SST Product Review Plan

SST-ESC-PLA-001

Version 2.7

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2.7d	28-11-2022	Implemented comments by Stefano: Section 3.2.1: DMA list updated, added email addresses, Wolfang name moved before the surname Section 3.3.1: Reviewer Board updated, added email addresses and CTAO reviewers Section 4.1 Review Schedule Updated, RIXs deadline (submission to Review Chair) moved to Jan 9.	SST Team / CTAO	Alessio Trois

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1 Introduction

1.1 Scope & Purpose

In this document we describe the detailed organisation of the SST Product Review (SST-PR) to assess the SST Telescope Baseline at the completion of the SST Bridging Phase. The Product Review has been planned in accordance with [AD1] and it is part of the DVER outcomes foreseen in [AD2] and [AD3]. This plan has been prepared considering the collaboration between SST-STR project team (INAF/OP-INSU) and SST-CAM consortium in the development of the 42 telescopes foreseen for the SST sub-array of CTAO South Site.

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	1.8m
Effective mirror area (including shadowing)	>5 m^2
Focal length	2.15 m
Total weight	17.5 t
Field of view	>8.8 deg
Number of pixels in SST Camera	2048
Pixel size (imaging)	0.16 deg
Photodetector type	SiPM
Telescope data rates (before array trigger)	>600 Hz
Telescope data rates (readout of all pixels; before array trigger)	2.6 Gb/s
Positioning time to any point in the sky (>30° elevation)	90s
Pointing Precision	< 7 arcsecs

1.2 Applicable Documents

The following applicable documents (AD) form a part of this document to the extent described herein. If not explicitly stated otherwise, the latest issue of the document is valid. In the event of conflict between the documents referenced herein and the contents of this document, the contents of this document are considered a superseding requirement.

[AD1] CTA Project Management Plan, CTA-PLA-MGT-000000-0003_1c, Version 1.2, 25 May 2020
[AD2] CTA-SST Engineering Review Panel Report - CTA-RER-SST-305000-0001_2a
[AD3] SST Engineering Review – DMA Disposition - CTA-INS-SST-305000-0001

1.3 Reference Documents

[RD1] The ASTRI-Horn telescope validation toward the production of the ASTRI Mini-Array: a proposed pathfinder for the Cherenkov Telescope Array, Proc. SPIE 11119, 2019
[RD2] A Compact High Energy Camera (CHEC) for the Gamma-ray Cherenkov Telescope of the Cherenkov Telescope Array, 35th International Cosmic Ray Conference -ICRC217-10-20 July, 2017
[RD3] The ASTRI mini-array at the Teide observatory, Proc. SPIE 11822, 2021
[RD4] SST-PRO-ANR-006 Trade-off & top level analysis Report
[RD5] Mechanical optimization of the M1 Dish for the Small-Sized Telescopes of the future Cherenkov Telescope Array, Proc. SPIE. 12188

1.4 Acronyms

ACADA	Array Control and Data Acquisition System
ACS	ALMA Common Software
ASTRI	Astrophysics with Italian Replicating Technology Mirrors
BKO	Bridging phase Kick-Off
CDR	Critical Design Review
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
DMA	Decision Making Authority
DVER	Design Verification and Engineering Review
HW	Hardware
IACT	Imaging atmospheric Cherenkov telescope
INAF	Istituto Nazionale di Astrofisica
ICD	Interface Control Document

LST	Large Sized Telescope
MST	Medium Sized Telescope
OBSPM	Observatoire de Paris – PSL, CNRS
PA	Product Assurance
PR	Product Review
QA	Qualitiy Assurance
SST	Small Sized Telescope
SST-CAM	SST Camera
SST-STR	SST Structure
SW	Software
TBC	To be confirmed
TBD	To be defined
TBW	To be written
TMS	Telescope Mechanical structure
VHE	Very High Energy

1.5 Definition of Terms

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

2 Review Principles

2.1 Review Objectives

The Product Review is the milestone closing the SST Bridging Phase, before entering the SST Design Consolidation Phase, and it is organised by the SST consortium, with the active participation from CTAO both as reviewers and in the DMA. During the review the design of the projects/subsystems will be presented, along with the status of all verification and validation steps. Despite that the SST was verified by prototypes it is expected that the outcome of the PR will identify any missing areas requiring further elaborations, and provide advice as input to the SST Design Consolidation Phase (in particular for serialized production and on-site AIT/V plans).

The expected outcome is reported in section 2.4.

Passing the Product Review represents an approval of the SST design baseline to be finalised in the SST Design Consolidation Phase.

The Product Review is performed in accordance with the guidelines provided by [AD2] and [AD3], with specific consideration of the development status achieved by the SST program based on the following scheme:

- An SST Structure prototype, ASTRI-Horn Cherenkov telescope, has been produced and tested extensively in Catania, Serra La Nave, during the years 2014-2020. [RD1].
- A Camera Unit prototype (CHEC-S SiPM) [RD2].
- ASTRI/ASTRI1 Structure prototype [RD3].
- Several Trade-Offs analysis have been done during the bridging phase [RD4] and [RD5] in accordance with [AD2] and [AD3].

Considering the above points, the objectives of this PR consist in providing answers to the following questions:

I. Does the documentation provided by the SST Project demonstrate the closure of the actions and recommendations assigned at the DVER (see the Appendix)?

II. Is the design of the SST as derived from the DVER and the successive trade-offs performed during the bridging phase (including internal interfaces definition) suitable for next consolidation phase?

III. Can the long lead items identified for the camera project be procured with an acceptable level of risk in advance of the formal CDR with CTAO?

If the above questions can be satisfactorily and positively answered the review objectives have been fulfilled and the SST has successfully passed this review.

