ASTRI Mini-Array
Top Level Use Cases

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Version	***Date***	***Modification***
0.1	July 19th, 2019	Definition
0.2	Sept 12th, 2019	Discussion on Data Acquisition system
0.3	Sept 23, 2019	Discussion that include the f2f and remote meetings (see minute of meetings)
0.4	Nov 15, 2019	
1.3	Dec 10, 2019	Version aligned with Architecture V 1.3
2.1	Feb 3, 2020	Version aligned with Architecture V 2.1
2.2	Apr 16, 2020	Added ASTRI-UC-0-020 and ASTRI-UC-0-025. Corrections on ASTRI-UC-0-070
2.3	Nov 9, 2020	Changes after the Concept Design Review. Version aligned with Architecture V 2.3
2.4	Apr 9, 2021	Upgrades after internal reviews and discussions
2.5	Jun 18, 2021	More specifications in ASTRI-UC-0-030

1. Introduction

The **ASTRI Mini-Array (MA)** is an INAF ground-based project to construct, deploy and operate a set of nine identical dual-mirror Cherenkov gamma-ray telescopes, and several other auxiliary equipment and infrastructures. The ASTRI Mini-Array scientific objective is to exploit the imaging atmospheric Cherenkov technique to measure the energy, direction and arrival time of gamma-ray photons arriving at the Earth from astrophysical sources. In the almost unexplored energy range 1-300 TeV this technique requires an array of optical telescopes (~ 4 m in diameter) at a site located at an altitude of > 2000m. The telescopes will have reflecting mirrors focusing the Cherenkov UV-optical light produced by atmospheric particle cascades (air-showers), initiated by the primary gamma-ray photons entering in the atmosphere, onto ultrafast (nanosecond timescale) cameras. Most of the collected data will come from the large number of charged primary cosmic-ray initiated air-showers, which will also be recorded, then appropriate data analysis methods will be employed to reduce the level of this background and allow an efficient detection of gamma-rays coming from astrophysical sources.
Besides the gamma-ray scientific program, the ASTRI Mini-Array will also perform:

- Stellar Hambury-Brown intensity interferometry: each of the telescopes of the ASTRI Mini-Array will be equipped with an intensity interferometry module. The Mini-Array layout with its very long baselines (hundreds of meters), will allow, in principle, to obtain angular resolutions down to 50 micro-arcsec. With this level of resolution, it will be possible to reveal details on the surface of bright stars and of their surrounding environment and to open new frontiers in some of the major topics in stellar astrophysics.
- Direct measurements of cosmic rays: 99% of the observable component of the Cherenkov light is hadronic in nature. Even if the main challenge in detecting gamma-rays is to distinguish them from the much higher background of hadronic Cosmic Rays, this background, recorded during normal gamma-ray observations, will be used to perform direct measurements and detailed studies of the Cosmic Rays themselves.

The ASTRI MA telescopes (including the Cherenkov Camera) are an updated version of the ASTRI-Horn Cherenkov Telescope operating at Serra La Nave (Catania, Italy) on Mount Etna.

The nine telescopes will be installed at the Teide Astronomical MA System, 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 System will be operated by INAF on the basis of a host agreement with IAC.

1.1. Purpose

To capture the greatest possible number of points of view during the requirements-gathering phase, the **observation-related use cases** have been developed and presented in this document. The goal is to understand how to serve the users of the ASTRI Mini-Array System. The Observation-related use cases describe how to perform observations from the proposal to the scientific exploitation of the observation from a user's point of view and the commonalities of all the science-related use cases. This category includes calibration and other technical related use cases.

Maintenance use cases have the goal to understand how to perform maintenance operations. Some calibration and technical use cases may foresee calibrations and validations tasks. Maintenance use cases will be covered in a future version of this document.

1.2. Scope

This document defines the Top Level Use Cases of the ASTRI MA project.

The use cases contained in this document are part of the functional requirements of the MA Software System to describe the workflow. These requirements complement the functional and quality requirements provided in [AD3].

The abbreviation and definitions [AD1] and the data model [AD2] documents are supporting documents. The software PBS is described in [AD4].

In this document, some colours are used:

- **blue bold**, for definitions;
- **black bold**, for main concepts, or name of systems or functional units;
- **green bold**, for roles covered by human actors.

2. Related Documents

2.1. Applicable documents

[AD1] N. Parmiggiani et al., ASTRI MA Glossary, ASTRI-INAF-LIS-2100-001 , issue 2.5
[AD2] A. Bulgarelli, G. Tosti, et al., ASTRI MA Data Model, ASTRI-INAF-DES-2100-003, issue 2.5
[AD3] A. Bulgarelli, et al., ASTRI MA Top Level Software Architecture, ASTRI-INAF-DES-2100-001, issue 2.5
[AD4] ASTRI MA Software PBS, ASTRI-INAF-DES-2100-002, issue 2.5
[AD5] ASTRI-MA Software Engineering Management Plan: ASTRI-INAF-PLA-2100-001, issue 1.0
[AD6] ASTRI Mini-Array Data & Documentation Management Plan, ASTRI-INAF-PLA-1000-003, issue 1.2
[AD7] ASTRI Mini-Array Calibration Plan, ASTRI-INAF-PLA-2600-001, issue 1.0
[AD8] ASTRI Mini-Array Environmental Conditions at Teide, ASTRI-INAF-SPE-2000-002, issue 1.1

2.2. Reference documents

[RD1] J. Schwarz, G. Chiozzi, P. Grosbol, H. Sommer, A. Farris, D. Muders, "*ALMA Project Software Architecture*", ALMA-70.15.00.00.001-H-GEN, Version J, 2007-08-13
[RD2] S. Lombardi, L.A. Antonelli, C. Bigongiari, M. Cardillo, F. Lucarelli, M. Perri, A. Stamerra, F. Visconti, "*ASTRI data reduction SW in the framework of the Cherenkov Telescope Array*". Proc. of SPIE 2018, paper number 10707-29.
[RD3] A. Bulgarelli, et al., "*CTA Top Level Use Cases*", Proc. SPIE 9913, Software and Cyberinfrastructure for Astronomy IV, 991331 (22 August 2016); doi: 10.1117/12.2232224.
[RD4] J. Knoedlseder, M. Mayer, C. Deil, et al., "*GammaLib and ctools*", 2016, A&A, 593, A1.
[RD5] Deil, C., Zanin, R., Lefaucheur, J., et al., "*Gammapy - A prototype for the CTA science tools*", 35th ICRC, 2017. Proceedings of Science, Vol. 301.
[RD6] V. Conforti, "*Software use cases to elicit the software requirements analysis within the ASTRI project*", https://openaccess.inaf.it/handle/20.500.12386/24491

3. Definitions

3.1. Actors

Actors represent roles played by human users, external hardware, or other systems. Actors do not necessarily represent specific physical entities but merely roles of some entities that are relevant to the specification of its associated use cases.

The following actors are humans and systems. In this section, the main actors are described in the context of the execution of the observations.

3.1.1. Humans

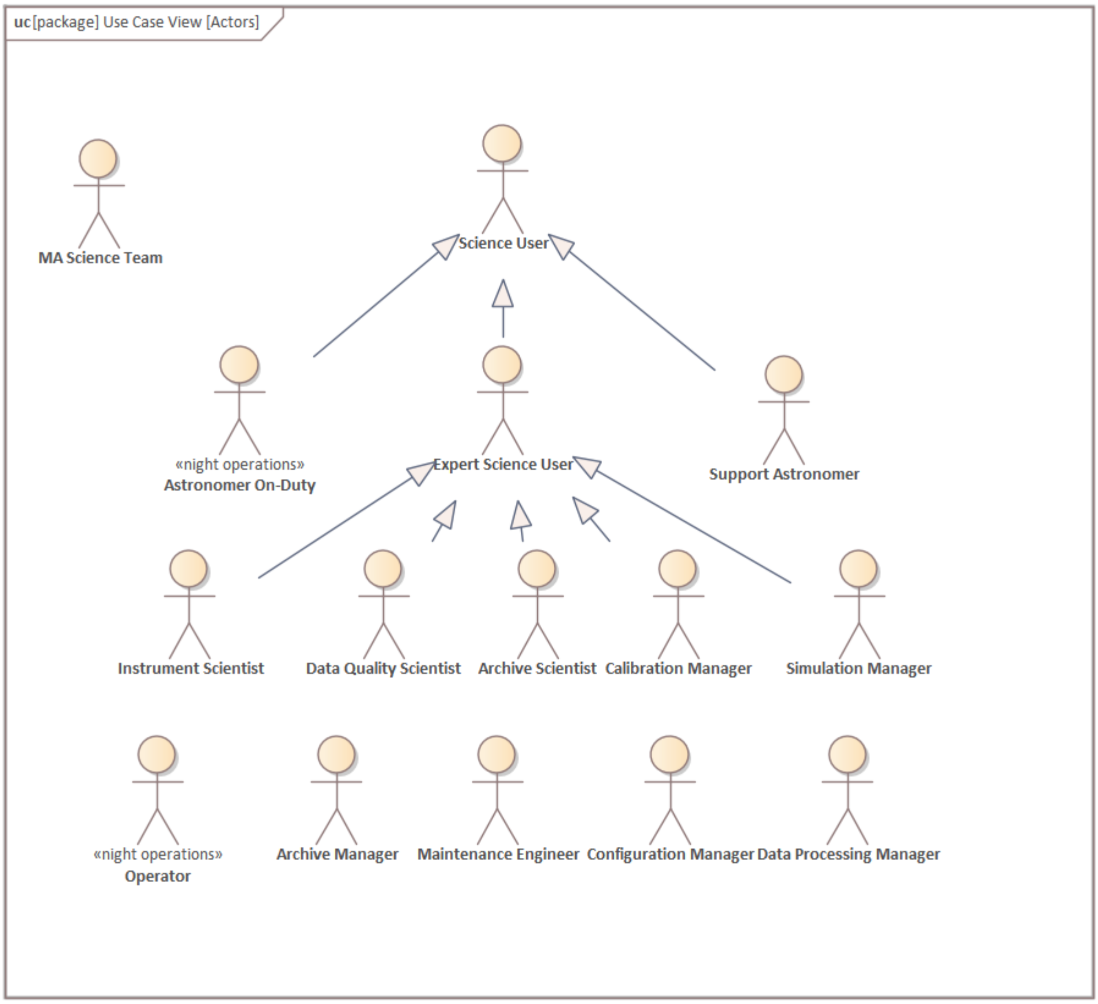

Figure 1: the main human actors of the ASTRI MA System.

All actors are part of the **ASTRI Collaboration:**

- **Archive Manager**: responsible for the quality and data integrity of the Archive system.
- **Archive Scientist**: responsible for the validation and correct distributions of the MA science data products.
- **Astronomer on-duty (AoD)**: a Science User that supports and supervises the observations from a scientific point of view.
- **Calibration Manager**: defines the calibrations methods and the instruments needed to calibrate the whole MA system.
- **Configuration Manager**: keeps track of the configuration of all instruments, part replacements, etc.
- **Data Processing Manager**: responsible for the Data Processing System operations.
- **Data Quality Scientist**: responsible for monitoring the quality of pipeline-produced data products and calibrations. Discusses problems with Instrument Scientist, Maintenance Engineer, and Calibration Manager.
- **Expert Science User**: a Science User that uses MA data at a lower level than the standard distributed data products. May submit technical Observing Projects.
- **Instrument scientist**: an instrument expert, capable of diagnosing problems and devising corrective actions based on recorded data. Supports operations and maintenance.
- **MA Science Team**: the scientific ASTRI experiment collaboration. All actors present in this document are part of the MA Science Team.
- **Maintenance Engineer**: manages and executes maintenance activities and conducts on-site preventive and corrective maintenance tasks.
- **Operator**: responsible for supervising and carrying out scheduled observations and calibrations during the night.
- **Science User**: a member of the MA Science Team that will interact with the system to perform observations related to the Observing Projects and that will analyze science data after the completion of the observations. The Science User uses the science data and tools to perform scientific analysis of the results of the observations.
- **Simulation Manager**: defines the Monte Carlo simulations plan for the calibration, the generation of the instrument response matrices, and the scientific validation of the Mini-Array. Keeps track of all the configuration parameters used in the simulation process. Run the Monte Carlo simulation chain for the generation of simulated data samples.
- **Support Astronomer:** actor that prepares the long- and short-term scheduling.

3.1.2. Systems

After a preliminary analysis a set of actors representing the MA software systems have been identified and can be summarised in the following list:

- **Science Support System** for Observing Projects and observation plans preparation, dissemination of scientific data and science tools.
    - **Observation Scheduler**: to support the preparation of observing projects, with **Visibility Checker** and **Sensitivity Calculator** tools;
    - **Science Gateway**: to retrieve science-ready data, science tools and tools to support the Observing Project preparation.
- **SCADA (Supervisory Control and Data Acquisition) System** controls all operations carried out at the MA site and data acquisition, monitoring and alarms:
    - **Central Control System:** coordinates the sequence of operations, coordinating the control systems and collectors and sequences start, shutdown and configuration of the on-site MA Systems, checks the status of the assemblies, get the Scheduling Blocks and select the Observing Block; interprets the Observing Mode specified to command downstream to the telescopes and other subsystems;
    - **Array Data Acquisition System (ADAS)** acquires Cherenkov Cameras and Stellar Intensity Interferometry Instrument;
    - **Online Observation Quality System** focuses on ongoing problems and status of the observations;

  - **Logging System, Monitoring System** and **Alarm system** monitor the overall performance of the systems through the acquisition of environmental, monitoring and logging points and alarms from instruments and generates status reports or notifications to the Operator;
  - **Operator HMI**: the user interface.
  - **Telescope Control System**: coordinating all telescope subsystems, starting up and shutting down the system, supervising optical system control, telescope mount control and instrument control (Camera, Optical Camera and SI[3]).
  - **Atmosphere Characterization Control System**: to control, configure and get the status of all elements of the Atmosphere Characterisation System.
  - **Array Calibration Control System**: to manage the interfaces with the Array Calibration System.

