SST Programme: Telescope Technical Requirements Specification

SST-PRO-SPE-001

Version 1b

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Current Release				
Ver.	Created	Comment	Distribution	Editor(s)
1b	08/11/2022	Document for the Product Review	SST Team, CTAO	A. Trois, SE Team

Version History				
Ver.	Created	Comment	Distribution	Editor(s)
1bD	10/05/2022	Final Draft for the PR	SST Team	Trois, SE Team
1.1bD	20/05/2022	Editorial corrections	SST Team	Trois, SE Team
1b	08/11/2022	Editorial corrections	SST Team	Trois, SE Team

Table of Contents

List of Figures

1 Introduction

1.1 Scope & Purpose

The SST Telescope Technical Requirements Specification plan the functional and performance requirement for the design, development, verification and delivery of the SST Telescopes, provided as SST Consortium to CTAO. The SST Telescope requirements collected in this specification are classified as SST Level C requirements. They are:

- derived by transposition or decomposition from the CTAO JAMA level requirements from;
- derived by ICDs documents.

This document is the source of level D requirements, which are collected in the set of SST Sub-System specifications.

1.2 Content

This document is organised as follows:

Chapter	Content
1	Introduction
2	System Overview
3	Telescope Requirements Tree
4	General
5	Environmental
6	Functional
7	Performance
8	Design
9	Interfaces
Annex A	Compliance Matrix

1.3 Applicable Documents

[AD1] CTA Architecture Document v1.0 14.04.2018

[AD2] SST Requirements - V1, JAMA REF: SET KEY: PROD_SST; GLOBAL ID: CTA-160212; ID: CTA_-SET-54

[AD3] Common Telescope Requirements - V1, JAMA REF: SET KEY: PROD_TEL; GLOBAL ID: CTA-200234; ID: CTA_-SET-67

[AD4] Common On-Site Requirements - V1, JAMA REF: SET KEY: PROD_ONSITE; GLOBAL ID: CTA-200443; ID: CTA_-SET-68

[AD5] Environmental Requirements - V1, JAMA REF: SET KEY: PROD_ENV; GLOBAL ID: CTA-200109; ID: CTA_-SET-66

[AD6] SST-PRO-DSR-002 - SST Telescope Architecture and Design Report

[AD7] CTA-ICD-SEI-000000-0002_2h - Generic Telescope Control

[AD8] CTA-SPE-TEL-000000-0001 ICD

[AD9] CTA-ICD-ACA-303000-0001-1a - Telescope Camera Event and Trigger Data ICD

[AD10] CTA-ICD-SEI-000000-0016_DRAFT - ICD between the CTAO-SOUTH Power Distribution System and Small Sized Telescopes

[AD11] Spatial Coordinate Reference Systems

[AD12] CTA-STD-OSO-000000-0001 - Software Programming Standards

[AD13] CTA-TRE-SEI-000000-0016-Draft 04 - CTAO System Control Concept

[AD14] CTA-STD-SEI-000000-0004-1a-DRAFT02 - CTAO System Control Standards

[AD15] CTA-TRE-SEI-000000-0017-1a-Draft 05 - CTAO System Control Development Guidelines

[AD16] CTA-ICD-SEI-000000-0004-1b - Array Element Monitoring

[AD17] CTA-ICD-SEI-000000-0005 - Array Element Logging ICD

1.4 Reference Documents

[RD1] CTA Top-level Data Model Specification (CTA-SPE-OSO-000000-0001)

[RD2] R1/Event Data Model Specification (CTA-SPE-COM-000000-0002)

[RD3] ASTRI Technical Design Report - MAN-PO/140530

[RD4] SST Optical Design - (SST-OPT-DSR-001)

[RD5] CTA-TRE-COM-303000-0001 2g ACADA Architecture Design

[RD6] CTA-TRE-COM-003000-0001 3b ACADA Use Cases

[RD7] CTA-SPE-COM-303000-0001 2i Requirement Specification for ACADA

[RD8] CTA-INS-SEI-000000-0004_2b Guidelines to the Requirements Specification Template

1.5 General Specification and Standard Documents

[SD1] Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on Machinery, and amending Directive 95/16/EC

[SD2] MILITARY HANDBOOK: ELECTRONIC RELIABILITY DESIGN HANDBOOK - MIL-HDBK-338B

[SD3] MILITARY HANDBOOK: RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT- MIL-HDBK-217F

[SD4] Basis of Structural Design - EN Eurocode 0

[SD5] Steel – Design of Steel Structures – All parts - EN Eurocode 3

[SD6] Design of Composite Steel and Concrete Structures – All parts - EN Eurocode 4

[SD7] Design of Aluminium Structures – All parts - EN Eurocode 9

[SD8] Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements - EN 61010-1

[SD9] Safety of machinery, Functional safety of safety-related electrical, electronic and programmable electronic control systems - EN 62061,

[SD10] Safety of machinery -- Safety-related parts of control systems -- Part 1: General principles for design - EN ISO 13849-1

[SD11] Safety of Machinery – Emergency Stop – Principles for design - EN ISO 13850

[SD12] Low-voltage electrical installations - EN 60364 series

[SD13] Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors, 2010 - EN 60445,

[SD14] Insulation coordination for equipment within low-voltage systems - EN 60664 series,

[SD15] Reliability Modelling and Prediction reference - MIL-STD-756B

[SD16] System Safety - MIL-STD-882E

[SD17] Procedures for performing a Failure Mode, Effects and Criticality Analysis reference - MIL-STD-1629A

[SD18] EMC Directive 2004/108/EC

[SD19] Electromagnetic Compatibility (EMC) - EN 61000 series

[SD20] Functional Safety and IEC 61508, Functional safety of electrical/electronic/programmable electronic safety-related systems

[SD21] IEC 61131-3, Programmable controllers - Part 3: Programming languages

[SD22] Lightning protection standard - EN 62305:2011

[SD23] Cleanrooms and associated controlled environments — Part 1 - ISO 14644-1:2015

[SD24] ECSS-Q-ST-80C Rev.1 (15 February 2017)

[SD25] CTA-STD-OSO-000000-0002 1h CTA SW Licensing Policy

[SD26] CTA-SPE-OSO-000000-0001 1b Top-level Data Model

[SD27] CTA-SPE-COM-000000-0002 1e R1-Event Data Model

[SD28] CTA-STD-OSO-000000-0001 1a Software Programming Standards

1.6 Definition of Terms and Abbreviations

ACADA	Array Control and Data Acquisition System
AIT	Assembly Integration and Testing
AIV	Assembly Integration and Verification
ASTRI	Astrophysics with Italian Replicating Technology Mirrors
BKO	Bridging phase Kick-Off
CU	Camera Unit
CDR	Critical Design Review
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
FAR	Final Acceptance Review
FRC	France Contribution
DR	Delivery Review
DVER	Design Verification Engineering Review
ERIC	European Research Infrastructure Consortium
ESC	Executive Steering Committee
HW	Hardware
IACT	Imaging Atmospheric Cherenkov telescope
ICD	Interface Control Document
IKC	In Kind Contribution
INAF	Istituto Nazionale di Astrofisica
INSU	Institut National des Science de l'Univers
LCS	Local Control System
LCSS	Local Control System Software
LST	Large Size Telescope
KO	Kick-Off
MPIK	Max-Planck-Institut für Kernphysik
MST	Medium Size Telescope
OP	Observatoire de Paris
OS	Optical System
PA	Product Assurance
PBS	Product Breakdown Structure
PM	Project Manage
PR	Product Review
PMP	Programme Management Plan
PO	Project Office
PQR	Production Qualification Review
PR	Product Review
PRM	Programme Manager
PRR	Production Readiness Review
PSE	Programme System Engineer

QA	Quality Assurance
QM	Quality Manager
RAMS	Reliability, Availability, Maintainability & Safety
SE	System Engineer
SST	Small Size Telescope
SST-CAM	SST Camera
SST-MEC	SST Mechanical
SST-OPT	SST Optics
SST-STR	SST Structure
SST-TCS	SST Telescope Control Subsystem
TBC	To Be Confirmed
TBD	To Be Decided
TCS	Telescope Control System
TMS	Telescope Mechanical Structure
TRR	Test Readiness Review
VHE	Very High Energy
WBS	Work Breakdown Structure
WP	Work Package
WPD	Work Package Description

1.6.1 Glossary

1.6.1.1 General Project Management

TERM	DEFINITION
"As Built" Configuration	The as-built configuration or applied configuration is defining the as-built status per each serial number of Configuration Item (CI) subject to formal acceptance.
"As Designed" Configuration	The as-designed configuration or Applicable configuration is defining the current design status of a Configuration Item (CI)
AIV	AIV is the Assembly Integration and Verification, which is referred to the integration activities related with the verification of the system or sub-system. In the framework of SST for briefness this term includes also the Assembly Integration and Testing which is related with the integration activities and testing to be performed during the integration at system and subsystem levels
Baseline	Set of information which describes exhaustively a situation at a given instant of time or over a given time interval.
Change	Vehicle for proposing modifications to an approved baselined data or the business agreement.
Configuration	Functional or physical Characteristics of a product defined in configuration definition documents subject to configuration baseline.
Configuration Item	Aggregation of hardware, software, processed materials, services or any of its discrete portions, that is designated for configuration management and treated as a single entity in the configuration management process. **NOTE:** A configuration item can contain other lower-level configuration item(s).
Deviation	Written authorization to depart from the originally specified requirements for a product prior to its production.
Firmware	Firmware is software programmed onto an electronic device which is treated like a pure hardware.
Hardware	Hardware is a single or an assembly of physical electronic devices which cannot be changed in its user environment.
Item	Any part, component device, sub-unit, unit, equipment or device that can be individually considered.
Model	Physical or abstract representation of relevant aspects of an item or process that is put forward as a basis for calculations, predictions or further assessment useful for the preparation of SST production
Partners	are those entities taking responsibility for IKC delivery by signing IKC agreements with CTAO, plus any organisation identified by these signing entities as playing an essential role in SST delivery. The institutes are the partners of the CTA-SST consortium.
Product	A product (hardware, software, service) required in the frame of the program and included as element of the product tree having a unique identifier. A product may be deliverable or not.
Product Breakdown Structure	Hierarchical structure depicting the product orientated breakdown of the project into successive levels of detail down to the configuration items necessary to deliver the required functions. The Product Breakdown Structure (PBS) in general is influenced by Institutes/partners decisions to group certain products or by program history. It identifies products and their interfaces; it serves as the basis for the WBS
Service	Service is the result of at least one activity necessarily performed at the interface between the SST consortium and CTA and is generally intangible.
Software	Set of computer programs, procedures, documentation and their associated data.
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.

1.6.1.2 CTA Constituents

TERM	DEFINITION
CTAO	The Cherenkov Telescope Array Observatory, an international user facility distributed over four primary sites: a Headquarters, Science Data Management Centre, and two array-sites in the northern and southern hemispheres: CTA-N and CTA-S.
CTA North	CTA Observation site hosting an Array of Cherenkov Telescopes, in the Northern Hemisphere. The selected CTA North site is Observatorio del Roque de los Muchachos (ORM), La Palma, Spain. CTA North may be abbreviated as CTA-N.
CTA South	CTA Observation site hosting an Array of Cherenkov Telescopes, in the Southern Hemisphere. The selected CTA South site is lies between the locations of the Paranal and Armazones ESO telescope sites in Chile. CTA South may be abbreviated as CTA-S.

TERM	DEFINITION
Headquarters	The primary centre for CTAO governance, administration and management. The selected site for the CTA Headquarters (HQ) is Bologna, Italy.
Science Data Management Centre (SDMC)	The primary centre for the management of CTA data products and science user support including proposal handling. The selected site for the CTA Science Data Management Centre (SDMC) is Zeuthen, Germany.
Array Site	One of the two observation sites, CTA-N or CTA-S.
System	The word system is used at multiple levels in the CTAO hierarchy to refer to an element implemented in hardware or software or both that performs a function or functions identified in the design of CTAO. CTAO is therefore a System of Systems.
Array	All of the Cherenkov Telescopes at one of the Observatory Sites.
Sub-array	A sub-set of the Cherenkov Telescopes at one of the Array Sites. May be qualified by a Cherenkov Telescope type (LST, MST, SST) to denote the sub-set of all telescopes of that type on a given site.
Array Element	A system deployed on an Array Site which is needed for the scientific operation of CTA and which is interfaced to the OES and SAS systems. Array Elements (and in cases of enough complexity, such as that of a Cherenkov Telescope, also their sub-systems) are required to implement well-defined common States. An Array Element consists of one or more Controllable Systems and may also include Sensors, plus a software system to manage these elements.
Cherenkov Telescope	A system composed of a Cherenkov Camera and Telescope Structure which is used to collect and image Cherenkov light from Air Showers.
Telescope Structure	All of the hardware and software associated to a single optical telescope capable of pointing to different parts of the sky and collecting light on to a Cherenkov Camera. A Telescope Structure forms part of a Cherenkov Telescope System. Telescope Structure may be abbreviated as 'Structure'.
Cherenkov Camera	All of the hardware and software associated with Cherenkov image detection, digitisation, transmission and pre-processing. A Cherenkov Camera forms part of a Cherenkov Telescope System and has as its principal elements a Camera Unit and software deployed on a Camera Server. Cherenkov Camera may be abbreviated as 'Camera'.
Camera Unit	The part of a Cherenkov Camera that can be mounted and unmounted from a Telescope Structure and tested in the Camera Test Facility at a CTA Array Site.
Controllable System	A system on an Array Site consisting of hardware elements, a Local Control System (LCS) at the location of the hardware, and a software component (the LCS Controller) running on the on-site data centre. Controllable Systems implement standard interfaces to the ACADA and/or SAS systems and are integrated in to Array Elements to science operations, but independently controllable for engineering purposes / technical operations.
Sensors	A data collecting instrument plus an associated software component which delivers information to the OES or SAS via a standard interface.
Interface Cabinet	A permanent installation close to each Cherenkov Telescope, or other Array Element with comparable needs, which serves as the main interface point for power and network between a Telescope and central services as well as supporting local maintenance and engineering work and interfacing local to array-level safety systems. The Interface Cabinets at an Array Site form part of the on-site Infrastructure.
Large Sized Telescope (LST)	A type of Cherenkov Telescope present on both CTA array sites with focus on the low energy range of CTA.
Medium Sized Telescope (MST)	A type of Cherenkov Telescope present on both CTA array sites with focus on the medium energy range of CTA.
Small Sized Telescope (SST)	A type of Cherenkov Telescope present on the Southern CTA array site with focus on the high energy range of CTA.
Camera Test Facility (CTF)	Facility installed at one of the CTA Array Sites that can be used for a detailed evaluation of the performance of a Camera Unit of any of the types present on a given Array Site.
Observation Execution System (OES)	A software system responsible for the control and monitoring of telescopes and auxiliary (non-telescope) instruments at a CTA site, for the efficient scheduling and execution of pre-scheduled observations and those triggered dynamically, for the monitoring of the system performance, for the data acquisition and volume reduction as well as the automatic generation of science alerts.
Data Processing and Preservation System (DPPS)	A software system responsible for producing the science data products given to Science Users; including therefore the production and analysis of simulation data, (re)processing and the long-term preservation of data products and related information that will facilitate reproducibility as well as their transfer from the array sites.
Science User Support System (SUSS)	A software system providing the main point of access for proposal submission and to high-level CTA data products and corresponding sets of CTA tools to support data analysis. Provides means for proposal evaluation, for generation of the long-term schedule and for user support. Also includes outreach services.
Operations Support System (OSS)	A collection of software systems supporting CTA operations. Includes configuration management, issue tracking, maintenance planning, authentication and authorisation systems.
Safety and Alarm System (SAS)	The hardware and software system for monitoring and control of the primary safety-relevant aspects (incl. interlocks) of the Telescopes and Infrastructure elements at a CTA array site. Includes an integrated alarm system.

TERM	DEFINITION
Management and Administration System (MAS)	A collection of software systems associated with the administration of CTA. Includes procurement, logistics, human resources management, and systems supporting the generation of performance/status reports for external stakeholders.
Array Common Elements (ACE)	Array Elements, Controllable Systems and/or Sensors that are located at one of the array sites for the purposes of supporting centrally co-ordinated calibration and environmental monitoring activities.
Central Computer Time Synchronisation System	Centrally provided NTP-based timing System designed to provide timing information for the purposes of general activities such as logging.
Central Precision Time Synchronisation System	Centrally provided WR-based Timing Distribution System designed to keep clocks in sync to sub-ns precision for Cherenkov Event Timing purposes.

1.6.1.2.1 SST Constituents

TERM	DEFINITION
Contractor	Industry involved in the SST Programme which has a contract with an institute
Executive Steering Committee	The SST Executive Steering Committee (ESC) is the high-level decision-making body which will manage the strategic direction of the Programme and will be in charge of overseeing progress and facilitating global collaboration among the participating groups.
Institutes	Research Institutes involved in the SST Programme.
Interface Cabinet *	A permanent installation close to each Cherenkov Telescope, or other Array Element with comparable needs, which serves as the main interface point for power and network between a Telescope and central services as well as supporting local maintenance and engineering work and interfacing local to array-level safety systems. The Interface Cabinets at an Array Site form part of the on-site Infrastructure.
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-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-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.
(Telescope) Structure	All of the hardware and software associated to a single telescope capable of pointing to different parts of the sky and collecting light. A Telescope Structure forms part of a Cherenkov Telescope System. Telescope Structure may be abbreviated as 'Structure'.

1.6.1.3 States and Modes

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TERM	DEFINITION
State	A State represents a situation where some invariant conditions hold; this condition can be static (waiting for an event) or dynamic (performing a set of activities). The behaviour of a system can be described through its state at different points in time. When a system is in a given state, it can perform different actions or do a transition to another state so that other actions can be performed
Sub-state	A state within another state, where transitions can be managed and triggered internally by the system according to external conditions (e.g., available time inside the current state).
Transition	A Transition defines the logical movement from one State to another.
Mode	The condition of a system or subsystem in a certain state when specific capabilities (or functions) are valid.
Local Mode	Mode of operation of a field-deployed Controllable System activated and deactivated by a person physically present at the location of the system. Whilst in Local Mode the remote execution of all actions that could endanger the safety of a local person is prevented. Local Mode supports engineering and maintenance activities.
Remote Mode	Mode of operation of a Controllable System to allow control by a person not present at the location of the system. Whilst in Remote mode all actions, even those that could endanger the safety of a person present at the system location, are allowed. Remote mode supports observatory science operation mode and system/array-level technical operations mode.
Science Operations Mode	Mode of operation of the Telescope suitable for Science Observations.
Technical Operations Mode	Mode of operation of the Telescope suitable for maintenance and engineering activities, with basic monitoring ongoing, corresponding to typical day-time operations.
Element	May refer to the whole Telescope, or one of its two logical constituents, Structure or Camera

1.6.1.3.1 Machine States

TERM	DEFINITION
Off (State)	The Telescope is without electrical power and beyond the control of the Telescope Control System.
On (State)	The Telescope electrical power is switched on, and it is available to operate under the operational states described below.

TERM	DEFINITION
Maintenance (State)	The Telescope is in a state designed to perform maintenance activities and is unavailable for scientific operations or any kind of remote control. Monitoring information is still, in general, available for ACADA.

1.6.1.3.2 Operational States

TERM	DEFINITION
Configuration (Settings)	Ensemble of settings for a hardware or software system, service, process or any of its discrete portions, determining its functional and/or physical characteristics at a given moment of time.
Initializing (State)	The Telescope just transitioned to the ON machine state and is initializing all its internal components in order to arrive at the Initialized state.
Initialized (State)	The Telescope is in a configuration suitable for survival in extreme conditions, minimising use of power whilst still providing basic status monitoring, and maximising the instrument lifetime.
Standby (State)	The Telescope is in a state which is still safe with respect to adverse conditions, but has all components activated, with preparations for Observation initiated. Structure has all its internal systems on and is unparked, and Camera is warmed up, but not yet ready for observations (e.g., lids are closed).
Ready (State)	The Telescope is prepared for rapid transition to the Observing State. Internal calibration activities may take place in this state.
Observing (State)	The Telescope is in a state associated with observatory data taking, with configuration dictated by performance requirements. Data are being taken by Camera, Structure is tracking (or pointing to) the target, and calibration activities may take place.
Fault (State)	The Telescope has encountered a serious problem which means it is currently unable to reach one of the standard states or is unable to continue to maintain the current status. For errors that permit to continue the operation of the corresponding state within requirements, the Telescope should stay in its correct state while such error is solved (the error is to be logged). Whenever the Telescope enters in the Fault state, an Alarm shall be raised to IPS and/or ACADA depending on the nature of the Alarm. The transition to this state is automatically performed by the system.

1.6.1.4 Data Model

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1.6.1.4.1 Data Categories

TERM	DEFINITION
A – Real-Time	Data products produced and distributed rapidly for science alert generation and rapid data quality evaluation. These generally have the lowest precision and highest systematic uncertainties arising from basic calibration and simplified analysis techniques.
B – Next-Day	Data products produced and distributed after some off-line processing on-site, typically by the next observation day. These have somewhat better precision, lower systematics, and better data quality measurements than category-A products, but still may use simplified analysis or calibration techniques appropriate for relatively fast science alerts and proposal monitoring.
C – Final	Data products produced by the full high-quality data processing chain, off-site in CTA Observatory data centres, with a delay of up to a week from data taking. These use the best calibration and algorithms, providing precision and systematics meeting or exceeding CTA Observatory requirements, have the most accurate data quality assessment, and thus are the products intended for final analysis and publication of results.