2.2 SST Requirements Prerequisites

A prerequisite for carrying out the Product Review is that:

- The requirement set against which the SST design must be evaluated by means of the review must be sufficiently complete and stable and must have been agreed between CTAO and SST before the review.

At the moment of writing this plan, the only officially recorded set of requirements related to the SST are those reported in the Jama database. The Jama requirements are applicable for the Product Review.

The ADP will also consider all the ICD and Standards documents provided by CTAO even if in draft version.

2.3 Success Criteria

The SST Product Review will be declared successful if:

a. The objectives listed above (I to III) have been fulfilled;

b. Any critical action items resulting from the review and documented in the panel report have been adequately addressed. (Non-critical action items can be followed in the normal Action Item List (AIL) of the project, without preventing the next phases to start).

2.4 Expected Output of the Review

The expected output of the review is:

Board Review Report - The review board will generate a report addressing the objectives listed in Section 2.1 herein and producing a recommendation related to the outcome of the review and its success. Such PR report shall be generated within two weeks (goal) of the completion of the Review. The report shall also contain or reference the agreed AIL generated during the review with indication of which are the critical ones (see par 3.8).

2.5 Documentation for the Review

In general terms, under consideration of the above objectives, the documentation to be delivered to support the review can be structured in the following main blocks.

2.5.1 Management Documentation

2.5.1.1 SST Programme Documentation

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
1	SST Programme: Programme Management Plan [SST-PRO-PLA-001]	In this document we describe the Program Management Plan (PMP) to deliver the Small-Sized Telescopes (SSTs) required for the southern site of CTA (CTA-South), as an in-kind contribution (IKC). This document is issued in the framework of SST-PO. The current CTA PMP [AD 1] is the main input of preliminary SST	SST-ER-02 SST-ER-13

		PMP from which the In-Kind Contribution Allocations and Management adopted the scheme A. The scope of this document is then: • To define the deliverables from the SST Partners to CTAO. • To outline the SST organisation and identify a scheme by which SST Partners will be bound. • To specify the anticipated SST Partners involved and the anticipated resources available. • To specify the scope of the work and the phases over which it will be performed. • To outline the essentials of a management plan. • To present the steps needed to establish the proposed programme.	
2	SST Programme: Configuration & Data Management Plan [SST-PRO-PLA-002]	This document establishes the overall Configuration And Data Management (CADM) rules and procedures to achieve an effective control over the design and finally over the products as built status and relevant supporting data. It defines rules and procedure for documentation release and control to be undertaken by SST Consortium. This plan defines the how and when the CADM rules and procedures are applied to ensure that: • Each Configuration Item (CI) and related documentation are uniquely identified, • The design standard of the CI is defined, traceable and retrievable at each point in time, • Effective change control is established and maintained, • Reports are timely established and released to support program activities • Design and product inspections are performed to verify the current configuration status • Applicable CM process is monitored to verify correct application of CADM requirements • Program documentation is received, reviewed, released and recorded in an orderly and consistent manner	SST-ER-15 SST-ER-02
3	SST Programme: Cost Plan [SST-PRO-PLA-003]	This document outlines an approach to presenting cost estimates for the SST. The approach is designed to unify efforts made by different contributors, namely the STR-INAF, STR-Meudon, and CAM teams. Cost estimates are required prior to IKC-Agreement signing to ensure the intended IKC remains viable. Estimates will be used internally, and shared with CTAO following approval from the ESC, when and if the Money Matrix is updated	SST-ER-01 SST-ER-02
4	SST Programme: Risk Management Plan [SST-PRO-PLA-004]	The SST Risk Management Plan (RMP) is aimed to provide to SST-ESC a plan for the identification of risks scenario and potential causes. The risk shall be managed in the framework of SST Consortium responsibilities.	SST-ER-02

		The purpose of this plan is to specify the SST Programme risk management processes and describe the methods to be implemented in the SST Consortium and translated into management requirement documents to the industrial contractor, where applicable	

2.5.2 PA, QA and Safety Documentation

2.5.2.1 SST Programme: PA, QA and Safety Documentation

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
5	SST Programme: Product Assurance & Quality Plan [SST-PRO-PLA-005]	This document describes the general quality requirements, activities, methods and required resources applicable to all the Work Packages (WPs) of the SST programme and projects, with the aim to meet the quality objectives and to assure the expected performance and reliability. This quality plan will provide assurance that: • The CTA SST items in all their parts are compliant with the specifications • The risks are identified, assessed and controlled • The traceability and quality of deliverables are accessible at all times • Non-conformities (NCs) are identified and addressed This quality plane is: • Written and updated by the the Lead and Deputy Programme Quality Managers • Approved by the SST Programme Office (SST-PRO) • Implemented by the SST Project Office coordinators with the help of the QM	SST-ER-11 SST-ER-02
6	SST Programme: System Safety Management Plan [SST-PRO-PLA-006]	The safety management plan is a living document that must be revised at each programme design. The safety management plan defines: • the system safety programme tasks to be implemented; • the personnel or SST partners responsible for the execution of the tasks; • the schedule of system safety programme tasks related to project milestones; • the interface of the safety programme activity with the project system engineering and product assurance; • how the SST partners accomplish the tasks and verifies satisfactory completion.	SST-ER-02

2.5.2.2 SST Camera PA Documentation

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
7	SST Camera - Declared Item List [SST-CAM-LIS-001]	Preliminary Declared item list for the camera indicating only the items critical for the procurement. The complete DIL will be delivered for the CDR	