- **Data Processing System** to calibrate, reduce and analyse the data, and checks the quality of the final data products:
  - **Stereo Event Builder**: perform the off-line software stereo array trigger of Cherenkov data;
  - **Cherenkov Data Pipeline**: data calibration, reconstruction and analysis and scientific analysis of Cherenkov data;
  - **Science Tools**: Cherenkov DL3 data shall be analysed by means of science analysis tools to get the final science products.
  - **Intensity Interferometry Data Pipeline**: data reconstruction and scientific analysis of Intensity Interferometry data.
- **Archive System**: provides a central repository for all persistent information of the MA system.
- **Simulation System**: provides scientific simulated data.

The detailed list of the systems with a functional decomposition and associated requirements is given in [AD3].

3.2. Data Models

A description of the logical data models is given in [AD2].

3.3. Modes

The functions performed by these actors could be
- **Manual mode**: human intervention is needed or the function is performed by humans;
- **Automated mode**: a function without any manual intervention.

The function could be performed:
- **On-line mode**: during the observation
- **Off-line mode**: after the end of the observation

The functions could be performed **remotely (remote mode)**: the function works without a human operator physically located at the site where the MA is installed.

A **robotic system** is an automated system monitored remotely.

4. Observation-related use cases

- ASTRI-UC-0-001: Observe with the ASTRI Mini-Array
- ASTRI-UC-0-010: Prepare an Observation
- ASTRI-UC-0-020: Manage an observation during the night
- ASTRI-UC-0-025: Perform the monitoring of assemblies
- ASTRI-UC-0-030: Determine Environmental Conditions
- ASTRI-UC-0-035: Characterise the Atmosphere
- ASTRI-UC-0-050: Perform an Array calibration for Cherenkov observations
- ASTRI-UC-0-051: Perform a telescope calibration for Cherenkov observations
- ASTRI-UC-0-060: Execute online observation quality quick-look
- ASTRI-UC-0-070: Perform a gamma-ray or intensity interferometry observations of a target
- ASTRI-UC-0-090: Perform Cherenkov data reduction and analysis
- ASTRI-UC-0-100: Provide look-up tables and instrument response functions
- ASTRI-UC-0-110: Release data
- ASTRI-UC-0-115: Provide scientific analysis software
- ASTRI-UC-0-120: Perform a scientific analysis
- ASTRI-UC-0-200: Archive data

4.1. ASTRI-UC-0-001: Observe with the ASTRI Mini-Array

Summary and Scope: This UC describes the basic path to perform an observation with the ASTRI Mini-Array system, from long-term plan preparation to data release.

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Version: 1.0

PRE-CONDITION CONSTRAINTS	
SCENARIO 1. PREPARATION OF THE LONG-TERM OBSERVATION PLAN	
1. The **Science User** submits an *Observing Project (OP)* using the **Science Support System**. The **Science User** specifies the Observing Strategy.	ASTRI-UC-0-010 / Basic Path. Prepare the long-term observation plan / Step 1
2. The **MA Science Team** performs a technical and scientific evaluation of the submitted *Observing Project*.	ASTRI-UC-0-010 / Basic Path. Prepare the long-term observation plan / Step 2
3. The **Support Astronomer**, with the help of the **Observation Scheduler** tool**,** prepares and optimizes the *long-term observation plan.* *An observation plan is a list of scheduling blocks.*	ASTRI-UC-0-010 / Basic Path. Prepare the long-term observation plan / Step 3
SCENARIO 2. PREPARATION OF THE SHORT-TERM OBSERVATION PLAN	
1. Each day the **Support Astronomer** prepares and validates the list of *Scheduling Blocks* for the next night of observation (the *short-term observation plan*) *A SB with a list of observing blocks is prepared and covers a night of observation.*	ASTRI-UC-0-010 / Basic Path. Prepare the short-term observation plan / Step 1
2. The **Support Astronomer** saves the *short-term observation plan* in the **Science Archive** and sends it to the Array Observing Site.	ASTRI-UC-0-010 / Basic Path. Prepare the short-term observation plan / Step 3
3. The **SCADA/Central Control System** uploads and automatically validates the *SBs* of the *short-term observation plan* as soon as they are received.	ASTRI-UC-0-010 / Basic Path. Prepare the short-term observation plan / Step
SCENARIO 3. ON-SITE MONITORING AND ALARM DURING THE DAY	
1. The **Monitoring System** reads the ENV parameter values (data) and sends them to the **Operator HMI**. The **Operator** checks the values.	

	ASTRI-UC-0-030 / Basic Path. During the day / Step 2
2. The **Alarm System** reads the ENV parameter that can generate an alarm for the safety of the MA System, and checks for *transition* and/or *survival* ENV conditions, and sends them to the **Operator**. The **Operator** responds to and acknowledges alarms.	ASTRI-UC-0-030 / Basic Path. During the day / Step 3
SCENARIO 4. PREPARATION OF THE SCADA SYSTEM	
1. The **Operator** uses the **Startup System** to start the observing system initialization procedure.	
2. The **Operator** waits until all the software and hardware components reach the operational state.	
3. The **Startup System** starts the SCADA system.	
SCENARIO 5. PERFORM A SCIENTIFIC OBSERVATION	
1. If needed, the **Operator** follows the calibration plan that is executed by the **Central Control System**.	ASTRI-UC-0-050 ASTRI-UC-0-051
2. The **Operator**, for preliminar checks, and/or the **SCADA/Central Control System** selects the short-term observation plan for the current night. Alternate: 2a, *Repoint for change in environmental or atmosphere characterisation conditions in degraded status.* Alternate: 2b, *Insert an Observing Project for a ToO event (during the observation night).*	ASTRI-UC-0-020 / Basic Path. Nominal observation / Step 6 Details on ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 1-4
3. The **Central Control System** validates the Scheduling Block, then selects and automatically validates the Observing Blocks of the Scheduling Block.	ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 5 and 7
4. The **Central Control System** checks the operational conditions of the Observing Block. Exception: 4a, *Environmental conditions are outside operative ranges during the night.* (See details below). Rejoins Main Scenario at End	ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 8

5. The **Central Control System** commands the **Atmosphere Characterisation Control System** to start data acquisition. 6. The **Central Control System** configures telescope assemblies (including scientific instruments) and commands the **Telescope Control System**, one for each telescope, to move the telescopes from the current position to the position specified by the Observing Strategy.	ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 9.1 ASTRI-UC-0-035: Characterise the Atmosphere
7. The **Central Control System** a. configure the Array **Data Acquisition System;** b. configure the **Online Observation Quality System**.	ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 9.2
8. The ASTRI Mini-Array is observing. During the observation: a. The Array **Data Acquisition System** acquires data. b. The **On-Line Observation Quality System** runs automated on-line data analysis (ASTRI-UC-0-060) c. The **Monitoring System** performs a status check of all assemblies (ASTRI-UC-0-025) of the MA System and of the environmental conditions (ASTRI-UC-0-030) and stores the acquired data. d. The **Environmental Monitoring System Collector** check if there are transition of survival ENV conditions e. The **Alarm System** performs a status check of all assemblies and environmental conditions and generates alarms to the **Operator** if alarm conditions are met. f. The **Logging System** acquires and analyses logs from systems that generate logs. Exception: *8a, Environmental conditions are outside operative ranges during the night.* (See details below). Rejoins Main Scenario at End Exception: *8b, Status alarm.* (See details below). Rejoins Main Scenario at End Exception: *8c*, *Operational conditions are not met* (See details below). Try with the next Observing Block and rejoin the main scenario at step 4; if Observing Blocks of the SB are finished, rejoin the main scenario at step 2.	ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 9.3.1 - 9.3.6 ASTRI-UC-0-035: Characterise the Atmosphere
9. The **Operator** checks that the sequence of operations is nominal during the observation.	ASTRI-UC-0-020 / Basic Path. Nominal observation/ Step 7
10. When the Run is finished, get the next Observing Block and rejoin at step 4.	ASTRI-UC-0-070 / Basic Path. Execution of a Scheduling Block for observations / Step 10
11. At the end of the night, a. If the current run is not finished, the **Operator** stops the current Run. b. Shutdown the Array	ASTRI-UC-0-020 / Basic Path. Nominal observation / Step 7
SCENARIO 6. SHORT-TERM CHERENKOV DATA REDUCTION AND ANALYSIS	

1. Raw data from a Run are automatically transferred off-site, as soon as a Run is finished, and archived in the ASTRI Bulk data Archive.	ASTRI-UC-0-090 / Basic Path. Short-term / Step 1
2. The **Stereo Event Builder** applies an off-line software stereo trigger before the execution of the data processing. 3. The **Data Processing System - Cherenkov Data Pipeline** reduces and analyses raw data using pre-computed calibration factors and coarse LUTs/IRFs.	ASTRI-UC-0-090 / Basic Path. Short-term / Step 2-4
4. Automated scientific analysis is executed to generate preliminary science products on a run-basis (ASTRI-UC-0-120), which are then archived in the **Science Archive** (ASTRI-UC-0-200).	ASTRI-UC-0-090 / Basic Path. Short-term / Step 5
5. The **Science Gateway** displays the preliminary science results to the **Operator** and the **Astronomer on-duty.**	ASTRI-UC-0-090 / Basic Path. Short-term / Step 12
SCENARIO 7. LONG-TERM CHERENKOV DATA REDUCTION AND ANALYSIS	
1. Automated scientific analysis, using the best available calibrations and the final specific IRFs, is executed by the **Data Processing System** to generate ASTRI MA system science products to be delivered to the **Science User**. 2. The results are stored in the **Archive System**	ASTRI-UC-0-090 / Basic Path. Long-term / Step 1 and 4 ASTRI-UC-0-200
SCENARIO 8. PROVIDE USER SUPPORT	
1. The ASTRI MA system produces and validates high-level science-ready data, IRFs and ASTRI MA System science-products related to an Observing Project. 2. The ASTRI MA system archives science-ready data, IRFs and MA System science-products in the **Science Archive.** 3. The **Science Support System** informs via mail notification the **Science User** about the availability of data. 4. The **Science User** downloads the validated high-level data from the **Science Gateway** web pages.	ASTRI-UC-0-110 / Basic Path. Release data / Step 1-4
1. The **MA Science Team** issues a request for a set of instrument response functions (IRFs) 2. A request for the production of global IRFs is issued in this case to the **Simulation System** and **Data Processing System**. 3. The newly produced Observation-related IRFs, along with the high-level observation-related event list, are made available to the **Science User** through the **Science Archive.**	ASTRI-UC-0-100 / Basic Path. IRFs generation / Step 1-3
1. The **MA Science Team** issues a request for a set of telescope-wise and array-wise look-up-tables (LUTs) 2. Using a set of simulated gamma-ray data and real or simulated background data, the **Data Processing** System software applies a machine learning algorithm for the calculation of suitable telescope- and array-wise look-up-tables for gamma/hadron classification, energy reconstruction, and event arrival direction estimation. 3. The generated LUTs are archived with version and validity period in the **CALDB**, ready to be used by the **Data Processing System**.	ASTRI-UC-0-100 / Basic Path. LUTs generation / Step 1-3
1. The **MA Science Team** develops and validates software tools (the **Science Tools**) for the scientific analysis of the high-level ASTRI MA data.	ASTRI-UC-0-115 / Basic Path / Step 1-4

2. The Science User downloads the **Science Tools** from the **Science Gateway** web pages and installs the software on his local computing infrastructure.	
EXCEPTIONS	
Exception. Environmental conditions are outside operative ranges during the night If environmental conditions are outside operational limits (*transition* or *survival*, see [AD2]): 1. The **Alarm System** raises an alarm and sends it to **Operator HMI**. 2. The **Environmental Monitoring System Collector** raises a critical event notification and sends it to the **SCADA/Central Control System.** 3. The **SCADA/Central Control System** puts the **MA System** in a *safe state* automatically. 4. The Operator checks environmental conditions and alarms. 5. The Operator acknowledges the alarm. 6. The Operator takes immediate action based on the severity of alarms (environmental conditions *transition* or *survival*).	ASTRI-UC-0-030
Exception. Status alarms 1. The **SCADA System** informs the Operator. 2. The **SCADA/Central Control System** puts the **MA System** in *safe state* automatically. 3. The Operator stops the current Run and puts the **MA System** in *safe state*, i.e. the telescopes in parking position if the **SCADA/Central Control System** does not react. The Scheduling Block is aborted. 4. The Operator acknowledges the received alarm and takes appropriate action to resolve issues.	
Exception. Operational conditions are not met Some operational conditions (status of array elements) go outside the operational ranges. The management of the conditions depends on the source and will be specified in more detailed use cases. A possible workflow is: 1. The **SCADA/Central Control System** informs the Operator via Operator HMI. 2. The Operator or the **SCADA/Central Control System** stops the current Run. 3. The Operator acknowledges the new state.	
POST CONDITION CONSTRAINT	
MINIMAL GUARANTEE	
SUCCESS GUARANTEE	

4.2. ASTRI-UC-0-010: Prepare an Observation

Summary and Scope: The **Science User** submits an *Observing Project*. The **MA Science Team** evaluates the Observing Project, the **Support Astronomer** prepares and schedules the *long-term observation plan* and *the short-term observation plan*.

