SST Mechanical Structure Design Report

SST-MEC-DSR-0014

Version 1a

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1 Introduction

1.1 Scope & Purpose

This is the Design and requirements specifications document of SST Mount Control System (MCS). Here we present the general architecture which defines the boundaries of the interconnected components, and therefore their requirements and interfaces, as well as requirements for software infrastructure and application framework.

The present document defines and describes the operational, functional, and non-functional requirements of SST-MCS.

In particular, we describe the part of the LCSs that are located on board of the SST telescope or in the telescope area, that is, the Field controllers, the fieldbuses and the sensors and actuators of each LCS. These parts of the LCSs shall be developed by external contractor.

The intended audience of this document is the potential users of the SST-MCS, systems engineers, designers, developers, testers (either unit or integration), and any contractor involved in the SST programme who is responsible for the production of the MAC and of any sub-system which interfaces the MCS.

1.2 Applicable Documents

The following documents, of the exact issue shown, form part of this specification to the extent specified herein. In the event of a conflict between the documents referenced herein and the content of this document specification, the content of this document specification shall be considered as a superseding requirement.

[AD1] CTA Architecture Document, v1.0 14.04.2018
[AD2] CTAO System Control Concept, Doc. No: CTA-TRE-SEI-000000-0016-1a, 05 October 2022

[AD3] CTAO System Control Development Guidelines, CTA-TRE-SEI-000000-0017-1a, 05 October 2022 1.
[AD4] CTAO System Control Standards, CTA-STD-SEI-000000-0004-1a, 2023-02-08
[AD5] Telescope Safety Design Specification, CTA-SPE-TEL-000000-0003_1a, 2023-01-18

[AD6] SST Mechanical Structure: Safety System, SST-MEC-DSR-002
[AD7] SST Mechanical Structure: Subsystem Technical Requirements Specification, SST-MEC-SPE-002

1.3 Reference Documents

[RD1] Camera Design Report, SST-CAM-DSR-001
[RD2] Mechanics Design Report, SST-MEC-DSR-001
[RD3] Optics Design Report, SST-OPT-DSR-001
[RD4] https://opcfoundation.org/about/opc-technologies/opc-ua/
[RD5] CTAO Alarm System (In preparation)
[RD6] Interface Control Document for ACADA – Generic Telescope Control, Doc. No. CTA-ICD-SEI-000000-0002, Issue 2, Rev.: h, 30.4.2020

1.4 Definition of Terms and Abbreviations

ACADA	Array Control and Data Acquisition System
ACS	ALMA Common Software
AMCU	Active Mirror Control Unit
AIV	Assembly, Integration, Verification/Validation
ASTRI	Astrophysics with Italian Replicating Technology Mirrors
CDR	Critical Design Review
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
ICD	Interface Control Document
GUI	Graphic User Interface
HW	Hardware
INAF	Istituto Nazionale di Astrofisica
IPS	Integrated Protection System
LCS	Local Control System
LPC	Low Power Cabinet
MACS	Mount Axes Monitoring Software
PDR	Preliminary Design Review
PLC	Programmable Logic Controller
PMC	Pointing Monitoring Camera
SDD	Software Design Document
SDLC	Software Development LifeCycle Software Release Document
SRD	Software Requirements Specification
SRS	
SST	Small Sized Telescope
SST-CAM	SST Camera
SST-STR	SST Structure
SUM	Software User Manual
SVerP	Software Verification Plan
SValP	Software Validation Plan

SW	Software
TBD	To be determined
TBC	To be Confirmed
TCS	Telescope Control System
TBC	To be Confirmed
TCU	Telescope Control Unit
UC	Use Case
UCD	Use Case Document
WP	Work Package
WPD	Work Package Description
WBS	Work Breakdown Structure
PA	Product Assurance

1.4.1 Glossary

TERM	DEFINITION
SST Programme	The overall SST organisational structure containing the SST-STR and SST Cam projects.
SST-STR	The SST Structure, consisting of elements under the control of the SST-STR Project.
SST-CAM	The SST Camera, consisting of elements under the control of the SST-CAM Project.
Central Facilities	Used as a catch-all in this document for on-site facilities not located at the Telescope Unit.
On-site Data Centre Farm	The central computing and storage facility on which all data is stored and all software installed.
Clock Distribution	The part of the central facility responsible for the provision and distribution of clocks for the precise time-tagging of images recorded by the Camera Unit.
Central Power Distribution	The part of the central facility responsible for distributing power to each Telescope Unit.
Central Site Safety System	The part of the central facility responsible for human safety, coordinating and acting upon safety information from all telescopes and other devices.
SST Software	All SW installed on the Farm that is under the responsibility of the SST Programme.
Telescope Manager	Part of the SST SW dealing with the high-level control interface to ACADA.
Camera Manager & DAQ	The SST SW dealing with the control of the Camera Unit and Camera Support Systems. Part of SST-CAM.
Structure Manager	The SST SW dealing with the control of the Structure. Part of the SST-STR.
Telescope Unit	All elements of a telescope located locally at that telescope.
Foundation	The physical foundation on which the Telescope Structure is mounted. Part of the Telescope Unit.
Interface Cabinet	The CTAO-controlled interface for power, network and timing connection to the telescope.
Telescope Structure	The telescope mechanical structure drives and optics.
Telescope Network Distribution System	The interface point from the Network Interface Cabinet to the telescope. Includes any patch panels, switches, associated mounting / housing and any fiber or copper cables routed about the Telescope Structure.
Telescope Control System	The control system for the telescope drives and any other active elements.
Telescope Safety System	Elements of the telescope explicitly for human safety, such as limit switches and access switches.
Telescope Power System	The interface point from the Power Interface Cabinet to the telescope. Includes any required hardware, associated mounting / housing and any cables routed about the Telescope Structure to other telescope elements.

Camera Unit	The physical camera as attached to the telescope structure.
Camera Support Systems	All support items required at the telescope to operate the Camera Unit, including the camera chiller, pipes.

2 SST Telescope 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. It currently envisages the construction and installation of 42 SSTs (30 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 2-1 reports the main properties of the Small-Sized telescope (SST).

Table 2-1: 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

More details about the SST Telescope design are described in [RD1], [RD2], [RD3]].

3 Overview of the SST Control System

The SST Control system baseline design is based on the CTAO System Control Concept [AD2]. Here we give a brief summary of [AD2] in order to insert the SST control system in the context.

