ASTRI Mini-Array
Software Engineering Management Plan

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DOCUMENT HISTORY

Version	Date	Modification
0.1	28/05/2020	Initial version
0.2	**07/10/2020**	Includes comments by the SW - SE team.
1.0	**Nov 9, 2020**	First version after internal check of the ASTRI-MA software team

1. Introduction

1.1. Purpose

This document provides the basis for implementing and communicating the ASTRI Mini-Array (MA) Software technical effort.

1.2. Scope

The scope of this document is to describe the Software System Engineering work required to produce the MA software. This plan will be used by the ASTRI Collaboration and external supplier Software Teams to provide the needed information about the necessary tasks to accomplish to successfully create the MA software.

1.3. Content

This document is mostly based on ISO/IEC 15288 [RD3] that is the main international standard for systems and software engineering and establishes a common framework for describing the life cycle processes of systems created by humans.

2. Related Documents

2.1. Applicable Documents

[AD1] ASTRI-MA Management Plan: ASTRI-INAF-PLA 1000-001

[AD2] ASTRI-MA Quality Plan: ASTRI-INAF-PLA-3000-0001
[AD3] ASTRI-MA Top Level Software Architecture: ASTRI-INAF-DES-2100-001
[AD4] ASTRI-MA Software Product Breakdown Structure: ASTRI-INAF-DES-2100-002
[AD5] ASTRI-MA Data Model: ASTRI-INAF-DES-2100-003
[AD6] ASTRI-MA Top Level Use Cases: ASTRI-INAF-SPE-2100-001
[AD7] ASTRI-MA Software Development Plan: ASTRI-INAF-PLA-2100-002
[AD8] ASTRI-MA Glossary: ASTRI-INAF-LIS-2100-001
[AD8] ASTRI-MA System Engineering Management Plan:
[AD9] ASTRI-MA Operation Concept: ASTRI-INAF-DES-1000-001
[AD10] ASTRI-MA Risk Management Plan: ASTRI-INAF-PLA-1000-002

[AD11] ASTRI Mini-Array Product Tree: ASTRI-INAF-DES-2000-001

[AD12] ASTRI Mini-Array Interface Management Plan: ASTRI-PLA-2000-YYYY

2.2. Reference Documents

[RD1] Pareschi G., et al., for the ASTRI Collaboration and the CTA Consortium, “The ASTRI SST-2M prototype and mini-array for the Cherenkov Telescope Array (CTA),” Proc. SPIE 9906, id. 99065T (2016).

[RD2] Science with the ASTRI mini-array at Teide: a great opportunity for gamma-ray astronomy and beyond! – Science support document for the ASTRI mini-array at Teide, May 2019

[RD3] Standards listed at https://www.sebokwiki.org/wiki/Relevant_Standards [referenced 09.10.2020]

[RD4] ECSS-M-00B Policy and principle (29 Aug 2003): https://ecss.nl/standard/ecss-m-00b-policy-and-principles-29-august-2003/

3. Definitions, Conventions and Acronyms

A complete list of definitions is given in [AD8]. Here we report some key definition in the Software engineering Domain:

Definition	Description	Origin
Artefact	A synonym to Work product	ISO/IEC/IEEE 15288
Configuration item	Item or aggregation of hardware, software, or both, that is designated for configuration management and treated as a single entity in the configuration management process.	ISO/IEC/IEEE 15288
Life cycle	Evolution of a system, product, service, project or other human-made entity from conception through retirement	ISO/IEC/IEEE 15288
Life cycle model	Framework of processes and activities concerned with the life cycle that may be organised into stages, which also acts as a common reference for communication and understanding	ISO/IEC/IEEE 15288
System Process	Set of interrelated or interacting activities of the system-of-interest to transform its inputs to outputs (like sensor values to actuator actions).	ISO/IEC/IEEE 15288
System Engineering Process	Set of interrelated or interacting activities the organization that develop the system-of-interest uses to transform input artefacts to output artefacts (like requirements specifications to architectural design).	ISO/IEC/IEEE 15288
Software System Engineering	The total technical and managerial effort required to transform a set of stakeholder needs, expectations, and constraints into a solution and to support that solution throughout its life cycle.	INCOSE

3.1. Abbreviations and acronyms

A list of Abbreviation and acronyms is given in [AD7].

