



The Software Quality Assurance programme of the ASTRI Mini-Array project

for the ASTRI Project
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- **The ASTRI Mini-Array project**
- **Software Architecture**
- **Software Quality Assurance**

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The ASTRI Mini-Array Project

- **ASTRI** (Astrofisica con Specchi a Tecnologia Replicante Italiana) is a gamma-ray experiment led by the **Italian National Institute for Astrophysics (INAF)**, in collaboration with Italian universities, international research institutes and private companies.
- **First step:** realization of **ASTRI-Horn**, the first Italian **end-to-end Cherenkov telescope** in dual-mirror Schwarzschild-Couder configuration. First detection of Crab Nebula at TeV energies with dual mirror configuration. ASTRI-Horn is the prototype of the ASTRI Mini-Array telescopes.
- **Current step:** implementation of the ASTRI Mini-Array experiment, consisting of nine ASTRI telescopes under installation at the Teide Astronomical Observatory in Tenerife (Spain) in collaboration with the Instituto de Astrofísica de Canarias.

Actually, the largest array of the Cherenkov telescopes under deployment



ASTRI-Horn telescope installed and operational on Mount Etna (Sicily, Italy).

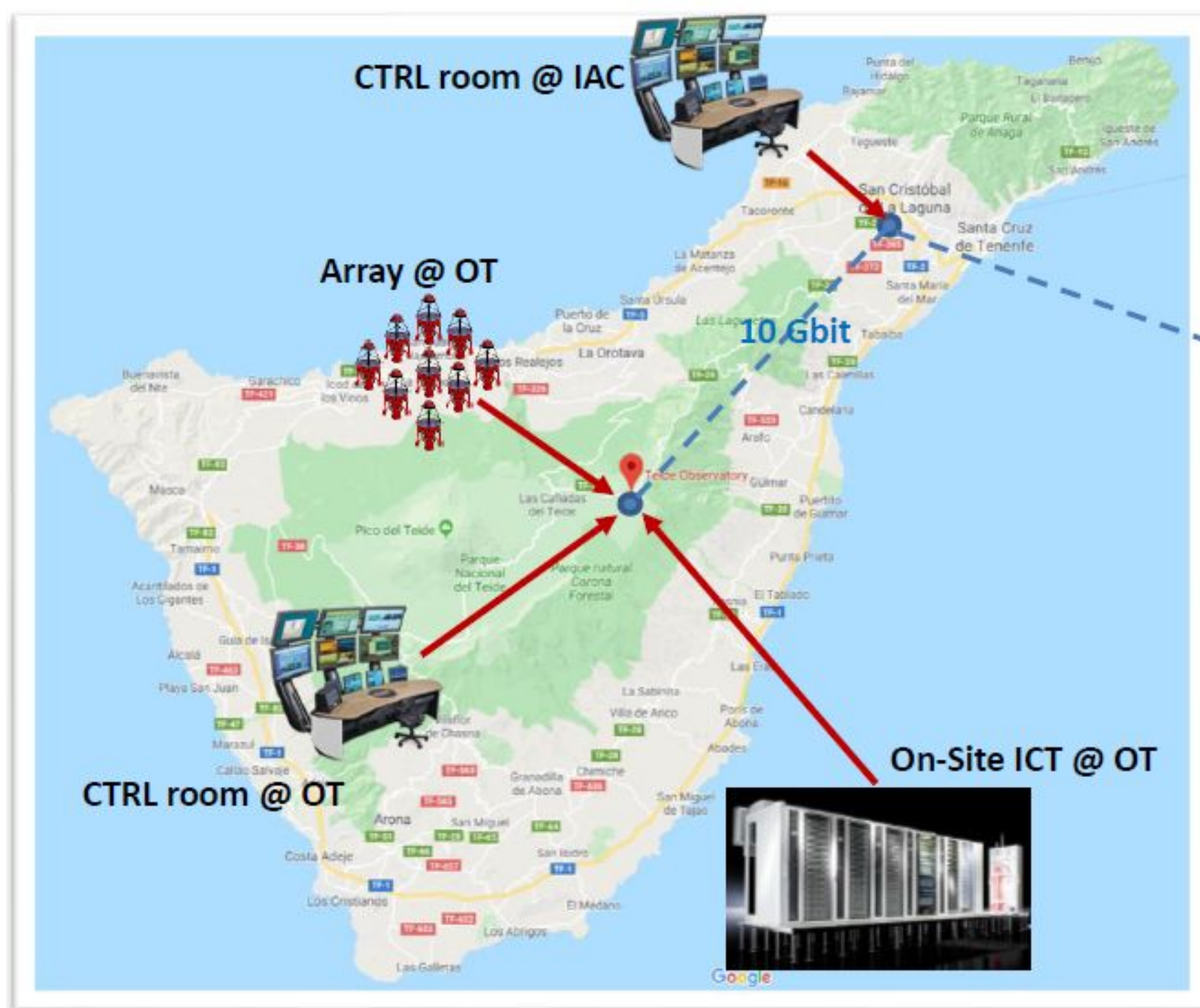
The ASTRI Mini-Array is devoted to:

