

		<b>ASTRI Mini-Array</b> Astrofisica con Specchi a Tecnologia Replicante Italiana					
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## ASTRI Mini-Array Software Quality Assurance Plan



Main Editor:	Name:	V. Conforti	Signature:		Date:	Jan 29, 2021
Verified by:	Name:	G. Tosti	Signature:		Date:	Jan 29, 2021
Approved by:	Name:	N. La Palombara	Signature:		Date:	Jan 29, 2021
Released by:	Name:	S. Scuderi	Signature:		Date:	Feb 05, 2021



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**Main Authors:** V. Conforti

**Contributor Authors:** N. La Palombara, V. Giordano, G. Tosti, A. Bulgarelli, F. Lucarelli, S. Scuderi, J. Schwarz

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## 1. Introduction

The **ASTRI Mini-Array (MA)** is an INAF project aimed to observe astronomical sources emitting at very high-energy in the TeV spectral band. The ASTRI MA consists of an array of nine innovative Imaging Atmospheric Cherenkov telescopes that are an evolution of the two-mirror ASTRI Horn telescope successfully tested since 2014 at the Serra La Nave Astronomical Station of the INAF System of Catania. Each telescope will be equipped with the new version of the ASTRICAM Silicon photomultiplier Cherenkov Camera. The main science goals of the ASTRI MA encompass both galactic and extragalactic science. The nine telescopes will be installed at the Teide Astronomical System, operated by the Instituto de Astrofísica de Canarias (IAC), on Mount Teide (~2400 m a.s.l.) in Tenerife (Canary Islands, Spain). The ASTRI MA will be operated by INAF on the basis of a host agreement with IAC.

### 1.1. Purpose

The purpose of this Software Quality Assurance (SQA) Plan is to establish the goals, the processes, and responsibilities required to implement the effective quality assurance functions for the ASTRI mini-array software.

The ASTRI mini-array Software Quality Assurance Plan provides the framework necessary to ensure a consistent approach to software quality assurance throughout the project lifecycle. It defines the approach that will be used by the Product Assurance Manager (PAM), the PA responsible for the software and all the actors involved to monitor and assess software development processes and products.

### 1.2. Scope

This plan covers SQA activities throughout the formulation, implementation and maintenance phases of the system. For all QA activities and tasks not described by this document, the provisions described in AD2 apply.

### 1.3. Contents

This document is organised as follows:

1. Section 3 depicts the organization of the Product Assurance office and the actors involved in the software quality assurance activities. The tasks and responsibilities to ensure the quality of product and process are described as well.
2. Section 4 details the documents shall be prepared and maintained.
3. Section 5 refers to the standards, practises and metrics.
4. Section 6 provides an overview of the review process.
5. Section 7 outlines the verification and validation activities.
6. The sections 8 and 9 concern the problem reporting and the quality process control.

### 1.4. Definitions and Conventions

### 1.5 Abbreviations

SQA    Software Quality Assurance



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SQM Software Quality Manager  
PAM Product Assurance Manager  
SQ Software Quality  
SDT Software Development Team

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## 2. Applicable and reference documents

### 2.1. Applicable documents

- [AD1] ASTRI Project Management Plan – ASTRI-INAF-PLA-1000-001 I1.9
- [AD2] ASTRI Mini-Array Product Assurance Plan - ASTRI-INAF-PLA-3000-001 I1.0
- [AD3] ASTRI Mini-Array Software Engineering Management Plan ASTRI-INAF-PLA-2100-001 I1.0
- [AD4] ASTRI Mini-Array Glossary and Abbreviations, ASTRI-LIS-9000-001
- [AD5] ASTRI Mini-Array Top Level Use Cases, ASTRI-SPE-9000-001
- [AD6] ASTRI Mini-Array Top Level Software Architecture - ASTRI-DES-2100-001 I2.3
- [AD7] ASTRI Mini-Array Science Requirements
- [AD8] ASTRI Mini-Array Software Development Plan - ASTRI-INAF-PLA-2100-002 I1.0
- [AD9] ASTRI Mini-Array Risk Management Plan ASTRI-INAF-PLA-1000-002 I1.3
- [AD10] ASTRI Mini-Array - Guidelines INAF-PRO-3000-001 I.1