1.6.1.4.2 Data Processing Levels

TERM	DEFINITION
R0 (raw low-level)	Streamed raw data from a device such as a Telescope or on-site instrument. R0 content and format is internal to each device and is comprised of the raw data transmitted from the device to its respective server in the on-site Data Centre.
R1 (raw common)	Streamed raw data meeting common standards, transmitted on-site from a Telescope or other on-site instrument or software system to Array Control and Data Acquisition (ACADA). The transformation from R0 to R1 implies some preliminary calibration and possible restructuring of data to fit a common data model. R1 data is not stored on disk and is not intended to have an associated archival file format. This data level is the interface between ACADA and all site instruments including the Cherenkov Telescopes.
DL0 (raw archived)	All data intended for long-term preservation, and the main interface between ACADA and the Data processing and Preservation System (DPPS). The transformation from R1 to DL0 includes data volume reduction, the addition of associated metadata (see e.g., Section 4), and the transformation into a common DL0 archival data format.
DL1 (processed)	Information derived from processing (for example further calibrated and parameterized) DL0 data. Generally, DL1 data products contain information that can be generated from DL0 data of the same instrument, without knowledge of other instruments.

TERM	DEFINITION
DL2 (reconstructed)	Information derived from combining and processing multiple DL1 data products or streams. The transformation between DL1 and DL2 includes joining or merging data from multiple instruments (for example multiple telescopes and the sub-array trigger), reconstruction of shower energy and geometry, application of inter-telescope calibration, as well as the generation of monitoring information derived from these processes or from combining multi-instrument DL1 monitoring information.
DL3 (science)	Information derived from processing DL2 data, specifically: sets of selected Air-Shower Events with a single final set of reconstruction and discrimination parameters, along with associated instrument response characterizations together with their periods of validity, and any technical monitoring data needed for science analysis. The transformation between DL2 to DL3 includes event-wise quality classification and progenitor discrimination, generation of instrument response functions, as well as the derivation of associated monitoring quantities. DL3 is the primary data level delivered to users for analysis and will be preserved long-term. It is the primary interface between DPPS and the Science User Support System (SUSS).
DL4 (intermediate quick-look)	Data products produced by binning of DL3 data, including data cubes and maps which are suitable for combination/summation to produce DL5 products. This includes things like counts and exposure cubes (stored per time, energy, and sky position bin, for example). These products are produced by automated science pipelines and are used to rapidly (re)generate DL5 data products for specific spatial, temporal, or spectral regions, e.g., in an interactive user interface, or for monitoring purposes.
DL5 (science quick-look)	Data products produced by combination of DL3 and DL4 products over a target-specific extraction region(s) of interest. Includes for example light-curves, flux maps or cubes, spectra, along with associated data such as source models and fit results.
DL6 (observatory science)	High-level “legacy” Observatory data products, such as CTA survey sky maps, diffuse gamma-ray background models, or CTA source catalogues.

1.6.1.4.3 Data Types

TERM	DEFINITION
Event	Contains data that changes for every triggered event (e.g., an Air-Shower Event, Array-Level Event, Local Event, Camera Event), with typically a high rate, which may be more than a kilohertz at the R0-DL0 level. For this reason, Event data may need special storage considerations. Examples include shower images/cubes, shower parameters, calibration coefficients that are measured event-wise, and trigger information. This is typically the highest volume and most complex data stream.
Monitoring	Contains time-series data that are used to monitor the status or quality of hardware, software algorithms, or other data products. These typically update periodically over time, at different rates during daytime, during the operation of the array, or during data processing, but at average rates much lower than Event data and faster than the length of a typical Observation Block. Examples would be low-control information like tracking positions, weather monitoring data, or the status or quality-control data of a particular hardware or software component.
Service	Contains data that act as a service to an observation, hardware or software component. Examples include software configuration input files, calibration look-up-tables or instrument response functions. Generally, these are quantities that change rarely. This data must include a validity range or a list of dependent/parent data products. In the case of DL3, the main Service data are Instrument Response Functions (IRFs), and we recommend using that term.

1.6.1.4.4 Data Associations

TERM	DEFINITION
CTA	Data that pertains to the CTA Observatory in general, independent of site or Array.
Site	Data that pertains to an entire Array Site or location (e.g., CTA North, CTA South, Headquarters, Science Data Management Centre (SDMC), or an off-site data centre). Examples include data from a common weather station, databases related to the overall array layout, or calibrations that affect the full array or array site.
Subarray	Data that may be repeated for each sub-array. Examples include the sub-array trigger data, reconstructed shower parameters, instrumental response functions, etc.
Telescope	Data that may be repeated for each Cherenkov Telescope. Examples include Cherenkov images, parameters, etc. These are generally indexed by a telescope id number or telescope type grouping.
Target	Data associated with a Science Target, e.g., a specific astronomical object or region-of-interest.

1.6.1.5 Conditions and Limits

TERM	DEFINITION
Observation Conditions	Environmental conditions under which full operation of the CTA System must be possible without incurring damage.
Precision Pointing Conditions	Environmental conditions under which it is expected that the optimum pointing precision of the CTA System can be achieved.
Normal Conditions	Environmental conditions under which standard operation, engineering and maintenance activities may be undertaken, during day or night.

TERM	DEFINITION
Transition Conditions	Environmental conditions under which environmental parameters may exceed those of the observing state, whilst the system transitions into a safe state.
Survival Conditions	Environmental conditions expected to occur with a probability of roughly 2% per annum at each array site. The level of damage incurred under survival conditions must not exceed the serviceability limit state.
Serviceability Limit	Damage can be repaired in-situ using available spare parts and a normal level of on-site manpower.
Collapse Prevention Limit	The structure is heavily damaged, with very limited residual strength and stiffness, yet retains structural integrity and resists collapse. Repairs may require additional resources beyond those usually available on-site.

1.6.1.6 Camera-Related

TERM	DEFINITION
(Sky) Pedestal	The mean digital signal derived in the absence of transient illumination yet in the presence of continuous background light (NSB) contributions.
Dark Pedestal	The mean digital signal extracted from a Camera pixel in the complete absence of incident light.
Electronic Pedestal	The mean digital signal extracted from a Camera pixel with photosensors inactive.
(Camera) Triggering	Identification by a Cherenkov Camera of a block of time for which data may be of interest for analysis and to which a Trigger Timestamp can be associated.
Internal Trigger	Triggering of a Camera due to a flash of light.
External Trigger	Triggering of a Camera due to an instruction received from Camera firmware, software or from the central control system.
Trigger Timestamp	Absolute time plus auxiliary information associated with a Camera Event.
Camera Event	Set of data from the pixels of a Cherenkov Camera associated with a Trigger and including time and amplitude information.
(Camera) Image	A data product resulting from processing of a Camera Event that contains a single value per pixel.
Local Event	Camera Event that is flagged as requested for long-term storage by a Camera, independently of whether it is an Array-Level Event. Local Events are typically of interest for calibration, monitoring or engineering purposes.
Camera Field of View (cFoV)	The Field of View of a CTA Camera is defined as twice the average angular distance of the centre of gravity of all Camera Pixel centres (i.e., the Camera centre) to the centre of all Edge Pixels.
Edge Pixel	Edge pixels are those pixels lying outside of 85% of the required FoV radius that have fewer nearest neighbouring pixels than flat sides, in the directions perpendicular to their flat sides and within tolerances large enough to account for rounding errors and distortions. The distance of a nearest neighbour must be less than half the average angular pixel pitch, such that there is a maximum of one nearest neighbour per flat side
Pixel Pitch	The average angular distance between the centres of two immediately adjacent pixels, measured using the effective focal length.
(Camera) Pixel	Photosensitive element and associated electronics in a Cherenkov Camera, capable of outputting a signal related to the input light level.
Broken Pixel	A Pixel which is not available to perform signal amplitude and/or time measurements with the required performance.
Data Volume Reduction	Processing that allows Camera Event data to be stored more compactly without significant loss of information, and hence without significant impact on the sensitivity of an array or sub-array.
Deadtime	Any period of inability of a Cherenkov Camera to trigger on or produce data for Events that is shorter than 0.5 seconds. Longer periods should be considered as unavailability rather than deadtime.

1.6.1.7 Telescope-Related

TERM	DEFINITION
(Optical) Point-Spread-Function (PSF)	The optical point-spread-function (PSF), as measured in the telescope focal plane, describes the response of the optical system to a point-like source of light. In general, this is a function of the position within the field of view and the pointing direction of the telescope and is affected by the environmental conditions. The optical PSF is typically characterised by the 80% angular light containment diameter Theta_80.
Theta_80	Theta_80 (θ_{80}) is the standard parameter for characterising the optical PSF of a telescope. It is the opening angle (diameter) relative to the light centroid at a specific place within the focal plane, within which 80 percent of those photons that are reflected into a 1 o diameter circle on the camera fall. Unless otherwise specified, the source of light should be assumed to be at infinity. Photons in the wavelength range 300 - 550 nm with the Cherenkov Reference Spectrum. Operating Illumination should be assumed.
Mirror Reflectivity	The fraction of photons incident on an optical element (facet) of a reflector dish, that are focussed into the required cFoV. The mirror reflectivity does not include any effects from shadowing by, for example, the support structure of either incoming or outgoing light.
Geometrical Mirror Area	It is the projected area of the primary mirror multiplied by (1-f), where f is the fraction of photons lost due to shadowing (for example by support structures, secondary mirror, camera etc.). The geometrical mirror area is generally a function of the position within the field of view.

TERM	DEFINITION
Effective Mirror Area	The effective mirror area characterises the light-collection power of the optical system. This quantity is the average of the product of the Geometrical Mirror Area and the mirror reflectivity weighted, in the range 300-550nm, by the Cherenkov Reference Spectrum. The effective mirror area is generally a function of the position within the field of view.
Optical Efficiency	The overall optical efficiency of the system for signal photons, ε_{sig}, is defined as: $\varepsilon_{\mathrm{sig}} = \int_0^\infty F(\lambda)\varepsilon(\lambda)d\lambda / \int_{300\mathrm{nm}}^{550\mathrm{nm}} F(\lambda)d\lambda$ where F (λ) is the nominal Cherenkov Reference Spectrum and ε is the probability that a photon of a given wavelength, incident on the primary mirror and parallel with the optical axis, results in the generation of a detectable photoelectron. This efficiency therefore includes the reflectivity of the mirrors, of light concentrators if present, camera dead space and the quantum and collection efficiencies of photosensors. The optical efficiency for background, ε_{bg} , is defined in an identical way but with F (λ) replaced by the Background Light Reference Spectrum .
Astrometric Accuracy	The accuracy with which a physical position on the focal surface can be mapped to a celestial coordinate in off-line analysis, averaged over the required field of view and expressed as the root-mean-square space-angle deviation from the true value over all pixels, averaging over a timescale of 1 minute.
Post-Calibration Astrometric Accuracy	Astrometric Accuracy achieved after application of full calibration procedure applied as part of the routine production of DL3 data
Online Astrometric Accuracy	Astrometric Accuracy achieved online using fast calibration procedures applied as part of the production of DL0 data

1.6.1.8 Simulation and Performance Related

TERM	DEFINITION
Differential Sensitivity	The Differential Sensitivity is the minimum detectable flux in five independent bins per decade in reconstructed energy. The required level of confidence in each bin is a five-standard deviation (5σ) statistical significance (calculated with equation 17 from Li & Ma 1983, ApJ 272, 317) and the presence of at least 10 excess events above background. We also require that the signal excess is at least five times the assumed rms background systematic uncertainty of 1% of the background remaining after cuts. Unless otherwise specified Reference Conditions should be assumed.
Energy Resolution	A measure of how well an array or sub-array in a given configuration can reconstruct the energy of a primary particle. Unless otherwise specified the primary should be assumed to be a gamma-ray. The energy resolution is defined such that 68% of particles will have a true energy within this ΔE of their reconstructed/estimated energy. It is derived from simulations via the energy dispersion matrix, after all appropriate selection cuts.
Angular Resolution	A measure of how well the reconstructed direction of a primary particle corresponds to the true arrival direction. Unless otherwise specified the primary particle should be assumed to be a gamma-ray. The angular resolution is defined as the opening angle of 68% containment for the angular distance to the true direction.
Gamma-ray Field of View (gFoV)	The Gamma-ray Field of View of a CTA array or sub-array is defined as twice the angular offset from the array or sub-array pointing direction at which the differential point-source sensitivity (for a 50-hour exposure) is degraded by a factor of two. Note that the gamma-ray FoV is an energy- and analysis-dependent quantity.
Effective (Collection) Area	The energy-dependent effective collection area of an array or sub-array is defined as the number of selected gamma-rays in a given observation time divided by the incident flux and observation time. Unless otherwise specified, the Effective Area should be assumed to include all quality and background rejection cuts, including angular cuts associated with a point-source analysis. Effective Area may be given as a function of either true or reconstructed primary energy.
Cherenkov Reference Spectrum	Spectral form of the Cherenkov light from air showers arriving at ground level that should be assumed for calculations (see attachment - which also shows the Background Light Reference Spectrum).
Background Light Reference Spectrum	Spectral form of the night sky background light that should be assumed for calculations unless otherwise specified (see attachment - which also shows the Cherenkov Reference Spectrum). Note that a modified spectrum is appropriate for moonlight conditions.
Moonlight Reference Spectrum	Spectral form for the brightness of the night sky that should be assumed for calculations under moonlight conditions - see orange curve in attached figure and spectra points in attached data file.
Reference Proton Flux	The Reference Proton Flux at the top of the atmosphere is given by the expression $dN/dE = 9.8 \times 10^{-6}$ $(E\,/\mathrm{TeV})^{-2.62}$ $\mathrm{TeV}^{-1}\,\mathrm{s}^{-1}\,\mathrm{cm}^{-2}\,\mathrm{sr}^{-1}$; where E is the energy of primary cosmic protons. Isotropy can be assumed and unless otherwise indicated an observation zenith angle of 20 degrees should be assumed.
Reference Electron Flux	The Reference Electron Flux at the top of the atmosphere is given by the expression $dN/dE = 2.385 \times 10^{-9}$ $(E\,/\mathrm{TeV})^{-3.34}$ $(1+1.95*(\exp(\,G\,(\log_{10}(\,E\,/\mathrm{TeV}))^{-1})$ $\mathrm{TeV}^{-1}\,\mathrm{s}^{-1}\,\mathrm{cm}^{-2}\,\mathrm{sr}^{-1}$; where E is the energy of primary cosmic electrons and G is a Gaussian function with mean=-0.101 and sigma=0.741. Isotropy can be assumed.
Reference Gamma-ray Flux	The Reference Gamma-ray Flux at the top of the atmosphere is given by the expression

TERM	DEFINITION
	$dN/dE = 2.83 \times 10^{-11} (E/TeV)^{-2.62} TeV^{-1} s^{-1} cm^{-2}$; where E is the energy of primary gamma-rays. Point-like emission and an observation zenith angle of 20 degrees should be assumed unless otherwise indicated.
Reference Conditions	The standard set of conditions to be used for performance comparison using simulations (unless otherwise specified) is: • 20-degree zenith angle observations. • A night sky background flux of 0.24 photons/ns/sr/cm^2 in the wavelength range from 300-650 nm (corresponding approximately to the extragalactic night sky background level during astronomical darkness), following the Background Light Reference Spectrum. • 50% of the time pointing exactly North and and 50% to the South. An on-axis point-like source can be assumed unless otherwise specified.

1.6.1.9 Proposal/Schedule Related

TERM	DEFINITION
Proposal	A scientific project proposed to the Observatory and assigned a unique identifier. A Proposal contains the list of Scientific Targets to be observed and associated constraints in terms of configurations, environmental conditions, observation times and external pre-conditions.
Science Target	A Science Target is a celestial object or region of interest which is to be observed to address the scientific case of a Proposal
Merged Target	A region of interest suitable for sub-array Observations to address the scientific case of one or more Proposals, defined by the merger of Science Targets as appropriate.
(Telescope) Target	A fixed celestial direction, horizon system direction, or defined trajectory to which the optical axis of a Telescope should be aligned.
Observation Block	The smallest scheduling unit, a continuous observation with a sub-array during which science data is collected on the Merged Target of the parent Scheduling Block. During Observation Blocks, the Camera configuration and Telescope Target remain fixed.
Scheduling Block	A set of Observation Blocks for the same sub-array, scheduled contiguously with a single Merged Target. Telescope Targets for Observation Blocks are generated from Proposals based on the specified observing strategy.
(Science) Observation	An Observation is the continuous collection of science data for a period of time with fixed Telescope Targets and configuration.
Science Alert	Filtered Candidate Science Alerts that have passed the associated trigger criteria and are suitable either for CTA Observations or issuing to external observatories.
Candidate Science Alert	Incoming notifications of potentially interesting scientific events either from external observatories or generated by the alert pipeline for internal consideration, that will be checked against trigger criteria to determine whether this becomes a Science Alert.
Long-term Schedule	Based on scientific proposals, the Long-Term Schedule allocates time under a perfect operation scenario, on timescales from yearly down to monthly, considering the expected CTA duty cycle. Long-term scheduling is performed by the Science User Support System.
Mid-term Schedule	Based on the Long-Term Schedule, the mid-term schedule takes planned maintenance and calibration activities into account, on timescales from monthly down to daily.
Short-term Schedule	Based on the Mid-term Schedule, the Short-term Schedule is activated each day prior to Observations commencing, incorporating Science Alerts and telescope availability during the night, operating in real time. Short-term scheduling is performed by the Observation Execution System.
Principal Investigator	
Guest Observer	

1.6.1.10 Array/Operation Related

TERM	DEFINITION
Air-Shower Event	Incident in which Cherenkov light from an atmospheric particle cascade is identified using one or more Cherenkov Telescopes.
Array-Level Event	A single Air-Shower Event Triggering multiple Cherenkov Cameras and judged suitable for storage.
Observing Night	A night during which environmental and system conditions are suitable for Science Observations to take place, with operations following a defined cycle. The Observing Night starts at sunset and finishes at sunrise.
Support Astronomer	Supports on-site science operations including scheduling of observations, data quality monitoring, and the handling of Science Alerts.
Available	A system is considered to be available if it is capable of providing all of the required functions with the required performance under the appropriate conditions over a given time interval, assuming that any required external resources are provided.

1.6.1.11 Software Related

TERM	DEFINITION
Logs	Logs are records of events that occur in the software elements (of the ACADA/Telescope/Controllable Systems). Events that cause logs are, among others: Errors, Alarms and usual software operations. Logs have different levels.
Trace logs	Messages indicating a function-calling sequence. Trace logs are generated whenever a function is entered and are used to report calls to a function. They are used to build call trees during very critical debugging situations. The amount of TRACE logs can be huge and will very likely affect the performance of the system substantially. TRACE logging should be switched on only in very particular situations and for a short amount of time.
Delouse Logs	A lower level than DEBUG, just to allow the finer tuning. Generally same meaning as DEBUG.
Debug Logs	Messages that contain information normally of use only when debugging a program. Such logs are therefore normally only interesting for software engineers. Analysis of DEBUG logs should take place only while investigating problems and can put a substantial load on the system.
Info Logs	Informational messages. This log level is used to publish information of interest during the normal operation of the system. This information is directed to operators, engineers or anybody else working with the system.
Notice Logs	Conditions that are not error conditions, but that may require special handling. These logs are used to catch the attention of people (normally operators or software engineers) looking at the logging output. They denote important situations in the system, but not necessarily error or fault conditions. A NOTICE logging level should be selected with care because many NOTICE messages weaken the attention of the reader.
Warning Logs	Warning messages. These logs are used to report to readers (normally operators or software engineers) conditions that are not errors but that could lead to errors or problems. A WARNING logging level should be selected with care because many WARNING messages weaken the attention of the reader.
Error Logs	Error messages. They are normally generated by the system when an Error (see below) happens and not explicitly used in applications by calling the logging API.
Critical Logs	Critical logs denote an Alarm condition that shall be reported to operators, such as hard device errors. They are normally generated by the Alarm System and not explicitly used in applications by calling the logging API
Alert Logs	A condition that should be corrected immediately, such as a corrupted system database. Alert logs denote an Alarm condition that shall be reported to operators. This denotes a problem more important than Critical. They are normally generated by the Alarm System and not explicitly used in applications by calling the logging API. Alerts are used for reporting errors that must be solved immediately.
Emergency Logs	Emergency logs denote an Alarm condition of the highest priority, a panic condition that must be solved immediately. This is normally broadcast to all users. They are normally generated by the Alarm System and not explicitly used in applications by calling the logging API.
Off (logging)	Level not to be used for actual logging, but to set log levels for filtering.
Alarm	A problem or condition that should be reported to the operator and may require their action. In addition, the alarm event is logged. Alarms can have different severity levels. This could match the log levels "CRITICAL, ALERT & EMERGENCY", or be finer grained.
Error (software)	A problem that is encountered when a program is being executed. Runtime errors can occur in software environments for many different reasons; for example, peripheral devices may not be turned on, or instructions may be invalid. OES errors are to be handled, solved if possible, and reported to the operator if not, but in any case, always logged using the logging system as "ERROR" logs.

1.6.1.12 RAMS Related

TERM	DEFINITION
Emergency stop button	A red mushroom-headed button that, when activated, will immediately start the emergency stop sequence.
Emergency stop (E-Stop)	An E-Stop is a function that is intended to avert harm or to reduce existing hazards to persons, machinery, or work in progress. E-Stop is not a safeguard but is considered to be a complementary protective measure.
Detection Ranking (DET)	DET is a relative numerical scale estimating the effectiveness of the controls to prevent or detect the cause or failure mode before the failure reaches the customer. The assumption is that the cause has occurred.
Occurrence Ranking (OCC)	OCC is a relative numerical scale estimating the probability that the cause, if it occurs, will produce the failure mode and its particular effect.
Emergency situation	An immediately hazardous situation that needs to be ended or averted quickly in order to prevent injury or damage.
Severity Ranking (SEV)	SEV is a relative numerical scale estimating how severe the end user (customer) will perceive the Effect of a failure.
Reliability	The probability that an item or system can perform a required function under given conditions for a given time interval.