2.5.3 System Engineering Plan Documentation

2.5.3.1 SST Programme: System Engineering Plan

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
8	SST Programme: Engineering Development and Verification Plan [SST-PRO-PLA-009]	This document presents the development logic and model philosophy of SST telescope. This design and development plan has been prepared considering the share of responsibilities between the SST consortium.	SST-ER-02
9	SST Programme: Factory AIT Plan [SST-PRO-PLA-011]	This document describes the SST AIT plan and procedures that shall be executed at the SST factory premise after the Production Phase of the SST Structures, Cameras and Optic. The scope of this activities is to demonstrate that the SST Telescope has been designed and built to satisfy the requirements of the project. After the positive conclusion of these activities the Telescope will be delivered to the CTAO Site where the SST telescope will be assembled, integrated and verified again. The current version of the document includes the AIT plan and procedure related to the Mechanical Structure and the Optical Assembly. The next version of the document will include the full factory AIT plan.	SST-ER-02
10	SST Programme: On site AIT Plan [SST-PRO-PLA-012]	The plan describes the process of the Telescope AIT that will be performed on site.	SST-ER-02
11	SST Programme: Verification Plan [SST-PRO-PLA-013]	The Purpose of the document is to present at high level the verification strategy of the SST Telescope during the life of the project giving to the AIV/AIT team the right tools and guidelines to perform the complete verification process with respect to the requirements. The telescope verification will be performed by the SST Institutes involved in the consortium instead the AIT, detailed in other documents, will be performed by the industries involved to support the programme. The verification will be carried out on-site with the exception of the first	SST-ER-02

		telescope that will be integrated and verified also in the factory. The contents of the AIV Plan will be consolidated before the Critical Design Review.	

2.5.3.2 SST Camera System Engineering Plan

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
12	SST Camera - Engineering Development and Verification Plan [SST-CAM-PLA_009]	This document describes the plan for completing SST Camera (SST-CAM) instrument engineering work prior to the series production of SST Cameras, namely: finalisation of the camera design, verification of that design, and technical preparation for the series production of cameras. The development of camera software will be covered in a dedicated document for the CDR, and the preparation of series production plans and funding is the remit of the SST Camera PM & Camera Board.	SST-ER-02

2.5.4 Design Definition documents

2.5.4.1 SST Programme: Design Definition documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
13	SST Programme: Technical Requirements Specification [SST-PRO-SPE-001]	The SST Telescope Technical Specifications specifies the functional and performance requirement for the design, the development, the verification and the 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.	
14	SST Programme: Architecture & Design Summary Report [SST-PRO-DSR-002]	This document provides a description of the concept, design and functional architecture of the SST telescope.	
15	SST Programme: STR/CAM I/F Control Document	ICD between Structure and Camera describing all the relevant interfaces (mechanical, electrical, control, etc.)	

	[SST-PRO-ICD-007]		
16	SST Programme: Telescope Concept of Operations [SST-PRO-OPD-001]	This document provides a brief and preliminary description of the concept of operations for the Telescope across all the various phases: Verification Phase, Commissioning Phase and Science Phase.	

2.5.4.2 SST Mechanical Structure Design Definition documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
17	SST Mechanical Structure - Subsystem Technical Requirement Specification [SST-MEC-SPE-002]	This document provides the Mechanical Requirements (Level D)	
18	SST Mechanical Structure – Design Report [SST-MEC-DSR-001]	Design description of the specific subsystem, in case with associated subsystem analysis, references, assumptions and conclusions with statement of compliance if relevant.	SST-ER-21 SST-ER-32 SST-ER-33
19	Mechanical Structure - On site Maintenance Plan [SST-MEC-PLA_015]	The On site Maintenance Plan describes the SST structure maintenance during the activities at CTAO south site.	SST-ER-02

2.5.4.3 SST Optics Definition documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
20	SST Optics - Subsystem Technical Requirements Specification [SST-OPT-SPE-002]	This document provides the Optics Requirements (Level D)	
21	SST Optics – Design Report [SST-PRO-DSR-001]	Design description of the specific subsystem, in case with associated subsystem analysis, references, assumptions and conclusions with statement of compliance if relevant.	SST-ER-35 SST-ER-36

2.5.4.4 SST Camera Design Definition documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
22	SST Camera - Subsystem Technical Requirements Specification [SST-CAM-SPE-002]	This document provides the Camera Requirements (Level D)	
23	SST Camera – Design Report [SST-CAM-DSR-001]	Design description of the specific subsystem, in case with associated subsystem analysis, references, assumptions and conclusions with statement of compliance if relevant.	

2.5.5 Design Justification documents

2.5.5.1 SST Programme Design Justification documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
24	SST Programme: Top level & trade-off analysis Report [SST-PRO-ANR-006]	The SST Telescope architecture baseline was presented KO of Bridging Phase on July 2021. This baseline (named Agreement Baseline) confirm the Baseline presented at the DVER in summer 2020. The actions and recommendation from DVER jointly with an updating of JAMA level B requirements and the outcomes from the bridging phase are combined for the identification of: • The level B (Top Level) requirements status revision for their implementation the SST baseline and decomposition on lower levels; • Possible design option which introduce improvement of SST architecture.	
25	SST Programme: Performance Analysis Report [SST-PRO-ANR-010]	This is the user-requirement document of the performance analysis for the SST model. Its purpose is to collect and describe the results of the simulation-level analysis on the single telescope for evaluating its instrumental performances. This is a live document that is expected to be constantly updated with the outcome of the simulations dedicated to the study of the expected SST single-telescope performances.	

		The current version of this document only contains a preliminary description of the performances of the separate telescope components determined with external tools or dedicated analyses.	