Figure 1Figure 1 shows the main CTAO Site central controllers, the Array Control and Data Acquisition (ACADA) and the Integrated Protection System (IPS) [AD1], and their iterations with the main CTAO Array Elements. ACADA is the central highly reliable and fault-tolerant SCADA system of the controllable instrumentation, provided for each site of the observatory. IPS is an independent system, implemented as integration of industrial solutions, dedicated to the protection of site assets. The IPS deals with all hardware, software and communication devices needed to ensure the safety and security of every observation site,

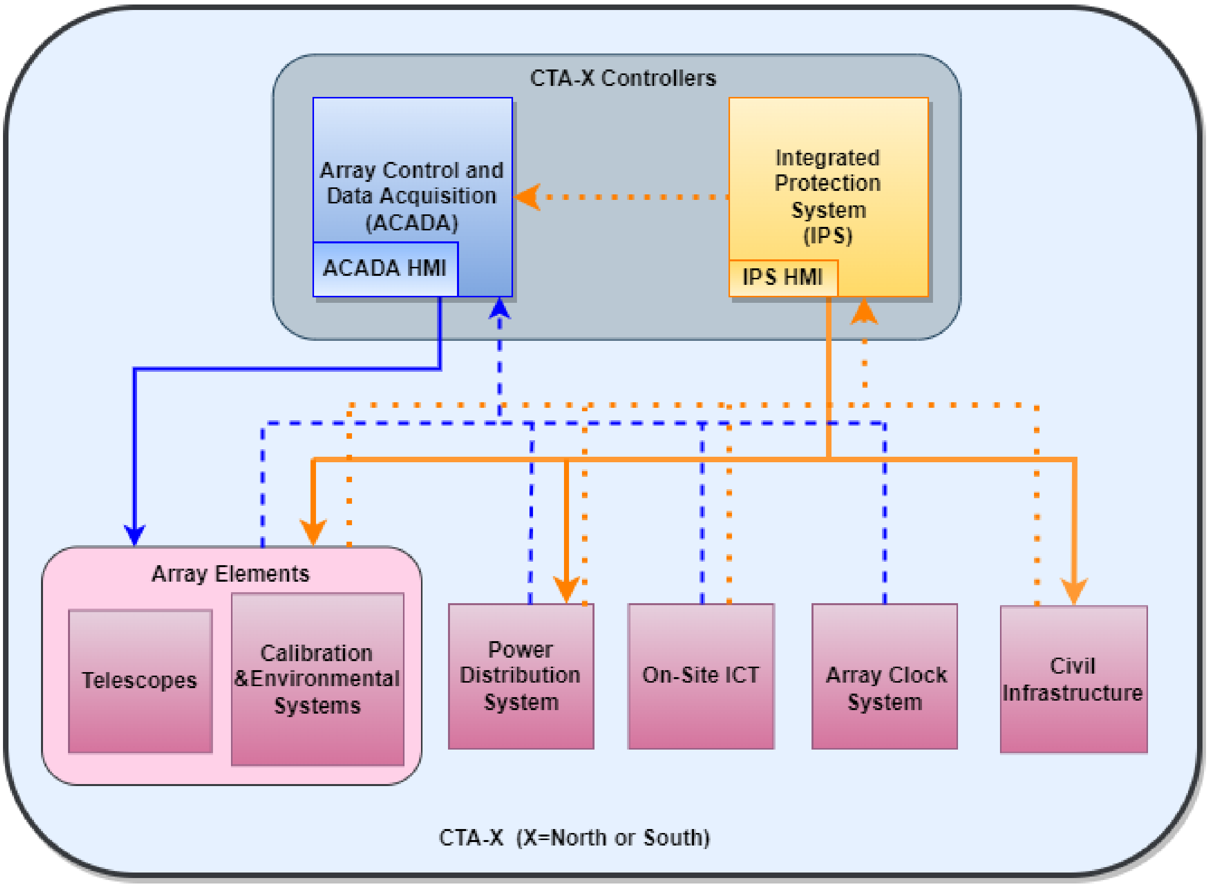
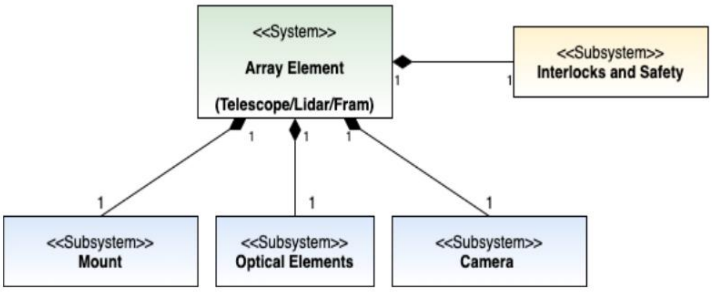


Figure 1. Main functional blocks of CTAO-South control systems [AD2].

In this context each SST is an Array Elements. The SST control system shall be developed following the CTAO System Control development Guidelines [AD3], its design and functionalities shall be compliant with the CTAO System Control Concept [AD2] and its implementation shall be compliant with the CTAO System Control Standards [AD4].

The SST Control system shall follow the technical and control architectural hierarchy illustrated in the following figure extracted from [AD2].



The Mount subsystem includes the hardware and software responsible of at least of the pointing of the SST to different parts of the sky.

The Optical Elements subsystem includes the hardware, software, and communication devices responsible for the light signal collection and delivery to the Camera.

The Camera subsystem includes the hardware, software, and communication devices responsible for the light detection, signal conditioning and readout.
The hierarchical levels of the SST Control systems are represented in the following figure [AD2].