### 2.2. Reference documents

- [RD1] <https://www.ict.inaf.it/gitlab/astri>
- [RD2] <http://redmine.oas.inaf.it/>
- [RD3] SRS - ASTRI Mini-Array Software Requirements Specification template
- [RD4] UCD - ASTRI Mini-Array Use Case Document template
- [RD5] ICD - ASTRI Mini-Array Interface Control Document template
- [RD6] SDD - ASTRI Mini-Array Software Design Document template
- [RD7] SVerP - ASTRI Mini-Array Software Verification Plan template
- [RD8] SValP - ASTRI Mini-Array Software Validation Plan template

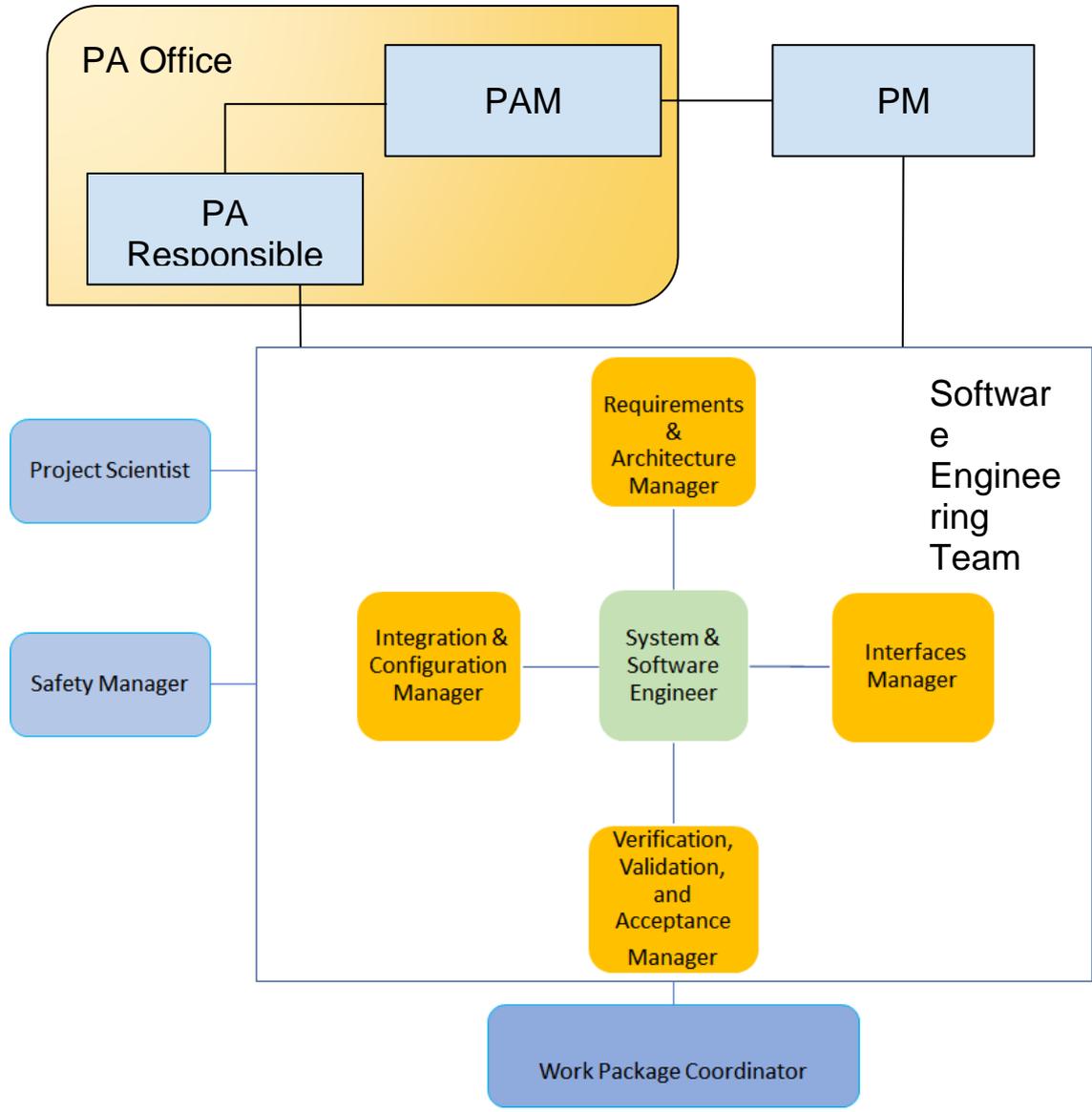
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### 3 Management

This section describes the management organizational structure, its roles and responsibilities, and the software quality tasks to be performed according to the AD2.