2.5.5.2 SST Mechanical Structure Design Justification documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
26	SST Mechanical Structure: Structural Analysis Report [SST-MEC-ANR-008]	FE modelling and structural analysis results description.	

2.5.5.3 SST Camera Design Justification documents

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
27	SST Camera: Structural Analysis Report [SST-CAM-ANR-008]	FE modelling and structural analysis results description.	

2.5.6 Mathematical Models

2.5.6.1 SST Programme Mathematical Models

#	Document Name [Protocol]	Notes	DVER Actions / Recommendations
28	SST Programme: Monte Carlo Model Input Parameter Description [SST-PRO-MAT-005]	This is the user-requirement document of the input parameters to the Monte Carlo model (MCM) for an array of SSTs. Its purpose is to collect the parameters relevant to the SST case that are used to describe the structure, optical and camera performances of Imaging Atmospheric Cherenkov Telescopes (IACTs) in software pipelines for the simulation of the detection of electromagnetic showers emitting Cherenkov light in the atmosphere. This is a live document that is expected to be constantly updated with the new versions of those SST parameters not yet frozen to an agreed value. The SST WT8 will enter such	

		updates as soon as they will be made available by the dedicated WTs.	

3 Review Organization

3.1 Review Organizer

This review is organized by the SST Executive Steering Committee in coordination with CTAO.

3.2 Decision- Making Authority

The Decision-Making Authority (DMA) for this review is a board composed of two representatives of the SST Executing Steering Committee and two CTAO representatives authorities.

3.2.1 List of DMA Members

The lists below include the DMA members.

Name	Affiliation & Role
Wolfgang Wild (wolfgang.wild@cta-observatory.org)	CTAO Project Manager
Stefano Stanghellini (stefano.stanghellini@cta-observatory.org)	CTAO Telescope Coordinator
Gianpiero Tagliaferri (gianpiero.tagliaferri@inaf.it)	INAF, Osservatorio di Brera SST ESC Chair
Stefan Funk (s.funk@fau.de)	FAU, Erlangen University SST ESC Member

3.3 Review Board

The review Board is comprised of members not directly involved in the SST project (external) and members provided by CTAO. The Chair is an external member.

3.3.1 List of Reviewer Board Members

The lists below include the review board members.

Name	Affiliation & Role		Expertise
Marco Feroci (marco.feroci@inaf.it	INAF, Director of IAPS (the largest INAF Institute); LAD-eXTP PI, coordinator of the European participation to eXTP, LOFT PI, SuperAgile PI	Proposed as Chair	Management, Instruments, Detectors
Francesco Giordano (francesco.giordano@ba.infn.it)	INFN, Bari University	Reviewer	Electronics, Detectors (expert of SiPM)

	In charge of Fermi tracker construction, Responsible of the INFN-Bari participation to Magic and CTAO, member of the camera team of the SCT project		
Gianlfredo Nicolini (gianalfredo.nicolini@inaf.it)	INAF, Osservatorio di Torino Co-I and Project Controller of METIS (before at ESO and then in Thales, where he was Head of "Metrology and Optical Instrumentation" team)	Reviewer	AIT/AIV, PA, system engineering
Marco Riva (marco.riva@inaf.it)	INAF, Osservatorio di Brera System Engineer of: ESPRESSO, HIRES and MAORY (ESO instruments)	Reviewer	Optomechanics, Mechanics, Optics, System Engineering
Christelle Rossin (c.rossin@opgc.fr)	Deputy Technical Director of the OSU Observatory of Physics of the Globe of Clermont-Ferrand (OPGC) (before as mechanical engineer at LAM for 15 years as well as Head of the Mechnanical Department and Thermo-Mechanical Architect of the Euclid Grisms during the last years at LAM)	Reviewer	thermo-mechanical simulation, vibrations, correlation between simulation and tests, and opto-mechanics for space projects
Anne Bonnefoi (anne.bonnefoi@lam.fr)	Thermo-Mechanical Architect for the Harmoni Laser Guide star subsystem	Reviewer	Thermo-mecanical simulation, vibrations, opto-mechanics for ground and space project
James Buckley (buckley@wustl.edu)	Washington University, St. Louis Prof. of Physics PI and Spokesperson of ADAPT Spokesperson for APT (VERITAS, CTA-SCT)	Reviewer	Electronics, Detectors

Nick Whyborn (nick.whyborn@cta-observatory.org)	CTAO lead system Engineer	Reviewer	System engineering
Amaya Paredes (amaya.parades@cta-observatory.org)	CTAO Telescope Engineer	Reviewer	System engineering
Volker Heinz (volker.heinz@cta-observatory.org)	CTAO-South Site Manager	Reviewer	AIT/AIV, system engineering
Silvio Rossi (silvio.rossi@cta-observatory.org)	ESO, Head of ALMA Technical Team	Reviewer	System engineering
Bernhard Lopez (bernhard.lopez@cta-observatory.org)	CTAO Quality Assurance	Reviewer	PA/QA

3.4 SST Team Participants

The following members of the SST Consortium are invited to the review:

Name	Affiliation and position
Alessio Trois	INAF, SST-PRO
Primo Attinà	INAF, SST-PRO
Salvatore Scuderi	INAF, SST-STR
Gino Tosti	INAF, SST-STR
Nicola La Palombara	INAF, SST-PRO
Giuseppe Leto	INAF, SST-PRO
Giorgia Sironi	INAF, SST-OPT
Carmelo Gargano	INAF, SST-PRO
Francesco Saturni	INAF, SST-PRO
Giovanni Pareschi	INAF, SST-ESC
Salvatore Caschera	INAF, SST-PRO
Richard White	MPIK, SST-CAM
Gianluca Giavitto	DESY, SST-CAM
Emma Rébert	OP-INSU, French Contribution
Jean-Laurent Dournaux	OP-INSU, French Contribution
Fatima de Frondat	OP-INSU, French Contribution

3.5 Roles and Responsibilities

3.5.1 The Review Board Chair

The chair shall be responsible for the overall organization and conduct of the review. The chair shall:

1. Manage the activities of the review Board;
2. Prepare RIXs where relevant;
3. Consolidate the RIXs received from the reviewer members and submit them to the SST Team coordinator;
4. Assure that all RIXs are processed, or contact the issuing board member in case dropped only with the consent of the issuing board member;
5. Act as representative for RIXs issued by reviewers who may not be able to attend the meeting;
6. Lead the review meeting;
7. Prepare and release the final board review report and submit it to the DMA.