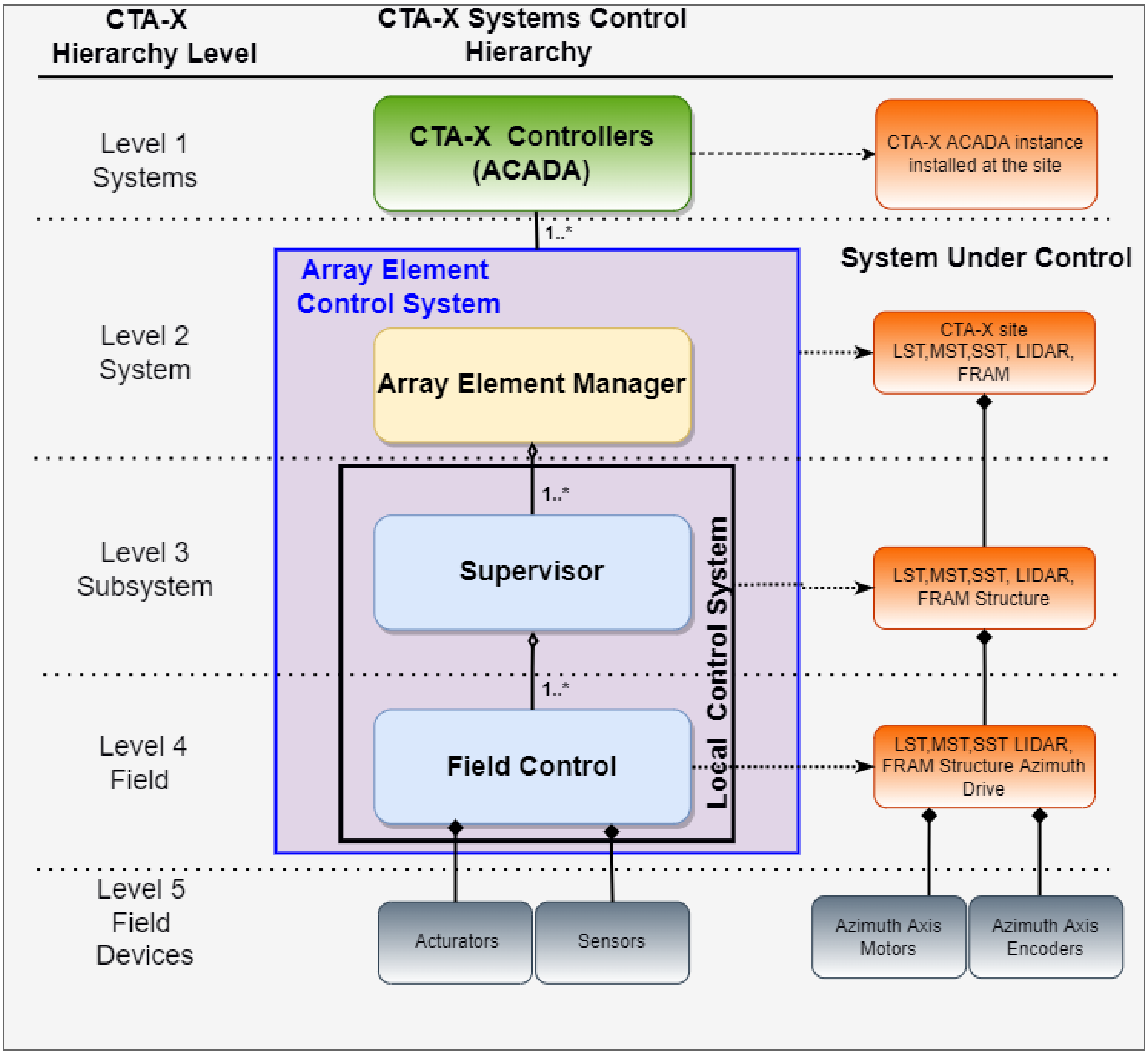
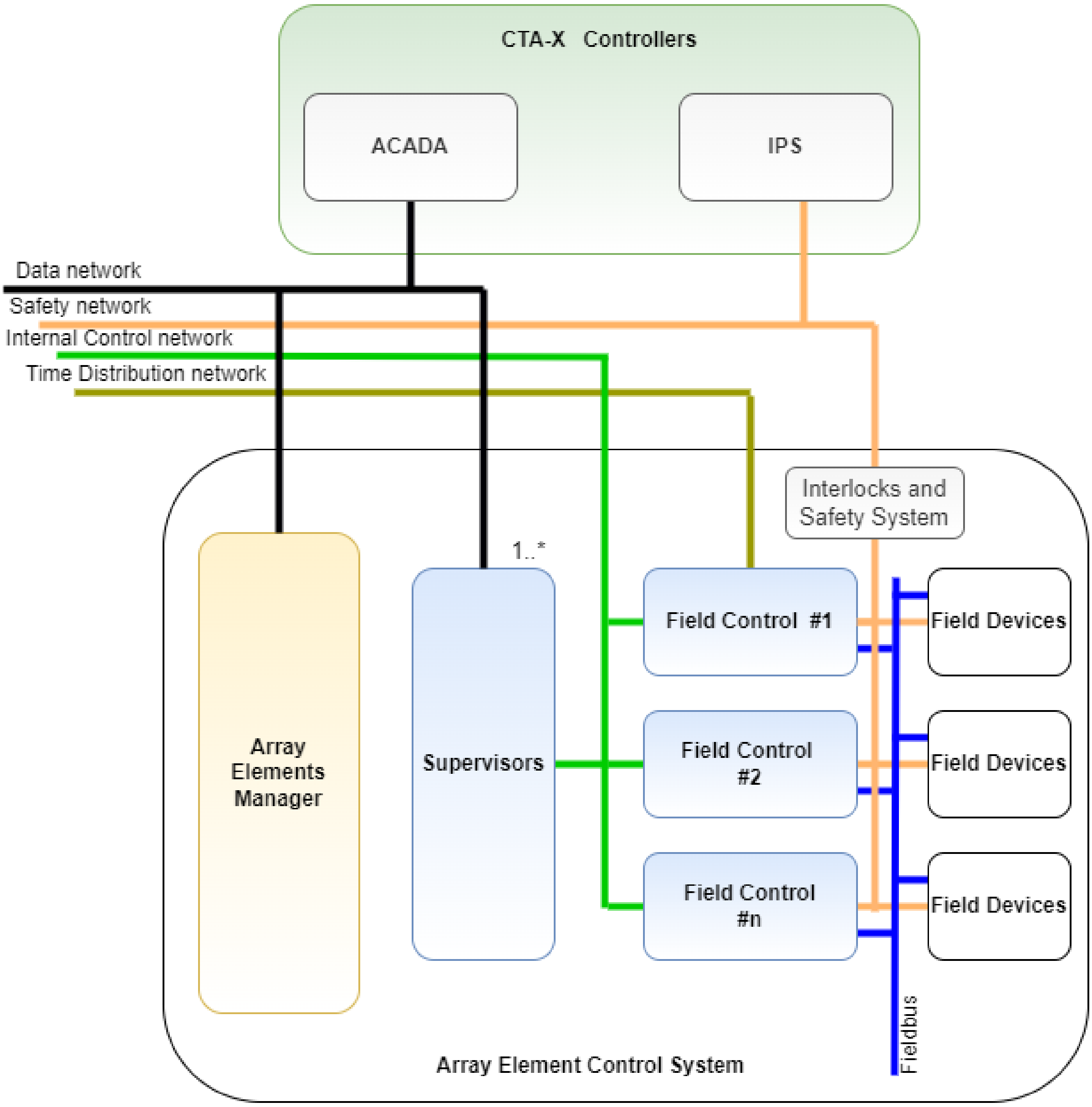


Figure 2. The CTAO-South control systems hierarchy for the controllable items [AD2].

The internal and external Communication interfaces of the SST Control system are summarized in the following figure.

Figure 3. General layout of the CTAO-South site Array Element Control Systems internal/external communication interfaces [AD2] .



The field electronics (the hardware components interfacing with sensors and actuators) should be installed in the SST areas, while Field controller, the Supervisors can be installed in the Array SST areas or in the CTAO On-Site Data Centre.

3.1 The SST Telescope Control System (TCS)

The SST Telescope Control System is described in dedicated Documents **Error! Reference source not found.** here we summarize the general functions and design.

The TCS is responsible for coordinating all telescope assemblies, starting up, configure and shutting down the assemblies of the Telescope thrown the interface with the Local Control system supervisors of the mount, optics, and camera.