#### 3.1 Management Organization

The ASTRI mini-array efforts are supported by numerous entities, organizations and personnel (see ASTRI mini-array web site for a detailed organizational chart). Relevant entities/roles that are of interest and applicable to this SQA (Software Quality Assurance) Plan and the software assurance effort are described at a high level below according to [AD1], [AD2] and [AD3].



The Product Assurance Manager (PAM) coordinates the Product Assurance (PA) activities and reports to the Project Manager (PM) the status of the PA activities. The PA responsible for the software coordinates the PA activities for the software product and reports to the PAM. The PAM and PA responsible for the software are members of the PA office which includes also the PA responsible for the telescope mechanical structure, optics, camera and safety.

The main actors for these activities are the software suppliers that are the Work Package coordinators (SCADA, Archive, Data Processing, Science User Support, and Simulation). The software engineering team, led by the System and Software Engineers provides support to the software coordinator concerning the software engineering activities. The software supplier can produce the software internally or through external contractors.

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## 3.2 Tasks

This section describes how the responsibilities of the SQ activity are translated into specific processes and product assessment tasks that need to be performed by the SQ actors during the development and maintenance activities of the ASTRI mini-array software. Every task is assigned to the different roles and bodies presented previously.

### 3.2.1 Product Assessments

The PA office personnel organize the activities to conduct software tests and reviews in order to guarantee the quality of the product from a technical and functional point of view.

The software supplier has in charge the software designing, development and testing of a specific sub-system. The software supplier works under the supervision of the software engineer, and it may be compounded by ASTRI people, a contractor, a mixture of both. Each sub-system coordinator shall clearly define the scope of the software product and describe the internal organisation listing roles, tasks and responsibilities. The following topics shall be included in the software requirement specification [RD3]:

1. organizational structure;
2. interfaces, either external or internal, involved in the project.

The software supplier shall produce the software verification plan (SVerP) and the software validation plan (SValP) which describe how metrication of the software product quality will be performed, to verify the implementation of the requirements. Such metrication activity will give a figure of the product quality involving requirement, design, code and testing activities as well as software documentation quality. The defined set of metrics shall also provide a valid assessment tool to verify whether the test coverage goal has been reached. All the software documentation produced during design, implementation, test and verification phase shall be subject to ASTRI MA documentation management assuring so the development and implementation traceability and permitting to maintain the software product during the operational phase.

### 3.2.2 Process Assessments

The process assessment to build the ASTRI mini-array software is fundamental to guarantee that the final product meets the science requirements. The PA office performs audits to evaluate the software development life cycle, presenting any issue to the PM and carrying out process improvements. The tasks defined for this activity, the responsible actors involved, and the outcomes are summarized in the next subsections.

#### 3.2.2.1 Software dependability and safety

The software supplier shall provide the dependability and safety analyses in order to identify the severity of the associated possible failures according to [AD9]. On the basis of the performed analyses, the software components criticality will be assigned, classifying them as:

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- Score 5: Software that if not executed, or if not correctly executed, or whose anomalous behavior can cause or contribute to a system failure resulting in: catastrophic consequences.
- Score 4: Software that if not executed, or if not correctly executed, or whose anomalous behavior can cause or contribute to a system failure resulting in: critical consequences.
- Score 3: Software that if not executed, or if not correctly executed, or whose anomalous behavior can cause or contribute to a system failure resulting in: major consequences.
- Class 2 or 1: Software that if not executed, or if not correctly executed, or whose anomalous behavior can cause or contribute to a system failure resulting in: minor or negligible consequences.

The software components criticality classification shall be defined and documented in a software Criticality Analysis Report. In order to assure the dependability and safety of the critical software components several measures can be applied:

- use of software design or methods that have performed successfully in a similar application;
- insertion of features for failure isolation and handling (software failure modes, effects and criticality analysis, FMECA);
- defensive programming techniques, such as input verification and consistency checks;
- use of a safe subset of a programming language;
- $\geq 70\%$  code branch coverage at unit testing level;
- full inspection of source code;
- witnessed or independent testing;
- gathering and analysis of failure statistics;

Critical software shall be subject to regression testing after

- any change of functionality of the underlying platform hardware (example: instruction set of a processor);
- any change of the tools that affect directly or indirectly the generation of the executable code.