AIT	Assembly Integration and Testing
ARR	Acceptance Readiness Review
ASTRI	Astrofisica con Specchi a Tecnologia Replicante Italiana
ECR	Engineering Change Request
FDR	Final Design Review
FMECA	Failure Mode Effects and Criticality Analysis
IAC	Instituto de Astrofísica de Canarias
INAF	Istituto Nazionale di AstroFisica
MTBF	Mean Time Between Failures
OAB	Osservatorio Astronomico di Brera
OAPd	Osservatorio Astronomico di Padova
PA	Product Assurance
PDR	Preliminary Design Review
PM	Project Manager
PO	Project Office
QAM	Quality Assurance Manager
SiPM	Silicon Photo-Multiplier
SE	System Engineer
SWDT	Software Development Team
SPAP	Software Product Assurance Plan
SOW	Statement Of the Work
TRR	Test Readiness Review
WP	Work Package

4. ASTRI MA System Software Overview

4.1. The ASTRI Mini-Array

The ASTRI Mini-Array (MA) is a project of the Italian National Institute for Astrophysics (INAF) to construct and operate an observatory to study astronomical sources emitting at very high-energy in the 1-100 TeV spectral band. The ASTRI MA will consist of an array of nine innovative Imaging Atmospheric Cherenkov Telescopes (IACTs). These telescopes are used to image light traces generated by cosmic-ray particles in the atmosphere onto an array of photon detectors. The light collected by the telescope covers a wavelength range from 300 nm to 600 nm, with the highest intensity being around 400 nm.

The MA telescopes will be an evolution of the two-mirror ASTRI Horn [RD1] telescope, successfully tested since 2014 at the Serra La Nave Astronomical Station of the INAF Observatory of Catania. Each telescope will be equipped with the new version of the ASTRI Silicon Photo-Multiplier (SiPM) Cherenkov Camera. The main science goals of the ASTRI MA, that encompass both galactic and extragalactic science, are described in [RD2].

The nine telescopes will be installed at the Teide Astronomical Observatory, operated by the Instituto de Astrofisica de Canarias (IAC), on Mount Teide (~2400 m a.s.l.) in Tenerife (Canary Islands, Spain).

The ASTRI-MA Project and its objectives are described in ASTRI-MA Project Management Plan [AD1].

4.2. MA System Software: Definition of the problem

The ASTRI MA System Software (MASS) covers the overall software tools needed to support the on-siste and off-site science, from preparation of the observing schedule to the production of the high-level scientific products (spectra, light curves, etc) and technical operation activities (maintenance, life cycle management, etc.).

The MASS includes all hardware, software and communication infrastructure required to control the MA Telescopes and other equipment down to, but not including, actuators and sensors.

MASS includes the definition of interfaces, requirements, standards for the field electronics/SW/HW of sub-systems but does not include the implementation of the subsystem Local Control System (LCS) itself. This plan considers the LCSs only as far as their delivery, acceptance, and integration are concerned but not their implementation.

MASS must support the maintenance of the hardware and software systems and the identification, book-keeping and reaction to possible issues.

Also, it must support the calibration of instrumentation and the verification of performance.

4.3. Description of the MA Software System

The ASTRI MA software system is fully described in [AD3], [AD4], [AD5], [AD6].

4.4. Assumption and Constraints

The ASTRI Team is not the only supplier of the MASS parts.

Domains of knowledge shall be separated and their interaction defined at interface level, e.g. some functionality required to be implemented in the local computer may be in the astronomy domain (e.g. coordinate computations in the telescope control unit) and not in the domain of the expertise of the external supplier.

Hardware and Software used shall be as much as possible standardized but external suppliers can adopt, after approval by the ASTRI Team, any solution to solve a particular problem.

LCSs are typically delivered as part of an externally contracted sub-system and then interfaced to the MASS infrastructure on the basis of specific Interface Control Documents.

Software delivered by the external contractors shall comply with interfaces [AD12] and coding standards defined in [AD7].

The MASS integration process to be followed is described in [AD7]. The integration of the MASS with the other component of the ASTRI MA must be compliant with the principle stated in the ASTRI-MA System Engineering Management Plan [AD9].

4.5. MASS Deliverables

The list of the main MASS components, the deliverables, is given in [AD4, Appendix A]. Each of the components will be developed according to an independent plan.

4.6. Evolution of the Plan

This plan defines the major activities and deadlines. The details will be maintained internally in electronic form as part of the SW Engineering work and will be under version control.

4.7. MASS Schedule

The MASS schedule is bound to the overall schedule of the ASTRI MA construction phase, starting in 2020 and be ready to provide a functional system in 2023. The detailed schedule of MASS will be produced in a d document [TBD].