TERM	DEFINITION
Risk Priority Number (RPN)	The RPN is a number which quantifies the risk and the impact of failures modes. The RPN is obtained as the product between 'Severity', 'Occurrence' and 'Detection' Ranking numbers.
Maintenance Logistic Time (MLT)	MLT is the time not associated with the Corrective Maintenance work itself (i.e. time for the maintenance technician to prepare work, to order or to obtain spares or special tools if not available on site etc.).
Preventive Maintenance	The maintenance carried out at pre-determined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item. This shall include First, Second- and Third-Line Maintenance.
Maintenance Person-Hours per Operating Hour (MPH/OH)	The total number of Person-Hours expended divided by the total Operating Hours. Note that MPH/OH is expressed in Maintenance Person-Hours per million Operating Hours.
Maintenance Person-Hours (MPH)	The sum of the individual task hours to: troubleshoot, fault isolate, replace, align or adjust and function check, multiplied by the number of personnel required to do each task.
Maintenance Labour Cost (MLC)	The sum of all direct ACMT cost per unit measure and the direct Preventive Maintenance per unit measure. Note: The unit measure may be per hour, calendar time, kilometre, etc.
Maintenance	All activities necessary to keep an asset in, or restore it to a specified condition, keep it safe, reliable and fit for service throughout the operational lifecycle phase.
Mean Time to Failure (MTTF)	The average time an item is expected to work before a failure occurs. MTTF is a reliability measure for non-repairable systems/components. MTTF is calculated as the total operating hours during a specific interval of time divided by the total number of confirmed failures during that same interval of time.
Mean Time Between Failures (MTBF)	The average time an item is expected to work before a failure occurs. MTBF is a reliability measure for repairable systems/components. MTBF is calculated as the total operating hours during a specific interval of time divided by the total number of confirmed failures during that same interval of time. Alternately, MTBF is also known as the reciprocal of the Failure Rate.
Mean Time to Repair (MTTR)	MTTR can be stated, at a given level of maintenance, as the average repair time for individual faults over the life of the equipment. MTTR may include response time (where applicable), diagnostics and rectification of the failure (including software reboot) up to the point that the system is restored to full functionality. In the event that the failure of an item of equipment cannot be rectified, this time measurement includes the time necessary to remove the failed item and replace it with a functioning one. Note: Maintenance Logistic Time required to obtain any special tools or spares is excluded.
Lowest Level Replaceable Unit (LLRU)	The LLRU is the smallest faulty unit the maintenance personnel can identify and isolate at all levels of maintenance within a given Mean Time to Repair (the smallest part of an item that can be replaced to provide an effective repair). Repairs of LLRUs will be undertaken in the specialized workshop.
Line Replaceable Unit (LRU)	The LRU is the smallest faulty unit the maintenance personnel can identify and correct at the First Level of Maintenance to restore system availability within a given Mean Time to Repair (MTTR). Each LRU should be designed for ease of replacement and fault isolation.
Third Level Maintenance (TLM)	If testing, repairing or replacement of a faulty LRU/LLRU, requires specialized skills or test equipment and facilities (typically at manufacturer's site).
Second Level Maintenance (SLM)	If testing, repairing or replacement of a faulty LRU/LLRU, has to be undertaken in a specialized workshop on site.
First Level Maintenance (FLM)	FLM is the maintenance procedure, usually at the location of the failure which consists of diagnosis, recovery of the diagnosis made by the system and possibly its analysis, LRU's/LLRU's replacement and final functional test. This procedure is designed to return the system to service in minimum time, using minimum specialized tools.
Failure Modes, Effects (Criticality) Analysis - FME(C)A	An extension of FMEA in which the "criticality" of the effects is also assessed (identifying risk associated with those failure modes, ranking issues in terms of importance and carrying out corrective actions to address the most serious concerns).
Failure Mode and Effects Analysis (FMEA)	A reliability evaluation and design review methodology to analyse system design and performance to determine the effects of each potential failure mode on the system. FMEA uses inductive logic (a process of finding explanations) on a "bottom up" system analysis. Information developed in this procedure is integrated with reliability, logistics, operations, maintainability and troubleshooting procedures.
Systematic Failure	An equipment failure due to an error in the specification, design, construction, installation, operation or maintenance.
Observing Affecting Failure (OAF)	A system failure, which causes an interruption of the Observing time.
Single Point of Failure (SPF)	A failure of a single item which can result in the failure of the system and it is not compensated for by redundancy or alternative operational procedures.
Human Error	A human action (mistake), which can result in unintended system behaviour/failure.
Error	A deviation from the intended design which could result in unintended system behaviour or failure. Note: This definition is usually applicable in reliability discussions and assessments to make a difference between two terms "failure" and "error". This term could have a different meaning in some other fields (i.e. Software).
Fault	An abnormal condition that could lead to a failure in a system. A fault can be random or systematic.
Failure Rate (FR)	The number of failures expected in a given interval of time. Failure rates are usually expressed in failures per million operating hours.For constant failure rate items (i.e. exponentially distributed

TERM	DEFINITION
	failures), the failure rate is the numerical inverse (the reciprocal) of the Mean Time Between Failures (MTBF).
Failure	A failure is any incident, malfunction, intermittent condition or a deviation from the specified performance of equipment that prevents it from performing its intended functions or requires manual intervention for safe operation. A failure is considered independent when it is not caused by the malfunction of other equipment, component abuse or incorrect maintenance procedure.
Downtime	The interval of time from the declaration of an Observing Affecting Failure (OAF) to the time that service is fully restored (considering only Observing State time).
Degraded Mode	A system condition with a known but reduced level of functionality in which the System continues to operate, following fault detection and reaction, or when manually selected.
Corrective Maintenance (CM)	The maintenance carried out after a fault recognition and intended to put a product into a state in which it can perform a required function. A CM can be postponed (see DCM) or trigger an emergency (see ECA).
Common Cause Failure	An issue that can cause multiple failures across the system.
Emergency Corrective Action (ECA)	Emergency Corrective Action is when immediate and rapid corrective action is taken, if a breakdown may have consequences for safety or equipment availability, or may have high economic impact.
Deferred Corrective Maintenance (DCM)	All Corrective Maintenance actions that are postponed. For any system breakdown the corrective action can be postponed (becoming a DCM) or a decision may be taken to implement Emergency Corrective Actions (ECA).
Availability	The ability of an item or system to be in a state to perform a required function under given conditions over a given time interval assuming that the required external resources are provided. Generally, the Availability is defined by the formula A = (Uptime) / (Uptime + Downtime), where "Uptime" is the total time that the system is performing required functions and "Downtime" is the time where the system is not able to perform (can include the "time off" if corrective maintenance activities are deferred to be performed during daytime, or "MTTR" if corrective maintenance activities can be done during night in safe conditions, see ECA).
Active Corrective Maintenance Time (ACMT)	The direct time spent by maintenance personnel after the arrival at the location of a failure; to troubleshoot, isolate the fault, repair and complete a functional check and verify that the equipment has been restored to operational status. The ACMT assumes that all documentation, spare parts and minimum required tools and test equipment for First Level Maintenance are available at the specialized workshop on site; Note: Maintenance Logistic Time required to obtain any of above items is excluded from the ACMT.

1.6.1.13 Generic (non-CTA specific)

TERM	DEFINITION
NSB	Night Sky Background (Light)
pe	photoelectrons(s)
rms	Root-mean-square
LRU	Line Replaceable Unit
Primary Care	Also known as first aid, the provision of initial care for an illness or injury. Primary care level capability can be said to exist if an individual is present who holds a first aid qualification covering the following aspects: 1) preservation of life, 2) prevention of further harm and 3) promotion of recovery.
GTI	Good Time Interval

2 System Overview

2.1 Scope of the SST Telescope

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 propagate over many kilometres at nearly 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 made of 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 CTA South "Alpha Configuration" would include LSTs, MSTs and SSTs. In particular, it envisages the construction and installation of 42 SSTs (a number that could increase up to 70 in future upgrades).

The SSTs are developed by an international consortium of institutes that will provide them as an in-kind contribution to CTAO. The SSTs rely on a Schwarzschild-Couder-like dual-mirror polynomial optical design, with a primary mirror of 4 m diameter, and are equipped with a focal plane camera based on SiPM detectors covering a field of view of ~9°. They are sensitive in the band from ~0.5 TeV up to ~300 TeV, providing the Observatory with sensitivity to the highest energies. The current SST concept has been validated by developing the prototype dual-mirror ASTRI-Horn Cherenkov telescope and the CHEC-S Cherenkov camera. Table 1 reports main properties of the Small-Sized telescope (SST).

Table 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	1.8 m
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)	90s
Pointing Precision	< 7 arcsecs

3 Telescope Requirements Tree

3.1 High-level SST Telescope Product tree and Flow Requirements

The SST Requirements flow is reported in Figure 3-1**Error! Reference source not found.**.

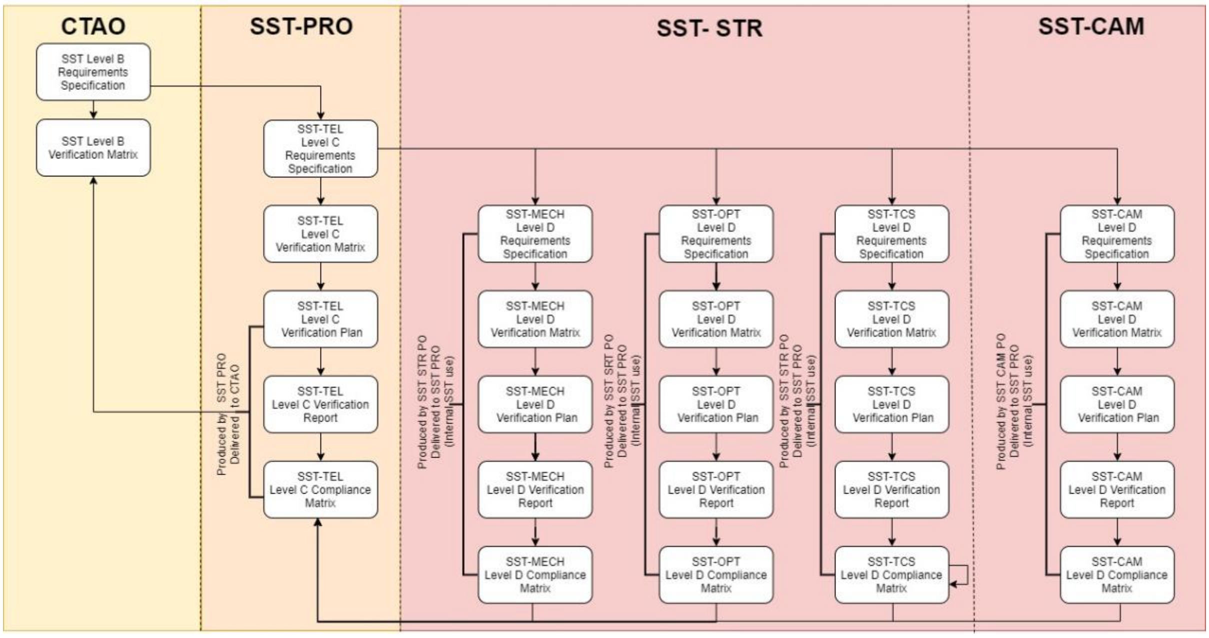


Figure 3-1 SST Requirements Flow

The Product Breakdown Structure provides the hierarchical product breakdown of the SST Telescope and is reported in Figure 3-2

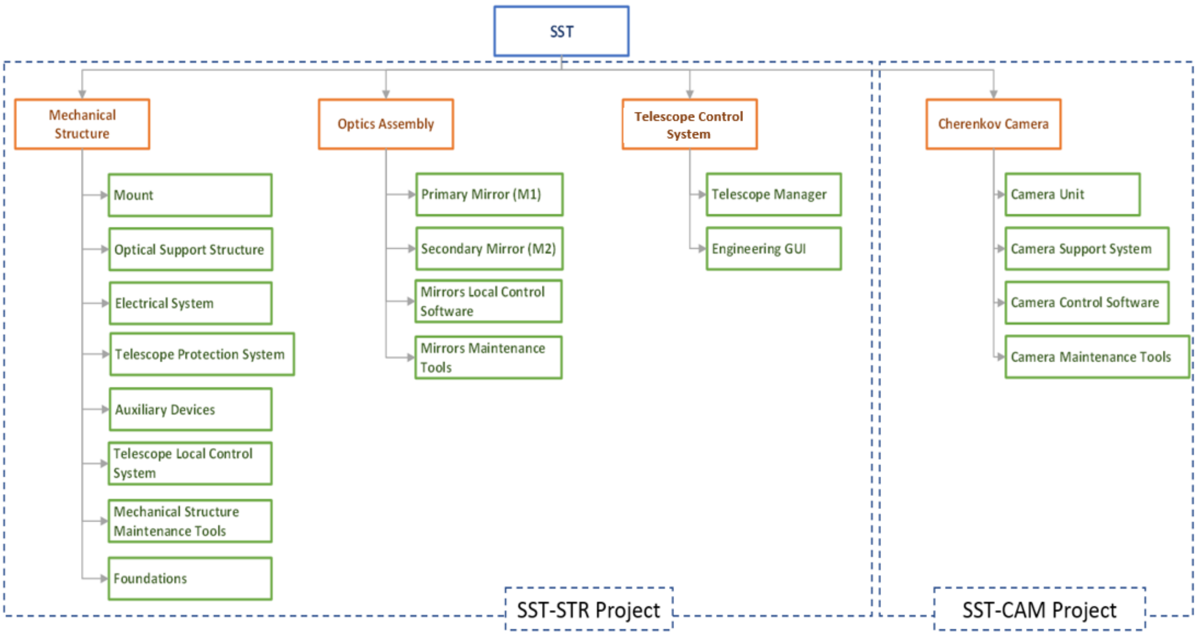


Figure 3-2 Telescope Product Breakdown Structure

The PBS includes the main physical elements that allocate the function and sub-functions of an SST Telescope.

The levels of the SST product tree shown in Figure 3-2 correspond to the following system hierarchy:

- **System** (Level C Requirements)
  - Telescope (SST-TEL)
- **Subsystems** (Level D Requirements)
  - Mechanical Structure (SST-MEC)
  - Optics (SST-OPT)
  - Camera (SST-CAM)
  - Telescope Control System (SST-TCS)

3.2 SST-CTAO Requirements

The SST-CTAO Requirements applicable are referenced in section 1.3.

3.3 SST-CTAO Interface Control Documents

The SST-CTAO Interface Control Documents applicable are referenced in section 1.3

3.4 Requirement structure

To facilitate later the requirements management, the requirements provided in this document respect editorial conventions to enable the identification of key attributes of requirements and facilitate the transfer of requirements to the requirement management system (JAMA).

Requirement ID	Requirement Name	Applicable Subsystem(s)	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-NNNN Note: NNNN is a unique number	Requirement Name	Values Admitted: {TEL and/or MEC and/or OPT and/or TCS and/or CAM}	Requirement Statement	Higher-Level Requirement(s). Note: In case the requirement is generate at C Level they will remain empty.	Values Admitted = {A; C; D; I; R; T} Note: Values are first letter of: Analysis (A), Certification (C), Demonstration (D), Inspection (I), Review of Design (R), Test (T)

3.5 Shall, Should, May

In this document:
Shall – Shall is used to designate a mandatory requirement.
Should – Should is used for requirements that are considered good and are recommended, but are not absolutely mandatory.
May – May is used for requirements that are optional.

3.6 Definition of Type of Technical Requirements

The definitions for the various categories of requirements listed in this document are the following:

- **Environmental**. These are all the requirements related to a product or the system environment during its life cycle; this includes the natural environments and induced environments (e.g. radiation, electromagnetic, heat, vibration and contamination).
- **Functional.** These are all the requirements that define what the product shall do, in order to conform to the needs statement or requirements of the user.
- **Lifetime.** These are all the requirements that define the lifetime of the various subsystems.
- **Performance.** These are the requirements that define the quantitative performance metrics of the Telescope.
- **Maintainability**. These are requirements stating all types of maintenance, their frequency and the conditions under which they are allowed. They may also constrain some of the design decisions, in terms of plan-for-
- **Availability.** These are the requirements that define the requirements on the availability of the product, i.e., the minimum time between failures requiring maintenance actions.
- **Design**. These are all the requirements related to the imposed design and construction standards such as design standards, selection list of components or materials, interchangeability, safety or margins.
- **Interface**. These are all the requirements related to the interconnection or relationship characteristics between the product and other items.
- **Documentation**. These are all the requirements related to the documentations to be provide be the products.
- **Documentation**. These are all the requirements related to the safety/protection systems to be implemented in the Telescope and its subsystems.

3.7 Definition of the verification methods

Verification shall be accomplished by one or more of the following verification methods [RD 08]:

- test;
- analysis (including similarity);
- review-of-design;
- inspection;
- demonstration;
- certification.

All safety critical functions shall be verified by test.
Verification of software shall include testing in the target hardware environment.

3.7.1 Analysis

Verification by Analysis consists of the use of analytical data or simulations under defined conditions to show theoretical compliance. Analysis (including simulation) is used where verifying to realistic conditions cannot be achieved or is not cost-effective and when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution.

3.7.2 Certification

Certification is a written assurance that the product or article has been developed and can perform its assigned functions in accordance with legal or industrial standards. The development reviews and verification results form the basis for certification; however, certification is typically performed by outside authorities, without direction as to how the requirements are to be verified. For example, this method is used for electronics devices via CE certification in Europe and UL certification in the United States and Canada.

3.7.3 Demonstration

Verification by Demonstration consists of a qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation. Demonstration (a set of verification activities with system stimuli selected by the system developer) may be used to show that system or subsystem response to stimuli is suitable. Demonstration may also be appropriate when requirements or specifications are given in statistical terms.

3.7.4 Inspection

Verification by Inspection consists of performing an examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation.

3.7.5 Review-of-design (ROD)

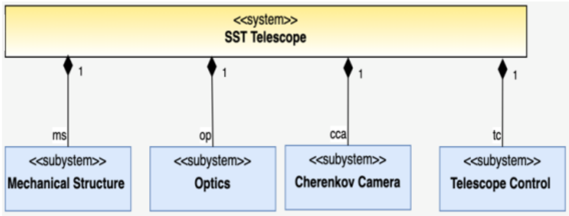
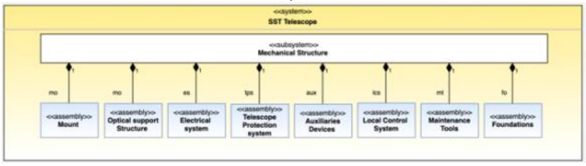
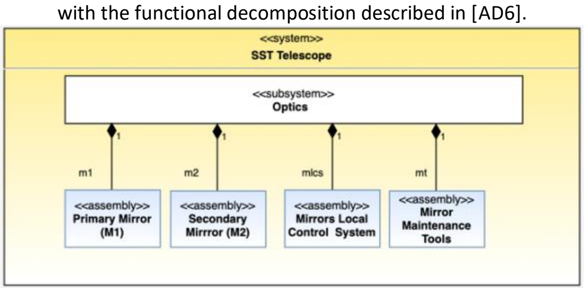
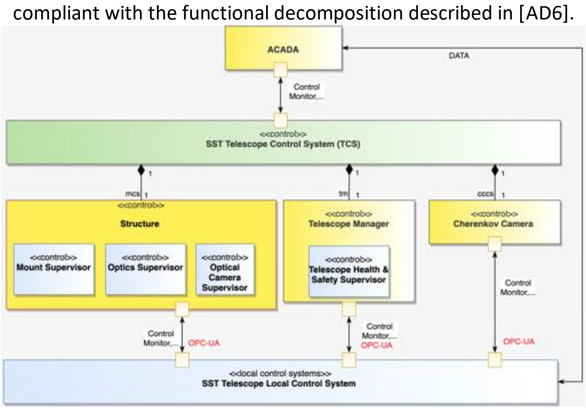
Verification by Review of Design consists of using approved records or evidence that unambiguously show that the requirement is met. For example, design documents and reports, technical description documents, and engineering drawings.

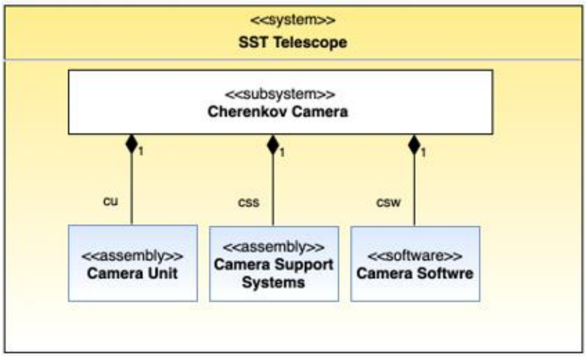
3.7.6 Test

An action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated. These verifications often use special test equipment or instrumentation to obtain very accurate quantitative data for analysis.