From a higher-level point of view, the SST TCS is controlled by the ACADA system based on well-defined software interfaces [RD6]. The TCS includes a Telescope Engineering HMI to operate the SST Telescope in standalone mode during installation, calibration, and maintenance activities. This HMI can be accessed remotely as well. The main blocks of the TCS (managers) are illustrated in the following figure together with the main SST Local Controls systems. The Figure 4 shows the hierarchy of the logical blocks of the TCS.

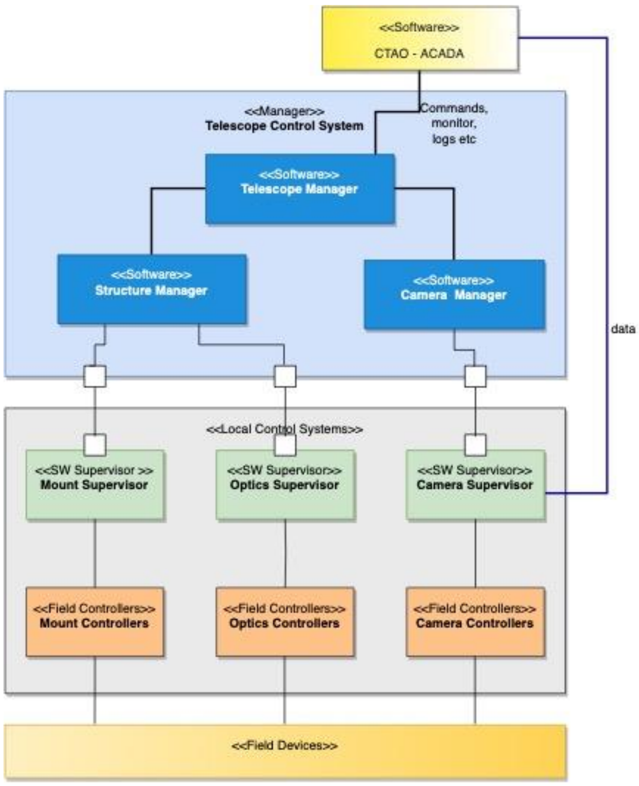


Figure 4. Logical blocks of the TCS and its interface with ACADA and SST Local Control System.

The TCS and the Local Control System Supervisors are implemented and delivered to CTAO by the SST Team.

4 SST Local Control Systems Architecture

SST Telescope includes several Local control Systems [AD2]. Each Local Control System (LCS) consists of supervisors (SW component), field controllers (hereafter Control Unit) and safety units, control software, local communication (Fieldbus) infrastructure required to guarantee functional operation of a given equipment and all the other support elements needed for integration, verification, and maintenance activities. The conceptual architecture of the LCSs above the Field device layer is given in the following figure.

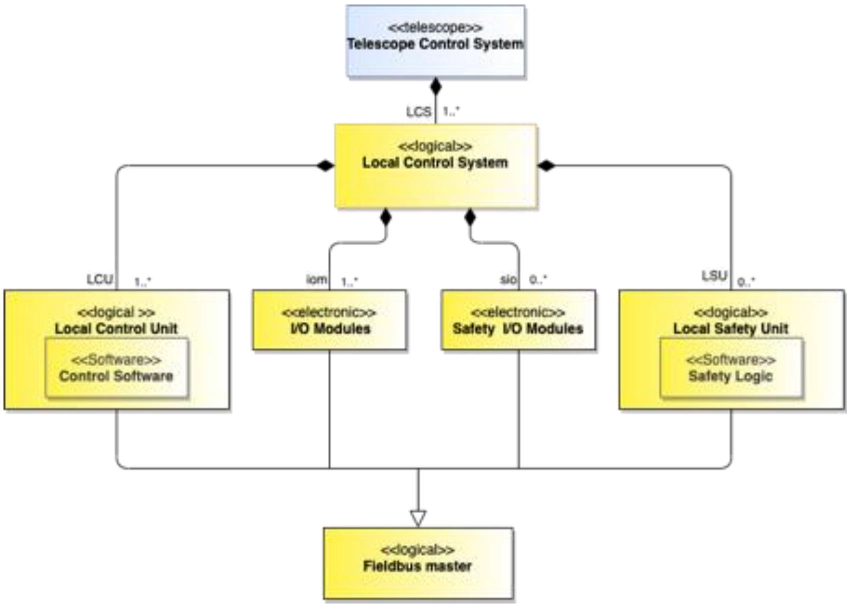


Figure 5. The logical Architecture of the Telescope Local Control Systems.

A Control Unit is a computing unit (PLC, PC-PLC, PC, etc.) in charge of executing the control and monitoring functions related to the associated item (e.g., drive systems, conditioning system, etc.).

A Safety Unit is a computing node in charge of executing the safety-related functions of the associated item.

A Fieldbus is an industrial communication network and protocol system that interfaces control and safety unit(s) to the field devices, that is the components of a control system that are attached or connected to the equipment under control, typically sensors (e.g., switches, encoders, etc.) and actuators (e.g., valves, circuit breakers, motors, etc.).

The SST LCS shall be used standalone for their verification in the development phase and during the AIT/V phase, but their functions shall be coordinated by the Telescope Control System (TCS) **Error! Reference source not found.** .

The TCS coordinates, monitors, and commands the Local Control Systems Supervisors through on the basis of specific interfaces defined in the Interface Description Language implemented in the Alma Common Software. The Supervisors communicates with the Field controllers trough the OPC-UA protocol [RD4] on the basis specific Interface Control Documents.

The following figure shows the SST architecture in which are schematically shown only the main blocks of the SST LCS Controllers and field devices.