4.8. Document content

This plan is organized as follows:

Section	Content
Section 1, Introduction.	This section provides an overview of the scope and purpose of the project.
Section 2, Related Documents.	This section provides a list of all documents, policies, templates,processes, and other sources of information referenced in the plan.
Section 3, Definition, Convention and Acronyms.	This section contains the abbreviations and acronyms required to properly understand this planning document.
Section 4, ASTRI MA System Software Overview	This section provides an overview of the scope and objectives of the project, the project's assumptions and constraints, reference to the project deliverables, schedule and a description of the evolution of the plan.
Section 5, Project Organization.	This section identifies interfaces to organizational entities external to the project, the project's internal organizational structure, and defines roles and responsibilities to the project, the project's internal organizational structure, and defines roles and responsibilities for the project.
Section 6, Management Process.	This section describes the planning, measurement, tracking, reporting, risk control mechanisms needed to provide management control over the technical processes and product quality, and appropriate project initiation and closeout procedures.
Section 7, Technical Process.	This section describes the technical solution in terms of a process model and implementation methods to be used to develop the various work, plans for maintaining the software, and the software acceptance.
Section 8, Supporting Processes.	This section describes processes that are employed to facilitate and control the technical processes and the state of the product. These include, but are not limited to, configuration management, verification and validation, documentation, quality assurance, reviews and audits, problem resolution, etc.

5. Project Organization

5.1. Organizational boundaries and external interfaces

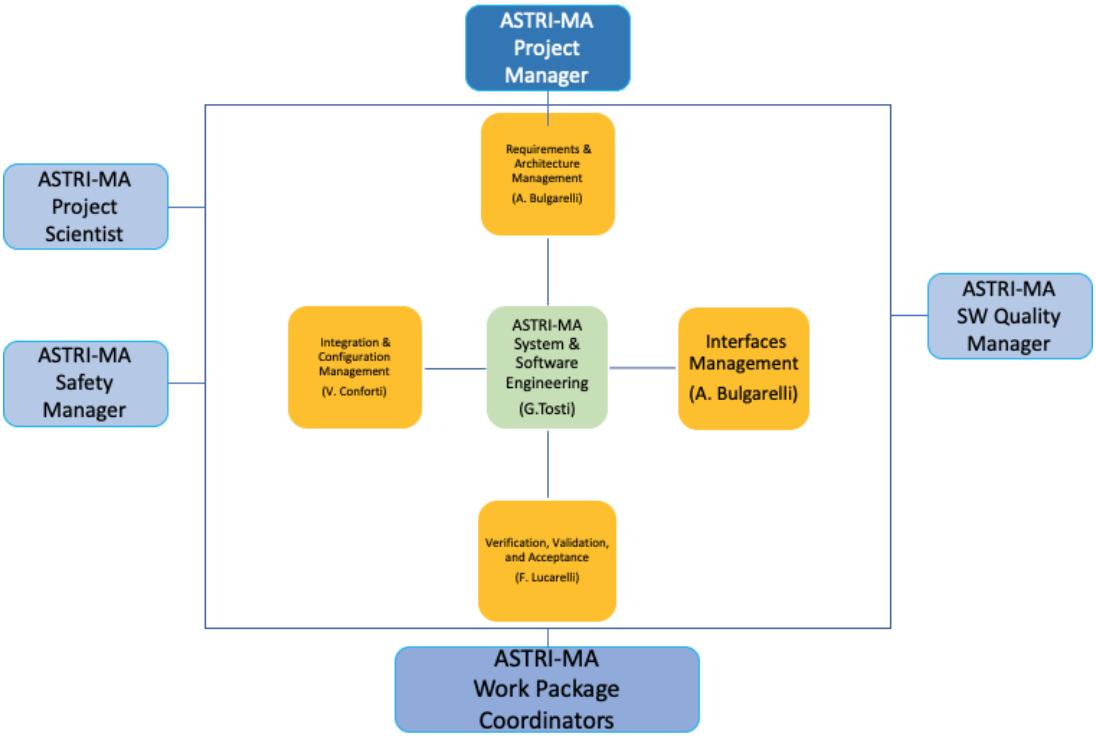
The ASTRI-MA Software system engineering is part of the ASTRI-MA System Engineering activities of the ASTRI-MA Project Office. It interacts with all ASTRI-MA work packages because it delivers coordination and integration services for the development of all ASTRI-MA Software.