4 General

4.1 Telescope Decomposition

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0001	Telescope Decomposition	TEL	The Telescope decomposition is given below. Each subsystem shall be designed and built to be compliant with the functional decomposition described in [AD6].  		R
C-SST-TEL-0003	Mechanical Structure Decomposition	MEC	The Mechanical Structure (MS) decomposition is given below. Each assembly/subsystem shall be designed and built to be compliant with the functional decomposition described in [AD6].  		R
C-SST-TEL-0005	Optical Assembly Decomposition	OPT	The Optical Assembly (OA) decomposition is given below. Each assembly/subsystem shall be designed and built to be compliant with the functional decomposition described in [AD6].  		R
C-SST-TEL-0007	Telescope Control System Decomposition	TCS	The Telescope Control System (TCS) decomposition is given below. Each assembly/subsystem shall be designed and built to be compliant with the functional decomposition described in [AD6].  		R

C-SST-TEL-0009	Cherenkov Camera Decomposition	CAM	The Cherenkov Camera decomposition is given in Figure. Each assembly/subsystem shall be designed and built to be compliant with the functional decomposition described in [AD6].  		R

4.2 Lifetime

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0520	Structural Elements Lifetime	MEC	The structural elements of a Telescope Structure must be designed for an operational Lifetime of 30 years.	B-TEL-0520	A, C, T
C-SST-TEL-0530	Drive Lifetime	MEC	Telescope drive systems, including servos and gearboxes, shall be designed for an operational Lifetime of 15 years.	B-TEL-0530	A, C, T
C-SST-TEL-0540	Mirror Lifetime	OPT	All Telescope reflective surfaces shall be designed for an operational Lifetime of 15 years, during which recoating may be expected on a frequency of less than once every 6 years.	B-TEL-0540	A, C, T
C-SST-TEL-1540	Camera Lifetime	CAM	Camera shall be designed for an operational Lifetime of 15 years.	B-TEL-1540	A, C, T

4.3 Availability

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0310	Telescope availability	MEC	The availability of each SST Telescope structure shall be > 98.5% of the observation time.	B-SST-0310	A
C-SST-TEL-1295	Pixel Availability	CAM	At least 95% of all Camera pixels shall be available and usable during Observations.	B-TEL-1295	T, A
C-SST-TEL-1296	Contiguous Regions of Unavailable Pixels	CAM	The size of any contiguous group of unavailable Camera pixels shall not exceed 2% of all camera pixels during Observations.	B-TEL-1295	T, A
C-SST-TEL-1550	Camera Availability	CAM	The availability of each SST Camera during observation time shall be > 98.5%.	B-SST-1550	T, A

4.4 Maintainability

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0316	Telescope Preventive Maintenance	TEL	The preventive maintenance of a single SST Telescope on-site shall require on average < 1 (TBC) person hours / week	B-SST-0320 B-SST-1560	A
C-SST-TEL-0318	Telescope Corrective Maintenance	TEL	The corrective maintenance of a single SST Telescope on-site shall require on average < 2 (TBC) person hours / week	B-SST-0330 B-SST-1565	A

C-SST-TEL-0320	Structure Preventive Maintenance	MEC, OPT	The preventive maintenance of a single SST Telescope Structure on-site shall require on average < 0.5 person hours / week	B-SST-0320	A
C-SST-TEL-0332	Structure Corrective Maintenance	MEC, OPT	The corrective maintenance of a single SST Telescope Structure on-site shall require on average < 1 person hours / week	B-SST-0330	A
C-SST-TEL-2100	Interchangeability	MEC	The design of TMS shall consider interchangeability requirements related to the long lifetime of the instrument. In particular the probable non-availability /-pourability of electronic components over the long instrument lifetime shall be considered.		A
C-SST-TEL-1560	Camera Preventive Maintenance	CAM	The preventive maintenance of a single SST Camera on-site shall require on average < 0.5 person hours / week.	B-SST-1560	A
C-SST-TEL-1565	Camera Corrective Maintenance	CAM	The corrective maintenance of a single SST Camera on-site shall require on average < 1 person hours / week.	B-SST-1565	A

4.5 Documentation

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0205	Astrometric Standards	TCS	The Telescope shall adhere to the common standards defined in [AD 12] for all astrometric calculations.	B-TEL-205	R
C-SST-TEL-0508	Maintenance Plans	MEC, OPT, CAM, TCS	Maintenance planning and procedures for covering access to, and repair / replacement of, any LRU shall be provided.	B-ONSITE-0510	R
C-SST-TEL-0522	Spare parts	MEC, OPT, CAM, TCS	The level of spare parts needed for the Telescope system maintenance shall be documented.	B-ONSITE-0520	R
C-SST-TEL-0532	Documentation	MEC, OPT, CAM, TCS	The Telescope and its subsystems shall be fully documented in terms of operational use and composition/design.	B-ONSITE-0530	R
C-SST-TEL-0340	Camera Loading and Unloading Procedure Documentation	MEC, CAM	Camera Unit loading and unloading procedures shall be clearly documented, specifying the levels of personnel and equipment needed for the procedure to be safely completed within one working day.	B-TEL-0340	R
C-SST-TEL-0501	Fixation to Foundation Documentation	MEC	The Telescope shall provide the design documentation of the Telescope Foundation, including the documentation about the interface between the Telescope Structure and the Foundation.	B-TEL-0500	R
C-SST-TEL-2170	MS local control system Interfaces	MEC	The MS local control system (LCS) interface with the SST Telescope Control system (TCS) shall be described in the Interface Control Document.		R
C-SST-TEL-2180	MS LCS – SST TCS Interface Control document	MEC	The MS LCS – SST TCS Interface Control document shall be provided as an excel file and a word document following the dedicated templates		R
C-SST-TEL-2190	MS Local control system ICD	MEC	Each MS Local control system shall use the OPC-UA communication protocol (IEC 62541) to exchange information with the TCS on the basis of a dedicated Interface Control Document.		R

4.6 Safety and Protection

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0431	Sunlight Protection Procedures Location	TEL	The Telescope Sunlight Protection Procedures shall be performed in place at the Telescope.	B-TEL-0430	R, T
C-SST-TEL-0432	Sunlight Protection Procedures Duration	TEL	The Telescope Sunlight Protection Procedures shall be performed within 30 minutes.	B-TEL-0430	R, T
C-SST-TEL-0433	Sunlight Protection Procedures Personnel	TEL	The execution of the Telescope Sunlight Protection Procedures shall be feasible by two trained persons.	B-TEL-0430	R, T
C-SST-TEL-0434	Sunlight Protection Procedures Power Availability	TEL	The execution of the Telescope Sunlight Protection Procedures shall be feasible without any connection to the main power supply.	B-TEL-0430	R, T
C-SST-TEL-0202	Safety and Alarm System Connection	TCS	The TCS shall provide to the CTAO IPS all the safety-relevant alarms (interlocks and others) as defined in dedicated TBC ICD document	B-ONSITE-0200	R
C-SST-TEL-0212	Loss of Communication with ACADA	TCS	The TCS shall initiate a transition to the Initialized State if communication with ACADA is lost for > 1 minute.	B-ONSITE-0210	T
C-SST-TEL-0220	Loss of Clock Connection	TCS	When the Telescope is in Ready or Observing state, the TCS shall initiate a transition to the Standby State if the connection to the Central Computer Time Synchronisation System is lost for more than >20 minutes.	B-ONSITE-0220	T
C-SST-TEL-0170	Safety Signalling	MEC, OPT, CAM	The Telescope system shall have all safety subsystems, sighs, acoustic and light signalling - according to ISO 7010:2019 and EN 981:1996+A1:2008 and subsequent amendments - needed to prevent human injuries.	B-ONSITE-0170	R, C
C-SST-TEL-0142	Sudden Loss of Power	MEC, CAM	Damage beyond the Serviceability Limit State shall not occur in case of sudden loss of electrical power	B-ONSITE-0140	R, A
C-SST-TEL-0160	Movement notification	MEC, CAM	An audible and visible alarm signal shall be generated before any potentially dangerous mechanical motion of the system commences according to Machinery Directive, Directive 2006/42/EC	B-ONSITE-0160	R, C
C-SST-TEL-0322	Fire Protection	MEC, CAM	Systems shall be designed for compliance with fire regulations described in the Guide to application of the Machinery Directive 2006/42/EC, Edition 2.2 – October 2019, Annex I, 1.5.6 §227, 3.5.2 §321.	B-ONSITE-0320	R, C
C-SST-TEL-0580	Drive Control Safety	MEC, CAM	Telescope drive control systems and any other moving part shall be provided with safety interlocks that prevent injury to personnel or damage to telescopes that might result from inadvertent operation, human error, or mechanical or control system failure. Refer to Guide to application of the Machinery Directive 2006/42/EC, Edition 2.2 – October 2019 for the safety of the machinery.	B-TEL-0580	R, D
C-SST-TEL-0180	Movement Control	MEC	Safety mechanisms shall exist to ensure that the Telescope system can never move in an uncontrolled manner.	B-ONSITE-0180	D
C-SST-TEL-0190	Emergency Stop	MEC	If there is a risk of human injury or death associated with mechanical motions of the System, then a general emergency stop function shall be provided according to Guide to application of the Machinery Directive 2006/42/EC Edition 2.2 – October 2019, 1.2.4.3 Emergency stop, §202 Emergency stop devices. In case of an emergency situation, the general emergency stop function will stop all significant motions of all moving structural	B-ONSITE-0190	R, D

			elements with the fastest controllable deceleration, such that no additional risks would be introduced.		
C-SST-TEL-0312	Lightning Protection	MEC	Systems shall be protected with a Class 1 lightning protection system in accordance with the international lightning protection standard IEC 62305-1-4:2010.12	B-ONSITE-0310	R, C
C-SST-TEL-2370	Error Recovery procedure failure	MEC	In case an error recovery procedure for any MS subsystem fails, the MS LCS shall automatically transit to Fault state that prevents damage. The MS LCS shall notify the fault State to the TCS on the basis of the MS to TCS Interface Control Document.		T
C-SST-TEL-2380	Alarm Generation	MEC	If an error recovery procedure for any MS subsystem fails the MS LCS shall send an alarm to the TCS on the basis of the MS LCS to TCS Interface Control Document.		T
C-SST-TEL-2390	Performance monitoring	MEC	The MS LCS shall monitor the performances of any MS subsystem and notify an alarm if they are not met to the TCS.		T
C-SST-TEL-2400	Support for troubleshooting activities	MEC	The MS LCS shall provide the support to all troubleshooting activities down to the level of LRUs of each MS Subsystem.		T

5 Environmental

Parameter	Precision	Observation	Transition	Damage	Survival
Air Pressure	750 +- 50 mbar				
Air Temperature	-5°C < T < 25°C		T<-5°C or T>25°C	-15°C < T < 35°C	
Temperature gradient	<=3°C/h	<=7.5°C/h	>7.5°C/h	>7.5°C/h to < 0.5°C/min for 20 min	0.5°C/min for 20 min
Relative Humidity	2% < RH < 90%		RH < 2% or RH > 90%	2% < RH < 100%	
Misting	T is >2°C greater than dew point		-		
Rain	-		≤2mm in 1h	≤70mm in 1h; ≤200mm in 24h;	
Snow load	-			-	<20kg/m2
Hailstone	-			-	Ø=5mm, E=0.2J
Wind, sustained for 10 min	≤11km/h	≤36km/h	≤50 km/h	<80km/h parked	≤100 km/h parked; ≤60 km/h in transitions
Wind gusts (1 sec)	-	-	-	-	≤170 km/h
Solar radiation				1200 W/m^2 averaged over 1 hour	
Dust and sand				2.9 x 10^5 particles of ≥5µm size per m^3 of air for 90% of the time at 2m above ground	
Illumination	-				≤10^6 photons ns−1 cm−2

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0060	Electromagnetic Compatibility	MEC, CAM	The Telescope and its subsystems shall be compliant with the Electromagnetic Compatibility (EMC) Directive 2014/30/EU.	B-TEL-0060	R, C

C-SST-TEL-0235	Precision Pointing Stability Temperature Gradient	MEC, OPT, CAM	The Telescope and its subsystems shall be able to satisfy the precision pointing requirements under temperature gradients of up to 3ºC/h	B-ENV-0235	T, A
C-SST-TEL-0310	Observation humidity	MEC, OPT, CAM	The Telescope and its subsystems shall meet the scientific performance requirements for observations within the relative humidity range 2% to 90%, provided that the condition for operation with un-misted mirrors (B-ENV-0330) is met.	B-ENV-0310	T, A
C-SST-TEL-0324	Survival humidity	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur due to relative humidity within the range 2% to 100% when in the Initialized State or when no power is available.	B-ENV-0320	T, A
C-SST-TEL-0334	Optical Surfaces Misting	CAM, OPT	The Telescope and its subsystems shall operate with un-misted optical surfaces (Mirror and camera window) when the dew point temperature is at least 2ºC lower than the ambient temperature.	B-ENV-0330	T, A
C-SST-TEL-0412	Rain in 24 hours	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur due to rain precipitation of up to 200 mm in 24 hours.	B-ENV-0410	T, A
C-SST-TEL-0420	Radio Frequency Interference	MEC, OPT, CAM	The Telescope and its subsystems shall be compliant with the Directive 2014/30/EU on radio frequency interference.	B-ONSITE-0420	R, C, T
C-SST-TEL-0422	Rain in 1 hour	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur due to rain precipitation of up to 70 mm in 1 hour.	B-ENV-0420	T, A, C
C-SST-TEL-0428	Rain wind speed	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit State shall not occur due to precipitation in the form of rain, snow or hail for wind speeds of up to 90km/h, averaged over 10 minutes.	B-ENV-0430	T, A, C
C-SST-TEL-0460	Rain during transition	MEC, OPT, CAM	During transitions, damage to the Telescope and its subsystems shall not occur due to rainfall of up to 2 mm/hour.	B-ENV-0460	T, A, C
C-SST-TEL-0525	Survival snow load	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit State shall not occur on the CTA site whilst in the Initialized state due to snow loads of up to 20kg / m^2.	B-ENV-0525	T, A, C
C-SST-TEL-0810	Solar radiation level	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur to components regularly exposed to direct solar radiation of up to 1200 W/m^2 (averaged over 1 hour) at a maximum ambient temperature of 35ºC	B-ENV-0810 B-ENV-0820	T, A, C
C-SST-TEL-0915	Dust and sand	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur due to an environment with up to 2.9 x 10^5 particles of ≥5µm size per m³ of air for 90% of the time at 2m above ground. Note: This limit corresponds to the definition of ISO-Class 9 of ISO14644-1 for particles of this size	B-ENV-0915	T, A, C
C-SST-TEL-1020	Aggressive atmosphere	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur on the CTA-S site due to the following Aggressive Atmospheric Concentration ranges: NO, NO2, SO2 < 4ppb	B-ENV-1020	T, A, C
C-SST-TEL-1112	Earthquake damage limitation (South)	MEC, OPT, CAM	The Telescope and its subsystems shall meet the Damage Limitation Requirement (DLR) as defined in Eurocode 8 based on the earthquake excitation at ground level defined in CTA-SPE-SEI-400000-0001-1c	B-ENV-1110	T, A
C-SST-TEL-1120	Earthquake collapse prevention (South)	MEC, OPT, CAM	The Telescope and its subsystems shall meet the No-Collapse Requirement (NCR) as defined in Eurocode 8, based on the earthquake excitation at ground level defined in CTA-SPE-SEI-400000-0001-1c	B-ENV-1120	T, A
C-SST-TEL-0135	performance Atmospheric Pressure	MEC, OPT, CAM	The Telescope and its subsystems performance requirements shall be met in the atmospheric pressure range of 770 +/- 50 mbar.	B-ENV-0135	A

C-SST-TEL-0210	Performance Temperature	MEC, OPT, CAM	The Telescope and its subsystems performance requirements shall be met in the temperature range [-5ºC;+25ºC]	B-ENV-0210	T, A
C-SST-TEL-0225	Survival Temperature	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit State shall not occur for ambient temperatures in the range [-15°;+35°]	B-ENV-0225 B-ENV-0220	T, A
C-SST-TEL-0230	Temperature Gradient	MEC, OPT, CAM	The Telescope and its subsystems scientific performance requirements shall be met during air temperature gradients of less than 7.5ºC/h	B-ENV-0230	T, A
C-SST-TEL-0250	Survival temperature gradients	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit State shall not occur for air temperature gradients of up to 0.5ºC/min for 20 minutes	B-ENV-0250	T, A
C-SST-TEL-0530	Hailstone damage	MEC, OPT, CAM	Damage to the Telescope and its subsystems shall not occur due to the impact of 5 mm diameter hailstones with kinetic energy of 0.2 Joule.	B-ENV-0530	T, A
C-SST-TEL-0625	Survival ice load	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit State shall not occur due to an ice thickness (on all surfaces) of up to 20 mm.	B-ENV-0625	T, A
C-SST-TEL-0710	Observation Wind Speed	MEC, OPT, CAM	The Telescope and its subsystems shall meet the Scientific performance requirements for observations under 10-minute average wind speeds of up to 36 km/h	B-ENV-0710	T, A
C-SST-TEL-0716	Precision Pointing Wind Speed	MEC, OPT, CAM	The Telescope and its subsystems shall be able to achieve precision pointing fulfilling B-SST-0020 under 10-minute average wind speeds of up to 11 km/h	B-ENV-0716	T, A
C-SST-TEL-0724	Maximum Wind Speed during Transitions	MEC, OPT, CAM	During transitions, damage to the Telescope and its subsystems shall not occur on-site due to wind speeds of up to 50 km/h averaged over 10 minutes, and damage beyond the Serviceability Limit State shall not occur due to wind speeds of up to 60 km/h, averaged over 10 minutes.	B-ENV-0720	T, A
C-SST-TEL-0743	Damage Wind Speed	MEC, OPT, CAM	No damage to the Telescope and its subsystems shall occur due to wind speeds of up to 80 km/h, averaged over 10 minutes.	B-ENV-0740	T, A
C-SST-TEL-0744	Survival Wind Speed	MEC, OPT, CAM	Damage the Telescope and its subsystems beyond the Serviceability Limit State shall not occur due to wind speeds of up to 100 km/h averaged over 10 minutes, when the Structure is parked and the Lids are closed.	B-ENV-0740	T, A
C-SST-TEL-0745	Survival Wind Gusts	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit State shall not occur on the CTA site due to wind gusts (duration 1 s) of up to 170 km/h.	B-ENV-0745	T, A
C-SST-TEL-1430	Survival Illumination	MEC, OPT, CAM	Damage to the Telescope and its subsystems beyond the Serviceability Limit shall not occur due to illumination levels of up to 10^6 photons ns^−1 cm ^−2 in any state.	B-ENV-1430	T, A

6 Functional

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0070	Pointing Tolerance for Observing	TCS, CAM	TCS shall command a transition of the Camera to the Observing State (enable trigger) as soon as the Structure's pointing direction is within the tolerance of the requested Target position, as defined in [AD7]	B-TEL-0070	T
C-SST-TEL-0440	Structure Pointing Information	TCS	The TCS shall provide the telescope nominal current pointing direction (in Horizon coordinates) on request from the ACADA.	B-TEL-0440	T

C-SST-TEL-0728	Error Notification	TCS	The TCS shall notify any error to ACADA in compliance to TBD specification.	B-ONSITE-0730	T
C-SST-TEL-0760	State Change Notification	TCS	The TCS shall notify ACADA whenever it changes State in compliance to [AD7]	B-ONSITE-0760	T
C-SST-TEL-0775	Error Condition Classification	TCS	The TCS shall classify the error condition in terms of severity as per a dedicated document.	B-ONSITE-0770	T
C-SST-TEL-0780	Configuration Settings	TCS	The TCS shall load configuration settings from the ACADA Configuration Database (CDB), in compliance with TBD ICD.	B-ONSITE-0780	T
C-SST-TEL-0800	Transition Interruption	TCS	The Telescope Control System shall implement interruptible transitions between its states in compliance with [AD7].	B-ONSITE-0800	T
C-SST-TEL-0112	Power On Transition	MEC, CAM, TCS	When the Telescope is powered (On State), the Telescope Local Control Systems shall automatically transit to the Initialized State.	B-ONSITE-0110	T
C-SST-TEL-0150	Transitions out of Initialized State	MEC, CAM, TCS	The Telescope Local Control Systems shall not automatically initiate a transition from Initialized State to higher states (Standby, Technical) according to [AD 08].	B-ONSITE-0150	T
C-SST-TEL-0280	Condition Monitoring	MEC, CAM, TCS	The condition of Telescope critical subsystems (drive systems, etc.) shall be continuously monitored by a dedicated Local Control System, to allow early identification of problems and increased availability due to replacement of parts prior to failure, following the Condition Monitoring Plan.	B-TEL-0280	T
C-SST-TEL-0622	State Machine	MEC, CAM, TCS	The Telescope and its subsystems shall implement the states and the machine states as defined in [AD7].	B-ONSITE-0620	T
C-SST-TEL-0632	State Transitions	MEC, CAM, TCS	The Telescope and its subsystems shall implement the transitions between state machine states defined in [AD7].	B-ONSITE-0630	T
C-SST-TEL-0633	Internal States and State Transitions	MEC, CAM, TCS	The Telescope Local Control systems shall implement the internal states and transitions as defined in a dedicated interface control document with the TCS		T
C-SST-TEL-0700	Fault Detection Isolation Recovery	MEC, CAM, TCS	The Telescope and its Local Control Systems shall implement a fault detection, isolation and recovery system.	B-ONSITE-0700	T
C-SST-TEL-0740	Fault Recovery Behaviour	MEC, CAM, TCS	The Telescope and its subsystems shall prevent damage to instrumentation in case of Fault Recovery actions fail.	B-ONSITE-0740	R, T
C-SST-TEL-0750	Fault State Transition	MEC, CAM, TCS	The TCS and Local Control Systems shall automatically transition to the Fault State in compliance to [AD7], whenever a Critical or Catastrophic Error happens (as defined in a dedicated Document).	B-ONSITE-0750	T
C-SST-TEL-0770	Condition Monitoring System	MEC, CAM, TCS	The Telescope and its subsystems shall implement a condition monitoring system.	B-ONSITE-0770	T
C-SST-TEL-0585	Telescope States	MEC, CAM, TCS	The Telescope shall implement States according to the Generic Telescope State Machine model specified in [AD7].		T
C-SST-TEL-0587	Telescope Modes	MEC, CAM, TCS	The Telescope shall implement Modes according to a common Generic Telescope Control model specified in t[AD7].		T
C-SST-TEL-0589	Telescope Transitions	MEC, CAM, TCS	The Telescope shall implement transitions between States and Modes according to the Generic Telescope State Machine model specified in [AD7].		T
C-SST-TEL-0729	Internal Error Notification	MEC, CAM	The Local Control Systems shall notify any error to TCS.	B-ONSITE-0730	T
C-SST-TEL-0761	Internal State Change Notification	MEC, CAM	The Local Control Systems shall notify to TCS whenever it changes State.	B-ONSITE-0760	T