- **Imaging of atmospheric Cherenkov light** for very high-energy gamma-ray astronomy. Wide-field stereoscopic observations in the 1-300 TeV energy band;
- Stellar Hanbury-Brown **intensity interferometry**;
- **Measurements of cosmic rays**, possible because 99% of the observable component of the Cherenkov light is hadronic in nature.

The ASTRI Mini-Array locations

The ASTRI Mini-Array Observing Site (AOS)

- Teide Observatory: ASTRI Mini-Array system
- IACTEC in La Laguna: Array Operation Center



The ASTRI Mini-Array in Italy

- Data Center in Rome
- Remote Array operation centers



ASTRI software allows Mini-Array to be operated remotely from the Array Operation Centers (AOCs)

Off-site at the Data Center in Rome:

- Stereo trigger
- Data processing
- Data archive & dissemination

On-site is foreseen a quick-look of data at telescope level activities.

The ASTRI Mini-Array System

- **Nine Telescopes** with their assemblies, including the **Cherenkov Camera** and the **Stellar Intensity Interferometer Instrument**.
- **Atmosphere Characterisation System:**
 - **1 LIDAR** (Light Detection And Ranging) atmospheric composition, structure, clouds and aerosols.
 - **3 SQM** (Sky Quality Meter): brightness of the night sky
 - **1 UVSIPM**: to evaluate diffuse night sky background.
- **Array calibration system:**
 - **Illuminator**: a portable ground-based device to evaluate the global throughput of each telescope