5.2. Internal Organizational Structure

The ASTRI MA SW system engineer coordinates the MASS development and installation for the ASTRI-MA project with responsibility and accountability for all aspects of the project assigned by the ASTRI-MA Project Office.

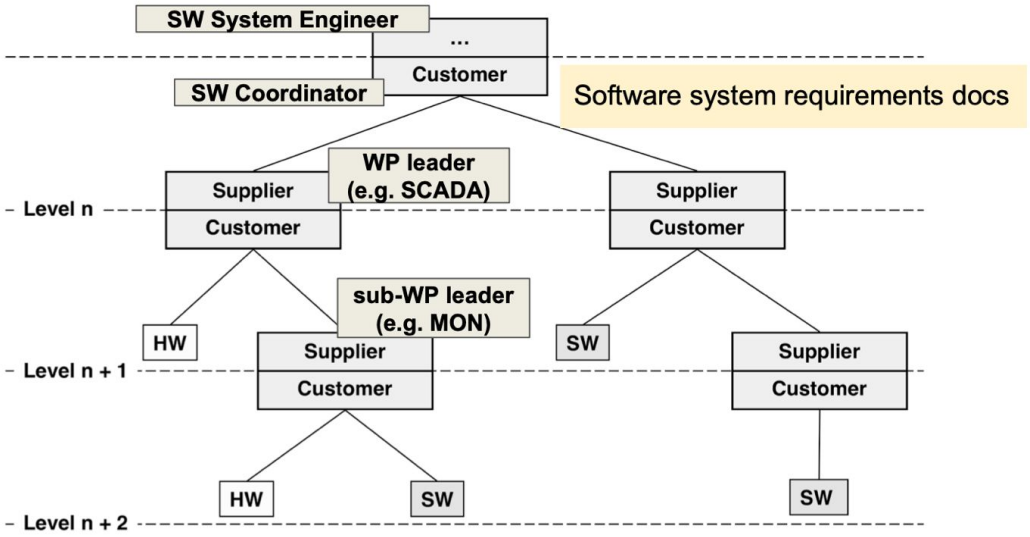
5.3. Project Roles and Responsibilities

The main roles and responsibility of the SW Engineering team are illustrated in the following diagram.



The SW engineering team coordinates its activities with the ASTRI MA Quality, Safety and Science teams.

The relation between SW System Engineering and the ASTRI MA Working Packages are defined in the [AD1] and follows the Customer-Supplier relationship [RD1] exemplified in the following figure



6. Management Processes

The MA Software management plan is developed within the framework provided by the ASTRI-MA Project Management Plan [AD1].

6.1. Startup

The MASS resources, staff and budget will be allocated and managed by the ASTRI-MA Project Office. ASTRI-MA System Engineering and ASTRI Team will provide the list of staff and resources needed for management and development of the MASS component developed in house.

6.2. Work Planning

6.2.1. Work Breakdown Structure, activities and schedules

The following table reports the activities needed in the different phases of the project lifecycle. The missing information will be addend in the next version of the document.

Project Activities With Associated Products/CIs Under each Activity	**Scheduled Delivery**	**Estimated Effort**	**Delivery Destination**
Perform Startup Activities			
User Requirements	X weeks after start	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Requirements
Perform Project Planning			
Software Engineering Management Plan (SWEMP)	X weeks after the user requirements are complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Plans
Software Calls for Tender			
Schedule for internal and joint external reviews	X weeks after the user requirements are complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Revi

Execute plans and manag software activities			
Project Schedule & Status Reports	Every X weeks after start	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Revi
Develop Software Requirements			
Software Requirement Specification	X weeks after the user requirements are complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Requirements
Develop Software Design			
Software Design Descripti	X weeks after Software Requirements Specification complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Desig
Develop Software			
Code	X weeks after Software Desig Description complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Code
Perform Software Testing			
Test Plan & Traceability Matrix	X weeks after Software Requirements Specification complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Testi
Test Plan Results (includin integration on ASTRI-MA system)	X weeks after Code complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Testi
ASTRI-MA SW-SE Evaluation period and Results	For X weeks after Test Plan Results delivered	Y FTE	Communicated to: <sender> to <receiver>