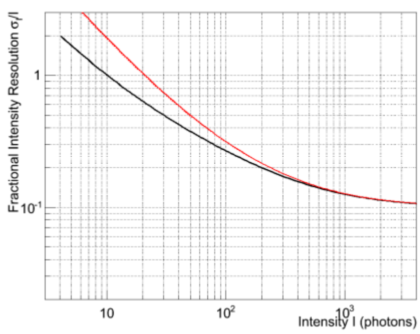
C-SST-TEL-0441	Structure Pointing Information	MEC	The Mount shall provide its nominal current pointing direction (in Horizon coordinates) on request from TCS.	B-TEL-0440	T
C-SST-TEL-2200	Power on	MEC	In remote mode the TMS LCS shall automatically transit from the Off state to the Initialized state when power is provided.		T
C-SST-TEL-2210	Local Errors	MEC	The TMS LCS shall monitor all parameters needed to assess the health and status of TMS and its subsystems.		T
C-SST-TEL-2220	Error reporting to upper level	MEC	The TMS LCS shall notify to the TCS any detected error.		T
C-SST-TEL-2230	Automatic recovery procedure	MEC	The TMS LCS, when possible, shall implement automatic error recovery procedures.		T
C-SST-TEL-2240	Recovery reporting to upper level	MEC	The TMS LCS shall notify to the TCS the results of the error recovery procedure on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2250	State Change Notification	MEC	The TMS LCS shall notify to the TCS the change of state of the TMS on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2260	Configuration Settings	MEC	The TMS LCS shall be able to receive all configuration data delivered by the TCS in order to prepare for transition among states on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2270	Transition Interruption	MEC	The TMS LCS shall allow to interrupt transitions between states upon request by the TCS. The TMS LCS shall return to the previous state within the corresponding transition time.		T
C-SST-TEL-2280	Time Synchronization	MEC	The TMS LCS internal time shall be synchronized to the CTAO NPT Time provided by the CTAO Time synchronization system.		T
C-SST-TEL-2290	Monitoring Data	MEC	The TMS LCS shall provide monitoring information to the TCS on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2300	Logging	MEC	The TMS LCS shall provide logging information to the TCS on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2310	Configuration	MEC	The TMS LCS shall receive configuration from the TCS on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2320	Command	MEC	The TMS LCS shall receive commands from the TCS on the basis of the TMS to TCS Interface Control Document.		T
C-SST-TEL-2330	Autostow	MEC	The TMS shall provide a configurable time period for stow after losing communication (default to 5 minutes).		T
C-SST-TEL-0424	Home Position	MEC	TMS shall have a "Home" position to which they move to during the Unparking states, and return to prior to the Parking state, at the minimum elevation at which all azimuthal angles are accessible.	B-TEL-0420	T
C-SST-TEL-1240	Trigger Monitoring	CAM	The Camera shall record and send to ACADA the times at which the trigger was enabled and disabled in compliance with [AD9].	B-TEL-1240	T
C-SST-TEL-1263	Event Collection	CAM	The Camera shall collect and deliver for further processing Events to ACADA in compliance with [AD 08].		T
C-SST-TEL-1265	Busy Triggers	CAM	The Camera shall generate and send trigger timestamps to ACADA whenever possible in the Observing State, even if it cannot provide data for a given Event, in compliance with [AD9].	B-TEL-1265	T

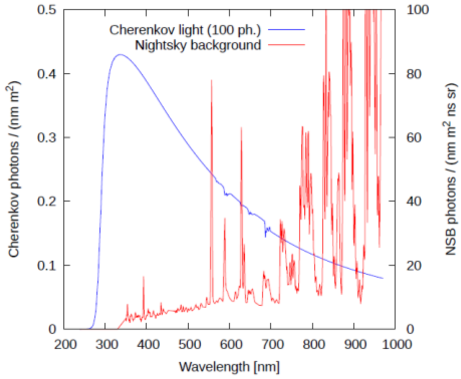
C-SST-TEL-1270	Deadtime Measurement	CAM	The Camera shall continuously monitor the Deadtime fraction. The availability for trigger or readout of an individual Camera in any given Event shall be derivable by the ACADA.	B-TEL-1270	T
C-SST-TEL-1271	Trigger Availability Monitoring	CAM	The Camera shall provide information to ACADA signalling its availability for trigger or readout.	B-TEL-1270	T
C-SST-TEL-1310	Camera Trigger Classes	CAM	The Camera shall assign to each Camera Event a class which indicates the desired action of the ACADA on receipt of the associated trigger timestamp, and which is permanently associated with the Event data itself, in compliance with [AD9].	B-TEL-1310	T

7 Performance

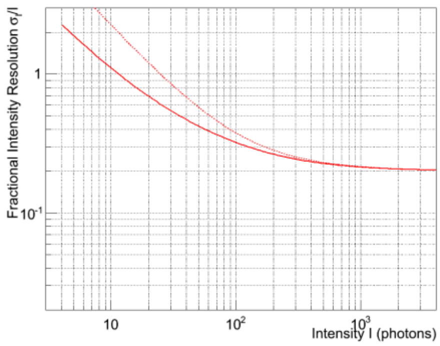
Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0011	Monte Carlo Model Verification	TEL	The Monte Carlo model and its configuration used for modelling the SST telescope shall be verified with as described in a dedicated document.	B-SST-0010	T
C-SST-TEL-0600	Telescope Average Power Consumption during Observations	TEL	The average power consumption by a single Telescope during Observations shall not exceed 7 kW	B-SST-0610 B-SST-1580	T
C-SST-TEL-0602	Telescope Peak Power Consumption during Observations	TEL	The peak power consumption by a single Telescope during Observations shall not exceed 11 kW	B-SST-0630 B-SST-1590	T
C-SST-TEL-0604	Telescope Peak Power Consumption in the Initialized State	TEL	The peak power consumption by a single Telescope in the Initialized State shall not exceed 3 kW	C-SST-0630 B-SST-1600	T
C-SST-TEL-0606	Telescope Annual Average Power Consumption in the Initialized State	TEL	The average power consumption over a full year by a single Telescope in the Initialized State shall not exceed 1 kW	B-SST-0640 B-SST-1610	T, A
C-SST-TEL-0041	Real-time Astrometric Data Delivery	TCS	TCS shall deliver Astrometric data to ACADA in real time whilst tracking	B-TEL-0040	T
C-SST-TEL-0042	Real-time Astrometric Data Validity	TCS	TCS shall deliver Astrometric data to ACADA valid Astrometric Data collected within the 5 seconds before the time of delivery to ACADA	B-TEL-0040	T
C-SST-TEL-0138	Optical PSF Monitoring Frequency	TCS	The TCS shall monitor the point-spread-function with a rate TBC.	B-TEL-0135	T
C-SST-TEL-0215	Fast Repositioning	TCS	The TCS shall command the TMS to move to any sky position using the most direct route and in the fastest possible time within safety constraints, if instructed to do so by ACADA with the "is Urgent" flag in compliance with [AD7]	B-TEL-215	T
C-SST-TEL-0260	Range Optimization	TCS	The TCS shall optimise its motion such that the TMS will not approach the end of the mechanical range of motion in Azimuth	B-TEL-0260	T

			during the full duration of Observation upon receiving a Repositioning and Tracking request by ACADA.		
C-SST-TEL-0261	Range Optimization when Fast Repositioning	TCS	The TCS shall optimise its motion such that the TMS will not approach the end of the mechanical range of motion in Azimuth during the full duration of Observation upon receiving a Fast Repositioning and Tracking request by ACADA.	B-TEL-0260	T
C-SST-TEL-0095	UV Light Contribution	OPT, CAM	The optical elements of the Telescope shall ensure that wavelengths below 290 nm in the Cherenkov light spectrum from local muons contribute less than 5% to the observed muon Image Amplitude.	B-TEL-0095	T, A
C-SST-TEL-0120	Mirror Reflectivity	OPT	The initial average specular reflectivity of all reflective surfaces of the Optical System shall be >85% at all wavelengths from 300-550 nm.	B-TEL-0120	T, A
C-SST-TEL-0125	Mirror Degradation	OPT	The loss in specular reflectivity of all reflective surfaces of the Optical system shall be <4% per year at all wavelengths from 300-550 nm.	B-TEL-0125	T, A
C-SST-TEL-0130	Optical PSF Quality	OPT	The Optical System shall focus light on to the focal surface with an optical PSF θ 80 of <0.25 degrees, up to 3.2 degrees from the centre of the cFoV.	B-SST-0130	T, A
C-SST-TEL-0137	Optical PSF Monitoring Accuracy	OPT	The Telescope Optical PSF 80% containment diameter (θ80) shall be known with <10% uncertainty throughout the required field-of-view during Observations.	B-TEL-0135	T, A
C-SST-TEL-0140	Optical Time Dispersion	OPT	The Optical System shall focus light (over 80% of the required camera field of view diameter) with a rms optical time spread of <1.5 ns.	B-SST-0140	T, A
C-SST-TEL-0020	Post-Calibration Astrometric Accuracy	MEC, CAM	The Post-Calibration Astrometric Accuracy of an SST Telescope whilst Tracking during Precision Pointing Conditions, shall be <7 arcseconds.	B-SST-0020	T, A
C-SST-TEL-0040	Online Astrometric Accuracy	MEC, TCS	The Online Astrometric Accuracy of the Telescope whilst Tracking shall be < 60 arcseconds	B-TEL-0040	T
C-SST-TEL-0090	Signal to Noise	MEC, OPT, CAM	The overall optical efficiency of the Telescope to background light, ε bg (including night sky background and albedo - following the Background Light Reference Spectrum and integrated over the full spectral response of the Telescope), shall be such that (ε sig)/ sqrt (ε bg) >0.35. (ε sig is the integral over the Cherenkov Reference Spectrum)	B-TEL-0090	T, A
C-SST-TEL-0110	Mirror Area	MEC, OPT, CAM	The Geometrical Mirror Area of the Telescope, corrected for the effect of shadowing by the camera and its support structure (and if present the secondary mirror), shall be >5 m2 for all angles within the required Camera Field of View.	B-SST-0110	T, A
C-SST-TEL-0450	Pointing Calibration Run Frequency	MEC, OPT	TMS shall not require dedicated pointing observations with an annual average of more than 3 hours per month of Grey Time plus 6 hours per month of Bright Moon Time.	B-TEL-0450	A
C-SST-TEL-0451	PSF Calibration Run Frequency	MEC, OPT	TMS shall not require dedicated PSF calibration observations with an annual average of more than 3 hours per month of Grey Time plus 6 hours per month of Bright Moon Time.	B-TEL-0450	A
C-SST-TEL-0030	Standard Post-Calibration Astrometric Accuracy	MEC, CAM	The Post-Calibration Astrometric Accuracy of an SST Telescope whilst Tracking shall be < 20 arcseconds under standard observing conditions.	B-SST-0030	A, T
C-SST-TEL-0035	Post-Calibration Astrometric Accuracy Algorithm	MEC, CAM	SST telescope shall provide algorithms to DPPS to achieve Post Calibration Astrometric Accuracy	B-SST-0020 B-SST-0030	R
C-SST-TEL-0214	Repositioning Time	MEC	The TMS shall be able to rotate from any point to any other point in the sky above 30° in elevation within 70 seconds at	B-SST-0210	T

			wind speeds below 36 km/h and making use of the full azimuthal and elevation movement ranges, in response to a repositioning request flagged as time critical.		
C-SST-TEL-0232	Tracking Accuracy in Azimuth	MEC	The TMS shall be able to Track any Astrophysical Target for the Horizontal Coordinate System Azimuth angle range specified in C-TEL-0230 with an instantaneous accuracy of <0.1 degrees on both axes for 99% of the tracking time.	B-TEL-0250	T
C-SST-TEL-0254	Tracking Accuracy in Elevation	MEC	The TMS shall be able to Track any Astrophysical Target for the Horizontal Coordinate System Elevation angle range specified in C-TEL-0240 with an instantaneous accuracy of <0.1 degrees on both axes for 99% of the tracking time.	B-TEL-0250	T, A
C-SST-TEL-0610	Average Structure Power Consumption during Observations	MEC	The average power consumption by a single TMS during Observations shall not exceed 3 (TBC) kW.	B-SST-0610	T
C-SST-TEL-0620	Peak Structure Power Consumption during Observations	MEC	The peak power consumption by a single TMS during Observations shall not exceed 7 (TBC) kW.	B-SST-0620	T
C-SST-TEL-0630	Peak Structure Power Consumption in the Initialized State	MEC	The peak power consumption by a single TMS in the Initialized State shall not exceed 2 (TBC) kW.	B-SST-0630	T
C-SST-TEL-0640	Annual Average Power Consumption in the Initialized State	MEC	The average power consumption over a full year by a single TMS in the Initialized State shall not exceed 0.5 (TBC) kW.	B-SST-0640	T, A
C-SST-TEL-1010	Intensity Resolution	CAM	The required fractional Intensity Resolution for Cherenkov signals in each Camera pixel for a specified background level of 0.24 photons ns-1sr-1cm-2 (black curve) and for the highest NSB levels required for a given telescope type (red curve) is given in the Figure below and Table attached. The average intensity resolution shall be calculated for the Reference Gamma-Ray Flux.  Figure 7-1: Fractional rms intensity resolution σ I /I per pixel for different Cherenkov light signal amplitudes, expressed in photons (p.e.). All sources of fluctuations, including Poisson fluctuations in photon number and calibration uncertainties (excluding uncertainties on average camera efficiency/throughput), must be included. Curves are shown for the nominal (black line) and high NSB (red line) cases.	B-TEL-1010	T, A
C-SST-TEL-1011	Dynamic Range	CAM	Intensity measurements shall be possible for instantaneous signals of between 0 and 4000 photons per camera pixel.	B-TEL-1010	T

C-SST-TEL-1030	Time Resolution	CAM	The rms difference in the reconstructed signal arrival time for any two simultaneously illuminated pixels in the Camera with amplitudes of five photoelectrons shall not exceed 2 ns. This is for a specified background level of 0.24 photons ns-1sr-1cm-2.	B-TEL-1030	T
C-SST-TEL-1130	Field of View Diameter	CAM	The Field of View diameter of the SST Camera Unit shall be at least 8 degrees.	B-SST-1130	A
C-SST-TEL-1150	Angular Pixel Pitch	CAM	The average SST Camera angular pixel pitch shall be <0.25 degrees for pixels situated on a hexagonal grid, or 0.25/1.075 degrees for pixels on a square grid.	B-SST-1150	R
C-SST-TEL-1160	Pixel Gap	CAM	The angular distance of any non-photosensitive gap between directly adjacent pixels, measured along the line joining their centres, shall be less than 0.058 degrees.	B-TEL-1160	R
C-SST-TEL-1170	Photon Detection Efficiency	CAM	The average efficiency of the focal plane detectors (i.e., conversion efficiency from photons to photoelectrons), weighted by the reference Cherenkov spectrum (see Figure 7-2) in the wavelength range 300-550 nm, including dead-space and the efficiency of any focal plane optics/windows etc., shall be >20 %.  Figure 7-2 : Reference spectra for night sky background (NSB) light and Cherenkov light from γ -ray initiated air- showers at ground-level. The Cherenkov light spectrum is shown including the transmission from an atmospheric depth of 240 g/cm 2 at 20 ◦ zenith angle, corresponding to the shower maximum of ≈100 GeV γ -ray showers, and detected at 2000 m above sea level. The Cherenkov spectrum is scaled to 100 photons/m 2 in the wavelength range from 300–600 nm, a value typical for γ -ray showers of about 500 GeV viewed at small core distances. Note that the NSB spectrum given is most appropriate for dark sky (moonless) observations, but the same spectral shape can be assumed for the full range of required operational NSB levels.	B-TEL-1170	T, A
C-SST-TEL-1210	Integration Window	CAM	Pixel signal integration shall be possible within a time window of between 20 and 30 ns with respect to the Camera trigger time for signals in the range 0-400 photons. The start time of this integration window shall be adjustable with respect to the trigger time in steps not larger than 2 ns.	B-SST-1210	T
C-SST-TEL-1220	Readout Window	CAM	The time window within which a Cherenkov signal can be reconstructed shall be at least 80 ns.	B-SST-1220	T
C-SST-TEL-1230	Minimum Image Amplitude	CAM	For gamma-ray initiated showers with the Reference Gamma Spectrum, the Cherenkov light intensity that is needed to generate a Camera trigger with a probability of at least 50 % over 90 % of the solid angle within the required camera field of view and with any image orientation, shall be smaller than: I thresh × (F NSB / 0.24 ns −1 sr -2 cm -2) 1/2 photons over the full required NSB range or I thresh if F NSB < 0.24 ns −1 sr -2 cm -2 . The value of the threshold image amplitude I thresh shall be < 250 photons in the wavelength range 300-550 nm. F NSB is given as the light flux at ground level in the wavelength range from 300-650 nm and can be assumed to follow the Background Light Spectrum.	B-SST-1230	T
C-SST-TEL-1235	Minimum Proton Image Amplitude	CAM	For proton initiated showers following the Reference Proton Spectrum, the Cherenkov light intensity that is needed to generate a local camera trigger with a probability of at least 50% over 90% of solid angle of the required camera field of view and with any image orientation, shall be < 480 photons.	B-SST-1235	T

C-SST-TEL-1260	Deadtime	CAM	The Deadtime during continuous observation at the minimum required Event Rate and time distribution specified in B-SST-1280 shall be <5%.	B-TEL-1260	T
C-SST-TEL-1275	Minimum Shower Fraction	CAM	The fraction of Trigger Timestamps delivered by the Camera to ACADA that are associated with atmospheric Cherenkov showers shall always exceed 10% during Observations.	B-TEL-1275	T
C-SST-TEL-1280	Event Rate	CAM	The SST Camera shall be able to collect and deliver for further processing Events arriving at a sustained event rate of at least 600 Hz with a random distribution in time.	B-SST-1280	T
C-SST-TEL-1285	Trigger Rate Cap	CAM	The SST Camera shall deliver Trigger information to ACADA at a rate (averaged over 100 ms) of less than 1200 Hz for events arriving at random.	B-SST-1285	T
C-SST-TEL-1300	Muon Trigger	CAM	The Camera shall be able to trigger on, and flag prior to transmission of R1 data to the ACADA, fully contained (within the sensitive area of the camera) muon rings, from muons impacting the mirror with an energy > 20 GeV with an overall efficiency greater than 90% (excluding dead-time).	B-TEL-1300	T
C-SST-TEL-1305	Local Event Rate	CAM	The Camera shall deliver events without associated array level coincidences (Local Events) to ACADA at a rate of less than 120 Hz. Such events shall be flagged as Local Events.	B-SST-1305	T
C-SST-TEL-1320	Image Intensity Threshold Monitoring	CAM	The Camera shall determine and monitor its image intensity threshold, characterised by I thresh, with a rms accuracy of at least 7% during Observation.	B-TEL-1320	T
C-SST-TEL-1370	Pedestal Subtraction	CAM	During Observations the Camera shall measure the Pedestal in each pixel and the event-to-event rms of this quantity with an uncertainty no greater than 20% of the event-to-event rms or 1.2 photons (if greater). The Pedestal shall be subtracted from the data prior to delivery to the ACADA (R1 level) and the Pedestal value being subtracted made available to the ACADA at least once every 2 seconds as part of the monitoring stream.	B-TEL-1370	T
C-SST-TEL-1380	Systematic Pixel Timing Uncertainty	CAM	The rms uncertainty on the mean relative reconstructed arrival time in every Camera pixel for uniform simultaneous pulsed illumination (<5 ns FWHM) shall not exceed 1 ns for amplitudes in the range 20 to 2000 photons per pixel.	B-TEL-1380	T
C-SST-TEL-1390	Linearity	CAM	The average response of every pixel to input signals between 10 and 1000 pe shall be known to a precision better than 8% at all times. The pixel-wise transfer (or response) function should be monitored at sufficient intervals to ensure that this requirement is always met.	B-TEL-1390	T
C-SST-TEL-1410	Camera Trigger Timing	CAM	The rms uncertainty on the Trigger Timestamp of a Camera relative to the time of arrival of light at the focal plane shall be less than 5 ns for an instantaneous flash of total amplitude 200 photoelectrons. This is for a specified background level of 0.24 photons ns-1sr-1cm-2.	B-TEL-1410	T
C-SST-TEL-1430	Post-Calibration Trigger to Image Timing Uncertainty	CAM	The difference between the mean reconstructed pixel time in a cleaned gamma-ray image and the Trigger Timestamp associated with this Camera Event shall be determined with a rms uncertainty of less than 2 ns after calibration. This is for a specified background level of 0.24 photons ns-1sr-1cm-2. This value includes all statistical and systematic contributions to the uncertainty.	B-TEL-1430	T
C-SST-TEL-1440	Post-Calibration Trigger Timing	CAM	The rms uncertainty on the post-calibration Trigger Timestamp of a Camera relative to the time of arrival of light at the focal plane shall be less than 2 ns for an instantaneous flash of total amplitude 200 photoelectrons, involving 10 pixels or more, and at any position in the field of view. This is for a specified background level of 0.24 photons ns-1sr-1cm-2.	B-TEL-1440	T
C-SST-TEL-1570	Peak Camera Power Consumption during Observations	CAM	The peak power consumption by a single SST Camera during Observations, including its full cooling system (but excluding the Camera Server), shall not exceed 4 (TBC) kW.	B-SST-1570	T