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Version: 1.0

Trigger:

Frequency: Many times

Phase:

Assumptions:

PRE-CONDITION CONSTRAINTS

1. The ASTRI Mini-Array System is ready for SVP or for nominal observations and engineering Observing Blocks.

SCENARIOS

Basic Path. Prepare long-term observation plan

1. The **Science User** submits an *Observing Project (OP)* using the **Science Support System**. The **Science User** specifies the Observing Strategy, that includes:

   1. the Target;
   2. the Observing Mode (e.g. Wobble, ON/OFF, ...) strategy, including the Instrument Configuration if needed;
   3. environmental condition constraints;
   4. atmosphere characterisation constraints (NSB allowed range, Sky Quality allowed range);
   5. time constraints (allowed time range, minimum requested time);
   6. array constraints (e.g. precision pointing, zenith angle range, minimum number of operating telescopes);
   7. tracking mode.

The **Science User** uses a *Visibility Checker* and a *Sensitivity Calculator* for the *Observing Project* preparation.
The *Observing Project* is stored in the **Science Archive**.
Observing Project submission.

Exception: *1a. Errors or problems in the Observing Project* submission (See details below). Rejoins Main Scenario at End.

2. The **MA Science Team** performs a technical and scientific evaluation of the submitted *Observing Project*. The priority of an *Observing Project* is decided by the **MA Science Team.**
Observing Project evaluation.

The MA Science Team checks whether the Observing Project is technically feasible, whether there are errors in the submitted information, and decides the priorities.

Exception: *2a. Errors or problems in the Observing Project* (See details below). Rejoins Main Scenario at End.

3. The **Support Astronomer,** with the help of the **Observation Scheduler** tool**,** prepares and optimizes the *long-term observation plan*, starting from the accepted and archived *OPs*, for the realization of the *Observing Project* based on visibility constraints and scientific priorities decided by the **MA Science Team**. The *long-term observation plan* is composed of a list of *Scheduling Blocks (SB)*.
Each *SB* is a set of *Observing Blocks* with calibration and observation sequences, characterised by a unique ID, defining the operations to be performed (*e.g.*, calibrate, observe to single sky position of a given Observing Mode).
The *long-term observation plan* is stored in the **Science Archive**.
Long-term observation plan preparation.

The SB is the smallest sequence of observing instructions that can be scheduled altogether.
Example of Observing Blocks: (i) calibration, (ii) observing: first wobble position on target (for wobble observing mode); (iii) observing: second wobble position on target (for wobble observing mode)

Basic Path. Prepare the *short-term observation plan*

1. Each day the **Support Astronomer,** in agreement with the **Astronomer on-duty (AoD),** prepares and validates the list of *Scheduling Blocks* for the next night of observation (the *short-term observation plan*), selecting the SBs from the *long-term observation plan* prepared beforehand. The preparation of the next-night SB list shall be done with the help of the **Observation Scheduler** tool, and shall take into account:
    1. the visibility of the scheduled source (already considered during the preparation of the *long-term observation plan*);
    2. the status of the array (*e.g.*, minimum number of available telescopes).

Get the list of Scheduling Blocks for next night.

2. Eventually, the **Support Astronomer** and the **AoD** evaluate the observation of targets reported to be in an active state by other observatories, and schedule them for the next observation nights with a *Scheduling Block*. The possible ToO observations of extremely relevant GRBs, GW, and neutrino events reported in the day or a few days before the next observation night, might be also evaluated.
Take into account ToO.

Exception: *2a. The science alert target is not observable* (See details below). Rejoins Main Scenario at End.

3. The *short-term observation plan* is stored in the **Science Archive** and sent to the Array Observing Site.
Next-night observation plan ready.

4. The **SCADA/Central Control System** uploads and automatically validates the *SBs* of the *short-term observation plan* as soon as they are received.

The validation of the SB should be done as soon as the SB is sent to the site. There should be a procedure that automatically validates it, checking, for example, that the pointing coordinates are not out of the nominal ranges, that the start and end time of the observation does not go beyond the end of the night, etc.

Exception: *4a. Errors or problems in the SBs validation* (See details below). Rejoins Main Scenario at End.
Alternate: *4a. The Operator manually uploads the short-term observation plan into the SCADA/Central Control System/MC system.*

Alternate. The Operator manually uploads the short-term observation plan into the SCADA/Central Control System system

1. The **Operator** manually uploads the short-term observation plan into the **SCADA/Central Control System** system.
2. The **SCADA/Central Control System** validates the SBs of the short-term observation plan.

   Exception: *2a. Errors or problems in the SBs validation* (See details below). Rejoins Main Scenario at End.

Exception. Errors or problems in the Observing Project submission

The **Science User** informs the **MA Science Team** of errors or problems occurred during the OP submission.

Exception. Errors or problems in the Observing Project

The **Support Astronomer** communicates errors and problems to the **Science User**. When ready, the **Science User** submits the corrected **Observing Project**.

Exception. The science alert target is not observable

The **Astronomer on-duty** logs that the science alert target is not observable during the night. If possible, the target is planned for the next night.

Exception. Errors or problems in the SBs validation

SCADA/Central Control System issues an alarm/warning concerning the *SBs* validation.

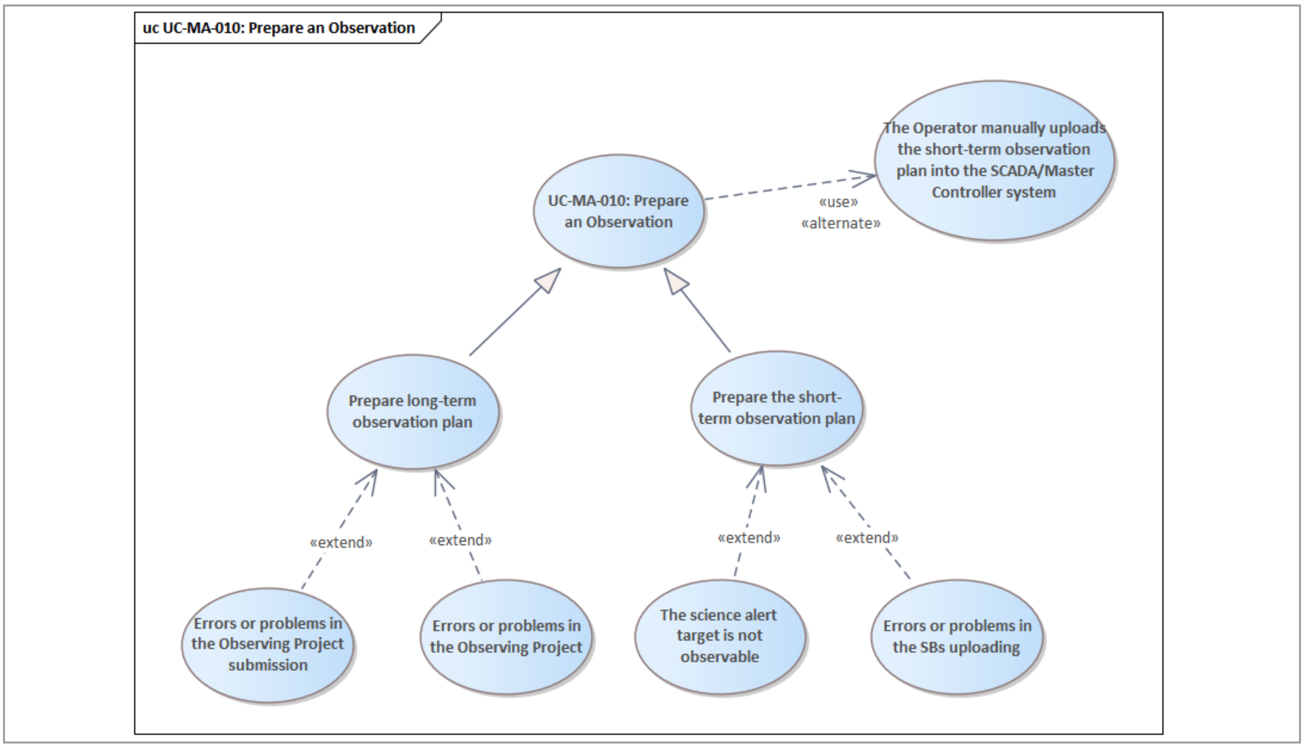
POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

1. The *short-term observation plan* is ready for the next night of observations.

SUCCESS GUARANTEE

1. The *Observing Project* goes into the archive and is ready for reviewing.
2. The accepted *Observing Project* and Targets are archived and ready to be scheduled.
3. The *long-term observation plan and short-term observation plans* are stored in the **Science Archive**.


uc UC-MA-010: Prepare an Observation
UC-MA-010: Prepare an Observation
«use»
«alternate»
The Operator manually uploads the short-term observation plan into the SCADA/Master Controller system
Prepare long-term observation plan
Prepare the short-term observation plan
«extend»
«extend»
«extend»
«extend»
Errors or problems in the Observing Project submission
Errors or problems in the Observing Project
The science alert target is not observable
Errors or problems in the SBs uploading

4.3. ASTRI-UC-0-020: Manage an observation during the night

Summary and Scope: The **Operator** and the **Astronomer on-duty** have to manage the observations during the night. There are different use cases summarised in this general use case:

1. nominal observations;
2. repoint for changes in environmental or atmosphere characterisation conditions;
3. receive an external science alert (e.g., a Target of Opportunity, ToO) during the observing night and submit an Observing Project for the ToO follow-up. The Operator evaluates the Observing Project and executes it.

Authors: Andrea Bulgarelli, Fabrizio Lucarelli, Saverio Lombardi

Version: 1.0

Trigger: at the beginning of the observing night

Frequency: each night

Phase:

Assumptions: all paths of this UC are performed using the **Operator HMI**

PRE-CONDITION CONSTRAINTS

1. The ASTRI Mini-Array System is ready for SVP or for nominal observations and engineering runs.
2. Software tools for the evaluation of pointing strategies are available.
3. The *short term observation plan* is ready and loaded in the SCADA system.

SCENARIOS

Basic Path. Nominal observation

1. The **Operator** checks that the following critical systems:
   a. Power Management Control system;
   b. On-Site ICT Control System;
   c. Environmental Monitoring Control System;
   d. Safety and Security Control system;

   are up and running, and that alarms have not been raised using the **Operator HMI** and the **Startup System GUI**.

   Exception: *1a, Alarm notifications are present from critical systems.* Rejoins Main Scenario at End.

2. The **Operator** checks environmental conditions using the **Operator HMI**.

   Exception: *2a, Transition or survival environmental conditions are present.* Rejoins Main Scenario at End.

3. The **Operator** starts the **MA System**

4. The **Operator** checks if the status of the array is nominal.

   Exception: *4a, Alarm notifications are present from array systems.* Rejoins Main Scenario at End.
   Exception: *4b, Degraded condition status of the array.* Rejoins Main Scenario at End.

5. The **Operator,** for preliminar checks, and/or the **SCADA/Central Control System** selects the short-term observation plan for the current night, then selects the Scheduling Block, and starts the execution of the list of Observing Blocks foreseen for that SB (ASTRI-UC-0-070).

   Exception: *5a, Exceptions of ASTRI-UC-0-070.*

   Alternate: *5a, Repoint for change in environmental or atmosphere characterisation conditions in degraded status.*
   Alternate: *5b, Insert an Observing Project for a ToO event (during the observation night).*

6. The **Operator** checks that the sequence of operations is nominal during the observation.

7. At the end of the night,
   a. If the current run is not finished, the **Operator** stops the current Run.
   b. The **Operator** puts the MA system in a *safe state* and switch-off all the non critical systems.
   c. The **Operator** checks that the following critical systems:
      i. Power Management Control system;
      ii. On-Site ICT Control System;
      iii. Environmental Monitoring Control System;
      iv. Safety and Security Control system;

   are up and running for daily operations and check also if Alarm System and Monitoring System are up and running.

   Alternate: *7a, Switch-off the system in automated mode*

Alternate. Repoint for environmental or atmosphere characterisation conditions in degraded status

1. During nominal observations, the **Operator** continuously evaluates the environmental and atmosphere conditions sent to the **Operator HMI** by the **Monitoring System** (ASTRI-UC-0-025), **Atmosphere Characterisation Control System** (ASTRI-UC-0-035), and the **Online Observation Quality System** (ASTRI-UC-0-060).

2. If the environmental or atmospheric conditions are not anymore favourable for the observation of the scheduled targets (*e.g.*, due to an increase of global cloudiness or atmospheric extinction), the **Operator** can decide to stop the scheduled observations for the current night and change to an alternative source/target, provided that the external conditions are still within the safe observation limits. The list of alternative targets shall be defined in advance, by the ASTRI **MA Science Team** or through the submission of a dedicated Observing Project, and included in the *long-term observation plan*.

   Note: The step 2 of this alternate will be evaluated and tested during the Science Verification Phase.

   Exception: *2a, Exceptions of ASTRI-UC-0-030*
   Alternate: *2a, Stop current run in automated mode if environmental and atmospheric conditions change*

Alternate. Insert an Observing Project for a ToO event (during the observation night)

1. The **Astronomer on-duty** receives a notification of an external science alert during the observation night.

2. The **Astronomer on-duty** evaluates the possibility to observe the external science alert target for the ToO follow-up, taking into account the visibility of the source and its scientific importance with respect to that of the observation in progress, selecting the corresponding *Observing Project* template previously submitted by a **Science User**, and the related *Scheduling Block(s)*. If a tiling strategy is needed, the **Astronomer on-duty** prepares a list of *Scheduling Blocks*.

Note: the template should include the time required to perform an observation.