3.5.2 The Review Board Members

The board members shall, under the authority of the review chair:

1. Review the submitted documentation following the document assignments defined in the review plan (see section 2.5). In case their review is not complete they shall notify the chair;
2. Identify discrepancies or request explanations by means of RIXs, respectively, using the provided template;
    2.1. Board members may call for support from other specialists; their contributions shall be clearly identified.
    2.2. Review Chair is board member and as such may submit RIXs.
3. Participate in RID close-out activities, recommend open RIDs for discussion at the meeting and engage in the discussion in the review meeting;
4. Evaluate the responses from the SST Team to the RIXs;
5. Prepare possible recommendations when the SST Team response to a RID is not considered satisfactory;
6. Provide written input to the board report in their area of expertise.

3.5.3 SST Team

The SST Team shall:

1. Ensure that all necessary information and documentation specified in this plan are available in time and up-to-date for the review;

2. Prepare responses to Review Item Discrepancies (RID) and Review Item Questions (RIQ) and review Item Comments (RICs);
3. Support the review as needed with availability of personnel and if needed logistic;
4. Support any requests from the chair to prepare presentations or other material for discussion at the review meeting;
5. Propose a schedule for the actions identified at the review;
6. Respond to the agreed action items within the agreed due dates.

3.6 Review Items

3.6.1 Review Item Generation

The review board shall identify problems, request explanations or send comments by submitting Review Item Discrepancies (RID), Questions (RIQ) or Comments (RIC), summarily called RIX.

RIDs shall be issued if a reviewer identifies discrepancies with specifications or requirements listed in one of the following documents: technical specifications, interface control documents and other requirements documents. This applies to the design and its sufficient level of detail, to the achievement of the specified requirements[1] and their verification, and to other matters pertaining to programmatic and management aspects as covered by this review. It also applies to project management including safety and product assurance aspects. The review chair has the right to downgrade RIDs that do not fulfil these conditions.

A RID shall state – as a baseline – which requirement is violated, and the reviewer issuing a RID should recommend a solution to the issue, if possible. The SST Team shall respond to all RIDs raised.

RIQs shall be issued if the reviewer wishes clarification on any review item. The SST Team shall reply to RIQs in the same way as to RIDs. RIQs may be upgraded to RIDs during the review process if appropriate, and vice versa.

RIQs may also be asked concerning requirements, specifications, and interfaces, if, in the reviewer's judgment, they prevent the project from reaching its scientific/technical, budget or schedule goals.

RICs may be issued if a reviewer wishes to comment or make suggestions regarding any documented review item.

RIXs will be managed using the tools provided by the redmine system and described in the redmine Product Review Wiki (https://redmine.iasfbo.inaf.it/projects/cta-sst-pr/wiki).

3.7 Board Review Report

The final board report is advisory to the DMA. It shall be approved by the review board, released by the board's chair, archived and sent to the DMA. It should contain:

A summary of the review objectives, an overview of the review board's composition, activities and meetings; a detailed response to each review objective and question identified in the review plan; the review board's assessment of the quality of the documentation submitted for review (completeness, technical content and compliance with Document Requirement Definitions (DRD)), a summary of the project's status and its major achievements;

1. A summary of major problems identified during the review, if any (including references to the applicable RID number(s) and identified solutions);
2. A list of all action items defined during the meeting (also those not originating from RIXs) together with their owners and scheduled closure dates. "Critical action items" shall be clearly marked as such if applicable;
3. Recommendations for issues for which no agreement or solution has been found;
4. The final recommendation of the board based on the level of achievement of the review objectives and measured against the defined success criteria. This should be one of the following:
    a. Product Review passed. No critical actions were identified.
    b. Recommend passing of the Product Review only after successful treatment of critical actions;
    c. Product Review not passed. Not all the objectives of the review have been achieved and the project phase should be extended. Recommend a delta review to be organized for a later date for which critical actions need to be closed. The delta review will have a formal board, usually a subset of the main review board.
5. A broad list of the documents reviewed, if different from the list in the review plan;
6. The final register of all RIXs, including the SST Team responses and the final RIX disposition. The final RIX register may be included as an appendix or as a separate Applicable Document.

The review board report should be delivered, signed by the chair on behalf of the board, to the DMA within the period specified in the review review schedule (see sec.5.1) after the review meeting.

3.8 Review Follow-Up

Once the DMA receives the board review report he will take the following steps:

1. Take any decision concerning the further proceeding with the project;
2. Communicate the conclusions of the review and the decisions to the SST Team.
3. If necessary, discussions shall take place and a way forward agreed and approved by the DMA.