C-SST-TEL-1580	Average Camera Power Consumption during Observations	CAM	The average power consumption by a single SST Camera during Observations shall not exceed 3 (TBC) kW.	B-SST-1580	T
C-SST-TEL-1590	Peak Camera Power Consumption in the Initialized State	CAM	The peak power consumption by a single SST Camera in the Initialized State, including its full cooling system (but excluding the Camera Server), shall not exceed 1 (TBC) kW.	B-SST-1590	T
C-SST-TEL-1600	Annual Average Camera Power Consumption in the Initialized State	CAM	The average power consumption over a full year of a single SST Camera in the Safe State, including its full cooling system (but excluding the Camera Server), shall not exceed 0.5 (TBC) kW.	B-SST-1600	T
C-SST-TEL-1630	R1 Intensity Resolution	CAM	The required fractional Intensity Resolution for Cherenkov signals in each Camera pixel for a specified background level of 0.24 photons ns-1sr-1cm-2 (black curve) and for the highest NSB levels required for a given telescope type (red curve), extracted using the R1 data delivered to ACADA using previously determined per-pixel coefficients, shall reach at least the values shown in the Figure 7-3 and table attached, degraded with respect to B-TEL-1010.  Figure 7-3: Fractional rms intensity resolution σ_I/I per pixel for different Cherenkov light signal amplitudes, expressed in photons (p.e.). All sources of fluctuations, including Poisson fluctuations in photon number, must be included. Curves are shown for the nominal NSB (solid line) and high NSB (dashed line) cases	B-TEL-1630	T
C-SST-TEL-1640	R1 Time Uncertainty	CAM	The rms difference in the signal arrival time for any two simultaneously illuminated pixels in the Camera with amplitudes of five photoelectrons, reconstructed from the R1 data delivered to ACADA, using previously determined per-pixel coefficients, shall not exceed 3 ns. This is for a specified background level of 0.24 photons ns-1sr-1cm-2.	B-TEL-1640	T
C-SST-TEL-1660	Survival Illumination Recovery Time	CAM	The Camera shall be able to recover full performance capabilities within 1 minute of the end* of any transient illumination up to the survival limit.	B-TEL-1660	T
C-SST-TEL-1670	Maximum Routine Illumination Recovery Time	CAM	Each pixel in an SST Camera shall be able to recover full performance capabilities within 1s following (i.e., once the source of light has been removed) maximum routine illumination of 2000 ph ns -1 in the wavelength range 300 - 650 nm.	B-SST-1670	T
C-SST-TEL-1680	Observation Illumination	CAM	SST Telescope shall be capable of gamma-ray observations with uniform night sky background illumination levels up to at least 4.3 photons ns −1 sr −1 cm −2 in the wavelength range 300-650 nm with the Moonlight Reference Spectrum.	B-SST-1680	T

8 Design

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0591	Telescope Transition Time: Initialized to Standby	TEL	The Telescope shall transition from the Initialized to the Standby State in less than 90 (TBC) minutes.	B-TEL-0710 B-TEL-1710	T
C-SST-TEL-0592	Telescope Transition Time: Standby to Ready	TEL	The Telescope shall transition from the Standby State to the Ready State in less than 3 (TBC) minutes	B-TEL-0720 B-TEL-1720	T
C-SST-TEL-0593	Telescope Transition Time: Ready to Observing	TEL	The Telescope shall transition from the Ready State to the Observing State in less than 2' (TBC) minutes.	B-TEL-0730 B-TEL-1730	T
C-SST-TEL-0594	Telescope Transition Time: Observing to Ready	TEL	The Telescope shall transition from the Observing State to the Ready State in less than 2' (TBC) minutes.	B-TEL-0730 B-TEL-1730	T
C-SST-TEL-0595	Telescope Transition Time: Return to Initialized	TEL	The Telescope shall transition from the Observing, Ready or Standby State to the Initialized in less than 5(TBC) minutes.	B-TEL-0740 B-TEL-1740	T
C-SST-TEL-0596	Telescope Transition Time: Off to Initialized	TEL	The Telescope shall transition from the Off State to the Initialized in less than 4 (TBC) minutes.	B-TEL-0750 B-TEL-1750	T
C-SST-TEL-1520	Maximum Solar Concentration	TEL	The Telescope and its subsystems shall not concentrate sun light to power densities greater than 5 kW/m 2. Areas and times at which power densities greater than 2 kW/m 2 may occur shall be identified and clearly documented.	B-TEL-1520	A
C-SST-TEL-0330	Flood Protection	TEL	The Telescope and its subsystems shall be designed to prevent all effects of water collection caused by surface water runoff.	B-ONSITE-0330	R, T
C-SST-TEL-0410	Light Pollution	TEL	The Telescope and its subsystems shall not produce light with an isotropic equivalent flux greater than 3x10^6 photons ns^-1 at source in the wavelength range 300-550 nm during observations in the absence of specific calibration instructions from ACADA.	B-ONSITE-0410	R
C-SST-TEL-2030	Reference System	TEL	The Telescope and its subsystems design, construction shall be compliant with [AD 11].		R
C-SST-TEL-2410	TCS Framework	TCS	TCS shall be implemented using the Alma Common software (ACS) framework		R
C-SST-TEL-2420	TCS System Properties	TCS	TCS shall expose monitoring system properties (states, monitoring, set point, etc) as ACS BACI.		R
C-SST-TEL-2010	Optical System Design	OPT	Optical system shall have an optical system based on a dual-mirror Schwarzschild-Couder design.		R
C-SST-TEL-0722	Local Control Mode	MEC, TCS	The TMS and TCS shall implement a maintenance mode during which it is unavailable for scientific operations or any kind of remote control, in compliance to [AD7]	B-ONSITE-0720	T
C-SST-TEL-2110	TMS Design	MEC, OPT, CAM	The design, construction and test of the Telescope and its subsystems shall consider only methods and procedures which are state-of-the-art in high precision mechanics, hydraulics and pneumatics, optical, electrical and electronics engineering, design and fabrication. These methods and procedures shall be appropriate for the applicable extreme environmental conditions and the long lifetime of the instrument. Preferable are those technologies which have been proven to lead to high		R

			reliable equipment for application at remote astronomical observatories at an altitude of >2300m above sea level		
C-SST-TEL-1110	Focal Plane Maximum Tilt Positioning	MEC, CAM	The centre of the focal plane instrumentation of the Camera Unit shall be positioned (in the direction perpendicular to the optical axis) by the TMS to within 0.12 degrees of the optical axis.	B-SST-1110	T
C-SST-TEL-0712	Structure Transition Time: Initialized to Standby	MEC	The TMS shall transition from the Initialized to the Standby State in less than 30 minutes.	B-TEL-0710	T
C-SST-TEL-0720	Structure Transition Time: Standby to Ready	MEC	The TMS shall transition from the Standby State to the Ready State in less than 3 minutes	B-TEL-0720	T
C-SST-TEL-0730	Structure Transition Time: Ready to Observing	MEC	The TMS shall transition from the Ready State to the Observing State in less than 2 minutes. The opposite transition shall be possible on the same timescale.	B-TEL-0730	T
C-SST-TEL-0731	Structure Transition Time: Observing to Ready	MEC	The TMS shall transition from the Ready State to the Observing State in less than 2 minutes. The opposite transition shall be possible on the same timescale.	B-TEL-0730	T
C-SST-TEL-0742	Structure Transition Time: Return to Initialized	MEC	The TMS shall transition from the Observing, Ready or Standby State to the Initialized in less than 5 minutes.	B-TEL-0740	T
C-SST-TEL-0752	Structure Transition Time: Off to Initialized	MEC	The TMS shall transition from the Off State to the Initialized in less than 4 minutes.	B-TEL-0750	T
C-SST-TEL-0100	Power Control	MEC	The electrical system shall be controlled both remotely and by a person present at the System location according to [AD 10]	B-ONSITE-0100	T
C-SST-TEL-0231	Mechanical Range of Motion in Azimuth	MEC	The TMS shall be able to rotate, in a controlled manner, both clockwise and counter-clockwise, in the range from -270° to +270° starting from the West geographical direction.	B-TEL-0230	R, T
C-SST-TEL-0234	Azimuth Range	MEC	The TMS shall be able to point to any Azimuth angle in the range 0 - 360 degrees.	B-TEL-0230	R, T
C-SST-TEL-0240	Elevation Range	MEC	The TMS shall be able to point to any Elevation angle in the range 20 - 89.2 degrees while Tracking.	B-TEL-0240	R, T
C-SST-TEL-0241	Mechanical Range of Motion in Elevation	MEC	The TMS shall be able to rotate, in a controlled manner, in the elevation range 0-91 degrees, starting from the horizontal direction.	B-TEL-0240	R, T
C-SST-TEL-0400	Park Position	MEC	The TMS shall have a reference "Park" position in which the Structure is mechanically locked and the locked status is signalled to the IPS (TBC). The "Park" position may vary during a year, but shall always be fixed for any given 24-hour period.	B-TEL-0400	R, T
C-SST-TEL-0462	Field of View Obstruction	MEC	The full field of view shall not be obstructed by any part of the TMS in an azimuth range of at least 270º for all elevations >= 0°.	B-TEL-0460	R, T
C-SST-TEL-0500	Fixation to Foundation	MEC	TMS to Foundation Interface shall be designed to ensure that the Telescope is anchored to the foundation to withstand the required static and dynamic loads as per C-TEL-0720, C-TEL-0740, C-TEL-0745, C-TEL-1110, C-TEL-1120.	B-TEL-0500	R, T
C-SST-TEL-2040	Structure Pointing Capability	MEC	The TMS shall include all the hardware and software to allow the telescope to point different parts of the sky with the required performances and all mechanical parts needed to support the telescope optics for collecting light.		R, T

C-SST-TEL-2050	Structure Motion Capability	MEC	The TMS shall provide the motion capabilities that allow the Telescope to point and track celestial object over its specified range as specified in C-SST-TEL-0231 and C-SST-TEL-0241.		R, T
C-SST-TEL-2060	Anchor Bars	MEC	The TMS shall be connected to the concrete foundation supporting the Telescope by means of anchor bars.		R, T
C-SST-TEL-2070	Telescope Foundation	MEC	The Foundations should contain a Telescope anti-seismic system if it may be considered necessary to avoid permanent damaging effects.		R, T
C-SST-TEL-2080	TMS local control system Design	MEC	The TMS Local control system shall be deigned, implemented and tested in compliance with [AD 13], [AD 14] and [AD 15].		R, T
C-SST-TEL-2090	TMS hand-paddle	MEC	The TMS local control system (LCS) shall allow to safely control the TMS motion locally through a dedicated hand-paddle for diagnostic or maintenance purpose.		R, T
C-SST-TEL-2120	TMS LCSS Design	MEC	The TMS Local Control System Software (LCSS) shall run on the Local Control Units (LCU) and Safety Unit (SU).		D
C-SST-TEL-2130	LCU Design	MEC	The TMS LCU shall be industrial grade PC (IPC).		R
C-SST-TEL-2140	LCSS Software System	MEC	The TMS LCSS shall run as PLC programs under the Beckhoff TwinCAT software system which turn any IPC into a real-time controller with a multi-PLC system.		R
C-SST-TEL-2150	LCSS Programming Languages	MEC	The TMS LCSS running on the PLC created by TwinCAT shall be written using the IEC61131-3 PLC programming languages.		R
C-SST-TEL-2160	Sudden Loss of Power	MEC	In the exceptional cases of a sudden loss of power all TMS subsystems shall not suffer any damage.		I, T
C-SST-TEL-2350	Camera Support Structure	MEC	The TMS shall include support structure to mount the Camera Unit on the focal plane.		R
C-SST-TEL-2430	Pointing Monitoring Camera	MEC	The TMS shall include a pointing monitoring camera as defined in [AD6].		T
C-SST-TEL-2020	Optical System Mount	MEC	The Optical System shall be mounted on an altitude–azimuth TMS.		R
C-SST-TEL-2450	Mirror Alignment System support	MEC	The M1 Optical Support System shall be designed to mount a motorized system to allow the tip, tilt and piston movements of each mirror segment.		R, T
C-SST-TEL-1180	Focal Plane Instrumentation	CAM	The SST Camera Unit focal plane shall be fully instrumented with photosensitive pixels (in compliance with the dead-space requirement C-SST-TEL-1160) up to a radius of at least 3.4 degrees.	B-SST-1180	T
C-SST-TEL-1350	Flat-Fielding Requirements	CAM	The Camera shall include a flat-fielding device or devices which provide pulsed illumination of all camera pixels with an intensity between 100 and 400 photons per pulse and a time duration in the range 1-10 ns FWHM, at a rate of at least 100 Hz. The mean wavelength of the pulsed light source should lie within 50 nm of the peak of the instrument response convolved with the Reference Cherenkov Spectrum. The pattern of illumination across the full camera field of view shall be known at the level of 2%. Locally initiated flat-fielding Events shall be flagged as such. Additionally, it shall be possible for the ACADA to initiate flat-fielding Event collection.	B-TEL-1350	R
C-SST-TEL-1710	Camera Transition Time: Initialized to Standby	CAM	The Camera shall transition from the Initialized to the Standby State in less than 90 minutes	B-TEL-1710	T
C-SST-TEL-1720	Camera Transition Time: Standby to Ready	CAM	The Camera shall transition from the Standby State to the Ready State in less than 3 minutes	B-TEL-1720	T

C-SST-TEL-1730	Camera Transition Time: Ready to Observing	CAM	The Camera shall transition from the Ready State to the Observing State in less than 30 seconds. The opposite transition shall be possible on the same timescale.	B-TEL-1730	T
C-SST-TEL-1731	Camera Transition Time: Observing to Ready	CAM	The Camera shall transition from the Ready State to the Observing State in less than 30 seconds. The opposite transition shall be possible on the same timescale.	B-TEL-1730	T
C-SST-TEL-1740	Camera Transition Time: Return to Initialized	CAM	The Camera shall transition from the Observing, Ready or Standby State to the Initialized in less than 5 minutes.	B-TEL-1740	T
C-SST-TEL-1750	Camera Transition Time: Off to Initialized	CAM	The Camera shall transition from the Off State to the Initialized in less than 4 minutes.	B-TEL-1750	T

9 Interfaces

Requirement ID	Requirement Name	Applicable SubSystem	Requirement Statement	Requirement Source	Verification Requirement
C-SST-TEL-0820	Monitoring Data	TCS	The TCS shall provide to ACADA all monitoring data necessary for operations, data analysis and condition monitoring, in compliance with the dedicated ICDs.	B-ONSITE-0820	T
C-SST-TEL-0830	Logging	TCS	The TCS shall implement a logging system compliant with [AD 17]	B-ONSITE-0830	T
C-SST-TEL-0840	Monitoring Data Content	TCS	The TCS shall provide monitoring data to ACADA in compliance with [AD 16]	B-ONSITE-0840	T
C-SST-TEL-0850	Monitoring Points	TCS	The TCS shall expose to ACADA up to 1000 monitoring points.	B-ONSITE-0850	T
C-SST-TEL-0200	Repositioning Request	TCS	The TCS shall respond to repositioning and tracking requests issued by ACADA in compliance with [AD7].	B-TEL-200	T
C-SST-TEL-0790	Command Response Time	TCS	The TCS shall respond to commands from ACADA within the times specified in [AD7].	B-ONSITE-0790	T
C-SST-TEL-0795	Command Verification	TCS	The TCS shall verify the validity of any commands received from ACADA and notify it about exceptions according to[AD7].	B-ONSITE-0795	T
C-SST-TEL-2000	Engineering GUI	TCS	The TCS shall provide an engineering GUI which shall allow Users to access all Telescope functionalities and monitoring points as defined in the TBD document.	B-TEL-2000	R
C-SST-TEL-0511	Interface to Site Network Infrastructure	MEC, CAM, TCS	The Telescope interfaces to the on-site network infrastructures shall be defined, specified and controlled by dedicated Interface Control Document.	B-TEL-0510	R
C-SST-TEL-0512	Interface to Site Timing Infrastructure	MEC, CAM, TCS	The Telescope interfaces to the on-site timing distribution infrastructures shall be defined, specified and controlled by dedicated Interface Control Documents.	B-TEL-0510	R
C-SST-TEL-0050	Camera Fixation	MEC, CAM	A suitable TMS / Camera Unit mechanical interface shall be provided to ensure safe and stable fixation compliant with C-TEL-0720, C-TEL-0740, C-TEL-0745, C-TEL-1110, C-TEL-1120	B-TEL-0050	R, T
C-SST-TEL-0051	Structure to Camera Mechanical Interface Positioning Accuracy	MEC, CAM	The TMS / Camera Unit mechanical interface shall ensure focal plane positioning compliant with C-SST-TEL-0040	B-TEL-0050, B-TEL-0040	R, T
C-SST-TEL-0052	Structure to Camera Mechanical Interface	MEC, CAM	The TMS / Camera Unit mechanical interface shall ensure that the focal plane positioning is	B-TEL-0050, B-TEL-0040	R, T

	Positioning Reproducibility		reproducible with the same accuracy upon Camera replacement.		
C-SST-TEL-0510	Interface to on-site Civil Infrastructure	MEC	The TMS interfaces to the on-site civil infrastructures shall be defined, specified and controlled by dedicated Interface Control Documents.	B-TEL-0510	R
C-SST-TEL-0513	Interface to Site Power Infrastructure	MEC	The TMS interfaces to the on-site power infrastructures shall be defined, specified and controlled by dedicated Interface Control Documents.	B-TEL-0510	R
C-SST-TEL-0514	Interface to on-site IPS and Alarm Infrastructure	MEC	The TMS interfaces to the on-site IPS and alarm infrastructures shall be defined, specified and controlled by dedicated Interface Control Documents.	B-TEL-0510	R
C-SST-TEL-2360	Power Interface	MEC	The TMS shall receive power from CTAO Power distribution system as prescribed by the associated Interface Control Document [AD 10]		R
C-SST-TEL-2050	Electrical and Communication Connections	MEC	All the electromechanical part of the TMS shall be provided with power and data communication via dedicated supply lines.		R
C-SST-TEL-1250	Pixel Readout	CAM	The Camera shall be able to deliver signal amplitude information from all camera pixels in each event together with all available time domain information.	B-TEL-1250	T
C-SST-TEL-1360	Forced Triggers	CAM	The Camera shall issue a Trigger at a specified absolute time on request from ACADA, and flag the generated Event as ACADA requested, in compliance with [AD9].	B-TEL-1360	T
C-SST-TEL-1420	Trigger Timestamp Delivery	CAM	Trigger Timestamp Information shall be issued by the Camera to the ACADA with a time delay of < 0.5 seconds from the light falling onto the Camera photodetector plane.	B-TEL-1420	T
C-SST-TEL-1450	Camera Output Data Rate	CAM	The Camera shall deliver Event data (including both Local Events and Array-Level Events) to ACADA at a rate never exceeding 6 Gbps (max instantaneous rate measured over 1 sec).	B-SST-1450	T
C-SST-TEL-1610	R1 Event Data	CAM	The format and transmission protocol of the Camera Event Data delivered to the ACADA (R1 level) shall comply with the format defined in [AD9]	B-TEL-1610	T
C-SST-TEL-1650	R1 Trigger Time Information	CAM	In addition to an absolute time derived from the system wide precision time distribution system, the (R1) Event data sent to the ACADA shall contain an event sequence number and/or NTP-based event time identifier, to be used for monitoring and diagnostic purposes.	B-TEL-1650	T
C-SST-TEL-0812	Absolute Time	CAM	The Camera Unit shall receive the absolute time provided by the Central Computer Time Synchronisation System for all calculations for which a time is needed and as the reference in all log, error and alarm messages.	B-ONSITE-0810	T

Annex A- Compliance Matrix

Compliance Matrix with respect [AD2], [AD3], [AD4] and [AD5].

Compliance status legend:

- C: Compliant
- NC: Not Compliant
- PC: Partially Compliant
- N/A: Not Addressed /Not available

The compliance status has been indicated on the basis of the prototypes already developed and analysis of the proposed design. The change request indicated will be proposed before the CDR after assessment of the non-conformance with respect to the requirement.