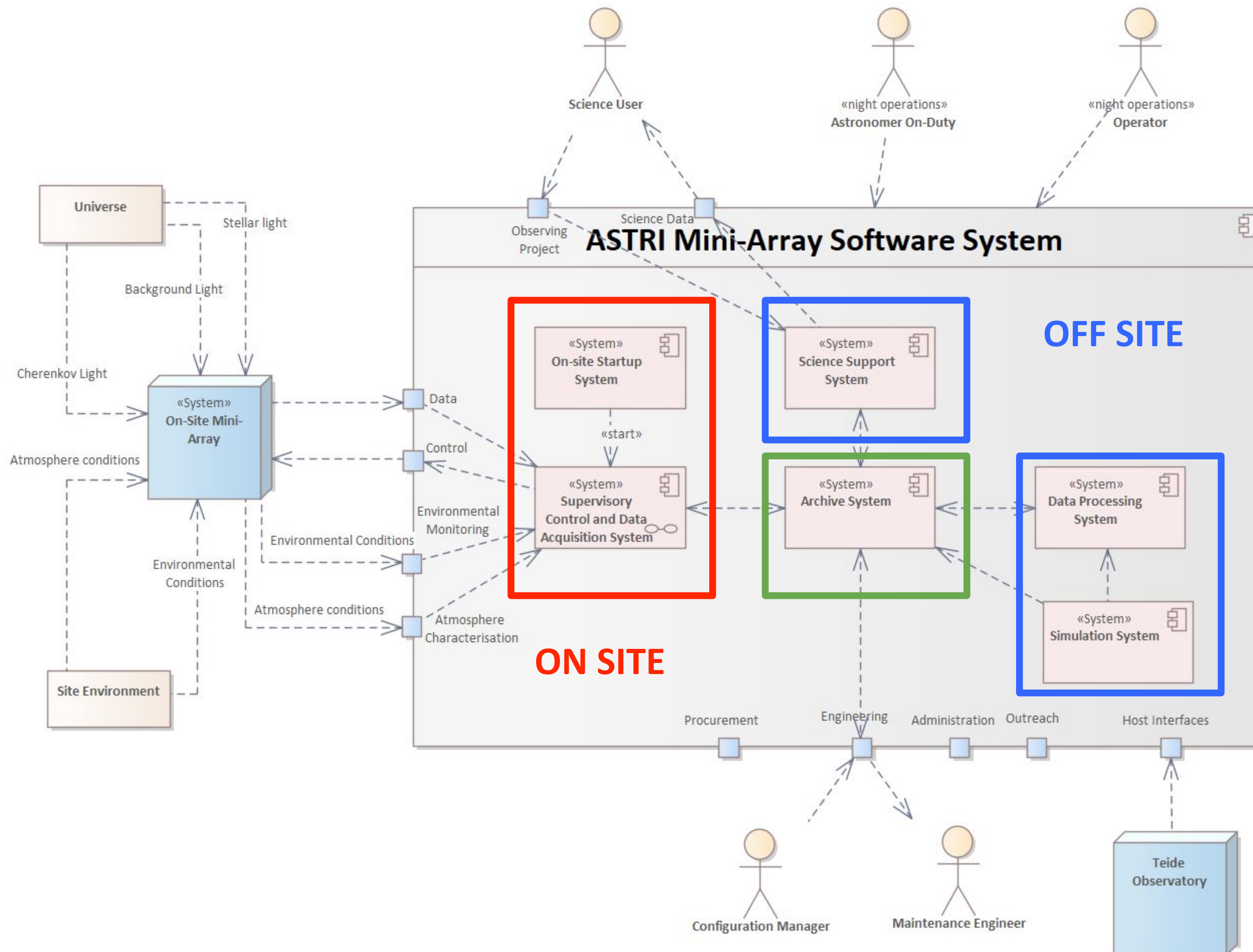


The ASTRI Mini-Array at the Teide Observatory

- **Telescope Power Management System**
 - transformer station
- **Information Communication Technology**
 - On-site Data Centre
 - Control room
- **Environmental Monitoring System:**
 - 2 Weather Stations
 - Humidity and sensors;
 - All-sky camera: cloud coverage
- **Safety and Security system**

ASTRI software control and monitor all observing systems of the ASTRI Mini-Array

Software architecture

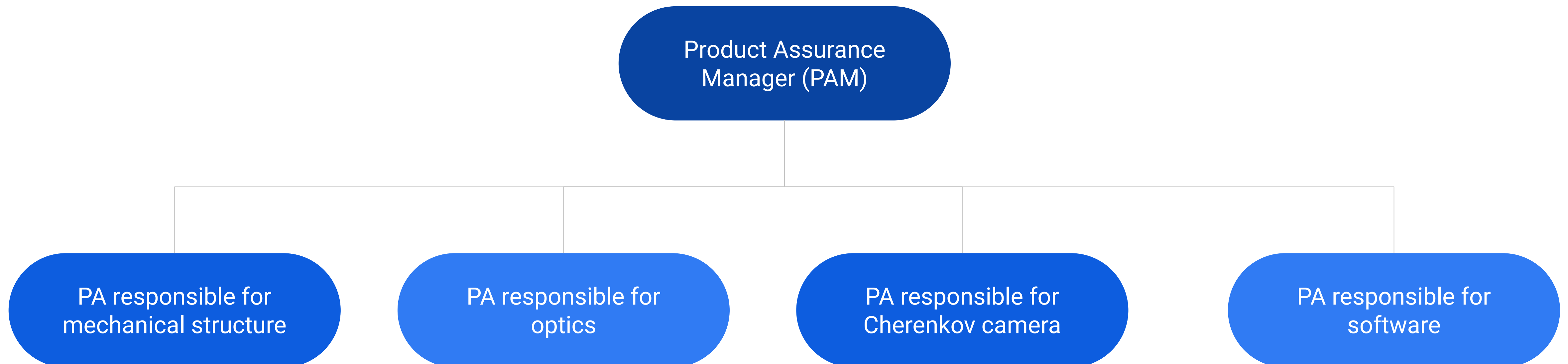


- **Supervisory Control And Data Acquisition (SCADA) System**
- **Archive System (on-site & off-site)**
- **Data Processing System**
- **Science Support System**
- **Simulations System**