3.9 Action Item Follow-Up

The review objectives are achieved once the approved recommendations and related actions are satisfactorily addressed or under control through normal work procedures. To ensure this, the following arrangements shall be made:

1. The SST Team implements the actions arising and agreed at the review collaborates and regularly interact with the chair toward their resolution;
2. All actions, whether they arise directly from an agreement given by the SST Team or from recommendations by the Review Chair, shall be followed up in the same manner;
3. Some action items may have been classified as "critical", because of their important nature. Their closure is mandatory for completing the PR. Therefore, they must sufficiently be addressed and/or an agreed treatment plan must be available for closing the review process.

All documents that have been updated as a consequence of the PR (e.g. due to modifications requested by action items) shall be properly released and archived. Document updates shall reference the originating RIX in the Change Record.

4 Schedule

4.1 Review Schedule

The Product Review will follow the following baseline schedule:

	Date	Event
	01-12-2022	Release of PR review plan to the board
	01-12-2022	**Acceptance Data Package made available to the board by SST Team**
	09.01.2023	RIXs deadline (submission to Review Chair).
T_{rev}-5W	**13.01.2023**	**Final consolidation of RIXs toward SST Team.**
T_{rev}-3W	**23.01.2023**	**Reply to RIXs by SST Team**
	30-01-2023	Review Board complete the evaluation of replies to RIXs.
	06-02-2023	Finalize agenda of review meeting with SST Team.
T_{rev}	**15-02-2023 (TBC)**	**SST Product Review Meeting**
	16-02-2023	Review Board provide the Board Draft Report and afterward instruct the SST Team.
T_{rev} +3W	**07-03.2022**	**The Review Board send the final board report to the DMA for consideration and final decision and release.**

The "SST Product Review Meeting" date is still TBC, it will be planned on the basis of the availability of the board members.

Notwithstanding the above schedule, reviewers are invited to prepare the RIXs and send them to the Chair in advance of the RIX submission deadline so that if possible, the SST Team can start to work on the answers to the RIXs.

4.2 Review Meetings

The Product Review agenda will be developed after the reviewers have evaluated the written responses to their RIXs and will be provided before the meeting.

Each review day may start with a short review board closed session and end with a review of the day's action items and a review board closed session. The main morning and afternoon sessions will each be about three hours in duration (not including breaks).

The focus of the review will be on the discussion of the open RIXs. This may include the presentation of additional material (text, diagrams etc.) if directly related to the RIX under discussion.

5 Logistics

5.1 Product Review Meeting

The SST Product Review will be held in an hybrid way, both in person and by Videoconferencing (VC). The place where the final meeting will be held is still TBD.

5.2 Review Website/Repository/General instructions

The documentation and material applicable to the review can be accessed on the dedicated Product Review Wiki Page:

https://redmine.iasfbo.inaf.it/projects/cta-sst-pr/wiki

All reviewers shall have access to the redmine repository and they have to follow the instructions reported in the wiki page.

6 Appendix

6.1 DVER Action Items

The table hereafter report the actions assigned at the DVER [AD3] to be closed by the Product Review.

The closure of the actions SST-ER-21, SST-ER-23, SST-ER-28, SST-ER-29 and SST-ER-33 has been post poned from the BKO to the product review.

AI#	RIX	Description	Area	Document/Description Action's Closure
SST-ER-01	#40489	Elaborate an updated version of the costs that will permit to better understand if they are solid and that will permit to consolidate the total number of telescope to be built	SST-PRO	The action is closed by the document "SST-PRO-PLA-003 Cost Plan" in which we detail the methodology we use to calculate the costs. The costs are considered by national organizations and others dedicated boards.
SST-ER-02	#40492 #40494	Consolidate of the overall management scheme prior to enter the Design Consolidation phase. In particular, reinforce the AIV project and I/F management. Update the management plan in consequence.	SST-PRO	The action is considering closed on the basis of the documents produced hereafter: SST-PRO-PLA-001 Project Management Plan SST-PRO-PLA_009 Engineering Development and Verification Plan SST-CAM-PLA_009 Engineering Development and Verification Plan SST-AIT- PLA_011 Factory AIT Plan SST-AIT-PLA_012 On site AIT Plan SST-PRO-PLA_013 AIV Plan SST-PRO-ICD-007 STR/CAM I/F Control Document
SST-ER-04	#40691	For the programmable components on the GECCO motor controller boards, we strongly advise to setup a test procedure in which all possible cases in the embedded software are covered.	SST-CAM	The adivse has been taken into account in the design of the latest slow-control board (in which the GECCO is used). A test setup is under development to exercise all possible cases in the GECCO, and the FW&SW are being revised to include full unit testing coverage. These aspects will be documented in: • The slow-control eng. specs. • The SW Development & Verification Plan The slow-control test procedures
SST-ER-05	#40698 #40693	PCB Design schematics : Implement an internal design review for the schematics & all boards (PCBs)	SST-CAM	Internal reivews are planned for all PCBs. So far the ¼ Backplane, SiPM base, bias-voltage board, preamp board and TARGET module boards have all been reviewed. Remaining are the slow-control board and flasher board (which will take place in Q1 2023).
SST-ER-06	#40690	Thermal behavior of the electronics cooling in the camera: Though the discussion during the review meeting permitted to better understand the problematics, the panel still consider that building a thermal model and implement it in a	SST-CAM	A basis model of the thermal behaviour has been produced and documented as an internal camera note. The document will be combined with measuements from QCAM to

