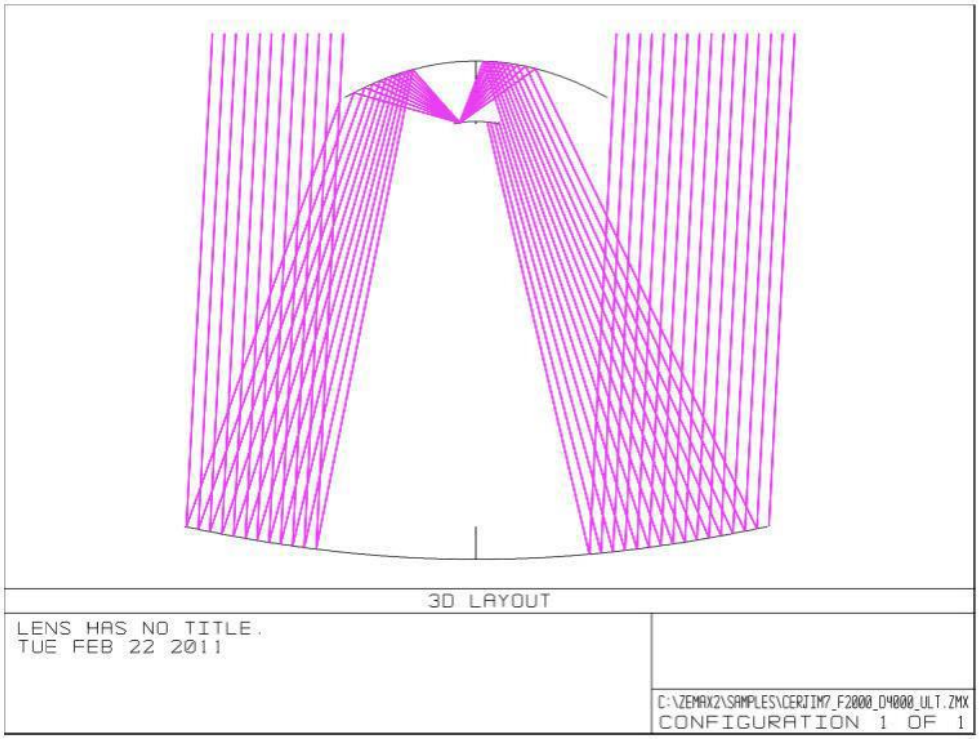

Figure 10-1 Optical System

For the evaluation of the effective area (in m^2) it has to be considered:

- The segmentation of the primary mirror
- The obscuration of the secondary mirror
- The obscuration of the detector
- The reflectivity of M1 and M2
- The protection window for the detector
- The efficiency of the detector as function of the incident angles (25° to 72°)

10.2 The primary mirror M1

The primary mirror is segmented following the scheme reported in Figure 10-2. The full reflector is composed of 18 segments (the central one is not used) produced using the cold slumping process. The segmentation requires three types of segments having different surface profiles:

- the green segments, inner corona: COR1;
- the blue segments, central corona: COR2;
- the yellow segments, outer corona: COR3.

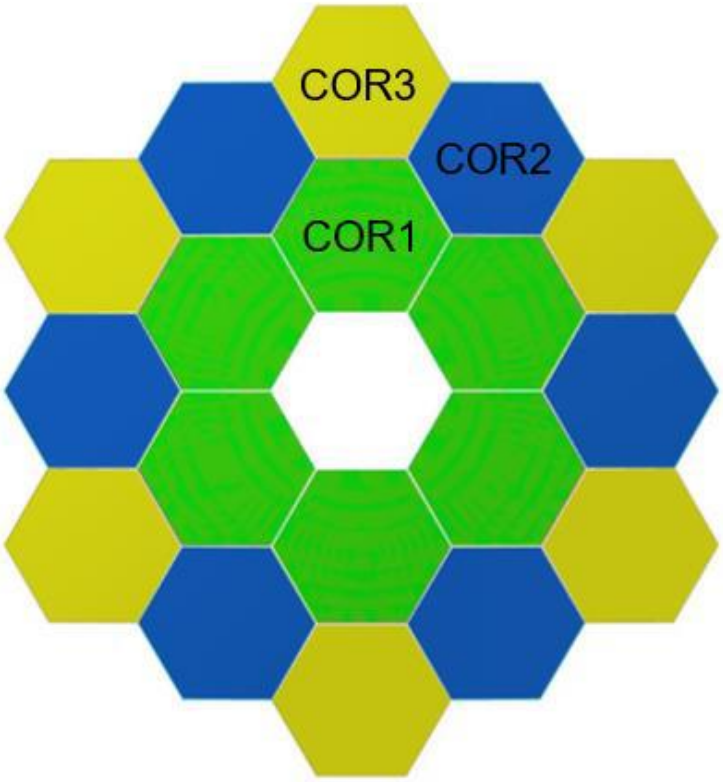

Figure 10-2 Tessellation of the primary mirror M1

The segments have hexagonal shape with aperture equal to 85 cm from face to face. Each segment has 9 mm of gap from the neighbours for mounting and alignment purposes. Each segment will be equipped with three actuators plus one fixed point for alignment. In this way Tip/tilt and piston misplacements of each segment can be corrected. The alignment system (actuators, controls etc.) will be installed only during commissioning and maintenance activities.