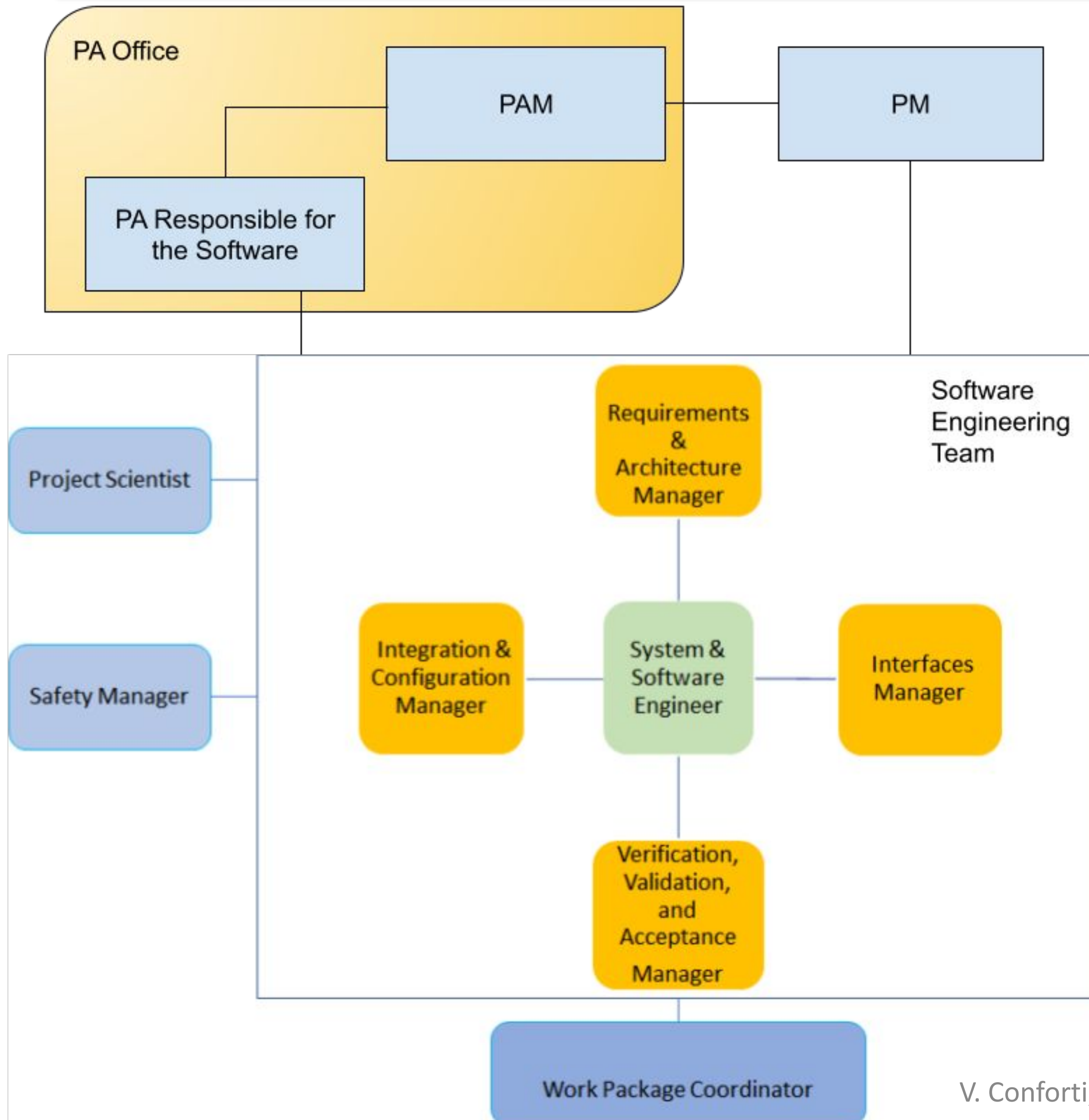
Product Assurance Programme

The ASTRI Product Assurance (PA) Programme defines the

- Strategy and organization for the management of the quality control
- Applicable quality requirements for design, procurement, and AIT/AIV
- Guidelines to manage the acceptance of the deliverable items



Product Assurance Organization



Product Assessment:

- The software supplier has in charge the software **designing, development** and **testing** of a specific subsystem.
- The software supplier shall produce the software **verification and validation** plan which define set of **metrics** to provide a valid assessment tool to reach the science goals.

Process Assessment:

- PA planning for individual processes and activities
- Documentation and configuration management
- Dependability and safety
- Software requirement analysis, architecture and design
- Verification and validation test, delivery & acceptance

Software Quality Assurance (QA)

- The PA responsible for the SW **prepares**, maintains, and applies a specific [Software Product Assurance Plan](#) (SPAP), based on the principles of the standard [ECSS-Q-ST-80C](#), which defines the SW QA/PA requirements to be applied for the whole software development life cycle process of all the software products.
- The PA responsible for the SW **coordinates** the software development teams concerning the QA activities related both to the products and to the processes (included software configuration control).
- The PA responsible for the SW **identifies** specific mechanisms for planning, controlling, and reporting on the PAM, as well as the procedures for alerts, audits, non-conformances, and for resolving detected software problems.
- The **SPAP** describes how to produce the software deliverables which pass the quality gates through the verification and validation activities.
- Each software release will be [accepted](#) only when it has been [verified](#), [validated](#) and is correctly [running](#) on the ASTRI Mini-Array infrastructures, and the ASTRI Mini-Array personnel has been [trained](#).