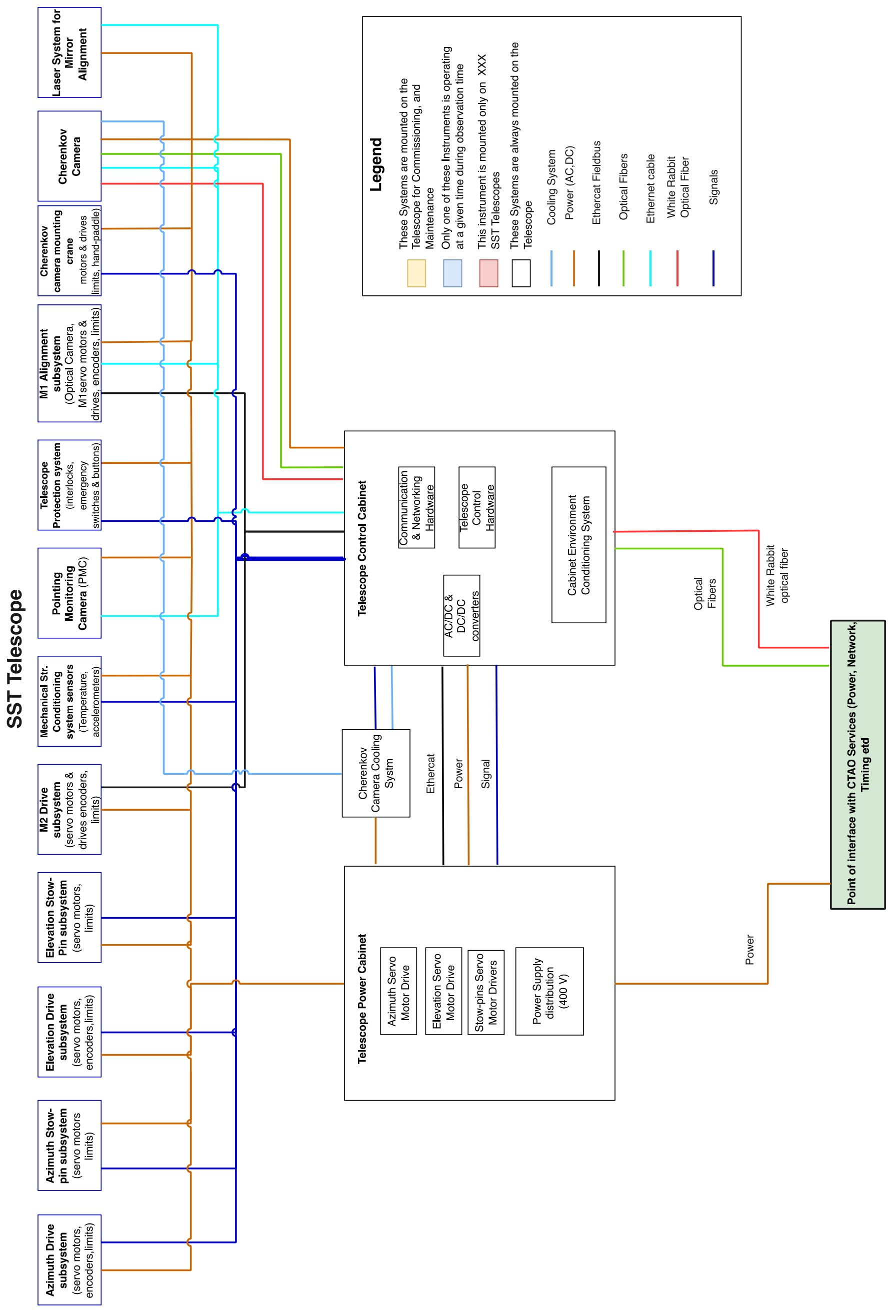


Figure 6. SST subsystems and HW devices interconnections.

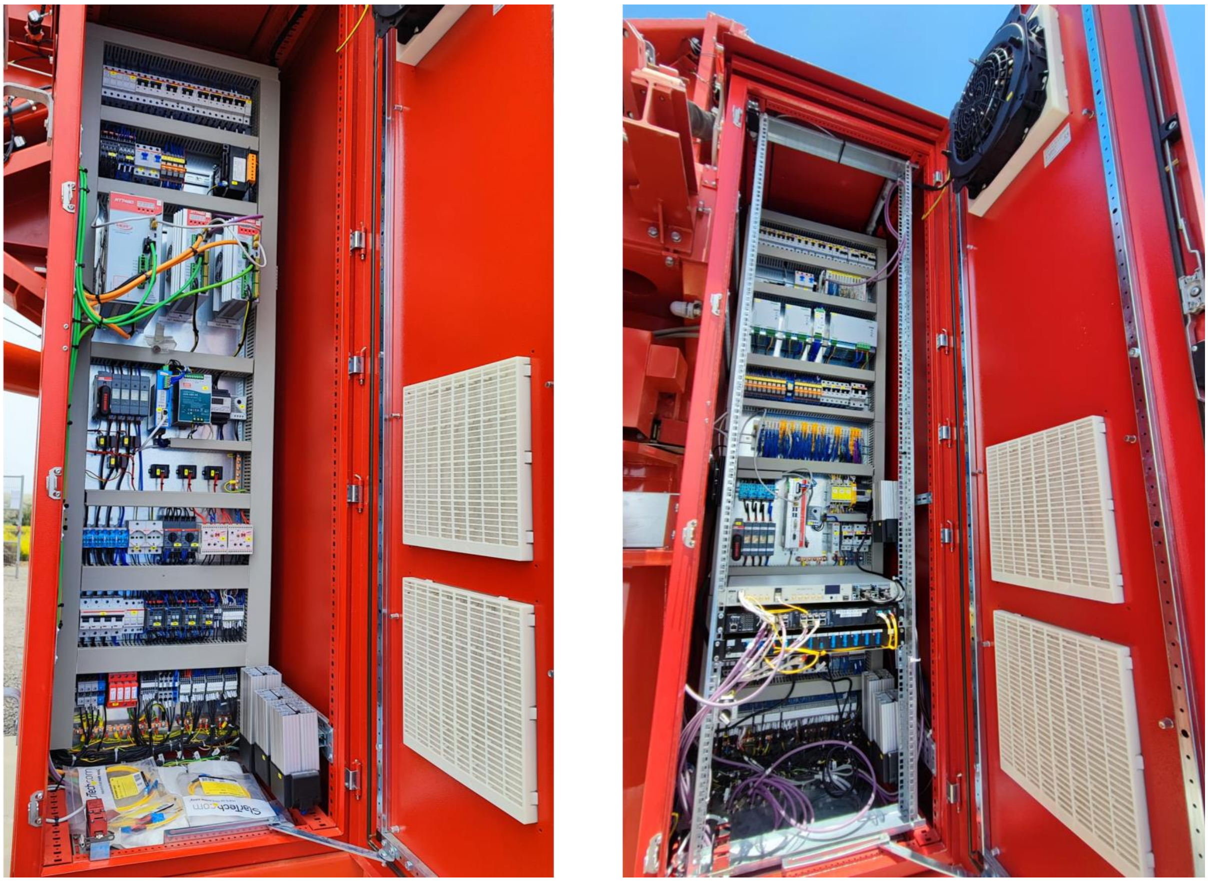


Figure 7. On the left the ASTRI Mini-Array Telescope Power Cabinet and on the right ASTRI Mini-Array Telescope Control Cabinet.

In this document we use the term Mount Local control System to indicate the control Hardware installed on board of the telescope and the Mount local control software running on the Telescope control Unit installed in the Telescope Control Cabinet.

The LCS Mount Supervisors are described in the TCS documentation and are developed by the SST Team.

The applicable documents [AD2], [AD3], [AD4], [AD5] shall be followed for all general topics not covered in this document.