10.3 The secondary mirror M2

The secondary mirror is a monolithic mirror realised by hot slumping glass foil. The M2 Mirror is mounted on the M2 Support that allow tip/tilt/piston adjustment and then the fine tuning of the entire SST telescope optical system.

11. ANNEX 4: SST CAMERA CHERENKOV DESCRIPTION

The SST Cherenkov Camera Design is fully described in [RD17].

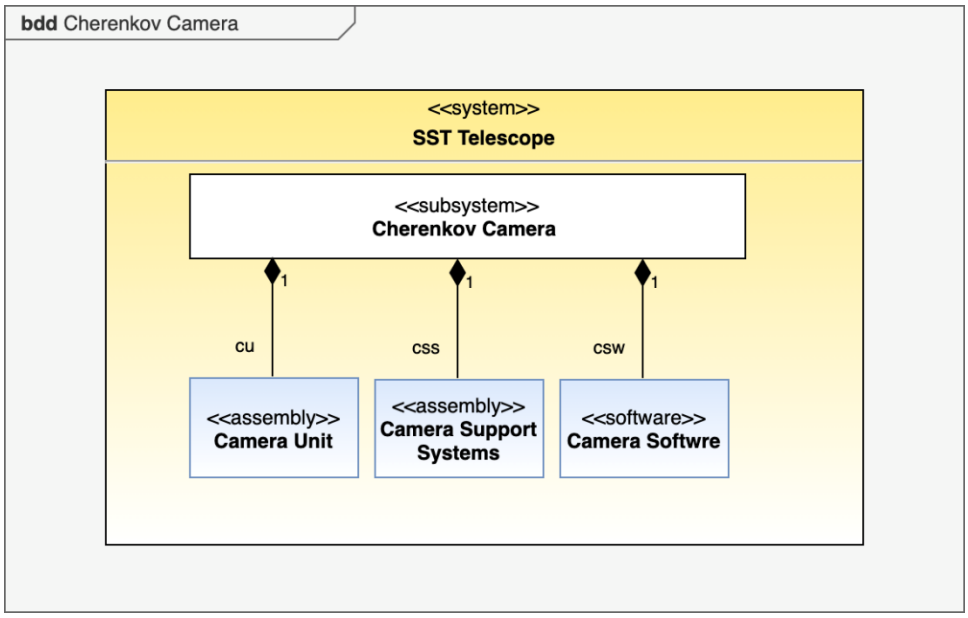

Figure 11-1 Cherenkov Camera Decomposition

The SST Camera comprises all the hardware, software and documentation associated with Cherenkov image detection, digitisation, transmission and pre-processing. The Cherenkov Camera PBS item contains all deliverables to CTAO from SST Camera Project.

The SST Camera is modular, it consists of a number of subsystems with components prototyped with CHEC-S and now designed to the final configuration. 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).

A schematic view of the overall SST Camera architecture is shown in Figure 11-1.

The Cherenkov Camera includes:

- Camera Unit
- Camera Support Systems
- Camera Software

11.1 Camera Unit

The Camera Unit is the main part of the SST Camera that is installed on the Telescope Structure. It is a photon-counting device consisting of an array of 2048 Silicon Photo-Multipliers (SiPM) and associated electronics responsible for self-triggering, fast (1 GS/s) digital waveform capture and nanosecond event timing. The Camera Unit design can record Cherenkov shower images with a good signal to noise ratio even in the presence of high levels of night-sky background light (NSB), being able to operate up to a rate of 1200 Hz.

Figure 11-2 Left side: overall 3D CAD view of the Camera Unit (excluding enclosure); right side: exploded view of the unit showing some of the main components.