Requirement Source	Requirement Name	Requirement Statement	Requirement Level C	Change Request	Compliance Status	Remarks
B-ENV-0135	Atmospheric Pressure	Performance requirements must be met in the atmospheric pressure range of 770 +/- 50 mbar.	C-SST-TEL-0135		C	
B-ENV-0210	Observation Temperature	Performance requirements for observations must be met within the ambient temperature range -5ºC to 25ºC	C-SST-TEL-0210		C	
B-ENV-0220	Survival Temperature	Damage must not occur due to ambient temperatures within the range -15ºC to 35ºC when in the Safe State	C-SST-TEL-0225		C	
B-ENV-0225	Survival Temperature Without Power	Damage must not occur due to ambient temperatures within the range -10ºC to 30ºC when no power is available.	C-SST-TEL-0225		C	

B-ENV-0230	Temperature Gradient	Performance requirements for observations must be met during air temperature gradients of less than 7.5ºC/h	C-SST-TEL-0230		C	
B-ENV-0235	Precision Pointing Temperature Gradient	It must be possible to achieve precision pointing under temperature gradients of up to 3ºC/h	C-SST-TEL-0235		C	
B-ENV-0250	Survival temperature gradients	Damage must not occur due to air temperature gradients of up to 0.5ºC/min for 20 minutes when in the Safe State	C-SST-TEL-0250		C	
B-ENV-0310	Observation Humidity	Performance requirements for observations must be met within the relative humidity range 2% to 90%, provided the condition for operation with un-misted mirrors (B-ENV-0330) is met.	C-SST-TEL-0310		C	
B-ENV-0320	Survival humidity	Damage must not occur due to relative humidity within the range 2% to 100% when in the Safe State or when no power is available.	C-SST-TEL-0324		C	
B-ENV-0330	Mirror Misting	Telescopes must operate with un-misted mirrors when the dew point temperature is at least 2ºC lower than the ambient temperature.	C-SST-TEL-0334		C	
B-ENV-0410	Rain in 24 hours	Damage must not occur due to rain precipitation of up to 200mm in 24 hours.	C-SST-TEL-0412		C	
B-ENV-0420	Rain in 1 hour	Damage must not occur due to rain precipitation of up to 70mm in 1 hour.	C-SST-TEL-0420 C-SST-TEL-422		C	
B-ENV-0430	Rain wind speed	Damage beyond the Serviceability Limit State must not occur due to precipitation in the form of rain, snow or hail for (10 minute average) wind speeds of up to 90km/h.	C-SST-TEL-0438		C	
B-ENV-0460	Rain during transition	During transitions, damage must not occur due to rainfall of up to 2 mm/hour.	C-SST-TEL-0460		C	
B-ENV-0520	Survival snow load (North)	Damage beyond the Serviceability Limit State must not occur on the CTA-N site whilst in the Safe State due to snow loads of up to 200kg / m^2	-		N/A	This requirement it is not applicable to SST, located on CTA-S only
B-ENV-0525	Survival snow load (South)	Damage beyond the Serviceability Limit State must not occur on the CTA-S site whilst in the Safe state due to snow loads of up to 20kg / m^2	C-SST-TEL-0525		C	
B-ENV-0530	Hailstone damage	Damage must not occur due to the impact of 5 mm diameter hailstones with kinetic energy of 0.2 Joule.	C-SST-TEL-0530		C	
B-ENV-0620	Survival ice load (North)	Damage beyond the Serviceability Limit State must not occur due to an ice thickness (on all surfaces) of up to 20 mm.	-		N/A	This requirement should be not applicable to SST, located on CTA-S only

B-ENV-0625	Survival ice load (South)	Damage beyond the Serviceability Limit State must not occur due to an ice thickness (on all surfaces) of up to 20 mm.	C-SST-TEL-0625		C	
B-ENV-0710	Observation Wind Speed	Performance requirements for observations must be met under 10 minute average wind speeds of up to 36 km/h	C-SST-TEL-0710		C	
B-ENV-0715	Precision Pointing Wind Speed (North)	It must be possible to achieve precision pointing on the CTA-N site under 10 minute average wind speeds of up to 15 km/h	-		N/A	This requirement it is not applicable to SST, located on CTA-S only
B-ENV-0716	Precision Pointing Wind Speed (South)	It must be possible to achieve precision pointing on the CTA-S site under 10 minute average wind speeds of up to 11 km/h	C-SST-TEL-0716		C	
B-ENV-0720	Transition Wind Speed	During transitions, damage must not occur on-site due to 10 minute average wind speeds of up to 50 km/h and damage beyond the Serviceability Limit State must not occur due to 10 minute average wind speeds of up to 60 km/h.	C-SST-TEL-0724		C	
B-ENV-0730	Survival wind speed (North)	Damage must not occur at the CTA-N site due to 10 minute average wind speeds of up to 100 km/h, and damage beyond the Serviceability Limit State must not occur due to 10 minute average wind speeds of up to 120 km/h when in the Safe State	-		N/A	This requirement it is not applicable to SST, located on CTA-S only
B-ENV-0735	Survival wind gust (North)	Damage beyond the Serviceability Limit State must not occur on the CTA-N site due to wind gusts (1s) of up to 200 km/h	-		N/A	This requirement it is not applicable to SST, located on CTA-S only
B-ENV-0740	Survival wind speed (South)	Damage must not occur at the CTA-S site due to 10 minute average wind speeds of up to 80 km/h, and damage beyond the Serviceability Limit State must not occur due to 10 minute average wind speeds of up to 100 km/h when in the Safe State	C-SST-TEL-0743 C-SST-TEL-0744		C	
B-ENV-0745	Survival wind gust (South)	Damage beyond the Serviceability Limit State must not occur on the CTA-S site due to wind gusts (1s) of up to 170 km/h	C-SST-TEL-0745		C	
B-ENV-0810	Solar radiation level	Damage must not occur due to solar radiation of up to 1200 W/m^2 (averaged over 1 hour) at a maximum ambient temperature of 35ºC when in the Safe state.	C-SST-TEL-0810		C	
B-ENV-0820	UV resistance	All components exposed to direct solar radiation must be UV resistant.	C-SST-TEL-0810		C	
B-ENV-0915	Dust and sand	Damage must not occur due to an environment with up to 2.9 x 10^5 particles of ≥5µm size per m^3 of air for 90% of the time at 2m above ground. Note: This limit corresponds to the definition of ISO-Class 9 of ISO14644-1 for particles of this size.	C-SST-TEL-0915		PC	The requirement in this form is not applicable to mirrors as does not define the amount of damage to the coating.

B-ENV-1010	Aggressive atmosphere (North)	Damage must not occur on the CTA-N site due to the following Aggressive Atmospheric Concentration ranges when in the Safe State: NO, NO 2 , SO 2 < 3ppb	-		N/A	This requirement it is not applicable to SST, located on CTA-S only
B-ENV-1020	Aggressive atmosphere (South)	Damage must not occur on the CTA-S site due to the following Aggressive Atmospheric Concentration ranges when in the Safe State: NO, NO 2 , SO 2 < 4ppb	C-SST-TEL-1020		C	
B-ENV-1110	Earthquake damage limitation (South)	Damage beyond the Damage Control Limit State must not occur at the CTA-S site due to the following ground accelerations: Peak horizontal ground acceleration up to 0.26g, peak vertical ground acceleration up to 0.3 g, with a 10% probability of exceeding these figures within 10 years (reference return period 95 years)	C-SST-TEL-1112		C	
B-ENV-1115	Earthquake damage limitation (North)	No damage must not occur at the CTA-N site due to peak horizontal ground acceleration up to 0.05 g and peak vertical ground acceleration up to 0.05 g.	-		N/A	This requirement it is not applicable to SST, located on CTA-S only
B-ENV-1120	Earthquake collapse prevention (South)	Damage beyond the Collapse Prevention Limit State must not occur at the CTA-S site due to the following ground accelerations: Peak horizontal ground acceleration up to 0.49g, peak vertical acceleration up to 0.6 g, with a 10% probability of exceeding these figures within 50 years (reference return period 475 years)	C-SST-TEL-1120		C	
B-ENV-1430	Survival Illumination	Damage must not occur due to illumination levels of up to 10^6 photons ns^−1 cm ^−2 in any state.	C-SST-TEL-1430		C	
B-TEL-0040	Online Astrometric Accuracy	The Online Astrometric Accuracy of the Telescope whilst Tracking must be < 60 arcseconds. Astrometric data delivered to the OES must have a period of validity ending not earlier than 5 seconds before the time of delivery.	C-SST-TEL-0041 C-SST-TEL-0042		C	
B-TEL-0050	Camera Fixation	A suitable Telescope Structure / Camera Unit mechanical interface must be provided to ensure a safe and stable fixation which ensures appropriate focal plane positioning.	C-SST-TEL-0050		**C**	
B-TEL-0060	Electromagnetic Compatibility	The Telescope Structure and Camera Unit (as well as its full cooling system) must be electromagnetically compatible, with noise generated by each sub-system having an acceptable level of impact on the performance of the other. The Cherenkov Telescope sub-systems should also be designed to tolerate EM noise associated with local maintenance and engineering activities.	C-SST-TEL-0060		**C**	

B-TEL-0070	Enable Trigger	Telescopes must initiate a transition of the Camera to the Observing State (enable trigger) as soon as the Structure's pointing direction is within the defined tolerance of the requested Target position.	C-SST-TEL-0070		**C**	
B-TEL-0090	Signal to Noise	The overall optical efficiency of the full Cherenkov Telescope to background light (including night sky background and albedo - following the Background Light Reference Spectrum and integrated over the full response of the Telescope), ε_{bg}, must be such that ε_{sig} / sqrt (ε_{bg}) >0.35. ε_{sig} is the integral over the Cherenkov Reference Spectrum .	C-SST-TEL-0090		**C**	
B-TEL-0095	UV Light Contribution	The optical elements of the Cherenkov Telescope (mirrors and camera) must jointly ensure by design that wavelengths below 290 nm in the Cherenkov light spectrum from local muons contribute less than 5% to the observed muon Image Amplitude.	C-SST-TEL-0095		**C**	
B-TEL-0120	Mirror Reflectivity	The initial average specular reflectivity of all Telescope Structure reflective surfaces must be >85% at all wavelengths from 300-550 nm.	C-SST-TEL-0120		**C**	
B-TEL-0125	Mirror Degradation	The loss in specular reflectivity of all Telescope Structure reflective surfaces must be <4% per year at all wavelengths from 300-550 nm.	C-SST-TEL-0125		**C**	

B-TEL-0135	Optical PSF Monitoring	The value of the optical PSF 80% containment diameter (θ 80) must be known with <10% uncertainty throughout the required field-of-view during all Observations. Telescope Structures must acquire point-spread-function measurements as often as needed to achieve this requirement.	C-SST-TEL-0137 C-SST-TEL-0138		**PC**	We are not sure if we are able to verify this requirement using the Cherenkov Camera. Mounting the optical camera to do it will imply one night downtime for the telescope tested. The plan was to use the pointing system (stars) in the camera to monitor the PSF. But the idea that it is always known across the entire FoV to <10% is really hard to prove.. and first we must prove that we can do it at all (with certain star fields etc) using the Cherenkov camera. The other option is to prove that it never changes with an extended campaign (repeated mountings of the optical camera) on the prototype, and then a once-per year check or something with the Cherenkov camera to star fields that can work. It will be assessed during Design consolidation phase
B-TEL-0200	Repositioning Requests	The Telescope Structure must respond to repositioning and Tracking requests issued from the OES using both Equatorial and Horizon coordinate systems, or a Target Name in cases where Equatorial and Horizon coordinates are inappropriate. Such Targets will be listed in a common database provided.	C-SST-TEL-0200		**C**	
B-TEL-0205	Trajectory Calculation	The Telescope Structure must adhere to common standards [ref] for all astrometric calculations.	C-SST-TEL-0205		**C**	
B-TEL-0215	Fast Repositioning	If indicated by the use of an urgency flag, the Telescope Structure must slew to the new position using the most direct route and in the fastest possible time within safety constraints.	C-SST-TEL-0215		**C**	
B-TEL-0230	Azimuth Range	The Telescope Structure must have a minimum azimuth range of movement of 510 degrees, with the central 360 degrees used for standard Observations.	C-SST-TEL-0231 C-SST-TEL-0234		**C**	
B-TEL-0240	Elevation Range	The Telescope Structure must be capable of repointing in the elevation range 0-91 degrees, with the range 20-89.2 degrees usable for standard Observations.	C-SST-TEL-0240 C-SST-TEL-0241		**C**	

B-TEL-0250	Tracking	The Telescope must be able to Track any Astrophysical Target for all azimuth angles and for elevation angles 20-89.2 degrees with an instantaneous accuracy of <0.1 degrees on both axes for 99% of the tracking time.	C-SST-TEL-0232 C-SST-TEL-0254		**C**	
B-TEL-0260	Range Optimisation	When repositioning, the Telescope Structure must optimise the telescope motion such that it will not approach the end of the azimuth range (requiring a 360 degree adjustment) within the next block of observations (the planned duration of the observation will be sent from OES). An exception is for urgent repositionings, where this is not required and the shortest route to the target position should be taken.	C-SST-TEL-0260		**C**	
B-TEL-0280	Condition Monitoring	The condition of key Telescope Structure elements must be continuously monitored, to allow early identification of problems and increased availability due to replacement of parts prior to failure, following the Condition Monitoring Plan.	C-SST-TEL-0280		**C**	
B-TEL-0340	Camera Loading / Unloading	Camera Unit loading and unloading procedures must be clearly documented, specifying the levels of personnel and equipment needed for the procedure to be safely completed within one working day.	C-SST-TEL-0340		**C**	
B-TEL-0400	Parked Position	Telescope Structures must have a reference 'Parked' position, corresponding to the Safe and Standby states, in which the Structure is mechanically secured and this situation is signaled to the SAS. The Parked position may vary during a year, but must always be fixed for any given 24 hour period.	C-SST-TEL-0400		**C**	
B-TEL-0420	Unparked Position	Telescope Structures must have a default position into which they unpark, during transition from Standby to Ready State, and return to prior to parking, at a minimum elevation at which all azimuthal angles are accessible.	C-SST-TEL-0420 C-SST-TEL-0422		**C**	
B-TEL-0430	Observation Pointing Safety	In case a Telescope is unable to reach the Safe state/parking position, there must be procedures and plans in place to ensure that damage due to the sun does not occur. It must be possible for two local CTAO personnel to complete a preventative action within 30 minutes at the Telescope, without a connection to the mains power supply.	C-SST-TEL-0431 C-SST-TEL-0432 C-SST-TEL-0433 C-SST-TEL-0434		**C**	

B-TEL-0440	Structure Pointing Information	The Telescope Structure must provide its nominal current pointing direction (in Horizon coordinates) on request from the OES, independently of the Telescope and Camera States.	C-SST-TEL-0440 C-SST-TEL-0441		**C**	
B-TEL-0450	Pointing Calibration Run Frequency	Telescope Structures must not require dedicated pointing or PSF calibration observations with an annual average of more than 3 hours per month of Grey Time plus 6 hours per month of Bright Moon Time.	C-SST-TEL-0450 C-SST-TEL-0451		**C**	
B-TEL-0460	Calibration by External Illuminating Device	The full field of view must not be obstructed by any part of the Telescope Structure in an azimuth range of at least 270º for all elevations at or above the horizontal.	C-SST-TEL-0462		**C**	
B-TEL-0500	Fixation to Foundation	Telescopes must provide sufficient design information and a suitable interface to ensure that the Telescope Structure is sufficiently well anchored to withstand the expected static and dynamic loads.	C-SST-TEL-0500		**C**	
B-TEL-0510	Interface Cabinet	Telescopes must connect to all of the on-site infrastructure systems using the Interface Cabinet provided as part of the on-site infrastructure.	C-SST-TEL-0510		**C**	
B-TEL-0520	Structure Lifetime	The structural elements of a Telescope Structure must be designed for an operational Lifetime of 30 years.	C-SST-TEL-0520		**C**	
B-TEL-0530	Drive Lifetime	Telescope drive systems, including servos and gears, must be designed for an operational Lifetime of 15 years.	C-SST-TEL-0530		**C**	
B-TEL-0540	Mirror Lifetime	Mirror facets must be designed for an operational Lifetime of 15 years, during which recoating may be expected on a frequency of less than once every 6 years.	C-SST-TEL-0540		**C**	
B-TEL-0580	Drive Control Safety	Telescope drive control systems must be provided with safety interlocks that prevent injury to personnel or damage to telescopes that might result from inadvertent operation, human error, or mechanical or control system failure.	C-SST-TEL-0580		**C**	
B-TEL-0710	Structure Transition Time: Safe to Standby	The Telescope Structure must transition from the Safe State to the Standby State in less than 30 minutes	C-SST-TEL-0712		**C**	
B-TEL-0720	Structure Transition Time: Standby to Ready	The Telescope Structure must transition from the Standby State to the Ready State in less than 3 minutes	C-SST-TEL-0720		**C**	

B-TEL-0730	Structure Transition Time: Ready to Observing	The Telescope Structure must transition from the Ready State to the Observing State in less than 2 minutes. The opposite transition must be possible on the same timescale.	C-SST-TEL-0730 C-SST-TEL-0731		**C**	
B-TEL-0740	Structure Transition Time: Return to Safe	The Telescope Structure must transition from the Observing, Ready or Standby State to the Safe State in less than 5 minutes.	C-SST-TEL-0742		**C**	
B-TEL-0750	Structure Transition Time: Off to Safe	The Telescope Structure must transition from the Off State to the Safe state in less than 4 minutes.	C-SST-TEL-0752		**C**	
B-TEL-1010	Intensity Resolution	The required fractional Intensity Resolution for Cherenkov signals in each Camera pixel for a specified background level of 0.24 photons ns -1 sr -1 cm -2 (black curve) and for the highest NSB levels required for a given telescope type (red curve) is given in the Figure below and Table attached. Intensity measurements must be possible for 0-4000 photon signals. The average intensity resolution should be calculated for the Reference Gamma-Ray Flux .	C-SST-TEL-1010 C-SST-TEL-1011		**C**	
B-TEL-1030	Time Resolution	The rms difference in the reconstructed signal arrival time for any two simultaneously illuminated pixels in the Camera with amplitudes of five photoelectrons must not exceed 2 ns. This is for a specified background level of 0.125 photoelectrons/ns.	C-SST-TEL-1030		**C**	
B-TEL-1240	Trigger Monitoring	Times at which the Camera trigger was enabled and disabled must be recorded and sent to the OES as part of a monitoring stream.	C-SST-TEL-1240		**C**	
B-TEL-1250	Pixel Readout	The Camera must be able to deliver signal amplitude information from all camera pixels in each event together with all available time domain information, unless it can be shown that for a given partial readout scheme, using end-to-end simulations, that the achievable sensitivity is not reduced by more than 3 %. Incomplete or mixed Events will be dropped and count towards deadtime and/or availability.	C-SST-TEL-1250		**C**	
B-TEL-1260	Deadtime	The fraction of the time during a continuous observation, at the required minimum Event Rate (B-*ST-1280), that the camera is unable to identify or record events (the Deadtime) must be <5 %.	C-SST-TEL-1260		**C**	
B-TEL-1265	Busy Triggers	A Camera must generate and send trigger timestamps to the OES whenever possible in the Observing State, even if it cannot provide data for a given Event.	C-SST-TEL-1265		**C**	
B-TEL-1270	Deadtime Measurement	The Deadtime of the Camera must be continuously monitored. The availability for trigger or readout of an individual Camera in any given Event must be derivable by the OES.	C-SST-TEL-1270 C-SST-TEL-1271		**C**	

B-TEL-1275	Minimum Shower Fraction	During Observations, the fraction of Trigger Timestamps delivered by Cameras to the OES that are associated with air showers must always exceed 10%.	C-SST-TEL-1275		**C**	
B-TEL-1295	Pixel Availability	During observations, at least 95% of all Camera pixels must be available and usable for data analysis. In addition, continuous regions of non-functioning pixels must not exceed 2% of all camera pixels. Pixels excluded due to NSB levels beyond those required are not included in this budget.	C-SST-TEL-1295 C-SST-TEL-1296		**C**	
B-TEL-1300	Muon Trigger	The Camera must be able to trigger on, and flag prior to transmission of R1 data to the OES, fully contained (within the sensitive area of the camera) muon rings, from muons impacting the mirror with an energy > 20 GeV with an overall efficiency greater than 90% (excluding dead-time). The fraction of falsely flagged muons in the data stream to OES may be high as long as this efficiency requirement is met and the overall Local Event limit (B-*ST-1305) is not exceeded.	C-SST-TEL-1300		**C**	
B-TEL-1310	Camera Trigger Classes	The Camera must assign to each Camera Event a class which indicates the desired action of the OES on receipt of the associated trigger timestamp, and which is permanently associated with the Event data itself. The trigger class will indicate if the Event is locally triggered or selected for calibration or engineering purposes, a potential sub-array level shower Event or some other class.	C-SST-TEL-1310		**C**	
B-TEL-1320	Image Amplitude Monitoring	During Observations, the Camera must determine and monitor its image intensity threshold, characterised by I_thresh, with a rms accuracy of at most 7%.	C-SST-TEL-1320		**PC**	The wording " a rms accuracy of at most 7%." is unclear (or just, wrong), either " an rms accuracy of at least 7%." or “an rms uncertainty of at most 7%." "During Observations" implies continuously, or discretely? So, is this in the Observing state? Or just before and after (counting as dead time perhaps)? It will be assessed during Design consolidation phase.