4.1 SST Mount Local Control Systems architecture

Mount Local Control systems include the software and hardware parts needed to safely control the motion of the telescope to any accessible sky position during the commissioning, testing, observing and maintenance operations. The main functions assigned to the Mount Local Control systems are:

1. Control the motion of the telescope both during science and technical operation in position closed (absolute point to point) and open (jogging) loop mode.
2. Monitor the slewing and tracking performances of the telescope.
3. Manage the mechanical structure monitor conditioning system.
4. Monitor and command the power state (on/off) of all telescope subsystems including the Cherenkov camera.
5. Signals errors and alarm conditions to the Supervisors.
6. Execute the command received by the Supervisors.
7. Provide status, logging and data points monitoring information to the Supervisors.
8. Execute, when possible, automatic error recovery procedures.
9. Manage the telescope safety and interlocks chain.

The baseline Mount Interlock and Safety system is not part of this document but it shall be designed and implemented by the contractor starting from the baseline design and the requirement specifications reported in the SST Safety System document [AD6] in compliance with the documents that are to be produced, and the safety standards and approach to be followed described in the CTAO Telescope Safety Design Specification [AD5].

The control hardware configuration of the SST Mount Control system (MCS) is sketched in the Figure 8 below. It consists of several subsystems:

- The Mount Axes Control system
- The Pointing Monitor Camera system
- The Telescope Conditioning monitor system
- The Telescope Power managements system
- The Telescope Stow-pin systems

For sake of completeness the Figure 8 also shows the following subsystems:

- The M2 mirror control devices
- The M1 External control cabinet
- The Laser Alignment system

they are logically part of Optics Local Control System, but they share the Control Unit, labelled as Telescope Control Unit (TCU), with the Mount control system, and the:

- Cherenkov camera mounting crane

The presence or not of this last system shall be consolidated in the Final design of the SST Telescope.

It is to note that all but M2 mirror control devices are not permanently mounted on the telescope, they will be mounted during the AIVT/V phases to perform mirror alignments then during maintenance interventions.

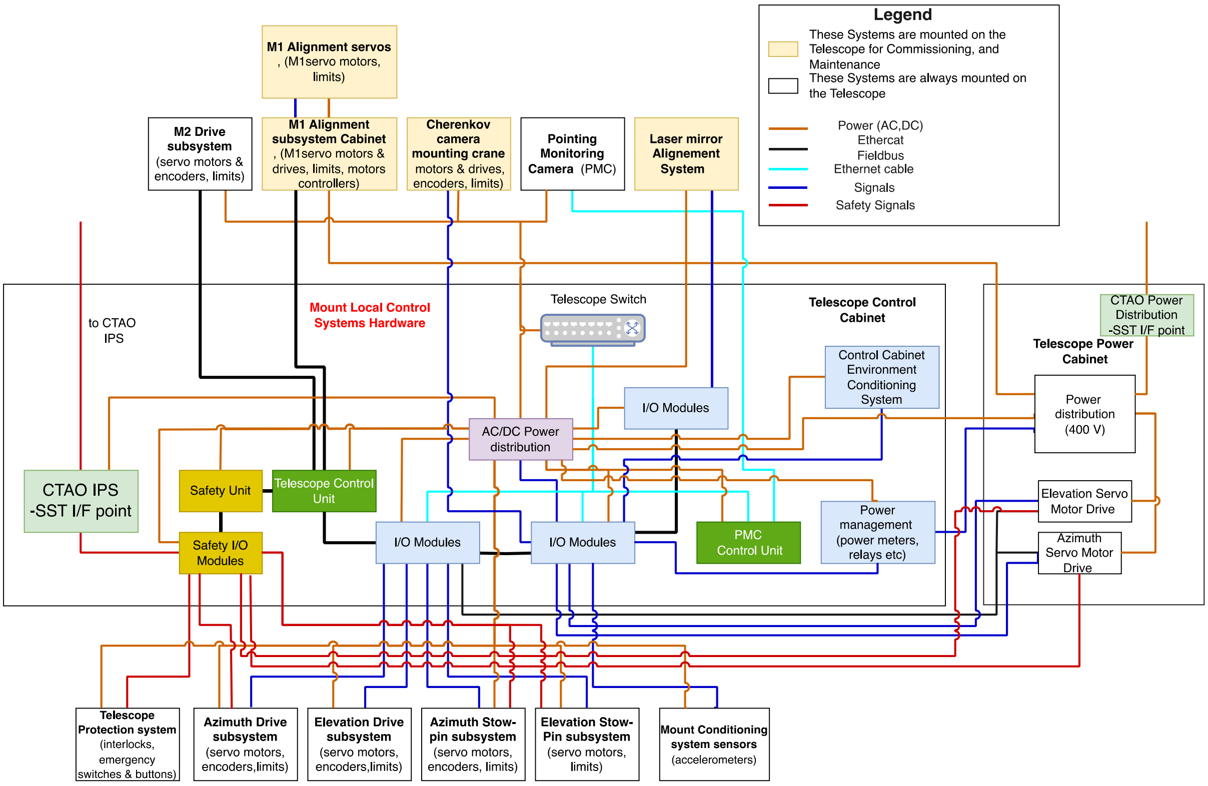


Figure 8. HW architecture of the SST Mount Local Control System.

All HW and SW components of the Mount control systems reported in the above Figure 8shall be part of the deliverables of external supplier/contractors and shall be defined starting from the baseline design reported in this document.

4.1.1 The Mount Axes Control (MAC)

The Mount Axis Control includes the:

- The Azimuth Drive Subsystem
- The Elevation Drive Subsystem

4.1.1.1 Azimuth Drive subsystem

The Azimuth axis includes two servomotors located at 180° relative to each other with reduction stages and transmits motion to the mechanical axis through a pinion mounted coupled to the Azimuth slewing-bearing. Among the two motors there is a difference in the applied torque in order to remote backlash.

The two motors shall be coupled together in a master-slave configuration, controlled in differential torque mode in order to eliminate backlash and hence guarantee good motion accuracy under all operational conditions. The motor drivers shall implement the STO safety functions and be compatible with the EtherCAT fieldbus to be managed by the TCU.

The master motors shall be equipped with a brake. The absolute Azimuth axis encoder shall provide an accuracy < 2” and shall be used to close the position loop of the azimuth axis. The encoder shall be connected to dedicated reading modules connected to the TCU.

4.1.1.2 Elevation Drive subsystem

The Elevation axis motion shall be powered by a servomotor equipped with a brake to provide safe operations and avoid accidents to people and hardware. The motor drivers shall implement STO/SS1 safety functions and be compatible with the EtherCAT fieldbus to be managed by the TCU.

The Elevation axis encoder shall be the Heidenhain RCN2580 absolute encoder, providing an accuracy of ± 2.5”. The encoder shall be connected to dedicated reading modules connected to the TCU.