Note: the preparation of the tiling strategy requires a tool that generates the grid of pointings.

Exception: *2a. The science alert target is not observable* (See details below). Rejoins Main Scenario at End.

Exception: *2b. No Cherenkov observations are possible due to SI3 planned observations*. Rejoins Main Scenario at End.

3. The **Astronomer on-duty** submits the *Scheduling Block(s)*.

   Exception: *3a. Errors or problems in the Scheduling Block submission* (See details below). Rejoins Main Scenario at End.

4. The **SCADA/Central Control System** automatically validates the new SBs**.**

   Exception: *4a. Errors or problems in the Scheduling Block validation* (See details below). Rejoins Main Scenario at Step 3.

5. If the *Scheduling Blocks* are valid, the **Operator** stops the current observation and loads the list of new Scheduling Block(s)**.**

6. The **Operator** starts the execution of the *Scheduling Blocks* (start the execution of ASTRI-UC-0-070 from step 1a).

   Exception: *6a, Check exceptions of ASTRI-UC-0-070.*

7. At the end of a *Run*, the **Astronomer on-duty** checks the results of the run using the Level-B data processing, as described in ASTRI-UC-0-090: “Main Scenario: short-term (as soon as a Run is available during the observation night)” to understand if there are important scientific results.

   Exception: *7a. Data Processing results are not available* (See details below). Rejoins Main Scenario at End.

Alternate. Switch-off the system in automated mode

1. At the end of the night,
   a. If the current run is not finished, the **SCADA** stops the current Run.
   b. The **SCADA** puts the MA system in a *safe state* and switch-off all the non critical systems.

Alternate. Stop current run in automated mode if environmental and atmospheric conditions change

1. If the environmental or atmospheric conditions are not anymore favourable for the observation of the scheduled targets (*e.g.*, due to an increase of global cloudiness or atmospheric extinction), the **Central Control System** can decide to stop the scheduled observations for the current night and change to an alternative source/target, provided that the external conditions are still within the safe observation limits. The list of alternative targets shall be defined in advance, by the ASTRI **MA Science Team** or through the submission of a dedicated observing project, and included in the *long-term observation plan*.

   Note: The step of this alternate will be developed and tested in future releases of SCADA.

Exception. **Degraded condition status of the array**

1. If the **MA System** is in degraded state the **SCADA System** can verify if there are the conditions to continue the observation.
2. The **SCADA System** notifies the **Operator** whether there are the conditions to continue the observation or not.
3. The **Operator** can acknowledge to continue the observation and logs the action using the **Operator Logbook**.
4. If the **Operator** decides to continue the observation, rejoins the main scenario at step 5, otherwise rejoins the main scenario at step 7, and logs the action using the **Operator Logbook**.
5. Maintenance activities are planned and executed.

Exception. Alarm notifications are present from array systems.

1. The **SCADA System** reacts in an automated way and puts the telescopes in a safe state.
2. If the **SCADA System** does not react in an automated way (depending on the conditions), the **Operator** stops the observation and puts the telescopes in a safe state: bringing them back to their parking positions with the camera lids closed and the cameras switched-off.
3. Maintenance activities are planned and executed.

Exception. Alarm notifications are present from critical systems.

1. The **SCADA System** stops operations. The observation is not performed.
2. Maintenance activities are planned and executed.

Exception. Transition or survival environmental conditions are present.

1. The **SCADA System** stops operations. The observation is not performed.
2. Wait until nominal conditions are restored.

Exception. The science alert target is not observable

1. The **Astronomer on-duty** logs that the science alert target is not observable during the night. If possible, the target is planned for next night.

Exception. Errors or problems in the Scheduling Block submission

1. The **Astronomer on-duty** informs the following day the **Support Astronomer** of errors or problems encountered during the SB submission.

Exception. Errors or problems in the Scheduling Block validation

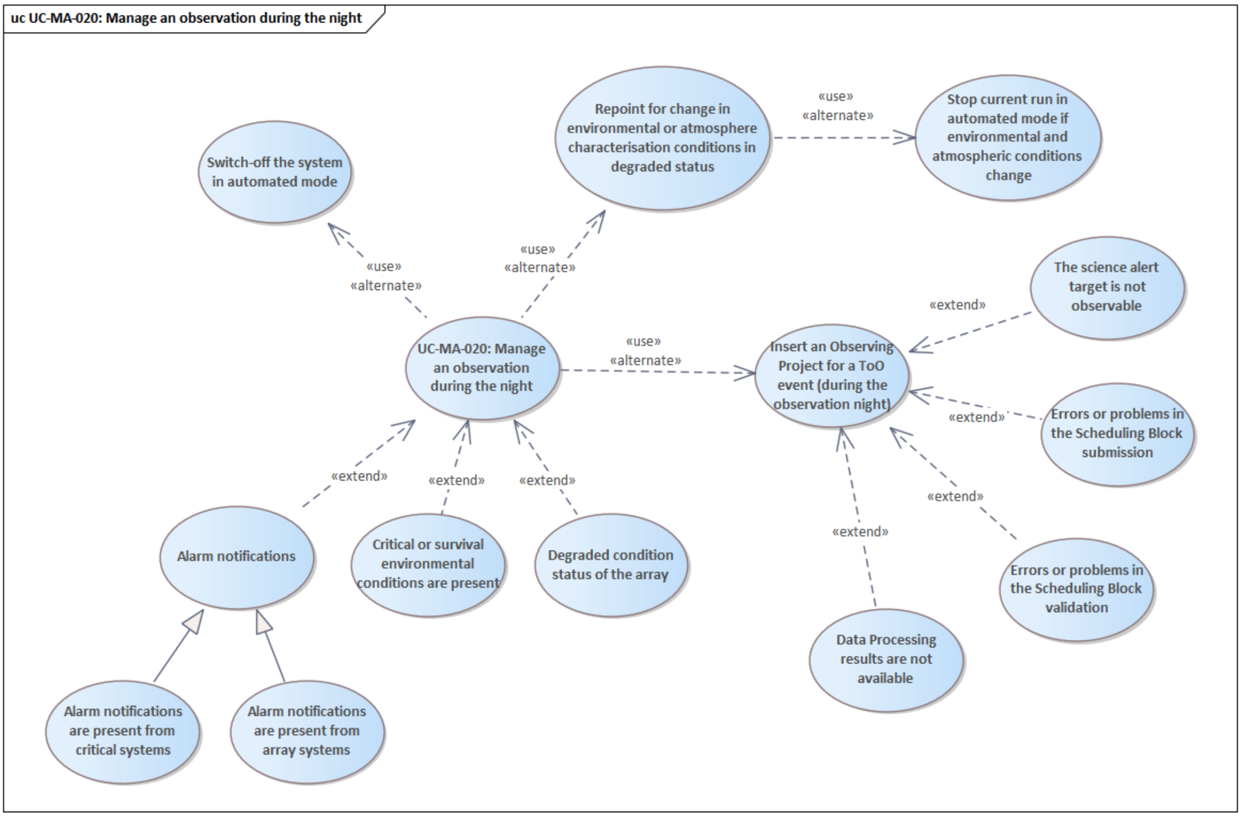
1. The **Operator** communicates errors and problems to the **Astronomer on-duty** and logs the action using the **Operator Logbook**.
2. When ready, the **Astronomer on-duty** resubmits the corrected Scheduling Block.

Exception. Data Processing results are not available

1. The **Operator** and **Astronomer on-duty** communicate errors and problems and logs the action using the **Operator Logbook**.
2. The observation continues until the end.

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE
Observations are executed. The MA System is in safe state if there are critical conditions.
SUCCESS GUARANTEE
Check ASTRI-UC-0-070.



4.4. ASTRI-UC-0-025: Perform the monitoring of assemblies

Summary and Scope: the **ASTRI MA System** assemblies expose monitoring points of all the relevant data items. The **Monitoring System** samples depending on the configuration, the exposed data items at a constant rate or on value change, described by the Monitoring Device Data Model (MONDM) as a list of monitoring points stored in the SCDB. The **Monitoring System** stores the monitoring information in a database (ASTRI-UC-0-200).

Authors: Alessandro Costa

Version: 1.0

Trigger: a device generates monitoring information (data item for a given property).

Frequency: <= 1 Hz

Phase:

Assumptions:

PRE-CONDITION CONSTRAINT

1. The **Monitoring System** is up and running.
2. Assemblies/Devices to be monitored are up and running.

SCENARIOS

Basic Path.

1. The **Monitoring System** identifies, using the **System Configuration DB**, the list of monitoring points (from device sensors) to be subscribed.
2. The data collector subscribes to the list of sensors.
3. The device makes available the value for a given monitoring point.
4. The data collector initiates the monitoring procedure.

    Exception: *4a. Monitoring System is disconnected.* Rejoins main scenario.

5. Values are passed to the queue.

    Exception: *5a. Dispatcher is unable to read from the queue system.* Rejoins main scenario.

6. Dispatcher reads the values from the queue and stores it in the **Monitoring Archive.**

Basic Path. Trend analysis

1. As data accumulate in the **Monitoring Archive**, quality control performs trend analyses of them.
2. The results can then be used to e.g., correct final data products or initiate maintenance actions. This analysis is also useful for the definition of the array configuration.

Exception. Monitoring System is disconnected

1. The **Monitoring System** is halted
2. Monitoring point values are not stored any more
3. The **Alarm System** raises an alarm

Exception. Dispatcher is unable to read from the queue system 1. Dispatcher is halted 2. Monitoring point values are still collected by the queue
POST CONDITION CONSTRAINT
MINIMAL GUARANTEE
Data items for a given monitoring point are stored.
SUCCESS GUARANTEE
Monitoring data are ingested and stored in the **Monitoring Archive.**

4.5. ASTRI-UC-0-030: Determine Environmental Conditions

Summary and Scope: Determine environmental conditions (ENV) and monitor the Environmental Monitoring System assemblies.

Given a predefined set of auxiliary systems devoted to the environmental monitoring, this UC has a multiple purpose: determine the environmental conditions (*normal, observation, transition, survival* [AD8]) during both day and night; provide ENV data to inform about possible hazard conditions to let **SCADA/Central Control System** to put the Mini-Array system in *safe state* with conditions identified by the **Environmental Monitoring System Collector**; provide the **Operator** through the **Alarm System** with necessary ENV parameters to determine *transition* or *survival* conditions; provide the **Operator** through the **Monitoring System** all ENV parameters.

The **Environmental Monitoring System** includes two weather stations (WS), nine rain sensors (RS), nine humidity sensors and one all-sky camera (ASC) close to a SQM; (see [AD3]). Further information (e.g. earthquake monitoring, dust content, lightning probability, weather forecast) could require the usage of external services not included in this UC.

The following environmental conditions must be monitored, analyzed and reported continuously [AD8]:

- air pressure
- air temperature
- temperature gradient
- relative humidity
- rain (local the each Telescope)
- snow
- ice
- wind speed (mean and gusts across the full array) and direction
- cloudiness
- dew point (local to each Telescope)

The values that produce alarms are acquired by the **Environmental Monitoring System** and sent to the **SCADA** system.

All data values are acquired by the **Monitoring System** and archived in the **Archive System** (local and remote) and made available for the human-readable weather and atmosphere characterisation reports. Putting the MA System in a safe state is under the responsibility of the **Central Control System**.

Authors: M.C. Maccarone, A. Bulgarelli

Version: 1.1

Trigger: Continuously. A minimal set of systems devoted to this UC always runs, even during the day, for safety reasons for humans, equipment and data, and for historical recording.

Frequency: data could be acquired at different frequencies, depending on the auxiliary ENV assemblies. Generally, ENV parameters values should be acquired once every 2 seconds, at least.

Phase: This UC covers all AIV, SVP and production phases.

Assumptions:

PRE-CONDITION CONSTRAINTS
1. All the foreseen environmental systems have been fully defined and at least the necessary minimal set of such systems is correctly working 24/7.

2. The *normal, observation, transition, survival* for each basic ENV parameter has been fully defined [AD8].
3. The communication with the MA off-site system is working.

SCENARIOS

Basic Path. Startup

1. The **Startup System** switches-on and configures all **Environmental Monitoring System** assemblies.
2. The **Startup System** starts the **SCADA** system.

Basic Path. Monitoring environmental system and conditions

1. The **Environmental Monitoring System Collector** automatically checks the status of the **Environmental Monitoring System** assemblies.

Alternate. The **Monitoring System** automatically checks the status of the **Environmental Monitoring System** assemblies. *Note: e.g. during construction phase, AIV phase.*

Exception: 1a, *Weather station monitoring not reliable* (See details below). Rejoins Main Scenario at End.
Exception: 1b, *Rain sensors not reliable* (See details below). Rejoins Main Scenario at End.
Exception: 1c, *Humidity sensors not reliable* (See details below). Rejoins Main Scenario at End.
Exception: 1d, *All-sky camera not reliable* (See details below). Rejoins Main Scenario at End.

2. The **Environmental Monitoring System Collector** reads the ENV data and sends them to the **Operator HMI** and to the **Central Control System**.

Exception: 2a, *Environmental conditions are outside operative ranges.* (See details below). Rejoins Main Scenario at End

2.1. The **Operator** checks the values.

3. The **Alarm System** reads the ENV parameter that can generate an alarm for the safety of the MA System, and checks for *transition* and *survival* ENV conditions (see [AD8]), and sends them to the **Operator**.