			Configuration Managed on <repository/DB/> Testi
Acceptance Test: Run complete Tests Plan on ASTRI-MA system	X week after ASTRI-MA SW-SE evaluation period complete	Y FTE	All involved parts present
Acceptance Tests Results	X weeks after ASTRI-MASW-SE evaluation is complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Testi
Delivered Completed Co Data, & Documentation			
Source Code	X week after Acceptance Test Results delivered	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Code
Documentation to support operations and maintenance	X weeks after Software Requirements Specification complete	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Code
Software Version Description	X week after Acceptance Test Results delivered	Y FTE	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Code
Operations			
Real-time Support, Results Data, and Analysis	Results are delivered for the duration of the project	Max allowed Work year hours	Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> OPS
Perform Maintenance		Max allowed Work year hours	
Change Requests (CR)	First come first served		Communicated to: <sender> to <receiver> Configuration Managed on <repository/DB/> Maintenance

Training and maintenance services (bug fixes); includes electronic transfer of modified code and notification of fixes.	As needed		Communicated to: <sender> to <receiver> Electronic transfer of modified code and notification of fix.

6.2.2. Schedule allocation

The MASS schedule allocation is responsibility of the ASTRI-MA Project Office.

6.2.3. Resource allocation

The MASS resource allocation is responsibility of the ASTRI-MA Project Office.

6.2.4. Budget allocation

The MASS budget allocation is responsibility of the ASTRI-MA Project Office.

6.3. Project Control

6.3.1. Requirements control

The MASS requirements control is a function allocated to the ASTRI-MA System Engineer.

6.3.2. Schedule control

The MASS schedule control is a function allocated to the ASTRI-MA Project Office.

6.3.3. Budget control

The MASS budget control is a function allocated to the ASTRI-MA Project Office.

6.3.3.1. Contractor Cost control

The MASS Contractor cost control is a function allocated to the ASTRI-MA Project Office.

6.3.4. Quality Control

Quality control for MASS work products and processes will be performed in accordance with ASTRI-MA Quality Plan [AD2].

6.3.5. Reporting and Communication

6.4. Risk Management

The MASS risks are identified in Figure 2. They will be tracked by the ASTRI_MA Project Manager following the principle stated in [AD10].

Risk (description)	Metrics	Risk Reduction/ Prevention Plan	Contingency	Entrance Criteria
1. Requirements stability.	Track number of requirements: original, new, changed, deleted (using a requirements database)	Report requirements stability with estimated impact assessment on the baseline (freeze) requirements at planned time in schedule.	Reduce functionality to meet cost and schedule or increase funds and schedule to include new/changed requirements	If number of changed req. and number of new requirements exceeds XXX
2. Introduction of new Technology	Evaluation of the staff expertise in the use of the new technologies discipline.	Provide technical training in and enforce design and coding standards.	Includes expert consultant(s) to assist development	If the design or coding milestones fall behind schedule by more than XXX
3. Delay in delivery of required hardware and/or other external supplied software components.	Development, installation, and test milestones of each required outside element. (Progress reports from all critical external software suppliers and vendors)	Incentivate/penalize each vendor and supplier that is delivering a required item for delivering on time/not delivering on time.	Identify alternative vendors and suppliers and purchase spares as backup.	Delta time threshold over XXX weeks past scheduled delivery date
4. Integrated system testability. (Difficulties to test the real system from beginning to end as it exists in the field.)	Percentage of Interfaces tested and verified as correct.	Develop a simulator and test environment that replicates as nearly as possible the whole system, especially the interfaces.	Move testing to site	If any required interfaces cannot be tested in a simulator environment by their due date.

Figure 2 - Major MASS Risks list

6.5. Closeout

The ASTRI-MA is an ongoing project and the plan to dismiss this project is TBD.

6.6. MA Interfaces management

Interfaces management for MASS work products and processes will be performed in accordance with ASTRI-MA Interface Management Plan [TBD]

7. Technical Processes

7.1. Life cycle stages

Software life cycle covers the software aspects of a project from inception through retirement. The life cycle model adopted for the MA System Software is based on life cycle stages that are associated to time windows within the lifetime of the system. Each life cycle stage has its starting and ending milestone.