4.1.2 Pointing Monitoring Camera (PMC)

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 CCD camera that uses the GigE protocol and a system of lenses to assure a FoV of >= 3x2 deg and a pixel sampling of <7 arcsec, a sky coverage wide enough and sampled enough to obtain an astrometric accuracy of 5 arcsec over the full sky. The PMC with its astrometric calibration is also used to implement a telescope-pointing model TPOINT-like with grid pointing directions over all the sky.

The Control Unit of the PMC shall be a Compact PC to which shall be directly connected, via Ethernet (1000 Mb/s) to the CCD Camera. The PMC Control Unit shall use Linux and run the CCD control astrometric software and the OPC-UA server software. The coordination if the activity between the PMC and the Mount Axis Control is performed by the Mount Local Control System Supervisor.

4.1.3 The Telescope Conditioning Monitor System

This system consists of accelerometers and temperature sensors 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.

4.1.4 The Power Management System

This system consists of sensors to monitor power, voltages and currents absorbed by the telescope and the state of all DC power supplies, and several relays to switch-on and off all the telescope subsystems. The output signals of these sensor and the commands to the relays are managed by dedicated I/O modules connected to the Telescope Control Unit.

4.1.5 The Stow-Pins system

The telescope structure is also provided with two stow-pins that keep the telescope in safe (or parked) position when engaged. The Elevation stow-pin guarantees no motion when the telescope is in parked position at the angle of 0°. The Azimuth stow pins guarantees that the Azimuth axis cannot be moved, and the design is like that used for the elevation stow pin. The Stow-pin systems are equipped with switches as defined in [AD5]. The TCU monitors and controls the Stow-pin systems.

4.2 SST Mount Local Control System Interfaces

The Mount Local Control systems controllers (e.g., PLC or PC-based) shall communicate with the Supervisors (see [AD2]) through the OPC-UA protocol based on specific Interface Control Documents defined in Microsoft Excel files.

The excel files in which are reported the baseline ICD between the Mount Field controllers and their supervisors are part of this document.

4.3 The Telescope Control Unit

The Telescope Control Unit shall be a Beckhoff PC C6920-0080 (8 cores TC380).

All the MCS Local Control Software running on the TCU shall be developed using the PLC Structured Text (ST) or Functional Block Diagram (FBD) language, both following the IEC 61131-3 standard, and shall run under Beckhoff TwinCAT 3 (The Windows Control and Automation Technology) runtime environment. TwinCAT 3 is a software system which provides a modular and flexible software framework for the automation field, making available important integrated motion functionalities.

Beckhoff TwinCAT software transforms any compatible PC into a real-time controller with a multi-PLC system, axis control and programming environment. TwinCAT replaces conventional PLCs with embedded IEC 61131-3 software PLC, software for Numerical Control (NC) and software for Computer Numerical Control (CNC) in Windows 11, 10, Windows 7, CE.

It uses the Beckhoff real-time kernel that runs independently from Windows, guaranteeing full operation and control of all the hardware devices connected to the PC, also in case of failure of the Windows operating system.

This system was already tested and currently used on the ASTRI-Horn prototype and ASTRI Mini Array.

4.4 Telescope Coordinate System and Motion Ranges

The Telescope reference frame (TEL Coordinate System), through which the position of the Azimuth and Elevation axes can be retrieved/commanded for engineering and maintenance purposes is described here.

The Horizon coordinate system (SKY Coordinate system), largely used in Astronomy, shall be accepted as input by the MCS software. The MCS Software running on the TCU shall implement the SKY->TEL and TEL->SKY coordinate transformations.

The full clockwise (CW) and counter-clockwise (CCW) motion range of the AZ axis shall be 540 °, from -270° to + 270° starting from the 0° located at the West Point.

To check if the TEL AZ axis has reached its position moving CW or CCW a dedicated “Yoke roller” switch (Lyre) shall be mounted inside the base of the telescope in the West direction (0°). This mechanical zero point of the TEL Coordinate System is defined as the position at which the z-axis of the telescope faces at West and the Lyre is not engaged. The z-axis of the telescope coincides with the symmetry axis of its optical subsystem. This shall be the position at which the cables wrap inside the base is completely unwound.

If the TEL AZ axis, starting from the zero point, rotates in counter-clockwise direction, the positions assume negative values (-90° at South, -180° at East and -270° at North) while if it moves in clockwise direction the positions increase toward positive values (+90° at North, +180° at East, +270° at South).

As soon as the axis starts to rotate, in one direction or another, the cable wrap begins to roll. The security positions for not causing damage are about -271° and 271° in counter-clockwise and clockwise directions respectively. That is, starting from the zero point (West, Lyre not engaged), the axis can perform 270° in the counter-clockwise direction and 540° in clockwise direction, starting from North (-270°).

The TEL Elevation reference system for SST application shall have the zero point at the position where the z-axis of the telescope points to the horizon direction. Going upwards from the origin the values increasing up to reach the Zenith direction (+90°).

The full Telescope elevation motion angles range to avoid mechanical damages shall be from <-1°, to > 91°.

4.5 MCS Software State Machine

The MCS Software running on the TCU shall implement a State machine as that represented in Figure 9.

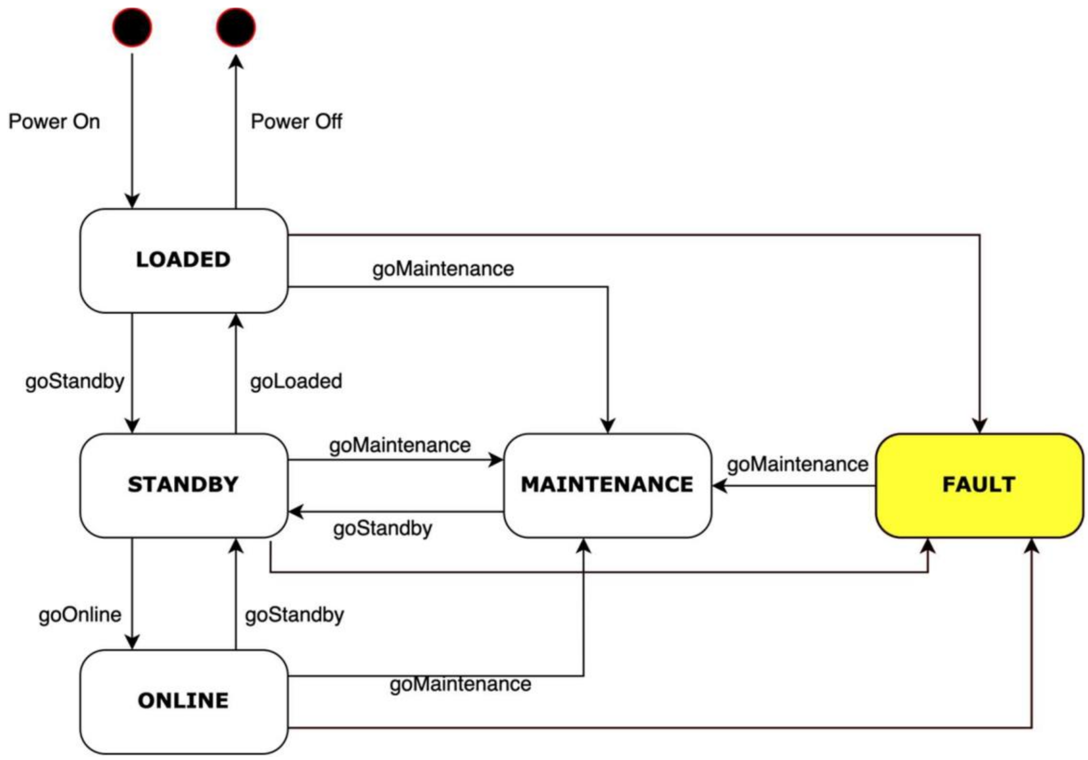


Figure 9. MCS Software State Machine.