Exception: 3a, *Environmental conditions are outside operative ranges.* (See details below). Rejoins Main Scenario at End

3.1. The **Operator** acknowledges alarms.

4. The **Monitoring System** acquires ENV data and monitoring points and saves them in the **Monitoring Archive**.

4.1. The **Operator** checks ENV conditions.

Exception: 4a, *On-site Monitoring Archive system problems.* (See details below). Rejoins Main Scenario at End
Exception: 4b, *Environmental conditions are outside operative ranges.* (See details below). Rejoins Main Scenario at End

5. The **Monitoring System** creates a human-readable environment condition report that is issued and transmitted to the **Operator HMI** and continuously stored in the **Monitoring Archive**.

5.1. The **Operator** reads the report.

6. If applicable: monitoring of earthquakes, transmitting proper parameter values to the **Alarm System**.

Exception: 6a, *Earthquake.* (See details below). Rejoins Main Scenario at End

7. All ENV data so acquired, as well as the environment reports, are archived in the **Site Archive System** and then transferred to the off-site **Archive System**.

Basic Path. Monitoring environmental conditions during the day

1. If necessary: the **Operator** checks the weather forecast provided by national agencies for the ASTRI MA night observation and properly modifies the short-term observation plan.

Note: *the weather forecast could be obtained by external meteo services available at Teide. To Be Investigated*

Exception: 1a, *Weather forecasts predict ENV values outside operative ranges for the next night.* Rejoins Main Scenario at End

Basic Path. Shutdown

1. The **Startup System** switches-off all **Environmental Monitoring System** assemblies.

Exception. Weather station monitoring not reliable

If the weather station monitoring is not reliable,
1. The **Alarm System** raises an alarm to the **Operator**.
2. The **Environmental Monitoring System Collector** raises an alarm to SCADA sub-systems.
3. During the day (outside the observation period): corrective actions are foreseen.
4. The **Operator** checks the status of the assembly and acknowledges the alarm.
5. If both weather stations are not reliable the **Central Control System** shall stop the operation and all telescopes will be put in a safe *state* and will be commanded to reach the parking position.
6. The **Operator** informs the **Maintenance Engineer** that one or both weather stations are not reliable.

Exception. Rain sensors not reliable

If the rain sensor(s) is(are) not reliable:
1. The **Alarm System** raises an alarm to the **Operator**.

2. The **Environmental Monitoring System Collector** raises an alarm to SCADA sub-systems.
3. The **Operator** checks the status of the device and acknowledges the alarm.
4. If necessary, the **Central Control System** shall stop the operation and all telescopes will be commanded to reach the parking position.
5. The **Operator** informs the **Maintenance Engineer** that devices are not reliable.

   During the day (outside the observation period): corrective actions are foreseen.

Exception. Humidity sensors not reliable

If the humidity sensor(s) is(are) not reliable:
1. The **Alarm System** raises an alarm to the **Operator**.
2. The **Environmental Monitoring System Collector** raises an alarm to SCADA sub-systems.
3. The **Operator** checks the status of the device and acknowledges the alarm.
4. If necessary, the **Central Control System** shall stop the operation and all telescopes will be commanded to reach the parking position.
5. The **Operator** informs the **Maintenance Engineer** that devices are not reliable.

   During the day (outside the observation period): corrective actions are foreseen.

Exception. All-sky camera not reliable

1. The **Alarm System** raises an alarm to the **Operator**.
2. The **Environmental Monitoring System Collector** raises an alarm to SCADA sub-systems.
3. The **Operator** checks the status of the ASC and acknowledges the alarm.
4. The **Operator** informs the **Maintenance Engineer** that ASC is not reliable.

Exception. Earthquakes

If during the night, the **Operator** stops the observation.

Exception. Weather forecasts predict ENV values outside operative ranges for the next night.

The **Operator** makes a decision to perform an observation during the night or change schedule.

Exception. Environmental conditions are outside operative ranges

If environmental conditions are outside operational limits (*transition* or *survival*, see [AD8]):
1. The **Environmental Monitoring System Collector** raises a critical notification event and sends it to the **SCADA/Central Control System.**

   Alternate. The **Monitoring System** raises a critical notification event and sends it to the **SCADA/Central Control System.**

2. The **SCADA/Central Control System** puts the **MA System** in a *safe state* automatically.
3. The **Alarm System** raises an alarm and sends it to **Operator HMI**.
4. The **Operator** checks environmental conditions and alarms.
5. The **Operator** acknowledges the alarm.
6. The **Operator** takes immediate action based on the severity of alarms (environmental conditions *transition* or *survival*).

Exception. On-site Monitoring Archive System problems.

1. The **ICT System Collector** identifies problems and raises appropriate notification to the **Alarm System** and to the **Central Control System**
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

1. The values of ENV parameters are transmitted to the **Alarm System**.
2. If the environmental conditions are outside operative ranges the **SCADA/Central Control System** puts the MA System in safe state automatically when the environmental conditions are outside operative ranges.
3. The ENV data is saved on disk.

SUCCESS GUARANTEE

1. The values of ENV parameters are transmitted to the **Monitoring System, Alarm System**, **Environmental Monitoring System Collector** and to the **Operator.**
2. The environmental conditions have been determined.
3. If the environmental conditions are outside operative ranges the **Central Control System** puts the MA System in *safe state* automatically.
4. ENV conditions alarms are raised and managed by the **Operator** and by the **Central Control System**.
5. The ENV data are archived in the **Site Archive System,** and then transferred to the off-site **Archive System**.
6. The human readable environmental reports are issued and transmitted to the **Operator.**
7. The human readable environmental reports are archived in the **Site Archive System,** and then transferred to the off-site **Archive System**.

4.6. ASTRI-UC-0-035: Characterise the Atmosphere

Summary and Scope: Characterise the atmosphere (ATM); provide the ATM data to the **ASTRI MA Software System**.

Given a predefined set of auxiliary systems devoted to the atmosphere characterisation (LIDAR, SQM, UVSiPM), this UC has the purpose to characterise the atmosphere during the observation period; provide the **Atmosphere Characterisation Control System** and **Monitoring System** with the necessary ATM data and monitoring to inform the **Operator** about possible expected degradation of the data quality and schedule changes during the night. Note that from a general point of view, ATM values outside limits could create warnings but not alarms; a possible warning could arise from the dust content in the atmosphere and such information is obtained from LIDAR data.

The LIDAR system, the sky quality meters (SQM) and the UVSiPM device form the **Atmosphere Characterisation System** (see [AD3]). The LIDAR system is used to analyze the atmospheric extinction at the beginning of the night or at the start of operations. The SQM and UVSiPM assemblies, installed on board or nearby the telescopes, will be used only during the observation night.

All the acquired high-level ATM data (atmospheric extinction, atmospheric transmission, dust, night sky brightness, NSB values) must be archived in the **Archive System** (local and remote) and made available for the human-readable atmosphere characterisation reports.

The low-level ATM data used to generate the high-level are saved on Local Control Software computer of the assemblies.

Authors: A. Bulgarelli, M.C. Maccarone

Version: 1.0

Trigger: At the beginning, during and after the observing night.

Frequency: At the beginning, during and after the observing night.

Phase: This UC covers all AIV, Commissioning/SVP and production phases.

Assumptions:

1. This UC requires that the high-level results (Atmosphere Characterisation DL1 data, see [AD2]) of the **Atmosphere Characterisation System** are provided by the Local Control Software and SCADA does not perform any kind of on-line analysis of DL0 raw data.
2. The Atmosphere Characterisation DL0 data is saved on LCS and transferred periodically off-site.

PRE-CONDITION CONSTRAINTS
1. All the foreseen Atmosphere Characterisation systems have been fully defined and at least the necessary minimal set of such systems is correctly working during the observation night. 2. The reliability criteria ATM systems have been fully defined. 3. The communication with the MA off-site system is working. 4. The high level results (*Atmosphere Characterisation DL1* data, see [AD2]) of the LIDAR, SQM and UVSiPM are provided by their Local Control Software 5. The cross calibration between SQM and UVSiPM pointing to zenith has been already performed
SCENARIOS

Basic Path. LIDAR data

1. The **Atmosphere Characterisation Control System** switch-on and configure the **LIDAR** at sunset.

   Exception: 1a, *LIDAR assembly problems.* (See details below). Rejoins Main Scenario at End

2. The **Atmosphere Characterisation Control System** acquires a **LIDAR** shot to zenith. The **LIDAR** provides the following *atmosphere characterisation conditions* high-level results (*Atmosphere Characterisation DL1* data, see [AD2]):
   a. atmospheric extinction, each day for 30 min at sunset before the start of the observation, and at dawn for 30 min after the end of the observation;
   b. presence of dust (or dust storm);
   c. atmospheric transmission.

   Note: *in addition to the zenith, the LIDAR shot could be aimed at the main pointing locations foreseen in the night short-term observation plan. To Be Investigated (see also [AD3]) and will be detailed in an additional UC.*

   Exception: 2a, *LIDAR data acquisition problems.* (See details below). Rejoins Main Scenario at End

3. The **Atmosphere Characterisation Control System** saves the acquired high-level results in the **Local Bulk Repository**.

   Exception: 3a, *Local Bulk Repository system problems.* (See details below). Rejoins Main Scenario at End

4. The **Atmosphere Characterisation Control System** sends the high-level results of the **LIDAR** to the **Operator HMI.**

   Open point: *the result of the LIDAR must be saved by the Data Capture? Consider that the Data Capture save the results for the scientific analysis for each run, not for the overall observing night*

5. The **Operator HMI** creates a human-readable atmosphere characterisation report for the **Operator** during the observation.

6. The **Operator** reads the **LIDAR** report.

   Exception: 6a, *Atmosphere characterisation conditions are outside operative ranges.* (See details below). Rejoins Main Scenario at End
   Exception: 6b, *Presence of dust (or dust storm).* (See details below). Rejoins Main Scenario at End

7. The **Atmosphere Characterisation Control System** switch-off the **LIDAR** at the end of the operations.

   Exception: 7a, *LIDAR assembly problems.* (See details below). Rejoins Main Scenario at End

8. The **LIDAR** high-level results are transferred to the off-site **Archive System**.

   Open point: *the atmospheric extinction profiles could also be acquired before the start of a single observation, to have the profile at the same time of the data. In this case a special shot is foreseen but the shot interferes with astronomical observations. Not covered in this UC for now.*

Basic Path. SQM and UVSiPM data

1. The **Atmosphere Characterisation Control System** switch-on and configure the two **SQMs** and the **UVSiPM** mounted on telescopes, plus the third **SQM** fixed on-ground.

   Exception: 1a, *UVSiPM assembly problems.* (See details below). Rejoins Main Scenario at End

Exception: 1a, *SQM assembly problems.* (See details below). Rejoins Main Scenario at End

3. The **Atmosphere Characterisation Control System** starts the data acquisition.

Exception: 2a, *UVSiPM assembly problems.* (See details below). Rejoins Main Scenario at End
Exception: 2a, *SQM assembly problems.* (See details below). Rejoins Main Scenario at End

4. The **Atmosphere Characterisation Control System** continuously acquires the high-level results (DL1.ATM) to check illumination and diffuse NSB level during the observation (ATM data):

   1. night sky brightness values from **SQMs**;
   2. NSB related values from the **UVSiPM**.

   Note: *the size of the proper FoV for SQM and UVSiPM is under definition.*
   This point depends on when you check NSB. If we are observing with the ASTRI cameras, a quick analysis of the VAR data could be sufficient and check the relationship with the data from the SQMs and from the only UVSiPM; if the telescope where UVSiPM is located is 'pointing' but no ASTRI camera is active, then we will analyze the SQM and UVSiPM data; finally, if the telescopes are 'pointing' but UVSiPM is not active and the cameras do not acquire VAR data, then it must be based only on the SQM data

Exception: 4a, *SQM or UVSiPM data acquisition problems.* (See details below). Rejoins Main Scenario at End

5. The **Atmosphere Characterisation Control System** sends a sample of night sky brightness values from SQMs and NSB values from the UVSiPM to the **Central Control System.** These values are saved by the **Data Capture**.

6. The **Monitoring System** acquires DL1.ATM data and saves the acquired high-level results in the **Local Bulk Repository**.

Exception: 6a, *Local Bulk Repository system problems.* (See details below). Rejoins Main Scenario at End

7. The **Atmosphere Characterisation Control System** sends a sample of the high-level results to the **Operator HMI.**

8. The **Operator HMI** creates a human-readable atmosphere characterisation report for the **Operator** during the observation.

9. The **Operator** reads the report.

Exception: 9a, *Atmosphere characterisation conditions are outside operative ranges.* (See details below). Rejoins Main Scenario at End

10. The **Atmosphere Characterisation Control System** switch-off **SQMs** and **UVSiPM** at the end of the operations.

Exception: 10a, *UVSiPM assembly problems.* (See details below). Rejoins Main Scenario at End
Exception: 10a, *SQM assembly problems.* (See details below). Rejoins Main Scenario at End

11. The SQM and UVSiPM high-level results are transferred to the off-site **Archive System**.

Basic Path. Assembly monitoring

1. The **Atmosphere Characterisation Control System** monitors the LIDAR assembly continuously to detect hardware problems. Only the monitoring points useful to detect problems are acquired.

Exception: 1a, *LIDAR assembly problems.* (See details below). Rejoins Main Scenario at End

2. The **Monitoring System** acquires all LIDAR monitoring points (MONDM) and stores them into the **Monitoring Archive**.

Note: *pattern "identification of an assembly event with a control software"*

3. The **Atmosphere Characterisation Control System** monitors the UVSiPM and SQM assemblies continuously to detect hardware problems. Only the monitoring points useful to detect problems are acquired.