Roles and Responsibilities

PA Manager

- quality management at system level + general guidance for the PA team
- assist resolution of non-compliances, issues and/or risk for software quality activities

Software Engineer

- cooperate with project scientist to produce and maintain software requirements
- ensure traceability among deliverables

Software Supplier

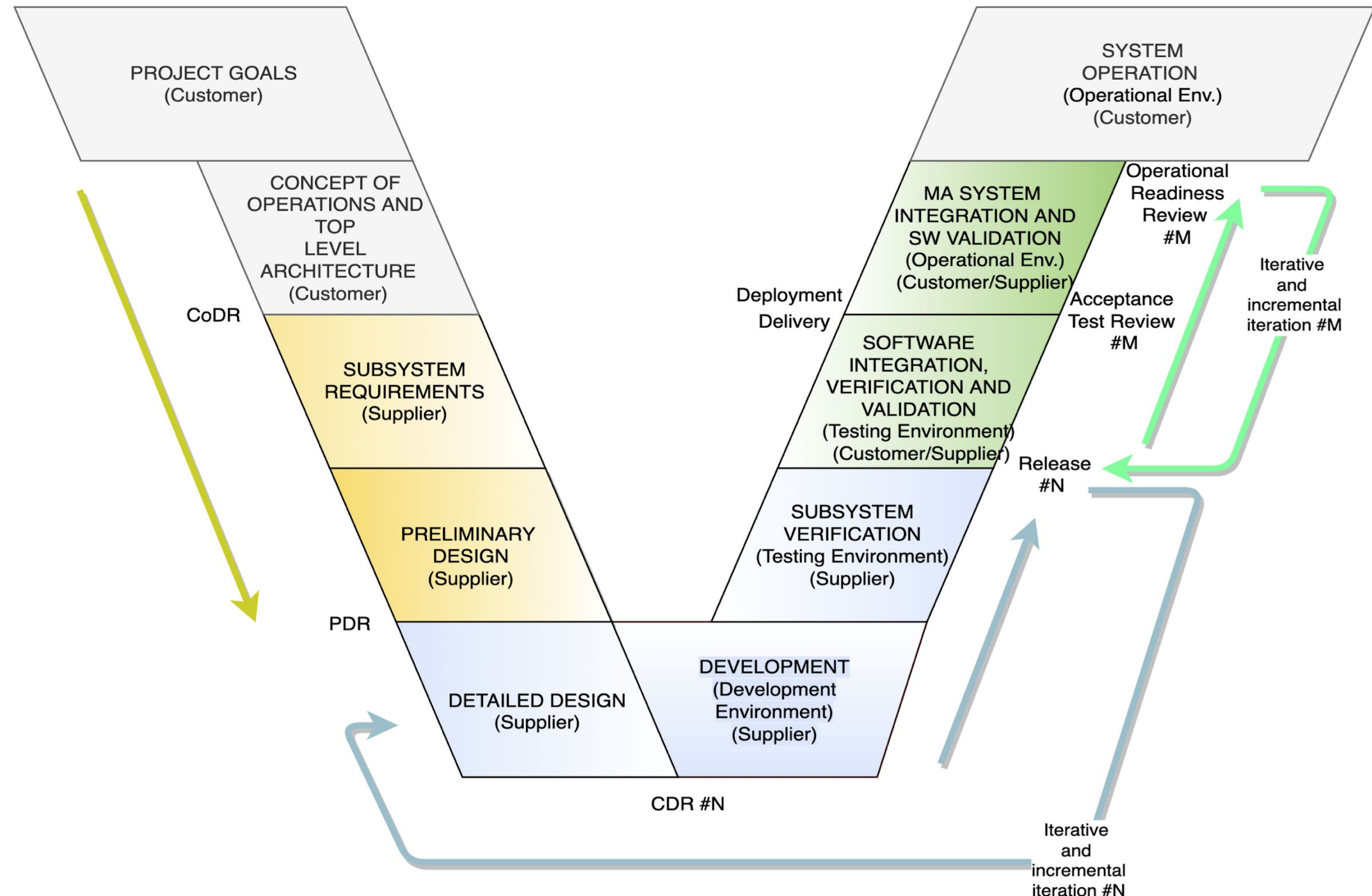
- Produce and maintain the deliverables under version control
- Produce verification and validation plan and perform related activities