B-TEL-1350	Flat-Fielding	Cameras must include a flat-fielding device or devices which provide pulsed illumination of all camera pixels with an intensity between 100 and 400 photons per pulse and a time duration in the range 1-10 ns FWHM, at a rate of at least 100 Hz. The mean wavelength of the pulsed light source should lie within 50 nm of the peak of the instrument response convolved with the Reference Cherenkov Spectrum. The pattern of illumination across the full camera field of view must be known at the level of 2%. Locally initiated flat-fielding Events must be flagged as such. Additionally, it must be possible for the OES to initiate flat-fielding Event collection.	C-SST-TEL-1350		**C**	
B-TEL-1360	Forced Triggers	It must be possible for Cameras to Trigger at a specified absolute time on request from OES, and flag the generated Event as OES requested.	C-SST-TEL-1360		**C**	
B-TEL-1370	Pedestal Subtraction	During Observations the Camera must measure the Pedestal in each pixel and the event-to-event rms of this quantity with an uncertainty no greater than 20% of the event-to-event rms or 1.2 photons (if greater). The Pedestal must be subtracted from the data prior to delivery to the OES (R1 level) and the Pedestal value being subtracted made available to the OES at least once every 2 seconds as part of the monitoring stream.	C-SST-TEL-1370		**C**	
B-TEL-1380	Systematic Pixel Timing Uncertainty	The rms uncertainty on the mean relative reconstructed arrival time in every Camera pixel for uniform simultaneous pulsed illumination (<5 ns FWHM) must not exceed 1 ns for amplitudes in the range 20 to 2000 photons per pixel.	C-SST-TEL-1380		**C**	
B-TEL-1390	Linearity	The average pixel response for input signals between 10 and 1000 pe must be known to better than 8% rms at all times. The pixel-wise transfer (or response) function should be monitored at sufficient intervals to ensure that this requirement is always met.	C-SST-TEL-1390		**C**	
B-TEL-1410	Camera Trigger Timing	The rms uncertainty on the Trigger Timestamp of a Camera relative to the time of arrival of light at the focal plane must be less than 5 ns for an instantaneous flash of total amplitude 200 photoelectrons, involving 10 pixels or more, and at any position in the field of view. This is for a specified background level of 0.125 photoelectrons/ns.	C-SST-TEL-1410		**C**	
B-TEL-1420	Trigger Timestamp Delivery	Trigger Timestamp Information must be issued by the Camera to the OES with a time delay of < 0.5 seconds from the light falling onto the Camera photodetector plane.	C-SST-TEL-1420		**C**	

B-TEL-1430	Post-Calibration Trigger to Image Timing Uncertainty	The difference between the mean reconstructed pixel time in a cleaned gamma-ray image and the Trigger Timestamp associated with this Camera Event must be determined with a rms uncertainty of less than 2 ns after calibration. This is for a specified background level of 0.125 photoelectrons/ns. This value includes all statistical and systematic contributions to the uncertainty.	C-SST-TEL-1430		**PC**	The SST team are not responsible for (and have no control over) image cleaning. The reconstructed event time is clearly critical, but to verify this requirement the SST team should be provided with the intended algorithm / tool.
B-TEL-1440	Post-Calibration Trigger Timing	The rms uncertainty on the post-calibration Trigger Timestamp of a Camera relative to the time of arrival of light at the focal plane must be less than 2 ns for an instantaneous flash of total amplitude 200 photoelectrons, involving 10 pixels or more, and at any position in the field of view. This is for a specified background level of 0.125 photoelectrons/ns.	C-SST-TEL-1440		**PC**	It should really be made clearer how this fits with 1410... does this calibration have to be done already for R1.
B-TEL-1520	Maximum Solar Concentration	Telescopes should never concentrate sun light to power densities greater than 5 kW/m 2 when in their parked position. Areas and times at which power densities greater than 2 kW/m 2 occur must be identified and clearly documented by telescope providers.	C-SST-TEL-1520		**C**	
B-TEL-1540	Camera Lifetime	Cameras must be designed for an operational Lifetime of 15 years.	C-SST-TEL-1540		**PC**	It will be assessed during Design consolidation phase
B-TEL-1610	R1 Event Data	Camera Event Data delivered to the OES (R1 level) must be time-ordered and use a compact common format, occupying at most 16-bits per sample timeslice for data-cube information.	C-SST-TEL-1610		**C**	
B-TEL-1630	R1 Intensity Resolution	It must be possible to extract a signal estimate from the R1 data delivered to OES, using previously determined per-pixel coefficients, to reach the Intensity resolution shown in the figure below and table attached, degraded with respect to B-TEL-1010. Figure : Fractional rms intensity resolution σ I /I per pixel for different Cherenkov light signal amplitudes, expressed in photons (p.e.). All sources of fluctuations, including Poisson fluctuations in photon number, must be included. Curves are shown for the nominal NSB (solid line) and high NSB (dashed line) cases.	C-SST-TEL-1630		**C**	

B-TEL-1640	R1 Time Uncertainty	It must be possible to extract pixel signal timing information from the R1 data delivered to OES, using previously determined per-pixel coefficients, such that the time resolution requirement (B-TEL-1030) relaxed by a factor of 1.5 is satisfied.	C-SST-TEL-1640		**C**	
B-TEL-1650	R1 Trigger Time Information	In addition to an absolute time derived from the system wide precision time distribution system, the (R1) Event data sent to the OES must contain an event sequence number and/or NTP-based event time identifier, to be used for monitoring and diagnostic purposes.	C-SST-TEL-1650		**C**	
B-TEL-1660	Survival Illumination Recovery Time	The Camera must be able to recover full performance capabilities within 1 minute of the end* of any transient illumination up to the survival limit.	C-SST-TEL-1660		**PC**	1 min may be too short to recover. For PMTs the camera would have some active shutdown of HV. Once the source is gone, then it's very quick to ramp the HV back up. For SiPMs (SST Camera technology) with bias resistors, the current is automatically limited, so no damage occurs. But the SiPM gets warm. Even with the best active control, it may be tough to reach full performance again in 1 min. We will assess this compliance during the Design Consolidation Phase
B-TEL-1710	Camera Transition Time: Safe to Standby	The Camera must transition from the Safe State to the Standby State in less than 90 minutes	C-SST-TEL-1710		**C**	
B-TEL-1720	Camera Transition Time: Standby to Ready	The Camera must transition from the Standby State to the Ready State in less than 3 minutes	C-SST-TEL-1720		**C**	
B-TEL-1730	Camera Transition Time: Ready to Observing	The Camera must transition from the Ready State to the Observing State in less than 30 seconds. The opposite transition must be possible on the same timescale.	C-SST-TEL-1730		**C**	
B-TEL-1740	Camera Transition Time: Return to Safe	The Camera must transition from the Observing, Ready or Standby State to the Safe State in less than 5 minutes.	C-SST-TEL-1740		**C**	
B-TEL-1750	Camera Transition Time: Off to Safe	The Camera must transition from the Off State to the Safe state in less than 4 minutes.	C-SST-TEL-1750		**C**	
B-TEL-2000	Engineering GUI	A common engineering GUI must be used by all Telescopes, with full functionality provided by the GUI. Aspects which may not be relevant to a given Telescope are disabled in that particular instance of the GUI.	C-SST-TEL-2000		**C**	

B-SST-0010	Monte Carlo Verification	Monte Carlo simulations must demonstrate that the SST sub-system fulfils the complete set of SST sub-system performance requirements when situated in the layout given in [1] located at CTA-S.	C-SST-TEL-0010		**C**	
B-SST-0020	Post-Calibration Astrometric Accuracy	The Post-Calibration Astrometric Accuracy of an SST Telescope whilst Tracking during Precision Pointing Conditions, must be <7 arcseconds.	C-SST-TEL-0020 C-SST-TEL-0035		**C**	
B-SST-0030	Standard Post-Calibration Astrometric Accuracy	The Post-Calibration Astrometric Accuracy of an SST Telescope whilst Tracking must be < 20 arcseconds under standard observing conditions.	C-SST-TEL-0030 C-SST-TEL-0035		**C**	
B-SST-0110	Mirror Area	The Geometrical Mirror Area of an SST Telescope Structure, corrected for the effect of shadowing by the camera and its support structure (and if present the secondary mirror), must be >5 m 2 for all angles within the required Camera Field of View .	C-SST-TEL-0110		**C**	
B-SST-0130	Optical PSF Quality	The SST Telescope must focus light on to the focal surface with an optical PSF θ 80 of <0.25 degrees, up to 3.2 degrees from the centre of the cFoV.	C-SST-TEL-0130		**C**	
B-SST-0140	Optical Time Dispersion	The SST Telescope must focus light (over 80% of the required camera field of view diameter) with a rms optical time spread of <1.5 ns.	C-SST-TEL-0140		**C**	
B-SST-0210	Repositioning Time	The SST Telescope must be able to rotate from any point to any other point in the sky above 30° in elevation within 70 seconds at wind speeds below 36 km/h and making use of the full azimuthal and elevation movement ranges, in response to a repositioning request flagged as time critical.	C-SST-TEL-0210		**C**	
B-SST-0310	Telescope Availability	The availability of each SST Telescope Structure during observation time must be > 98.5%	C-SST-TEL-0310		**C**	
B-SST-0320	Telescope Preventive Maintenance	The preventive maintenance of a single SST Telescope Structure on-site must require on average < 0.5 person hours / week	C-SST-TEL-0320		**PC**	It will be assessed during Design consolidation phase
B-SST-0330	Telescope Corrective Maintenance	The corrective maintenance of a single SST Telescope Structure on-site must require on average < 1 person hours / week	C-SST-TEL-0330		**PC**	It will be assessed during Design consolidation phase
B-SST-0610	Average Power Consumption during Observations	The average power consumption by a single SST Structure during Observations must not exceed 4 kW.	C-SST-TEL-0610		**C**	

B-SST-0620	Peak Power Consumption during Observations	The peak power consumption by a single SST Structure during Observations must not exceed 11 kW.	C-SST-TEL-0620		**C**	
B-SST-0630	Peak Power Consumption in the Safe State	The peak power consumption by a single SST Structure in the Safe State must not exceed 2 kW.	C-SST-TEL-0630		**C**	
B-SST-0640	Annual Average Power Consumption in the Safe State	The average power consumption over a full year by a single SST Structure in the Safe State must not exceed 0.5 kW.	C-SST-TEL-0640		**C**	
B-SST-1110	Focal Plane Positioning in x and y	The centre of the focal plane instrumentation of the Camera Unit must be positioned (in the direction perpendicular to the optical axis) by the Telescope Structure to within 0.12 degrees of the optical axis during Observations.	C-SST-TEL-1110		**C**	
B-SST-1130	Field of View Diameter	The Field of View diameter of the SST Camera Unit must be at least 8 degrees.	C-SST-TEL-1130		**C**	
B-SST-1150	Angular Pixel Pitch	The average SST Camera angular pixel pitch must be <0.25 degrees for pixels situated on a hexagonal grid, or 0.25/1.075 deg for pixels on a square grid.	C-SST-TEL-1150		**C**	
B-SST-1180	Focal Plane Instrumentation	The SST Camera Unit focal plane must be fully instrumented with photosensitive pixels (in compliance with the dead-space requirement B-TEL-1160) up to a radius of at least 3.4 degrees.	C-SST-TEL-1180		**C**	
B-SST-1210	Integration Window	Pixel signal integration must be possible within a time window of between 20 and 30 ns with respect to the Camera trigger time for signals in the range 0-400 photons. The start time of this integration window must be adjustable with respect to the trigger time in steps not larger than 2 ns.	C-SST-TEL-1210		**C**	
B-SST-1220	Readout Window	The time window within which a Cherenkov signal can be reconstructed must be at least 80 ns.	C-SST-TEL-1220		**C**	

B-SST-1230	Minimum Image Amplitude	For gamma-ray initiated showers with the Reference Gamma Spectrum , the Cherenkov light intensity that is needed to generate a Camera trigger with a probability of at least 50 % over 90 % of the solid angle within the required camera field of view and with any image orientation, must be smaller than: I thresh × (F NSB / 0.24 ns −1 sr -2 cm -2) 1/2 photons over the full required NSB range or I thresh if F NSB < 0.24 ns −1 sr -2 cm -2 . The value of the threshold image amplitude I thresh must be < 250 photons in the wavelength range 300-550 nm. F NSB is given as the light flux at ground level in the wavelength range from 300-650 nm and can be assumed to follow the Background Light Spectrum .	C-SST-TEL-1230		**C**	
B-SST-1235	Minimum Proton Image Amplitude	For proton initiated showers following the Reference Proton Spectrum , the Cherenkov light intensity that is needed to generate a local camera trigger with a probability of at least 50% over 90% of solid angle of the required camera field of view and with any image orientation, must be < 480 photons.	C-SST-TEL-1235		**C**	
B-SST-1280	Event Rate	The SST Camera must be able to collect and deliver for further processing Events arriving at a sustained event rate of at least 600 Hz with a random distribution in time.	C-SST-TEL-1280		**C**	
B-SST-1285	Trigger Rate Cap	The SST Camera must deliver Trigger information to the OES at a rate (averaged over 100 ms) of less than 1200 Hz for events arriving at random.	C-SST-TEL-1285		**C**	
B-SST-1305	Local Event Rate	The Camera must deliver events without associated array level coincidences (Local Events) to the OES at a rate of less than 120 Hz. Such events must be flagged as Local Events.	C-SST-TEL-1305		**C**	
B-SST-1450	Camera Output Data Rate	The Camera must deliver Event data (including both Local Events and Array-Level Events) to the OES at a rate never (in any second) exceeding 2 Gb/s.	C-SST-TEL-1450	X	**NC**	Same comment of req B-SST-1280. At 600 Hz R1 we break 2 Gb/s (hitting 2.55 Gb/s). Under expected MC stero rate (340 Hz) and our expected local trigger (60 Hz) we're at 1.96 Gbps... so the 2 Gb/s should be okay under normal operation, but not at 600 Hz R1 (which we will never have). We will propose a CR before the CDR.
B-SST-1550	Camera Availability	The availability of each SST Camera during observation time must be > 98.5%.	C-SST-TEL-1550		**C**	
B-SST-1560	Camera Preventive Maintenance	The preventive maintenance of a single SST Camera on-site must require on average < 0.5 person hours / week.	C-SST-TEL-1560		**C**	

B-SST-1565	Camera Corrective Maintenance	The corrective maintenance of a single SST Camera on-site must require on average < 1 person hours / week.	C-SST-TEL-1565		**C**	
B-SST-1570	Peak Camera Power Consumption during Observations	The peak power consumption by a single SST Camera during Observations, including its full cooling system (but excluding the Camera Server), must not exceed 4 kW.	C-SST-TEL-1570		**C**	
B-SST-1580	Average Camera Power Consumption during Observations	The average power consumption by a single SST Camera during Observations must not exceed 3 kW.	C-SST-TEL-1580		**C**	
B-SST-1590	Peak Camera Power Consumption in the Safe State	The peak power consumption by a single SST Camera in the Safe State, including its full cooling system (but excluding the Camera Server), must not exceed 1 kW.	C-SST-TEL-1590	X	**NC**	In extreme cold conditions, the cooling system can exceed 1kW power consumption. We will propose a CR before the CDR.
B-SST-1600	Annual Average Camera Power Consumption in the Safe State	The average power consumption over a full year of a single SST Camera in the Safe State, including its full cooling system (but excluding the Camera Server), must not exceed 0.5 kW.	C-SST-TEL-1600		**C**	
B-SST-1670	Maximum Routine Illumination Recovery Time	Each pixel in an SST Camera must be able to recover full performance capabilities within 1s following (i.e. once the source of light has been removed) maximum routine illumination of 2000 ph ns -1 in the wavelength range 300 - 650 nm.	C-SST-TEL-1670		**PC**	Same comment as B-TEL-1660 because 1 second is probably difficult for the SiPM to thermally recover. We will assess this compliance during the Design Consolidation Phase.
B-SST-1680	Observation Illumination	SSTs must be capable of gamma-ray observations with uniform night sky background illumination levels up to at least 4.3 photons ns −1 sr −1 cm −2 in the wavelength range 300-650 nm with the Moonlight Reference Spectrum .	C-SST-TEL-1680		**C**	
B-ONSITE-0100	Power Control	It must be possible for the System power to be controlled both remotely via the SAS and by a person present at the System location.	C-SST-TEL-0100		**C**	
B-ONSITE-0110	Power On	When the system is in Remote Mode it must automatically transition from the Off state to the Safe state when power is provided.	C-SST-TEL-0112		**C**	
B-ONSITE-0140	Sudden Loss of Power	In exceptional cases a sudden loss of power to Systems may occur and must not cause damage beyond the serviceability limit state.	C-SST-TEL-0142		**C**	

B-ONSITE-0150	Safe State Transition	When in remote mode, Systems may not initiate a transition out of the Safe state into the Standby State unless instructed by the OES.	C-SST-TEL-0150		**C**	
B-ONSITE-0160	Movement Notification	An audible and visible alarm signal must be generated before any potentially dangerous mechanical motion of the system commences.	C-SST-TEL-0160		**C**	
B-ONSITE-0170	Safety Signalling	The System must have all the safety subsystems, signs, and acoustic signaling, needed to prevent human injuries.	C-SST-TEL-0170		**C**	
B-ONSITE-0180	Movement Control	Safety mechanisms must exist to ensure that the system can never move in an uncontrolled manner.	C-SST-TEL-0180		**C**	
B-ONSITE-0190	Emergency Stop	If there is a risk of human injury or death associated with mechanical motions of the System, then a general emergency stop function must be provided which in case of an emergency situation will stop all significant motions of all structural elements with the fastest controllable deceleration, such that no additional risks would be introduced.	C-SST-TEL-0190		**C**	
B-ONSITE-0200	Safety and Alarm System Connection	The status of system safety interlocks must be provided to the Safety and Alarm System.	C-SST-TEL-0202		**C**	
B-ONSITE-0210	Automatic Transition	The System must initiate a transition to the Safe State if communication with OES is lost for > 1 minute.	C-SST-TEL-0212		**C**	
B-ONSITE-0220	Loss of Clock Connection	When in the Ready or the Observing state, the System must initiate a transition to the Standby State if the connection to the Central Computer Time Synchronisation System is lost for more than >20 minutes.	C-SST-TEL-0220		**C**	
B-ONSITE-0310	Lightning Protection	Systems must be protected with a Class 1 lightning protection system in accordance with the international lightning protection standard IEC 62305-1-4:2010.12.	C-SST-TEL-0312		**C**	
B-ONSITE-0320	Fire Protection	Systems must be designed for compliance with fire regulations as stipulated in the European standard EN 1991.	C-SST-TEL-0322		**C**	
B-ONSITE-0330	Flood Protection	Systems must be designed to prevent all effects of water collection caused by surface water runoff.	C-SST-TEL-0330		**C**	
B-ONSITE-0410	Light Pollution	Systems must not produce light with an isotropic equivalent flux greater than 3x10^6 photons ns^-1 at source in the wavelength range 300-550 nm during observations in the absence of specific calibration instructions from OES.	C-SST-TEL-0410		**C**	

B-ONSITE-0420	Radio Frequency Interference	Systems must be compliant with standard X on radio frequency interference.	C-SST-TEL-0420		**C**	
B-ONSITE-0510	Maintenance Plans	Maintenance planning and procedures for covering access to, and repair / replacement of, any LRU must be provided.	C-SST-TEL-0508		**C**	
B-ONSITE-0520	Spare Parts	The level of spare parts needed for long-term System maintenance must be documented.	C-SST-TEL-0522		**C**	
B-ONSITE-0530	Documentation	Systems must be fully documented in terms of operational use and composition/design.	C-SST-TEL-0532		**C**	
B-ONSITE-0620	State Machine	All Systems must implement a state machine compliant with the diagram shown.	C-SST-TEL-0622		**C**	
B-ONSITE-0630	State Transitions	Transitions between the Safe, Standby, Ready and Observing states must not require any intervention in the field.	C-SST-TEL-0632		**C**	
B-ONSITE-0710	Remote Control	It must be possible to remotely control and monitor the System from the Data Centre using the OES.			**C**	
B-ONSITE-0720	Local Control Mode	Systems must implement a local control mode for maintenance and diagnostic purposes, during which remote operation of safety-relevant sub-systems is blocked. OES must be informed when the System enters Local Mode.	C-SST-TEL-0722		**C**	
B-ONSITE-0730	Local Errors	If the System encounters an error that impacts on proper function/performance, this must be reported to the OES. If recovery from the error is possible, the OES must be notified again when recovery is complete.	C-SST-TEL-0728 C-SST-TEL-0729		**C**	
B-ONSITE-0740	Local Error Recovery	All foreseeable error recovery mechanisms must be attempted automatically. In case recovery fails the System must move automatically to a State that prevents damage to instrumentation.	C-SST-TEL-0740		**C**	
B-ONSITE-0750	Alarm Generation	If an error leads to the situation where recovery is not possible and a safe state cannot be reached without human intervention then an Alarm must be raised and the System must enter the Fault State.	C-SST-TEL-0750		**C**	
B-ONSITE-0760	State Change Notification	The system must notify the OES whenever it changes State.	C-SST-TEL-0760 C-SST-TEL-0761		**C**	

B-ONSITE-0770	Problem Notification	The system must inform the OES whenever component problems or failure lead to a situation where full performance cannot be met, and provide on request the status of all compromised or problematic LRUs, to support observation and maintenance planning. Such notifications must be categorised in terms of severity.	C-SST-TEL-0770		**C**	
B-ONSITE-0780	Configuration Settings	It must be possible for the system to load configuration settings delivered via the OES in preparation for a State Transition.	C-SST-TEL-0780		**C**	
B-ONSITE-0790	Command Response	The system must respond to commands from the OES, acknowledging receipt of command within 50 ms and with verification of completion of the action (or occurrence of an error) reported within 50 ms of the time of completion or failure.	C-SST-TEL-0790		**C**	
B-ONSITE-0795	Command Verification	Commands received by the System must be verified for validity; any commands that exceed safety limits of the System must be rejected and a warning raised.	C-SST-TEL-0795		**C**	
B-ONSITE-0800	Transition Interruption	It must be possible for OES commands to interrupt transitions between states. When interrupted, the System must return to the original state within the corresponding transition time.	C-SST-TEL-0800		**C**	
B-ONSITE-0810	Absolute Time	The system must make use of the absolute time provided by the Central Computer Time Synchronisation System for all calculations for which a time is needed and as the reference in all log and alarm messages.	C-SST-TEL-0812		**C**	
B-ONSITE-0820	Monitoring Data	The system must make sufficient monitoring data available to OES for the purposes of diagnosis of component degradation or failure and all necessary information to support science data analysis. The transfer rate of such information must be controllable by the OES.	C-SST-TEL-0820		**C**	
B-ONSITE-0830	Logging	The actions of the System must be logged via OES. Logging levels must be configurable and follow the defined standards.	C-SST-TEL-0830		**C**	
B-ONSITE-0840	Monitoring Stream Content	In addition to the value, monitoring streams must contain the following information: variable name, time stamp, host component, units.	C-SST-TEL-0840		**C**	
B-ONSITE-0850	Monitoring Points	The system must expose monitoring points to the OES up to a maximum of 1000 monitoring points per Controllable System.	C-SST-TEL-0850		**C**	
B-ONSITE-0700	Automatic Alarm Recovery	Systems must automatically implement standard recovery procedures in the case of Alarms occurring internally to the System.	C-SST-TEL-0700		**C**	

End of the document