Exception: 2a, *UVSiPM assembly problems.* (See details below). Rejoins Main Scenario at End
Exception: 2a, *SQM assembly problems.* (See details below). Rejoins Main Scenario at End

Note: *pattern "identification of an assembly event with a control software"*

4. The **Monitoring System** acquires all UVSiPM and SQM monitoring points (MONDM) and data points (DL1.ATM) and stores them into the **Monitoring Archive**.

5. The **Operator** can show the DL1.ATM data acquired by the Monitoring **System** through the **Operator HMI**.

Exception. LIDAR data acquisition problems.

1. The **Atmosphere Characterisation Control System** notifies the **Alarm System.**
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions [RD].

Note: *if the LIDAR high-level data is not acquired or the LIDAR is not present the observation must go on.*

Exception. SQM or UVSiPM data acquisition problems.

1. The **Atmosphere Characterisation Control System** notifies the **Alarm System.**
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions.

Note: *if the SQM high-level data is not acquired or the LIDAR is not present the observation must go on.*
Note: *if the UVSiPM high-level data is not acquired or the LIDAR is not present the observation must go on.*

Exception. Atmosphere characterisation conditions are outside operative ranges

If atmosphere characterisation parameters are outside operational limits, the **Operator** is informed through the **Operator HMI**. The decision about whether to continue observations can be taken by the **Operator** (ASTRI-UC-0-020). The **Operator** is informed about the atmosphere characterisation and any expected problems during the night, mainly concerning the data quality, and decides appropriate actions. Generally, ATM values outside limits could influence the data quality and the operational conditions for the given *Observing Block* (see ASTRI-UC-0-070).

Exception. Presence of dust (or dust storm)

If dust is present, the **Operator** is informed through the **Operator HMI**. The decision about whether to continue observations can be taken by the **Operator** (ASTRI-UC-0-020).

Exception. LIDAR assembly problems.

1. The **Atmosphere Characterisation Control System** identifies abnormal or fault conditions and raises appropriate notification to the **Alarm System**.
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions [RD].

Note: *if the LIDAR high-level data is not acquired or the LIDAR is not present the observation must go on.*

Exception. SQM assembly problems.

1. The **Atmosphere Characterisation Control System** identifies abnormal or fault conditions and raises appropriate notification to the **Alarm System**.
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions [RD].

Note: *if the SQM high-level data is not acquired or the LIDAR is not present the observation must go on.*

Exception. UVSiPM assembly problems.

1. The **Atmosphere Characterisation Control System** identifies abnormal or fault conditions and raises appropriate notification to the **Alarm System**.
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions [RD].

Note: *if the UVSiPM high-level data is not acquired or the LIDAR is not present the observation must go on.*

Exception. Local Bulk Repository system problems.

1. The **ICT System** identifies problems and raises appropriate notification to the **Alarm System**
2. The **Alarm System** raises the alarm to the **Operator** through the **Operator HMI.**
3. The **Operator** acknowledges the alarm and takes appropriate actions

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

The ATM data are saved on disk.

SUCCESS GUARANTEE

1. The atmosphere characterisation has been performed.
2. The ATM data are archived in the **Local Bulk Repository,** and then transferred to the **off-site Archive System**.
3. The **Data Capture** has saved a sample of the ATM data.
4. The human readable atmosphere characterisation report is shown to the **Operator.**

4.7. ASTRI-UC-0-050: Perform an Array calibration for Cherenkov observations

Summary and Scope: The array calibration must be performed only after a successful calibration of each individual telescope (see ASTRI-UC-0-051). The array calibration is mainly referred to the inter-calibration among the ASTRI-MA telescopes and to the array time resolution. Moreover it will provide a comparison of the systematics present in the optical throughput and in the pointing precision. A set of specific pointing of all the ASTRI-MA telescopes could be required.

Authors: M.C. Maccarone, A. Bulgarelli, T. Mineo

Version: 1.0

Trigger: The array calibration must be performed during the commissioning/SV phase when the ASTRI-MA will be completed. Moreover it can be scheduled as a result from e.g., a period of very strong winds, a period of strong dust intrusions or even a dust storm, from any inconsistency found in the data or in the long-term monitoring displays, or, if necessary, after manual interventions on a telescope.

Frequency: During the commissioning/SV phase and whenever needed, or if during the long-term monitoring of the array it has been found that something goes wrong.

Phase: This UC covers the commissioning/SV phase.

Assumptions: The **Calibration Manager** has prepared the planning for the array calibration.

PRE-CONDITION CONSTRAINTS

1. The environmental conditions and atmosphere characterisation conditions are within the limits required by any calibration item under consideration.
2. A calibration *Observing Project* has been prepared and submitted to the **Science Support System**.
3. The array calibration cannot interfere with the regular scientific data taking.

SCENARIOS

Basic Path.

1. The **Operator** follows the calibration plan, executed by the **Central Control System**, whose main steps include:
   a. **Intercalibration.** Observation of a ‘natural’ source, pointing all telescopes to it, to derive the systematics of each telescope.

   b. **Optical throughput and Pointing.** Observation of a star, pointing all telescopes to it, to derive the corresponding value for each telescope.

2. The **Calibration Manager** performs a detailed analysis of all the acquired data using the **Data Processing System,** and all the calibration parameters and coefficients derived from the analysis, including their uncertainties and possible quality flags, are transferred to the long-term analysis and to the **Archive System**.

Exception: 2a, *Analysis results not clear.* (See details below). Rejoins Main Scenario at End

Exception. Analysis results not clear

If the analysis results of these calibration procedures do not provide a clear picture of the situation, **the Calibration Manager decides to repeat the array calibration or … (TBD)**

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

The array is calibrated at a sufficient level and ready for observations.

SUCCESS GUARANTEE

The array is calibrated and ready for observations.

All calibration parameters and coefficients, including their uncertainties and possible quality flags, are transferred to the **CALDB** of the ASTRI-MA **Archive**.

4.8. ASTRI-UC-0-051: Perform a telescope calibration for Cherenkov observations

Summary and Scope: Acquire telescope calibration data for Cherenkov observations (via dedicated programmes and external equipment) and perform the analysis of these data whose outcomes will be archived in the CALDB. This UC allows us to acquire data directly from each telescope (mainly scientific and variance VAR data) observing a given source, natural or artificial.The UC, or part of it, would be included in a calibration proposal devoted to telescope calibration and performance validation and it can require the use of auxiliary instrumentation (Optical Camera, PMC, UVSiPM, Illuminator).

Authors: T. Mineo, M.C. Maccarone

Version: 1.0

Trigger: The telescope calibration must be performed during the AIV phase and it is referred to all its subsystems. Part of the telescope calibration/monitoring will be performed during the commissioning/SV phase and production phases. Moreover it can be scheduled as a result from e.g., a period of very strong winds, a period of strong dust intrusions or even a dust storm, from any inconsistency found in the data or in the long-term monitoring displays, or, if necessary, after manual interventions on the telescope.

Frequency: Whenever needed.

Phase: Firstly during the AIV phase or if, during the long-term monitoring of the array, it has been found that something in a telescope goes wrong. Part of the telescope calibration/monitoring will be performed during the commissioning/SV and production phases

Assumptions: The **Calibration Manager** has prepared the planning for the telescope calibration.

PRE-CONDITION CONSTRAINTS

1. The environmental conditions and atmosphere characterisation conditions are within the limits required by any calibration item under consideration.
2. A calibration *Observing Project* has been prepared and submitted to the **Science Support System**.
3. The reference and configuration data used to configure the device used for the array calibrations (i.e, the **Illuminator**), have been specified in the calibration *OP* and archived in the **System Configuration DB (SCDB)**.
4. After checking the calibration *Observing Project*, the MA team (daily **Operators,** and the **Calibration Manager**) has prepared everything needed for any planned calibration item.
5. The telescope calibration cannot interfere with the regular scientific data taking.

SCENARIOS

Basic Path.

1. The **Operator** follows the calibration plan, executed by the **Central Control System**, whose execution and order of steps could be different from what is expressed here in the following. Main steps could include:

    a. **Optics calibration**: mirror reflectivity, PSF

    b. **Camera calibration**: gain, pedestal, camera trigger determination, ...

    c. **Pointing calibration**: accuracy, ...

    d. **Absolute calibration**: optical throughput, ...

2. The **Calibration Manager** performs a detailed analysis of all the acquired data using the **Data Processing System,** and all the calibration parameters and coefficients derived from the analysis, including their uncertainties and possible quality flags, are transferred to the long-term analysis and to the **Archive System**. Exception: 2a, *Analysis results not clear.* (See details below). Rejoins Main Scenario at End
Exception. 2a, Analysis results not clear If the analysis results of these calibration procedures do not provide a clear picture of the situation, the **Calibration Manager** decides to repeat the telescope calibration or … (TBD)
POST CONDITION CONSTRAINT
MINIMAL GUARANTEE
The telescope is calibrated at a sufficient level and ready for observations
SUCCESS GUARANTEE
The telescope is calibrated and ready for observations. All calibration parameters and coefficients, including their uncertainties and possible quality flags, are transferred to the **CALDB** of the ASTRI-MA **Archive**.
OPEN POINTS

4.9. ASTRI-UC-0-060: Execute online observation quality quick-look

Summary and Scope: This UC describes the observation quality quick-look operations to be performed during Cherenkov and Intensity Interferometry data acquisition.

Authors: Andrea Bulgarelli, Nicolò Parmiggiani

Version: 1.1

Trigger: start of a run

Frequency: for each Observing Blocks

Phase: This use case covers the SVP and production phases.

Assumptions:

PRE-CONDITION CONSTRAINTS
Observation is running. The Central Control System is running, ACS is running
SCENARIOS
Basic Path. Startup 1. The **Central Control System** starts the **Array Data Acquisition System** and the **Online Observation Quality System** at the beginning of the night *Start system*
Basic Path. Cherenkov Camera Data Acquisition Flow 1. The **Central Control System** send the runID to the **Online Observation Quality System** 2. The **Array Data Acquisition System** gets the data from the Cherenkov cameras and provides the data to the **Online Observation Quality System.** *Camera Data Acquisition acquisition* 3. The **Online Observation Quality System** analyses the Cherenkov camera data to: 1. determine data quality status information at telescope level (from EVT.R0); 2. check pointing precision and accuracy using VAR data; *Observation quality check of camera data.* Exception: *3a*, *Camera data quality status problems* (See details below). Rejoins Main Scenario at End. 4. The **Central Control System** send the stop of the Run to the **Online Observation Quality System**
Basic Path. SI^3 Data Quality Check 1. The **Central Control System** send the runID to the **Online Observation Quality System**

2. The **Array Data Acquisition System** gets the data from the SI^3 instrument and provides the data to the **Online Observation Quality System**.
SI^3 Data Acquisition acquisition

3. The **Online Observation Quality System** analyses the SI^3 data to:

1. determine SI^3 status, analysing HK;
2. determine data quality status information at telescope level;
3. check pointing precision and accuracy using the count rates of the four detector quadrants;
4. check target quality data using the total count rate of the detector;

Observation quality check of SI^3 data.

Exception: *3a, SI^3 data quality status problems* (See details below). Rejoins Main Scenario at End.

4. The **Central Control System** send the stop of the Run to the **Online Observation Quality System**

Basic Path. Shutdown

1. The **Central Control System** stop the **Array Data Acquisition System** and the **Online Observation Quality System** at the end of the night
Stop system

Exception. Camera data quality status problems
Exception. SI^3 data quality status problems

1. Send a notification to the **Central Control System** and **SCADA** performs automated actions
2. If foreseen, inform the **Operator**

Exception. Software malfunctioning

1. Send a notification to the **Central Control System** performs automated actions.
2. If, foreseen, inform the **Operator**.

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

Check camera status.
Check SI^3 status.

SUCCESS GUARANTEE

Check camera status and quality of calibrations.
Check SI^3 status and data quality.

OPEN POINTS

4.10. ASTRI-UC-0-070: Perform a gamma-ray or intensity interferometry observation of a target

4.10.1. Observing Strategy for Cherenkov observations

The target is a fixed location in the sky that corresponds to a gamma-ray point source in the same FoV or targets with a limited (TBD) extension.

Two observing strategies are possible in general, depending on the target scientific requirements:

1. Wobble Mode: to ensure gamma-ray measurement with simultaneous background determination, the target location is placed at an angular separation from the camera centre. The wobble direction and offset should be able to be set to any arbitrary value, within a reasonable range. This may be necessary in some cases if the observing strategy requires another symmetry, for example, to improve the exposure on multiple sources, or to avoid optically bright stars or regions. The wobble target position in the FoV is usually exchanged every 15-20 minutes, although the wobble distance from the camera center has to be kept fixed.
2. ON/OFF Mode: the target source is in the center of the camera. Observations on target and background determination are taken with two separate observations. The OFF region is a suitable closeby sky region without any known gamma-ray source in the FoV. The OFF region shall have the same ON source declination but will be offset in right ascension to both East and West with respect to the ON source region.

To be analysed:

- The case of gamma-ray extended sources with an extension smaller than MA FoV;
- The case of multiple gamma-ray sources in the same MA FoV.

The duration of one Observing Block will be typically 10-20 min.

Minimum set of parameters necessary to prepare the scheduling blocks for the wobble observations:

1. Wobble offset.
2. Wobble direction (the angle to the RA axis).
3. The number of wobble positions.
4. Duration of a single wobble pointing. The duration may be adjusted (shortened) in case of constraints such as scheduled / allocated time window.