### 3.2.2.2 Software documentation and configuration management

Software configuration control will be performed, assuring traceability of the developed software configuration items, either source code or documents, until final acceptance and utilization. The software engineer shall verify that the software version control system gitlab [RD1] is used. The Product Assurance manager shall verify that the Configuration management system defined in the Management Plan [AD1] is used. Software problems shall be handled since the start of code unit tests, by reporting them following the dedicated procedure defined in the software development plan [AD8]. The software problem reports shall be issued and maintained in gitlab [RD1] for the coding and in the redmine system [RD2] for the other artifacts (e.g. documents).

### 3.2.2.3 Product assurance planning for individual processes and activities

Here we report product assurance activities that are common for the software suppliers when managing their software processes:

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- verification of the correct implementation of the documentation configuration management;
- verification of the conformance to the applicable procedures and standards [AD8];
- verification of the application of the engineering measures to mitigate the risks associated with critical software;
- verification of the availability of development phases input documentation and tools;
- verification of the metric evaluation process (metrication).

The software process assessment will be performed by the software supplier performing several activities or verifying their performance as measured by the software engineers. Part of these activities is performed exploiting dedicated software tools and gives origin to product metrication object data. The results of the software product assurance activities performed shall be documented.

#### 3.2.2.4 Software requirements analysis

The software engineer and the software suppliers (WP coordinators) during the software requirements analysis shall perform the following tasks:

- control of the completeness of the requirement list, to be sure it contains proper and sufficient inputs for deriving the software technical specification;
- verification that the software technical specification includes, in addition to the functional requirements, all the necessary non-functional requirements;
- verification of the completeness of the requirement traceability matrix.

#### 3.2.2.5 Software architecture and design

The software supplier during the software architectural phase shall perform the:

- verification of the availability of all the necessary design tools;
- analysis of the software architecture, in order to verify that its complexity and modularity meet the requirements.

The software supplier during the software design phase shall perform the:

- analysis of the software design documentation in order to verify that it contains the appropriate level of information for maintenance activities;
- verification of the completeness of the requirement specification vs. software components traceability matrix.

#### 3.2.2.6 Verification and validation test

The verification and validation test shall be performed in accordance with the SVerP and SValP. The software supplier shall detail in the SVerP and SValP a strategy for each testing level (unit, integration), types of tests to be performed, the tools and organizations to perform the test activities. In case of retesting, all test related documentation (test procedures, data and reports) shall be updated accordingly.

The activities during the software verification and validation phase shall include the following tasks:

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- to verify the completeness of the test related documentation before the start of test activity;
- to verify that the code is put under configuration control after successful unit testing;
- to verify that test reports are adequately compiled and updated;
- to verify the traceability between the performed tests and the SVerP and SVaIP.

### 3.2.2.7 Software delivery and acceptance

The ASTRI MA software is not a standalone product, the software acceptance process will be part of the combined ASTRI MA hardware/software acceptance activities led by the AIV manager. The activities to be carried out before the software acceptance tests shall include the following tasks:

- verify that the software validation against requirements is complete;
- verify that no major software problems are open;
- verify that the software to be installed at the ASTRI MA site is generated from an opportunely configured source code version.

During delivery and acceptance test campaigns any discovered problem will be documented in non-conformance reports [AD1].

## 3.3 Roles and Responsibility

The software quality process involves both the ASTRI team and the external contractors. This section describes the roles and responsibilities based on the roles and responsibilities defined in the ASTRI mini-array management plan [AD1].

### 3.3.1 Product Assurance Manager (PAM)

Responsibilities include, but are not limited to:

- Secure and manage the quality management at system level.
- Provide general guidance and direction to the PA responsible for the software who is responsible for conducting software quality activities and assessments.
- Assist in the resolution of any non-compliances, issues and/or risks identified as a result of software quality activities.
- Escalate any non-compliances to project management.