		simulation tool would benefit to the project. It should not be a huge work to do it. We recommend testing this approach and try to implement at least a simplified airflow model.		produce the Camera Thermal Analysis Report in time for the CDR.
SST-ER-11	#40572	SSTER-SST05-QP "SST Program Quality Plan" : Implement the actions described by the SST-PO within its answer to the RIX	SST-PRO	SST-PRO-PLA-005 Product Assurance & Quality Plan. sec. 2.1 and 8.
SST-ER-12	#40612	SSTER-CAM06-PP version0.4 "SST Camera Production Plan": Update the document to reflect the answer given within the RIX by the SST-CAM PO	SST-CAM	RIX 40612 resulted in a recommendation that if the cameras are built at two AIT sites, then the first two should be built in parallel, and not series. This advise has been taken. However, the plan described in the “Camera Series Production Plan” (SSTER-CAM06-PP) is under revision, based on the evolving funding situation in the camera team. This document will not be updated until the plan is stable (expected well in time for the CDR).
SST-ER-13	#40656	SSTER-STR05-PMP: Build a more detailed breakdown of the PBS and WBS with a short characterization of the elements. Relate it in an update of this document.	SST-PRO	The PBS and WBS have been detailed in the document "SST-PRO-PLA-001 Project Management Plan" sec. 5
SST-ER-15	#40658	Define in accordance with CTAO standards, the decision process for major CRE's	SST-PRO	The Change Request/Request for Waiver have been described in SST-PRO- PLA-002 Configuration & Data Management Plan sec. 4
SST-ER-17	#40665	In the frame of a large array, the current ASTRI-SST design will undergo a process of industrialisation, with the aim of reducing the manufacturing costs of the telescope structure. In the process of cost optimisation, FEA is surely a tool to identify areas of the structure whose mass can be reduced. However, it is to be noted that the structure's manufacturing cost is not driven by the mere bulk steel, but by the cost of manufacturing process itself, i.e. by all the welding, machining, heat treatments, etc., there are needed to actually manufacture the parts. It is therefore this area that a future cost optimisation study shall focus.	SST-STR	The action is considered closed by the documents “SST-MEC-DSR-001 Design Report” and “SST-MEC-ANR-008 Structural Analysis Report” M1 Dish option1 leading to improved availability has been implemented in the telescope baseline (featuring standard structural profiles). Extensive FEA of the telescope structure has been performed to reduce structural margins. Updated have been implemented in the CAD model.
SST-ER-19	#40671	SSTER-STR03-PDR-04: Write a document describing how the lessons learned from the prototype have been implemented for the final design.	SST-PRO	The development history and status has been described in the document "SST-PRO-PLA_009 Engineering Development and Verification Plan" sec. 3
SST-ER-21	#40681	ASTRI-DES-EIE-3100-027c Identify the minimum stiffness and precision requirement for the bearing/drive and adapt the selected technology to the needs, e.g. ball bearing vs crossed roller. Commercial slewing systems with integrated drives such as: https://conedrive.com/products/slew-drive-and-slew-bearing-2-2-4/slew-drive-and-slew-bearing-2-2-2-2/	SST-MEC	The action is closed by the document SST-MEC-DSR-001 section 2.1.1 The current baseline for the azimuth bearing and drive system is cost-effective, being based on COTS components. Slewing drives of the needed diameter have not been found on the market. Reducing the diameter of the azimuth bearing is not possible for human access reasons.

		https://www.frusca.com/en/industry/slewing-drives should be investigated if they can fulfill the requirements.		
SST-ER-22	#40688	4c SST-STR Description of the Intended Final Design (Finite Element Analysis): Provide a document describing experimental tests finalized to compare computed values of displacements and frequencies with the measured ones.	SST-MEC	The action is considered partially closed by the document "SST-AIT-PLA-011 1aD SST Factory AIT Plan". The experimental tests will be defined and presented fat the CDR.
SST-ER-23	#40688	4c SST-STR Description of the Intended Final Design (Finite Element Analysis): Improve with a specific approach the qualitative explanation given for justifying the computed over stress under severe seismic conditions.	SST-MEC	The action is considered closed by the document "SST-MEC-ANR-008 Structural Analysis Report" section 4.5 The seismic analysis of the telescope has been fully updated with the current specification. No overstress is computed in the telescope structure.
SST-ER-24	#40688	4c SST-STR Description of the Intended Final Design (Finite Element Analysis): Produce checks of the stability of compressed elements (obviously considering also the bending moments) under the combination of severe horizontal and vertical seismic effects.	SST-MEC	The action is considered closed by the document "SST-MEC-ANR-008 Structural Analysis Report" section 4.5. Check of the stability of slender structural members under sever earthquake effects has been performed, and the stability check is passed for all members
SST-ER-25	#40692	PCBAs Testability/coverage: Implement the actions described by the SST-CAM within its answer to the RIX	SST-CAM	The test stategdy for PCBs has been discussed in internal camera PCB reviews. The amount of testing taking place Currently, the first production of the first few untis from revised PCB designs are underway. Following tests (and before producing ECAM), the camera team will work with PCB manufactures to better formalise tests, and internally document pre-camera integration test procedures. This will be documented in: • SST Common Standards • Camera Quality Plan / Camera Electronics Standards Low-level (i.e. PCB) test procedures (i.e. procedures used in house to test PCBs), and production-packs (i.e. material, including any required procedures, sent to manufacturers)
SST-ER-27	#40697	Timing/White Rabbit implementation: Implement in the design a common timing board for the different CTA cameras, to enhance knowledge and serviceability. the DMA remarks the following: This action cannot be adopted as worded, as it is not a direct responsibility of the SST Camera Project to provide a common timing solution	SST-CAM	A common timing solution has not yet been provided by CTAO.