Observing strategy
See [AD2] for more details:

1. Pointing Coordinate System: Ra-dec / Alt-Az / Gal: l,b
2. Nominal_Pointing: RA/DEC [J2000] provided by the user
3. Array: full-array
4. Observing strategies:
    a. Wobble mode. Homogeneous coverage of individual Wobble positions in the allocated time.
    b. ON/OFF
5. Array pointing: parallel
6. Zenith_Range: as specified in the proposal, centred around culmination otherwise
7. Precision_Pointing: according to the proposal and MA requirements
8. Requested_Time: as in the proposal
9. Minimum number of telescopes

4.10.2. Observing Strategy for Intensity Interferometry observation

The target is a star in the sky. The duration of an observation will usually be several hours, divided into segments of 10-20 minutes length. A single Stellar Intensity Interferometry (SII) observing mode is envisaged with minimal observational constraints dictated by the atmosphere characterisation (sky transparency > 40%) and the array status (at least 2 telescopes up and working).

Minimum set of parameters necessary to prepare the scheduling blocks for the observations:

1. pointing offset. The count rates on the four detector quadrants are checked by the OOQS automated on-line data analysis. A pointing offset is applied if the rates of the previous observation segment are not balanced.
2. pointing direction
3. number of segments
4. duration of a single segment. The duration may be adjusted (shortened) in case of constraints such as scheduled/allocated time window
5. focus position (infinity / out-of-focus). If the total rate exceeds 95 Mcounts/s, the target must be defocused.

Observing strategy

1. Pointing Coordinate System: Ra-dec / Alt-Az / Gal: Ra-dec
2. Nominal_Pointing: RA/DEC [J2000] provided by the user
3. Array: full-array
4. Precision_Pointing: according to the proposal and MA requirements
5. Requested_Time: as in the proposal
6. Minimum number of telescopes

4.10.3. Scenarios

Summary and Scope: The MA System performs an observation.

Authors: Andrea Bulgarelli, Fabrizio Lucarelli, Joe Schwarz, Stefano Vercellone, Gino Tosti, Luca Zampieri

Version: 1.1

Trigger: A Scheduling Block is ready for execution and divided into Observing Blocks.

Phase: This use case covers the SVP and nominal phases.

PRE-CONDITION CONSTRAINTS
1. A list of Scheduling Blocks and associated Observing Blocks is ready for the current night of observations (ASTRI-UC-0-010). 2. Possible array calibrations at the beginning of the night have been already performed (ASTRI-UC-0-050, ASTRI-UC-0-051). 3. Preliminary operations before an observation have been performed (ASTRI-UC-0-020), in particular a. for Cherenkov observation, the Observing Project has been prepared and translated into Scheduling Blocks. b. for Stellar Intensity Interferometry (SII) observations, Observing Project has been prepared and translated into Scheduling Blocks.

4. Possible atmosphere characterisation required at the beginning of the night is already performed (ASTRI-UC-0-035)
5. The **MA System** is ready for nominal observation
6. The environmental conditions and the status of the array are within operative ranges (ASTRI-UC-0-030).

FREQUENCY

1. Check Operational Conditions: in a continuous way during the night.
2. Execution of a Scheduling Block: at the beginning of the night and when a scheduling block is finished.
3. Check the status of the execution of a Run: during the observation.
4. Check the atmosphere characterisation condition: during the observation.

SCENARIOS

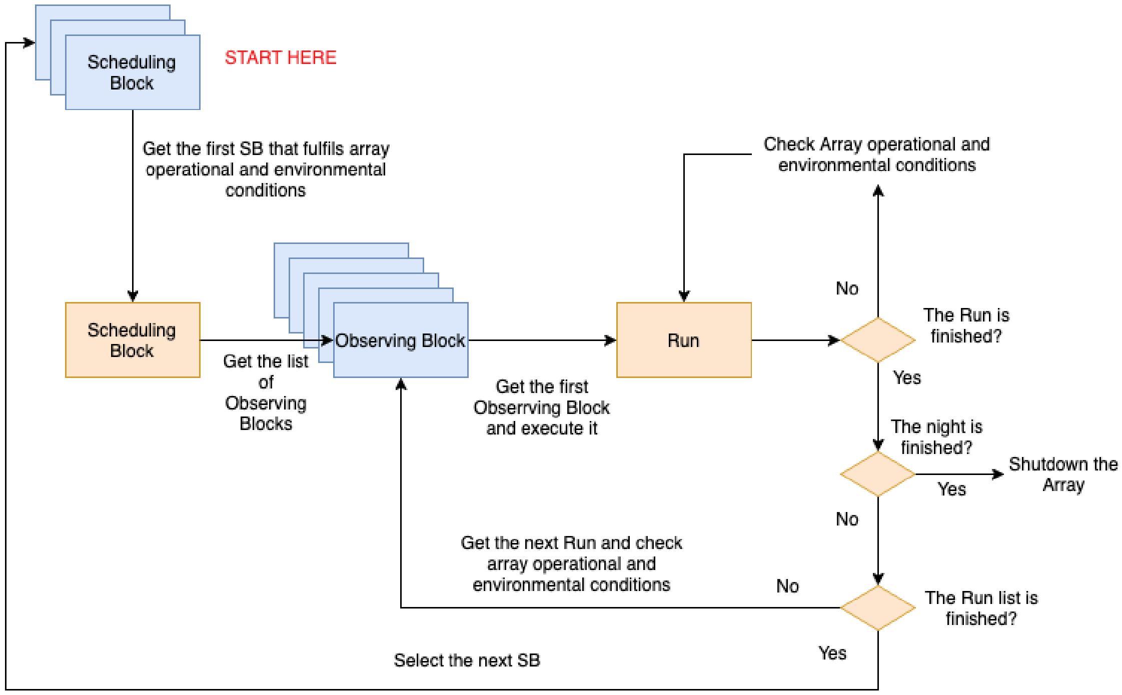
Basic Path. Startup of the scientific instruments at the beginning of the night

1. The **Central Control System** commands the **Telescope Control System** to switch-on and configure the scientific instruments
   a. for Cherenkov observations, the camera is configured reading the *baseline configuration* from the **SCDB.**
   b. for Stellar Intensity Interferometry (SII) observations, switch-on is obtained placing the arm with the SI^3 Focal Plane Optics and Front End Electronics in position, and powering on the SI^3 Front End Electronics and Back End Electronics. The *baseline configuration* is read from the **SCDB.**

2. The **Central Control System** commands the **Atmosphere Characterisation Control System** to start acquisition.

   Exception: *2a*, *Status alarms* (See details below). Rejoins Main Scenario at End.
   Exception: *2b, Software malfunctioning* (See details below). Rejoins Main Scenario at End.
   Exception: *2c, Hardware malfunctioning* (See details below). Rejoins Main Scenario at End.
   Exception: *2d,* Check exceptions of the ASTRI-UC-0-035

Basic Path. Execution of a Scheduling Block for observations



1. The **Operator** selects the first Scheduling Block (SB) that must be executed during the night from the *short-term observation plan*, using the **Operator HMI** with all the information and constraints for the execution.
Get a Scheduling Block for evaluation.

Alternate: *1a, The Operator adds Scheduling Blocks manually*
Alternate: *1b, End of the night.*

NB: A Scheduling Block (SB) has an Observing Strategy where observational constraints are defined (ENV and ATM status, array status) with a defined Observing Mode.

2. The **Operator** checks the array status with respect to SB constraints specified by the Observing Strategy.
Check Array status.

Exception: *2a*, *Operational conditions are not met* (See details below). Rejoins Main Scenario at Step 1.

Note: A SI3 observation requires a minimum of 2 telescopes and a maximum of 9.
Note: Check if there is a mimimum number of telescope for Cherenkov observation.

3. The **Operator** checks the environmental conditions and the atmosphere characterisation conditions with respect to the SB constraints specified by the Observing Strategy (see ASTRI-UC-0-030, ASTRI-UC-0-035)
Check environmental conditions.

Exception: *3a,* check exceptions of the ASTRI-UC-0-030, ASTRI-UC-0-035

Note: An SI3 observation requires a sky transparency > 40%.

4. The Operator commands the **Central Control System** to start and configure all systems for observation:
   4.1 the **Array Data Acquisition System**
   4.2 the **Online Observation Quality System**.

5. The Operator starts the observation. The Operator sets the **Central Control System** in an automated way. The **Central Control System** selects the short-term observation plan for the current night, then selects the next Scheduling Block ID.
Submit the Scheduling Block to the Central Control System for execution.

Alternate: *5a, The Central Control System works in a manual way.*

6. The **Central Control System** validates the Scheduling Block.
Validate the SB

Exception: *6a. Errors or problems in the SB validation* (See details below). Rejoins Main Scenario at End.

7. The **Central Control System** selects and automatically validates the Observing Blocks of the Scheduling Block
Select and validate the Observing Block

Exception: *7a, Software malfunctioning* (See details below). Rejoins Main Scenario at End.
Exception: *7b. Errors or problems in the Observing Blocks validation* (See details below). Rejoins Main Scenario at End.

There is at least an Observing Block for each wobble position and Observing Blocks for calibration activities.

8. The **Central Control System** checks the operational conditions of the Observing Block.
Check the Observing Blocks

Exception: *8a, Operational conditions are not met* (See details below). Try with the next Observing Block and rejoin the main scenario at step 6. If Observing Blocks of the SB are finished, rejoin the main scenario at step 1.
Exception: *8b,* check exceptions of the ASTRI-UC-0-030

The operations performed by the Operator in steps 1 and 3 are preliminary but the Central Control System performs the same operations in an automated way even if the Operator sets the Central Control System in a manual way.

9. The **Central Control System** starts the execution of the Observing Blocks, which becomes a sequence of Runs.
Execution of the Observing Block.

Exception: *9a, Software malfunctioning* (See details below). Rejoins Main Scenario at End.

9.1 The **Central Control System** commands one **Telescope Control System** for each telescope to configure telescope assemblies and to move the telescope from the current position to the position specified by the Observing Strategy. Scientific instrument is selected based on Scheduling Block configuration, and is configured with the Instrument Configuration of the Observing Mode.

Exception: *9.1a, Status alarms* (See details below). Rejoins Main Scenario at End.
Exception: *9.1b, Software malfunctioning* (See details below). Rejoins Main Scenario at End.
Exception: *9.1c, Hardware malfunctioning* (See details below). Rejoins Main Scenario at End.

Only one scientific instrument must work at the same time. The baseline configuration of each instrument can be retrieved from the SCDB, the Instrument Configuration of the Observing Mode [AD2] is read from the Observing Strategy configuration.

9.2 The **Central Control System** configures the **Array Data Acquisition System** and the **Online Observation Quality System** sending the runID.

9.3 The **Central Control System** starts the observation or calibration. The ASTRI Mini-Array is observing. A runID is shared between all **SCADA** subsystems involved in the execution of the Scheduling Block.

Alternate: *9.3a*, *The scheduling block could be part of an Observing Project for calibration*
Alternate: *9.3b*, *The scheduling block could be part of an Observing Project for scientific observation*

9.3.1 The **Array Data Acquisition System** acquires data of the Run and saves DL0 data in a local bulk repository.

Exception: *9.3.1a, Problems with data transfer and archiving in the local bulk repository* (See details below). Rejoins Main Scenario at End.

Note: for SI3, buffers the DL0 data on a local disc in compressed binary packets of 150 GB at a maximum rate rate of 4 Gbit/s, and then copies them in a Local Bulk Repository at a lower data transfer rate (1 Gbit/s).

9.3.2 The **Online Observation Quality System** runs automated on-line data analysis during the observation (ASTRI-UC-0-060)

Exception: *9.3.2a*, *Data quality is not met* (See details below). Rejoins Main Scenario at Step 1.

9.3.3 The **Monitoring System** performs a status check of all assemblies (ASTRI-UC-0-025) of the MA System and of the environmental conditions (ASTRI-UC-0-030) and stores the acquired data.

Exception: *9.3.3a*, *Operational conditions are not met* (See details below). Try with the next Observing Block and rejoin the main scenario at step 6, if Observing Blocks of the SB are finished, rejoin the main scenario at step 1.
Exception: *9.3.3b,* check exceptions of the ASTRI-UC-0-030

9.3.4 The **Alarm System** performs a status check of all assemblies and environmental conditions, or receives event notifications, and generates alarms to the **Operator** if alarm conditions are met.

Exception: *9.3.4a*, *Status alarms* (See details below). Rejoins Main Scenario at End.
Exception: *9.3.4b*, *Hardware malfunctioning* (See details below). Rejoins Main Scenario at End.
Exception: *9.3.4c, Check exceptions of the* ASTRI-UC-0-030

9.3.5 The **Logging System** acquires and analyses logs from systems that generate logs.

Exception: *9.3.5a*, *Status alarms* (See details below). Rejoins Main Scenario at End.
Exception: *9.3.5b*, *Software malfunctioning* (See details below). Rejoins Main Scenario at End.

9.3.6 The **Operator** checks assemblies status, alarms, environmental conditions and atmosphere characterisation conditions during the execution of the observation, the status of the execution of the Observing Block (the Run) via the **Operator HMI**.

Exception: *9.3.6a*, *Status alarms* (See details below). Rejoins Main Scenario at End.
Exception: *9.3.6b*, *Operational conditions are not met* (See details below). Rejoins Main Scenario at Step 1.

9.3.7 The **Central Control System/Data Capture** collects the data needed to perform the scientific analysis connected with the current Run.

10. At the end of the Run, the data are transferred to the off-site ASTRI Data Center. Get the next Observing Block and jump to step 6. If the Scheduling Block is finished, jump to Step 1.

11. The **Support Astronomer** can check the preliminary scientific results provided by the Level-B analysis executed offline and off-site (ASTRI-UC-0-090).