### 3.3.2 PA responsible for the software

Responsibilities include, but are not limited to:

- Develop and maintain the software quality assurance plan.
- Generate and maintain a schedule of software quality assurance activities.
- Conduct process and product assessments, as described within this plan, using objective criteria.
- Interface with Safety, Reliability, and IV&V personnel on software assurance activities.
- Identify and document non-compliances, observations, and risks from all software assurance related activities to the PAM.
- Communicate results from assessments with relevant stakeholders.

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- Ensure resolution of non compliances and escalate any issues that cannot be resolved within the project.
- Identify lessons learned that could improve processes for future projects.
- Escalate any non-compliances to the PAM.

### 3.3.3 Software Engineer

Responsibilities include, but are not limited to:

- cooperate with project scientist to produce and maintain the software requirement documents;
- ensure the traceability among the deliverables defined in the SDP.
- Escalate any non-compliances to the PA Responsible for the software.

### 3.3.2 Software Suppliers

Responsibilities include, but are not limited to:

- produce and maintain the deliverables defined in the SDP under version control;
- produce and maintain the software verification and validation plan;
- perform the verification and validation activities defined in the software verification and validation plan;
- Escalate any non-compliances to the Software Engineer.

## 4. Documentation

This section identifies the documentation governing the requirements, development, verification, validation, and maintenance of software that falls within the scope of this software quality plan. For each identified document we detail: the responsible, who is in charge to ensure the production and updating of the document; the supervisor, who is responsible for the contents assessment and the delivery of the document according to the project schedule; the amount, specifies the number of documents to be produced; and the references, indicate if the specific document or template is existing or is to be produce.

### 4.1 Software Engineering Management plan

Responsible: Software Engineer

Supervisor: PA responsible for the software

Amount: 1

References: ASTRI Mini-Array Software Engineering Management Plan [AD3]

### 4.2 Software Development Plan

Responsible: Software Engineering Team

Supervisor: Software Engineer

Amount: 1

References: ASTRI Mini-Array Software Development Plan [AD8]

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### 4.3 Science requirements document

Responsible: Project Scientist  
 Supervisor: Requirements and Architecture Manager  
 Amount: 1  
 References: to be produced.

### 4.4 Software requirements document

Responsible: Software Engineering Team  
 Supervisor: Requirements and Architecture Manager  
 Amount: 2  
 References:

- ASTRI Mini Array Top Level use cases [AD5]
- ASTRI Mini Array Top Level Software Architecture [AD6]

### 4.5 Software verification and validation plan

Responsible: Software Supplier  
 Supervisor: Verification, Validation and Acceptance Manager  
 Amount: at least two for each sub-system. The number is defined by the software supplier.  
 References:

- SVerP - ASTRI Mini-Array Software Verification Plan Template [RD7]
- SValP - ASTRI Mini-Array Software Validation Plan Template [RD8]

### 4.6 Software requirement specifications

Responsible: Software supplier  
 Supervisor: Requirements and Architecture Manager  
 Amount: at least one for each sub-system. The number is defined by the software supplier according to the requirement documents  
 References:

- UCD - ASTRI Mini-Array Use Cases Document Template [RD4]
- SRS - ASTRI Mini-Array Software Requirements Specification Template [RD3]

### 4.7 Software architecture and design document

Responsible: Software supplier (internally or committed to an external contractor)  
 Supervisor: Requirements and Architecture Manager  
 Amount: at least one for each sub-system. The number is defined by the software supplier according to the requirement specifications.  
 References:

- SDD - ASTRI Mini-Array Software Design Document Template [RD6]

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#### 4.8 Interface Control Documents

Responsible: Software supplier (internally or committed to an external contractor)

Supervisor: Interface Manager

Amount: at least one for each sub-system. The number is defined by the software supplier according to the design documents.

References:

- ICD - ASTRI Mini-Array Interface Control Document Template [RD5]

#### 4.9 Test reports and artifacts

Responsible: Software supplier (internally or committed to an external contractor)

Supervisor: Verification, Validation and Acceptance Manager

Amount: at least one for each sub-system. The number is defined by the software supplier according to the SVerP and SValP.

References:

- For the test procedure and reports a draft has been produced: ASTRI Mini-Array - Guidelines for the test documents [AD10]
- For the software, gitlab shall be used for the version control. Concerning the functional tests and the static code analysis the tools are to be defined.