		for other cameras. When such a common timing solution will be provided by CTAO, then the SST Camera Project will endeavour to integrate this into the camera design. Of course, if this is provided by CTAO in time, it will be possible to complete the action before the PDR.		
SST-ER-28	#40701	4d SST-STR Description of the Intended Final Design (Dynamic Simulation): Produce the results of the simulation of the control system considering different configuration of the telescope.	SST-MEC	The dynamic simulation will be performed in the next phase, the design consolidation phase, and presented at the CDR.
SST-ER-29	#40701	4d SST-STR Description of the Intended Final Design (Dynamic Simulation): Provide a testing plan finalized to compare numerical results with the ones obtained experimentally both in the factory and in the field	SST-MEC	The action is considered closed by the following documents: SST-AIT-PLA-011 1aD SST Factory AIT-AIV Plan draft sections 3.2.2.9, 3.2.2.10, 2.2.2.25; SST-AIT-PLA-012 1aD SST On-site AIT Plan" sections 4.1.2, 4.1.3, 4.1.4 Both factory and on-site tests are foreseen to compare results of the dynamic simulation with field tests, in terms of main axes eigenfrequencies and pointing/tracking accuracy.
SST-ER-31	#40664 #40680	Revisit the requirements for the encoders and look at the market to select the one that is the most suited to the telescope for the best price	SST-MEC	The survey carried out showed that the choice of an encoder with a lower precision does not allow a significant saving in terms of costs.
SST-ER-32	#40682	Investigate the potential suppress of the brake (if this one is not necessary) to increase the reliability of the overall system (trade-off on the risks versus cost).	SST-MEC	The action is closed by the document SST-MEC-DSR-001 sec. 2.1.2 The elevation brake is necessary as a certain degree of unbalance in introduced in the elevation assembly to eliminate backlash, and the total efficiency of the ball screw and reduction gears is quite high (about 75%).
SST-ER-33	#40591 #40702	Concerning design option #1: More discussion is needed with EIE & SST-PO to determine whether this option enhance the current ASTRI concept	SST-MEC	The action is closed by the document SST-MEC-DSR-001 sec. 2.1.3 Option #1 (different Camera replacement strategy described in SST-PRO-ANR-006 Top level & trade-off analysis Report) has been implemented in the design.
SST-ER-35	#40672	Mirror Coating: Clarify if the recoating is necessary and define the project baseline (recoating on site, recoating off site, new mirrors, ...). Address it in the SST maintenance plan.	SST-OPT	As described in "SST-OPT-DSR-001 Design Report" sec.2.6 we do not plan to recoating the mirrors.

SST-ER-36	#40672	Mirror Coating: In case recoating is requested describe in a dedicated document the de-coating & recoating process.	SST-OPT	As described in "SST-OPT-DSR-001 Design Report" sec.2.6 we do not plan to recoating the mirrors.

6.2 DVER Recomandations

The table hereafter report the recomandations included at the DVER [AD3] to be closed by the Product Review.

Topic	Recommendation #	Description	Closure
SST-AIV	REC-SST-ER #01	Trade and optimize the assembly strategy in view of reduced assembly and test effort on-site against increased transport cost. This shall be done before SST-PDR.	SST-MEC-DSR-001 Design Report section 2.2.1 Transport and assembly strategy have been optimized, based on the experience with the first telescope of the ASTRI mini-array.
	REC-SST-ER #03	A global work shall be done to consolidate the AIV & Commissioning phases with respect to schedule, human resources & needed facilities on site (both with industry and laboratories resources), and to verify that the cost of these activities is commensurate with available expected funds. SST-PO shall establish a dedicated interface document between the "SST-Program" and the "on-site construction program" that will describe the facilities, tools, logistic and services needed. This work shall be completed by SST PDR.	The following documents represent the SST plans about development, Assembly, Integration test and verification at subsystems level and at system level on factory and on-site: SST-PRO-PLA_009 Engineering Development and Verification Plan SST-CAM-PLA_009 Engineering Development and Verification Plan SST-AIT- PLA_011 Factory AIT Plan SST-AIT-PLA_012 On site AIT Plan SST-PRO-PLA_013 AIV Plan
	REC-SST-ER #05	SST-PO shall establish with the partners a potential IKC list and build coherently a consolidated production scheme and schedule for the STR (several options can be addressed). This schedule shall encompass ample margin.	SST-PRO-PLA-001 Project Management Plan SST-PRO-PLA_009 Engineering Development and Verification Plan
Consolidation of the SST-STR current design	REC-SST-ER #07	The panel recommends to further study the feasibility of modifying the M1 mirror dish structure using a beam structure, pending that the current overall structure design is kept unchanged (as an example: similar displacement & loads at interfaces with the overall structure).	SST Top Level & Trade-Off Analysis Report: SST-PRO-ANR-006| 1.a SST-MEC-DSR-001
Consolidation of the SST-CAM project	REC-SST-ER #08	Reopen a trade-off (time, costs, risks, etc.) between the implementation of testing ASICs before having them packaged and provisioning a sufficient number of fully	The following ASIC stratedgy has been implemented by the camera: • Use MPW runs (low cost) to confirm any ASIC changes

		integrated spare boards (with ASICs) to compensate production losses that may arise.	• Package a few ASICs from each new run and test on eval. boards prior to packaging remaining ASICs • Develop a socket to allow packaged ASICs to be tested prior to soldering This approach will be taken for ASICs for ECAM, and then adapted as needed for the series production ASIC run.
Maintenance & Operations:	REC-SST-ER #09	The panel recommends improving the overall access concept of the SST in view to enhance its maintainability. To this end, the following actions are suggested: • Review the overall access concept (especially the cabinet access). • Perform a hazard analysis to enhance the safety of operations. • Take into account experience feedback from multi telescope projects (example: ALMA) but also from the SST-prototype. • Make use of the prototype to challenge the updated access concept	SST-MEC-DSR-001 Design Report section 2.2.1 Maintainability and accessibility improvements have been implemented in the updated SST baseline.

End of the document