Configurations of the states reported in the block diagrams in Figure 9 are reported in more detail below.

OFFLINE: the MCS is powered off. When powering on the Loaded state is reached by default. Before powering off the MCS a PC_SHUTDOWN command shall be issued to shut down the TCU, to allow a shutdown operation of the machine.

LOADED: when MCS is powered on it enters the Loaded state by default. In the Loaded state no movement is allowed, brakes are engaged, motor drives are disabled.

STANDBY: This state is characterized by having the telescope parked, i.e., both axes in parking position (telescope pointed at South in azimuth and to the horizon in elevation), brakes engaged, and motor drives disabled. If these conditions are not verified when entering this state, then the parking procedure is started. The state is fully active when parking procedure is ended.
In Standby state the telescope can move but only to perform parking. No other commands other than state transitions can be performed.

ONLINE: In this state are possible the *Track*, *Slew* and *Move To* commands to observe the target.
This state is reachable only from the Standby state. The Standby state is the only exit state and

can be reached via command GO_STANDBY.

MAINTENANCE: In this state it is possible to perform all commands if the status of the MCS allows the execution. For example, it is not possible to move an axis if brakes are engaged or locking pins are inserted or the motor drive is disabled. A warning/error shall be is issued if a command cannot be performed due to the status of the MCS.

5 MCS Requirements

The design and implementation of the MCS shall comply with the guidelines provided in this Subsection.

Requirement ID	Requirement Name	Requirement Statement	Requirement Source	Verification Requirement
E-SST-MCS-0201	Power Management & Cabinet Conditioning system	The MCS shall implement the Power Management and Telescope Cabinet Conditioning System (mainly consisting of resistors, fans, humidity, and temperature sensors, etc.)	-	T
E-SST-MCS-0202	Power Monitor and Control	The MCS shall control (switch-on/off) and monitor the status of all the power supplies inside the telescope (24V, 400V, 220V, etc.).	-	T
E-SST-MCS-0203	Main Power status and Consumptions	The MCS shall monitor the voltage, current and power consumption of the main electrical components of the whole telescope system.	-	T
E-SST-MCS-0204	Cabinets and base temperature and humidity control	The MCS shall monitor the humidity, the temperature condition inside the telescope power and control cabinet and inside the Telescope base structure.	-	T
E-SST-MCS-0290	Accelerometers reading	The MCS shall manage the Telescope condition monitor system including the readings of the accelerometers mounted on the telescope axis drive systems.	-	T

E-SST-MCS-0205	Safety	The MCS shall monitor the status of interlocks managed by the Safety PLC.	-	T
E-SST-MCS-0206	Mount Axes Control	The MCS shall implement Mount Axes Control (MAC) to monitor and control the Azimuth and Elevation axes motion for pointing and tracking operations	-	T
E-SST-MCS-0207	Mount control software	The MCS 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.	-	T
E-SST-MCS-0208	Astrometry	The MCS software shall implement an astrometric module, running on the TCU, which performs all the astrometric routines needed to perform pointing and tracking operations.	-	T
E-SST-MCS-0209	MCS/Supervisor interface	The MCS shall interface with the Supervisor making use the OPC-UA protocol.	-	T
E-SST-MCS-0210	MCS/Supervisor Interface: monitoring, configurations, commands	The MCS shall expose as OPC-UA nodes all monitoring, configuration and commands variables. as reported in the annex 1 (SST_MCS_Supervisor_ICD.lsx file).	-	T

E-SST-MCS-6002	MCS monitoring of the Axes Encoders	The MCS shall monitor the status and read the absolute encoders mounted on the Azimuth and Elevation mechanical axes.	-	T
E-SST-MCS-6003	MCS monitor, configuration and command of the Drives and Motors.	The MCS shall monitor the status, configure and command the - AZ and EL drive systems (servo motors and drivers)	-	T
E-SST-MCS-8008	Telescope parking	The MCS software shall implement commands to park the Telescope at South point with elevation EL=0°.	-	T
E-SST-MCS-8010	Error handling	The MCS software shall implement errors handling and failure recovery procedures.	-	T
E-SST-MCS-8011	MCS Axes motion	The MCS shall allow to select the following Azimuth and Elevation axes motion modes: - Point-To-Point (slewing) - Jog - Tracking	-	A, T
E-SST-MCS-8012	Set-up parameters access	The MCS software shall allow to set-up parameters for the motion calibration and engineering purposes via OPC-UA.	-	T

E-SST-MCS-8013	Handle-paddle motion	The MCS shall allow the use of an hand paddle for local use of the telescope in compliance with the safety requirements reported in [AD5].	-	R, T
E-SST-MCS-8014	Autostow	The MCS shall allow to configure the time period after which to automatically put the telescope in parking position in case of inactivity or lose of communication with the Supervisor.		T

6 MCS Software Development and Software Interface requirements

Requirement ID	Requirement Name	Requirement Statement	Requirement Source	Verification Requirement
	MCS Software languages.	The MCS software shall be developed using the PLC IEC 61131-3 ST and FB languages.		A,T
E-SST-MCS-0302	MCS Control Unit network connection	The TCU shall be connected to the Telescope network switch, which is placed in the SST Telescope Control Cabinet (TCC).	-	A,I,T
E-SST-MCS-1001	MCS Software development	The MCS software shall be developed using the Beckhoff TwinCAT Engineering Tools following the guidelines given in the [AD3]	-	A,T
E-SST-MCS-1001	MCS Software Simulator	The MCS software shall include a full simulator developed using Beckhoff TwinCAT Engineering Tools. The simulator shall be accessible via OPC-UA and shall expose the full set of OPC-UA nodes as in operation.	-	T

E-SST-MCS-1002	MCS execution environment	The MCS software shall run under the Beckhoff TwinCAT Run-Time environment installed on the TCU.	-	R, T

End of the document