#### 4.10 Software user manuals

Responsible: Software supplier (internally or committed to an external contractor)

Supervisor: Integration and Configuration Manager

Amount: at least one for each sub-system. The number is defined by the software supplier according to the artifacts.

References:

- Template: ECSS- E- ST- 40C, 6 March 2009, Annex H- Software User Manual (SUM)

#### 4.11 Software release documents

Responsible: Software supplier

Supervisor: Integration and Configuration Manager

Amount: at least one for each sub-system. The number is defined by the software supplier

References:

- Template: ECSS- E- ST- 40C, 6 March 2009, Annex G- Software Release Document (SReID)

### 5.0 Standards, Practices, Conventions, and Metrics

The software supplier shall implement the standards, practices, and test procedures defined in the Software Development Plan [AD8]. The metrics to assess the quality of the software shall be defined in the Software verification and validation plans (SVerP, SValP).

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## 6.0 Software Reviews

This section identifies the number and type of system/subsystem reviews and engineering peer reviews that will be supported by the Software Engineering team according to the [AD3].

For each review the Software Engineering team will assess the review products to assure that reviews are being developed according to the specified criteria, the review content is complete, accurate, and of sufficient detail, and Requests for Action are captured, reviewed, and tracked to closure. In addition, the Software Engineering team will assess the processes used to conduct the reviews to determine if appropriate personnel are in attendance, correct information is presented, entry and exit criteria are met, and appropriate documents are identified for update.

The following software reviews may be assessed by the Software Engineering team:

- Preliminary Design Review (PDR)
- Critical Design Review (CDR)
- Operational Readiness Review (ORR)

## 7.0 Software Verification, Validation and Acceptance

The Software Engineering team will assure that the test management processes and products are being properly implemented. This includes all types of testing of software system components as described in the test plan.

The software supplier will monitor testing efforts to assure that test schedules are adhered to and maintained to reflect an accurate progression of the testing activities. The software supplier will assure that tests are conducted using approved test procedures and appropriate test tools, and that test anomalies are identified, documented, addressed, and tracked to closure. In addition, the software supplier will review post-test execution related artifacts including test reports, test results, problem reports, updated requirements verification matrices.

### 7.1 Software Verification

The verification process is the verification of the requirement specifications and shall be detailed in the SVerP. Therefore, any Software product that shall be delivered to the ASTRI MA shall include software tests that demonstrate the code is well written and meets its requirements. The SVerP shall detail tests at unit and integration level. The tests shall cover either functional or quality requirements (such as functional tests and static code analysis). Use of automatic testing procedure is strongly encouraged. The SVerP indicates the steps and verification procedures that will be used to verify the requirement. The verification report (test report) shall be produced to illustrate the results of the verification procedures.

### 7.2 Software Validation

The software validation process, defined in the SValP, confirms that the functional requirements and performances are correctly and completely implemented in the final product. These tests are performed by the end-users (customer) of the software products. These tests are performed independently of the specification document and may highlight missing or mis-specified

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requirements. These definitions consider that a software product can meet its requirements, but it may not satisfy the requirement in the eyes of the user.

### 7.3 Software Delivery and Acceptance

The acceptance is reached only when the software has been verified, validated, delivered, and installed and correctly running on the ASTRI MA infrastructures and the ASTRI MA personnel has been trained. The acceptance is the outcome of the ORR.

### 8.0 Problem Reporting and Corrective Action

The tracking, and trend assessment findings/non conformances and observations shall be managed through the redmine tool, available via <https://redmine.oas.inaf.it>.

### 9.0 Quality Processes Control

The PA office can conduct surveillance activities at supplier sites on software development activities. The PA office can conduct a baseline assessment of the supplier's processes and software engineering team activities to ensure that these actors have implemented the quality criteria defined in this document. This initial assessment will help to scope the level of effort and follow-on activities in the area of software quality assurance. Process and product assessments will be conducted and any findings will be reported and tracked to resolution.

### 10.0 SQA Plan Change Procedure and History

The Pa responsible for the software is responsible for the maintenance of this plan. It is expected that this plan will be updated throughout the life cycle to reflect any changes in support levels and software engineering activities. Proposed changes shall be submitted to the Pa responsible for the software along with supportive material justifying the proposed change. Changes to this document require prior approval of the ASTRI mini-array Product Assurance Manager (PAM).