The following life cycle stages are defined:

- Concept definition
- Design
- Development
- Commissioning
- Operation
- Decommissioning

In each stage it is possible to use one or more of the processes described in section 7 to carry out the system engineering work. These stages are illustrated in Figure 1 and described in [AD7]

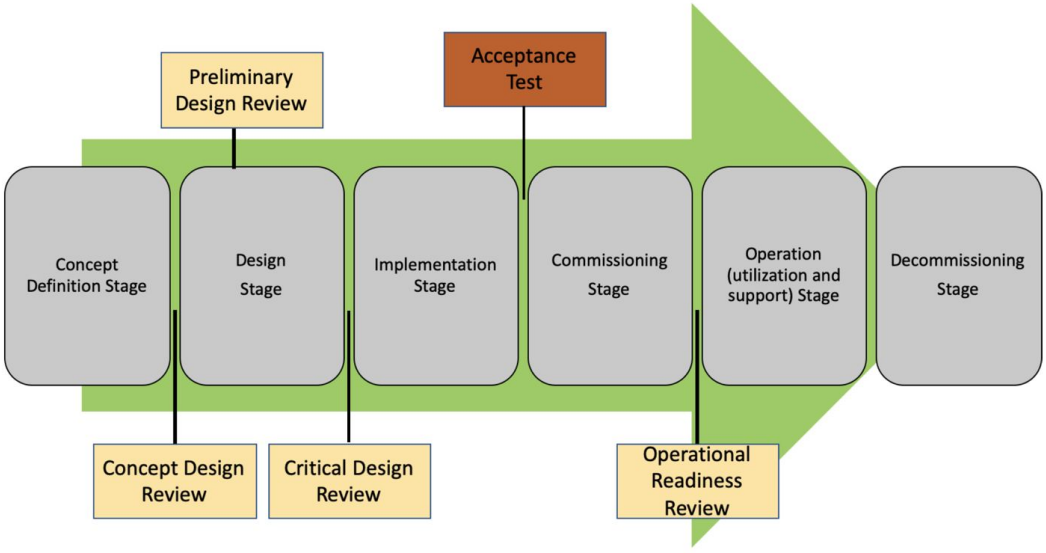


Figure 1- The ASTRI-MA SW Life cycle stages.

The transition betweens phases is defined through reviews.

Concept Design Review (CoDR): The scope of the CoDR is to explain the use cases and software system requirements, architecture, performance estimates, and subsystem design concepts for the ASTRI MA software system.

Preliminary Design Review (PDR): The scope of the PDR is to show that the ASTRI MA system level software requirements are validated, allocated and can be verified. The proposed design is feasible and satisfies all functional and performance requirements. The design is verificable and all risks are well identified, analyzed and mitigated.

Critical Design Review (CDR): The scope of the CDR is to demonstrate that the design reached an appropriate level of detail to support the production of the code, assembly, integration and test, meeting all performance, scheduling, and operational requirements.

Acceptance Test (AT): The scope of the AT is to verify the completeness of the developed software documentation, and test and analysis reports. Also it ensures that the software reached a level of maturity to be deployed at the Operation Facilities (Teide Site, Roma Data Centre)

Operational Readiness Review (ORR): The scope of the ORR is to establish that the software system is ready to be used for steady state ope, maintenance, emergency and recovery operations of the ASTRI MA, through examination of test results, analyses, and operational demonstrations. It also show that documentation is complete for each software configuration item.

7.2. Methods, Tools and Techniques

Development methodologies, programming languages and other notations, and the tools and techniques to be used to specify, design, build, test, integrate, document, deliver, modify and maintain the project deliverable are defined in the MASS Development Plan [AD7].

7.3. Project Infrastructure

The ASTRI-MA Project office staff is responsible for establishing and maintaining the facilities allocated to MASS.

7.4. Product Acceptance

Product acceptance is in accordance with the procedures that will be defined in [TDB]

8. Supporting Processes

8.1. Configuration Management plan

The objective of the MASS Configuration Management Plan is to establish and maintain the integrity of work products using configuration identification, configuration control, configuration status accounting, and configuration audits.

The configuration management plan is defined in [AD7]

8.2. Verification and Validation plan

The Verification and Validation (V&V) plan describes the process for the compliance assessments of the project deliverables. Defines steps in the verification process. Defines requirements for developing verification plans of the project requirements.

The ASTRI MA Verification and Validation plan is defined in [TBD]

8.3. Documentation plan

The Documentation plan is defined in [AD7]

8.4. Quality Assurance plan

The Quality assurance plan is described in [AD2]

8.5. Reviews plan

The purpose of MASS reviews is to provide project management with tracking and oversight of the progress of software development and fulfilment of requirements. Technical reviews facilitate information reporting that tracks progress against plans, identify and resolve action items, and verify appropriateness of the allocated resources.

A separate review plan will be prepared.

8.6. Contractor Management plan

Contractor resources needed by the MASS are identified in the planning process. Elements of the WBS may become contract requirements.

The acquisition and monitoring of required contractor support is in accordance with Italian contracting policies, and procedures.

9. Appendices

10. Templates