The Camera Unit consists of the following items:

- **Enclosure (ENC):** The mechanical assembly housing the camera Focal Plane Assembly (including photosensors), and the Electronics Rack Assembly (which in turn houses the TARGET Modules). The Enclosure includes a heat exchanger and fans, a second set of fans and the camera power supplies, all mounted to removable panels. The Enclosure is sealed and water tight. All power and data connectors are located in the Power Panel. The Enclosure forms the mechanical interface to the Telescope Structure, attaching directly via the Telescope Interface Plate. The Enclosure measures approximately 50 cm x 50 cm x 50 cm and is made from machined Al. components. The ENC accepts an AC 230 V input connection for power, a multi-core fibre connection for data and control and refrigerant fluid inlet and outlet.
- **Focal Plane Assembly (FPA):** A liquid cooled, curved plate that holds all 32 SiPMs in place, with a sealed, coated entrance window and door system. SiPMs are connected to the focal-plane readout electronics that provide an interface to the TARGET Modules. Preamplifiers and interface boards are also connected to the SiPMs. The SiPMs are mounted on the liquid-cooled plate providing temperature stabilisation. The coated entrance window protects the SiPMs. A motorised door protects the window from adverse weather and dust, and the SiPM

from daylight. The FPA also houses an internal camera illumination system to self-calibrate the camera.

- **Electronics Rack Assembly (ERA):** It consists of a mechanical rack, housing a Backplane board for camera-level triggering and read out, a Timing Board for precision time stamping, a SCSA (Slow-Control Sub-Assembly) for controlling the camera doors, the camera power distribution and monitoring of the environment inside the camera. The cabling connecting these boards is also part of the Electronics Rack.
- **TARGET Modules (TMs):** the 32 TARGET Modules are 3-board assemblies providing the first level of triggering and the digitisation of signals from the SiPM assemblies. Each module includes one FPGA, four TARGET sampling and four triggering ASICs.
- **Focal Plane Illumination Assembly (FPIA):** a system providing the illumination of the front of the camera for calibration and monitoring purposes. It is based on an LED Flasher system prototyped for CHEC-S. It is installed in the CU, with potential connection via fibre to an under-lid leaky fibre (part of the FPA), to a diffuser for illuminating M2 and to a fibre connected to a diffuser at M2. Alternatively, a second LED Flasher system is to be installed in the back of M2, for illuminating the camera directly. Finalization of design choice is pending tests.

11.2 *Camera Support Systems*

The hardware items associated with the Camera located at the Telescope, but not part of the Camera Unit, including the camera chiller, pipework and any external cabling.

- **Chiller Assembly:** The camera chiller, heater and associated pipework. The Chiller and Heaters are commercial units housed in a cabinet; the pipework is routed via the structure and connected the Camera Unit
- **Cabling:** All cabling external to the Camera Unit and attached to it. Such cabling is routed via the Telescope Structure.

11.3 *Camera Software*

All the SW installed on the Camera Server will be used to locally control and operate the camera, and acquire the data it produces. It can be further divided into:

- **Camera Local Control System:** it is the software providing the camera control, and interfacing to the telescope control system via OPC-UA. It also provides **Monitoring** and **Service** data to the Telescope Control System and/or directly to ACADA.
- **Camera Data Acquisition System:** it is the software that acquires the **Event** data produced by the camera and uploads it directly to ACADA in **R1** format.

12. ANNEX 5: SST TELESCOPE CONTROL SYSTEM DESCRIPTION

The SST Telescope is controlled remotely by the ACADA system that interfaces with the Telescope Control System (TCS).

The TCS includes a Telescope Engineering GUI (which includes both the control of SST-MAC and Cherenkov Camera) to operate the SST Telescope in standalone mode during installation, calibration and maintenance activities. Locally it is possible to interact with the Local control systems via the Subsystems AIT/V GUI provided by each Local Control system or the Telescoped Engineering AIT/AIV.

The TCS main blocks are sketched in Figure 12-1:

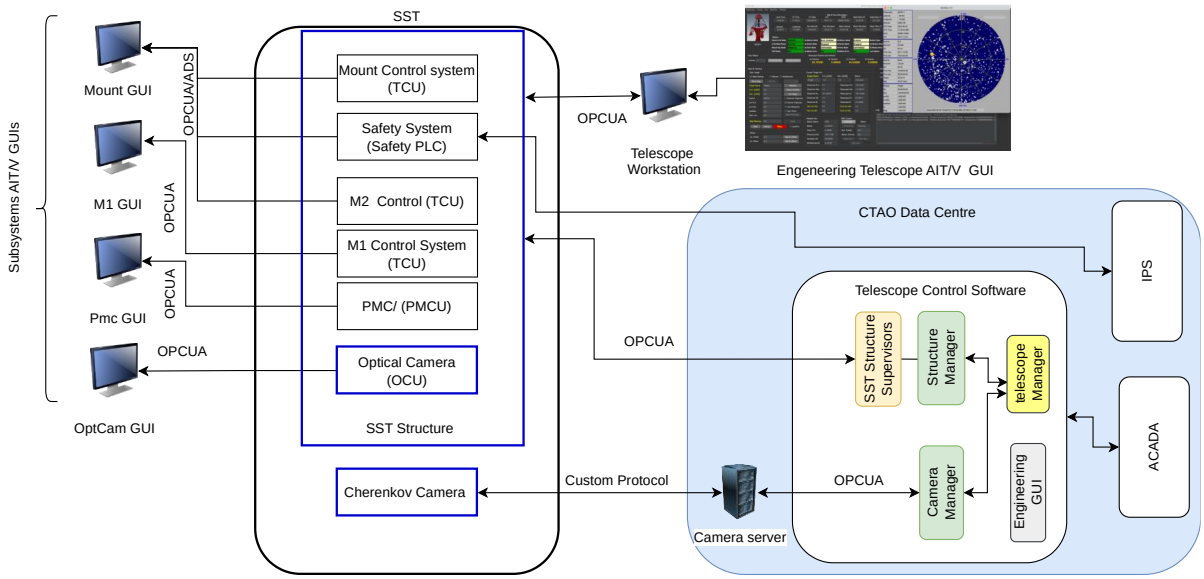

Figure 12-1 The Telescope Control system architecture

The TCS includes the Supervisors of all control systems installed on board each telescope.

The SST Team has the responsibility to develop the TCS including the Supervisors.

13. ANNEX 6: CHECKLIST NO. 3 - PURCHASE, LEASING AND RENTAL OF NON-MEDICAL PCS AND EEE

Scheda 3 - Acquisto, Leasing e Noleggio di computer e apparecchiature elettriche ed elettroniche

Verifiche e controlli da condurre per garantire il principio DNSH

Tempo di svolgimento delle verifiche	n.	Elemento di controllo	Esito (Sì/No/Non applicabile)	Commento (obbligatorio in caso di N/A)
Ex-ante	1	E' disponibile l'iscrizione alla piattaforma RAEE in qualità di produttore e/o distributore e/o fornitore?		
	2	I prodotti elettronici acquistati sono dotati di un'etichetta ambientale di tipo I, secondo la UNI EN ISO 14024, ad esempio TCO Certified, EPEAT 2018, Blue Angel, TÜV Green Product Mark o di etichetta equivalente)		*Specificare il tipo di etichetta ambientale di tipo I*
	In caso di assenza di un etichetta ambientale di tipo I dovranno essere verificati i requisiti seguenti al posto del punto 2			
	3	L'AEE è dotata di Etichetta EPA ENERGY STAR?		
	In alternativa al punto 3, rispondere al punto 3.1			
	3.1	E' disponibile una dichiarazione del produttore che attesti che il consumo tipico di energia elettrica (Etec), calcolato per ogni dispositivo offerto, non superi il TEC massimo necessario (Etec-max) in linea con quanto descritto nell'Allegato III dei criteri GPP UE ?		
	4	Nel caso di server e prodotti di archiviazioni dati, è disponibile la dichiarazione dei produttori/fornitori di conformità alla seguente normativa: ecodesign (Regolamento (EU) 2019/424)?		
	5	Nel caso di computer fissi e display, è presente la marcatura di alloggiamenti e mascherine di plastica secondo gli standard ISO 11469 e ISO 1043?		
	6	Nel caso di fornitura di apparecchiature TIC ricondizionate/rifabbricate, è disponibile una delle certificazioni di sistema di gestione seguente: • ISO 9001 e ISO 14001/regolamento EMAS (certificazione di sistema di gestione disponibile sotto accreditamento –il campo di applicazione della certificazione dovrà riportare lo specifico scopo richiesto); • EN 50614:2020 (qualora l'apparecchiatura sia stata precedentemente scartata come rifiuto RAEE, e preparata per il riutilizzo per lo stesso scopo per cui è stata concepita)?		
	7	E' disponibile una dichiarazione del produttore/fornitore di rispetto della seguente normativa: REACH (Regolamento (CE) n.1907/2006); RoHS (Direttiva 2011/65/EU e ss.m.i.); Compatibilità elettromagnetica (Direttiva 2014/30/UE e ss.m.i.)?		
	8	Sono state indicate le limitazioni delle caratteristiche di pericolo dei materiali che si prevede utilizzare (Art. 57, Regolamento CE 1907/2006, REACH)?		
	Alle apparecchiature per stampa, copia, multifunzione e servizi di Print&Copy si applica un requisito trasversale			
	9	E' verificata la conformità alle specifiche tecniche e clausole contrattuali dei Criteri ambientali minimi "Affidamento del servizio di stampa gestita, affidamento del servizio di noleggio di stampanti e di apparecchiature multifunzione per ufficio e acquisto o il leasing di stampanti e di apparecchiature multifunzione per ufficio, approvato con DM 17 ottobre 2019, in G.U. n. 261 del 7 novembre 2019" ?		

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