Documentation

Document	Responsible	Supervisor
<ul style="list-style-type: none"> • Software engineering management plan 	Software Engineer	Software PA
<ul style="list-style-type: none"> • Software development plan 	Software Engineering team	Software Engineer
<ul style="list-style-type: none"> • Science requirements 	Project Scientist	Requirement and architecture manager
<ul style="list-style-type: none"> • Software requirements 	Software Engineering team	Requirement and architecture manager
<ul style="list-style-type: none"> • Software verification and validation plan 	Software supplier	Verification, Validation and Acceptance Manager
<ul style="list-style-type: none"> • Software requirement specifications • Software architecture and design • Test reports and artifacts 	Software supplier	Verification, Validation and Acceptance Manager
<ul style="list-style-type: none"> • Interface Control Documents (ICDs) 	Software supplier	Interface Manager
<ul style="list-style-type: none"> • Software user manual • Software release document 	Software supplier	Integration and configuration manager

Software development approach

- Complexity of software management
 - High number of hardware assemblies
 - High number of software subsystems
 - Developers from research institutes and private companies working at different locations;
- Iterative incremental approach + agile methodologies
 - frequent iterations and releases
 - use case driven development
 - automated testing and continuous integration
 - formal reviews
- Integrated with Verification and Validation plans



ASTRI Mini-Array Software life-cycle and reviews

ASTRI Mini-Array Software QA status

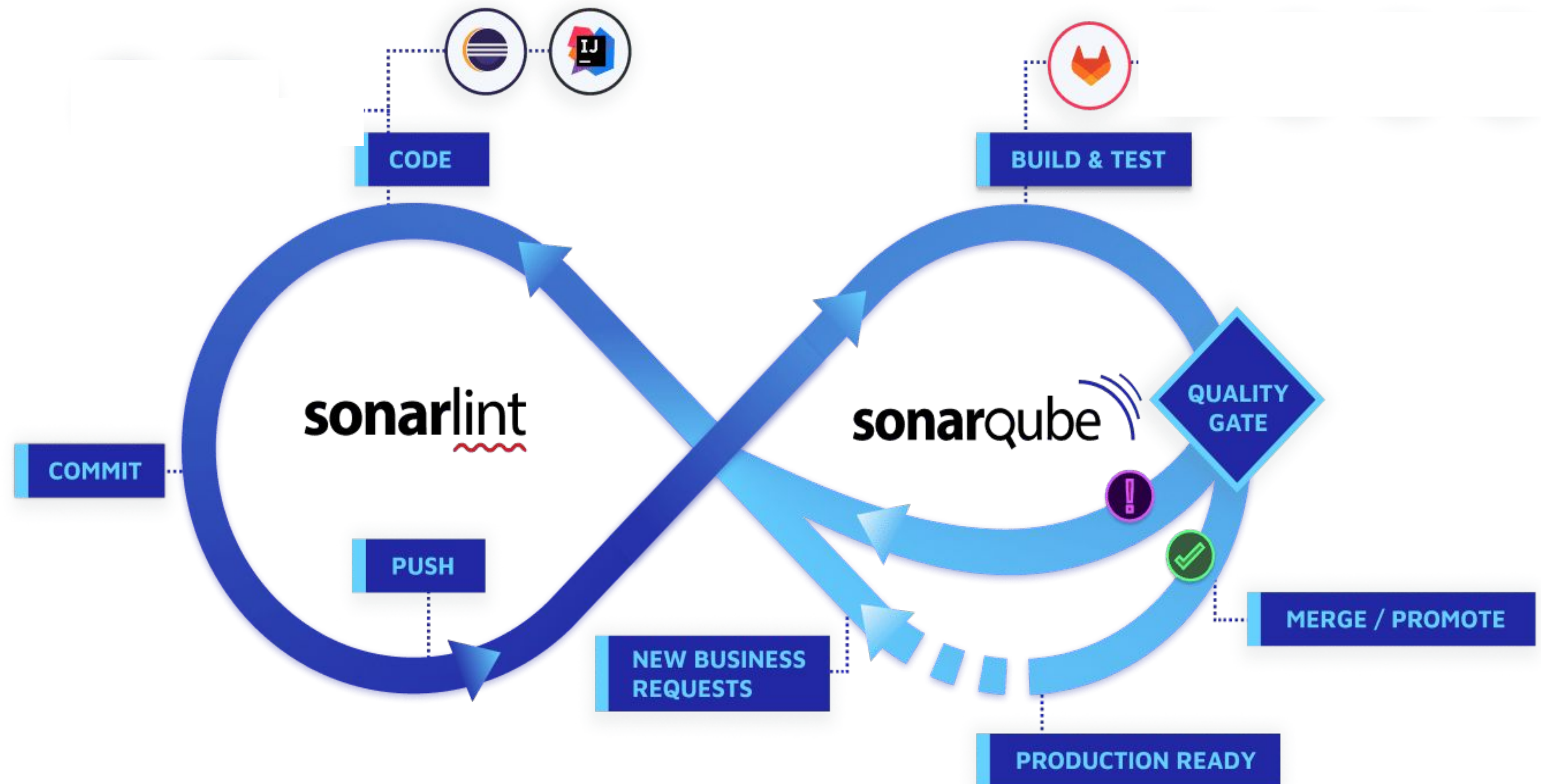
The documentation management:

- The documents pass through a revision process to be approved. Eventually the document version is published and released.
- All documents are under version control through redmine DMS plugin. Some released documents are:
 - Science Requirements
 - Product Assurance
 - ASTRI Mini-Array Product Assurance Plan
 - ASTRI Mini-Array Software Quality Assurance Plan
 - DPS subsystem
 - Stereo trigger software specification
 - SCADA subsystem
 - software requirement specifications
 - use cases
 - detailed design
 - verification plan
 - validation plan

ASTRI Mini-Array Software QA status

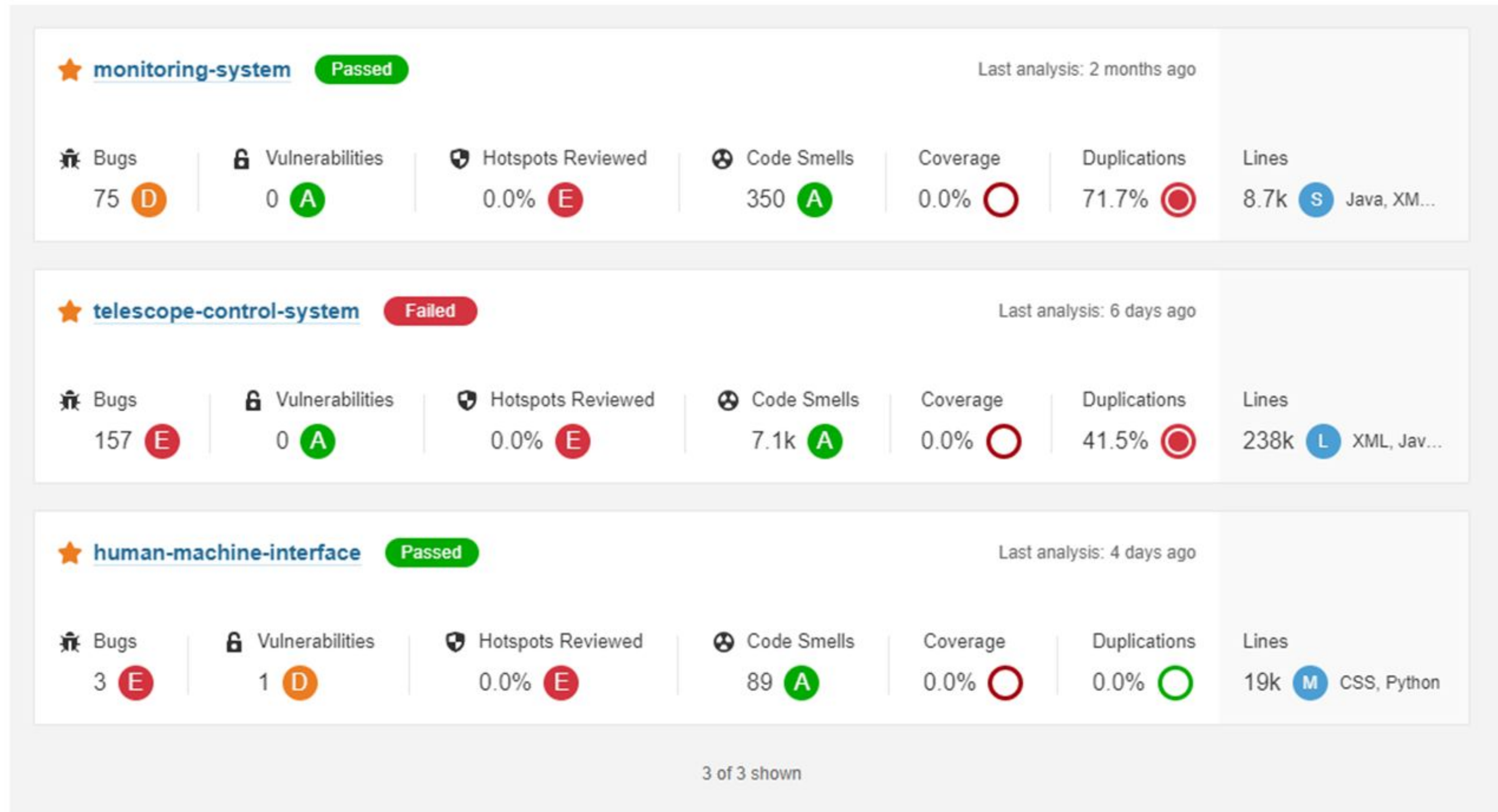
Software version control and quality check

- Gitlab
 - 7 groups
 - 44 members
 - 37 gitlab projects
 - 6 test pipelines
- SonarQube
 - quality profiles
 - Quality Gates
 - coverage
 - duplicated lines
 - maintainability rating
 - reliability rating
 - security hotspot
 - security rating



ASTRI Mini-Array Software QA status

Overview of ASTRI software project scanned by SonarQube



Infrastructure to support the software development and integration tests

- Virtual machines for the **development**
 - common framework and libraries (e.g Alma Common Software, Kafka, MySQL)
 - common compiler version (python, java, C, C++)
 - common environment (Operating system)
- Instrument Workstation for the **quality** requirements verification
 - transmission from instruments to data acquisition system
 - transmission from data acquisition system to on-line quality check
 - transmission from data acquisition system to archive system
- Test Bed for the **functional** requirements verification
 - test bed is a pool of virtual machines which simulates real on-site ICT system
 - integration test on test bed allow the supplier to make a verification that the software release meet the functional requirements

ASTRI Mini-Array Software QA status



Completed Reviews:

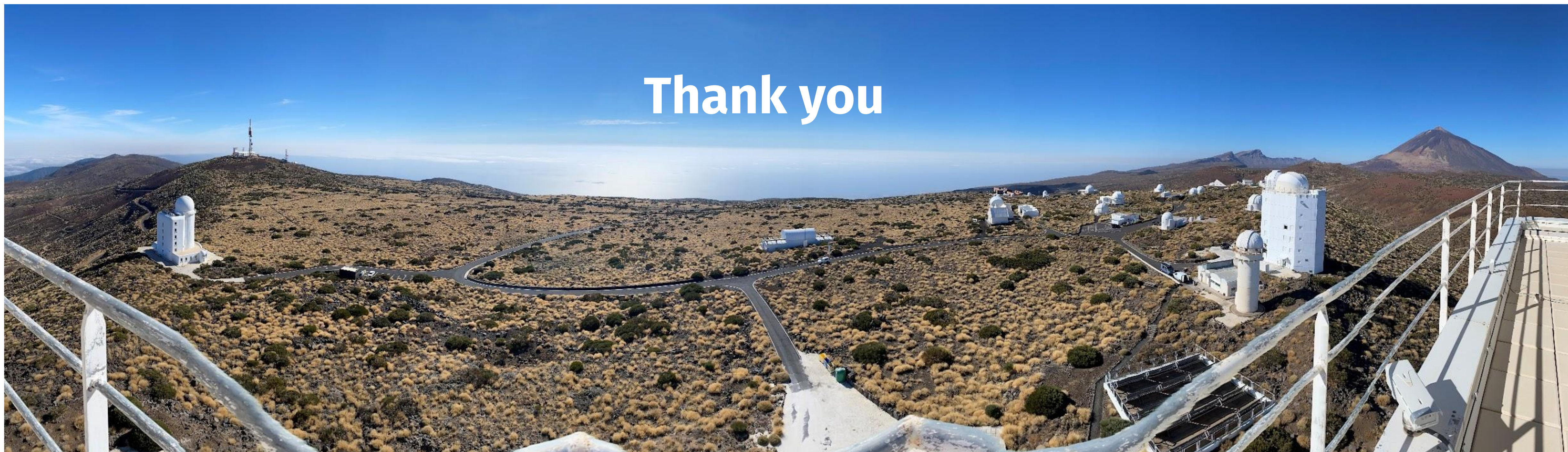
- CoDR: Conceptual Design Review
 - who: external panel
 - what: software architecture and use case documents
 - when: 2020
- CDR-1: Critical Design Review - SCADA subsystems
 - who: internal panel
 - what: requirement specifications, use cases, detailed design, verification plan documents
 - When: just completed

We plan to perform next reviews according to the iterative incremental approach and the project schedule.

- The guidelines and procedures concerning the Software Quality assurance are well defined and documented
- The PA team provides continuous support to the development teams, software suppliers and all the stakeholders
- Continuous assessment of the QA processes within the PA office through periodical meeting
- Lessons learned from ASTRI-Horn prototype applied to the ASTRI Mini-Array

ASTRI Mini-Array

Thank you



View from Vacuum Tower Telescope