Exception. Operational conditions are not met

Some operational conditions (status of array elements, environmental conditions, atmosphere characterisation) go outside the operational ranges. The management of the conditions depends on the source and will be specified in more detailed use cases. For environmental conditions check ASTRI-UC-0-030. For atmosphere characterisation check ASTRI-UC-0-035. A possible workflow could be:

1. The **SCADA System** informs the **Operator** via **Operator HMI**;
2. The **Operator** or the **SCADA/Central Control System** stops the current Run;
3. The **Operator** acknowledges the new state.

Exception. Errors or problems in the SB validation

SCADA/Central Control System issues a warning or critical event notification concerning the *SB* validation.

Exception. Errors or problems in the Observing Block validation

SCADA/Central Control System issues a warning or critical event notification concerning the *Observing Block* validation.

Exception. Data quality is not met

Some data quality and/or atmosphere characterisation conditions go outside the operational ranges.
1. The **System system** informs the **Operator** via **Operator HMI**.
2. The **Operator** decides to stop or continue the current Run.

Exception. Software malfunctioning

If the software system is not critical, continue the observation, otherwise go to “Status alarms” exception

Exception. Hardware malfunctioning

1. The **SCADA system** informs the **Operator** via **Operator HMI**.
2. If the hardware system is not critical, continue the observation, otherwise generate an alarm and go to “Status alarms” exception.

Exception. Problems with data transfer and archiving into the local bulk repository.

In case of problem with the transfer and archiving into the local bulk repository, an appropriately sized local cache of the ADAS will guarantee to preserve data of at least 1 night of observations.

Exception. Status alarms

1. The **SCADA system** that detect the issue, raise a warning or critical event notification
2. The **SCADA system** informs the **Operator**.
3. The **SCADA/Central Control System** stops the current Run and puts the **MA System** in a *safe state* (e.g. the telescopes in parking position) automatically. The Scheduling Block is aborted.
    a. **Alternative**. if for some notification event an automated reaction is not foreseen, the **Operator** stops the current Run and puts the **System** in a *safe state*, e.g. the telescopes in parking position. The Scheduling Block is aborted.
4. The **Operator** acknowledges the received alarm and takes appropriate action to resolve issues.

Alternate. The Central Control System works in a manual way. The **Operator** sets the **Central Control System** in a manual way. The **Operator** manually submits the selected Scheduling Block (SB) to the **Central Control System**, then the **Operator** starts the execution of the observation.
Alternate. The Operator adds Scheduling Blocks manually 1. The **Operator** could manually add SBs. Two alternative paths: a. Check ASTRI-UC-0-020, Alternate: Insert an Observing Project for a ToO event (during the observation night). b. Check ASTRI-UC-0-020, Alternate: Repoint for change in environmental or atmosphere characterisation conditions. 2. The **Operator** sets the **Central Control System** in a manual way.
Alternate. End of the night 1. Shutdown the array.
POST CONDITION CONSTRAINT
MINIMAL GUARANTEE
The SI3 or Cherenkov camera data and the monitoring DL0 data are saved on disk.
SUCCESS GUARANTEE
1. The scientific data go into the **Local Bulk Repository** and then are transferred to the offsite long-term **Bulk Archive**. 2. The logging, monitoring, alarm and quality data go into the **Archive**. 3. The Science Data Model has been built. 4. Success can be marked in case of a combination of: a. Effective exposure of the Ra-Dec position is more than X% of the allocated time (TBD). b. More than Y% of the allocated array took good quality data in the direction of the target (TBD). *Note, for SI3, X=80%, y=66%*

4.11. ASTRI-UC-0-090: Perform Cherenkov data reduction and analysis

Summary and Scope: The **ASTRI MA System** (automatically or manually) runs the ASTRI **Data Processing System** (including *A-SciSoft* [RD2]) for the reduction and analysis of the Cherenkov raw data, calibration and monitoring data acquired during the observations, producing science-ready data (event lists and observation-related IRFs), data-filtering tables (GTI), and data quality reports.

Two levels of data processing levels are foreseen: a short-term standard analysis processing (Level-B analysis pipeline), to be run at the end of each Run, and the long-term standard analysis processing (Level-C analysis pipeline).

The short-term Level-B analysis pipeline makes use of pre-computed calibration factors and coarse LUTs/IRFs, and runs up to the production of preliminary science results. The long-term Level-C analysis pipeline produces consolidated science-ready data and IRFs, intended for final analysis and publication of results (ASTRI-UC-0-110).

The short-term analysis shall be performed off-site to the Data Center, in an automated way. The analysis shall start as soon as the scientific data have been transferred and archived into the off-site permanent Archive. Only during the SVP phase, it is foreseen to run it manually onsite, to immediately check run consistency and the expected technical and scientific performance requested during the Cherenkov observations. The long-term analysis instead shall always run off-site at the ASTRI Data Center.

Both processes can run an automated mid/long-term data quality check and instrument monitoring after the observations.

The **ASTRI MA System** will also run the ASTRI Software to reduce and analyse Monte Carlo simulation data (simulation processing) in order to generate LUTs and IRFs used in the real data processing (ASTRI-UC-0-100: Provide Look-Up-Tables and Instrument Response Functions).

Authors: F. Lucarelli, S. Lombardi

Version: 1.0

Trigger:
Short-term standard analysis (Level-B):
- Raw data acquired for a single Run are transferred and archived in the ASTRI **Bulk Archive**.

Long-term standard analysis (Level-C):
- Raw data for an entire SB (or more than one SB correspondent to the same OP), acquired during the same observation night, are transferred and archived into the ASTRI **Bulk Archive**.
- A recalibration of ASTRI raw data takes place.

Frequency:
- Short-term analysis (Level-B): whenever a new Run is available.
- Long-term analysis (Level-C):
    - For each new SB available or next-day.
    - As often as a reprocessing is required.

Phase: This use case covers the SVP and the production phases.

Assumptions:

PRE-CONDITION CONSTRAINTS
• Short-term standard analysis (Level-B):   ○ the execution of a Run has finished (ASTRI-UC-0-070) and raw data have been transferred and archived in the ASTRI **Bulk Archive** (ASTRI-UC-0-200: Archive data).

- Atmosphere characterisation and environmental status data obtained at the beginning of the night or during the observations (ASTRI-UC-0-030, ASTRI-UC-0-035) are available to the **Archive**.
- The required calibration factors and LUTs/IRFs have been pre-computed and stored as service data (SVC) in the **CALDB** (ASTRI-UC-0-100).

- Final standard analysis (Level-C):
  - Raw data for an entire SB (or more than one SB correspondent to the same OP), acquired during the same observation night, are transferred and archived in the ASTRI **Bulk Archive** (ASTRI-UC-0-200).
  - Calibration, atmosphere characterisation and environmental status data obtained at the beginning of the night or during the observations (ASTRI-UC-0-030, ASTRI-UC-0-035) are available to the **Archive**.
  - LUTs/IRFs have been pre-computed and stored as service data (SVC) in the **CALDB** (ASTRI-UC-0-100).

For both processing levels:
1. enough computing power and storage capacity are available.
2. The ASTRI **Data Processing System** software (*A-SciSoft*) is installed and running.
3. Raw data is easily accessible to the **Data Processing System**.

SCENARIOS

Basic Path. Short-term (as soon as a Run is available during the observation night)

1. Raw data from a Run are automatically transferred off-site, as soon as a Run is finished, and archived in the ASTRI **Bulk data Archive**.

   Alternate: *1a*, Configuration during SVP (See details below). Rejoins Main Scenario at End.

2. **The ADAS** executes the **camera pre-processing**: raw binary data are transformed into FITS files

3. The **Stereo Event Builder** applies a software stereo trigger before the execution of the data processing.

4. The **Data Processing System** collects all the necessary configuration data, calibration factors, pre-computed LUTs and IRFs, as well as the monitoring data needed for processing the raw data of the Run (from e.g. the Science Data Model).

5. Raw data are reduced and analysed, and the following data products are generated:
   a. Reconstructed and tagged event lists and other high-level data products (on a run-basis) ready for use in preliminary Science Analysis.
   b. Data processing reports.
   c. Error notifications (if any), including alarms for errors occurred during the data processing.

   Exception: *4a*, *Error during the data processing* (See details below). Rejoins Main Scenario.

6. Automated scientific analysis, using predefined configurations and IRFs, is executed to generate preliminary science products (ASTRI-UC-0-120).

7. Preliminary science-ready data and science products are stored permanently in the **Science Archive** (ASTRI-UC-0-200).

8. The **Science Gateway** displays the results to the **Operator** and the **Astronomer on-duty**, in a compact and comprehensible way (ASTRI-UC-0-110).

9. Eventually, a science alert is manually generated in case a significant transient source is detected.

10. By the next-day, the **Data Processing Manager** checks eventual errors and takes appropriate action to restore the proper data processing execution.

Basic Path. Long-term (as soon as an entire SB is available during the observation night or next-day)

1. Raw data from a Scheduling Block are transferred off-site to the ASTRI **Bulk Archive**.

2. The **Data Processing System** collects calibration data from the beginning/end of the night, as well as all the necessary configuration data, pre-computed LUTs and IRFs, and monitoring data needed for processing the raw data of the SB (the Science Data Model).

3. Raw data are reduced and analysed, and the following data products are generated:
    a. Telescope calibration products: a) Camera Calibration products; and b) If available, Array Calibration products (ASTRI-UC-0-050, ASTRI-UC-0-051).
    b. Reconstructed and tagged event lists and Observation-related IRFs (on a daily basis) (ASTRI-UC-0-100) ready for use in the Science Analysis.
    c. Data processing reports.
    d. Error notifications (if any), including alarms for errors occurred during the data processing.
    e. Reports of data quality, including good time interval (GTI) data, and instrument monitoring information on a daily and longer term basis.

    Exception: *3a*, *Error during the data processing* (See details below). Rejoins Main Scenario.

4. Automated scientific analysis, using the best available MC simulations, calibrations and the final specific IRFs, is executed to generate ASTRI MA System science products to be delivered to the **Science User** (ASTRI-UC-0-120 and ASTRI-UC-0-110).

5. The calibration coefficients or their interpolation and extrapolation algorithms are updated whenever applicable.

6. Science-ready data products and **MA System** science products are stored in the **Science Archive** (ASTRI-UC-0-200).

7. Status information about availability of data release must be provided to the **Science User.**
8. By the next-day, the **Data Processing Manager** checks eventual errors and takes appropriate action to restore the proper data processing execution.

Alternative. Configuration during SVP

1. During the SVP, the ASTRI software can be manually run onsite.

Exception. *Error during the data processing* (See details below). Rejoins Main Scenario.

1. Error notifications (if any), including alarms for errors occurred during the data processing, are notified to the **Data Processing Manager**.

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

The **Data Processing Manager**, the **Operator**, and the **Astronomer on-duty (AoD)** are informed of possible errors during the execution of the data reduction and analysis.

SUCCESS GUARANTEE

Both data processing levels (B and C) have been carried out and science-ready data products and MA System science products have been stored in the **Science Archive**.

4.12. ASTRI-UC-0-100: Provide Look-Up-Tables and Instrument Response Functions

Summary and Scope: Look-Up-Tables (LUTs) and instrument response functions (IRFs) derived from Monte Carlo simulations of Cherenkov data are produced for the data reduction and analysis processing. LUTs are used during the data processing for event classification as well as energy and arrival estimation, both at single-telescope and array level. IRFs are required for the transformation of MA scientific data products (e.g. array-wise event lists, and instrument, environmental and atmosphere characterisation information) to MA science products (e.g. sky maps, light curves, spectral distributions). For all the scientific use cases related to gamma-ray astronomy, the required IRFs typically include: a) the effective areas vs true and reconstructed energy; b) the energy dispersion matrix; c) the gamma-ray point-spread function vs energy; d) a model for the distribution of background events vs reconstructed energy and direction. LUTs and IRFs are provided with an explicit time dependency or for a period of stable observing conditions. All IRFs contain details of associated statistical and systematic uncertainties. This use case includes both period-wise and time-averaged IRFs.

Authors: F. Lucarelli, S. Lombardi

Version: 1.0

Trigger:

Frequency: After every observation night and after each major software release of the MA Data Processing System for the Monte Carlo data reduction.

Phase: This use case covers the SVP and the production phase.

Assumptions:

PRE-CONDITION CONSTRAINTS

1. The **Data Processing System** software (*A-SciSoft*) is installed, configured and running.
2. For the generation of LUTs and global IRFs:
    a. A full MC production of simulated Cherenkov and calibration events have been produced by the **Simulation System** and archived in the **Simulation Archive**.
3. For the generation of high-level observation-related IRFs:
    a. A full MC production of simulated Cherenkov and calibration events have been produced by the **Simulation System** and archived into the **Simulation Archive**.
    b. The produced MC scientific data events are reduced and analysed with the **Data Processing System** and global period-wise IRFs are calculated, validated, and archived into the **CALDB**.
    c. Raw data from a particular set of SBs (i.e., all the SBs belonging to the same Observing Project acquired during the same night) are archived and reduced (ASTRI-UC-0-090).

SCENARIOS

Basic Path. LUTs generation

1. The **MA Science Team** issues a request for a set of telescope-wise and array-wise look-up-tables (LUTs):
    a. required for the data reduction and analysis of every observation.
2. Using a set of simulated gamma-ray data and real or simulated background data, the **Data Processing** System software applies a machine learning algorithm for the calculation of suitable telescope- and array-wise look-up-tables for gamma/hadron classification, energy reconstruction, and event arrival direction estimation.

3. The generated LUTs are archived with version and validity period in the **CALDB**, ready to be used by the **Data Processing System**.

Basic Path. IRFs generation

1. The **MA Science Team** issues a request for a set of instrument response functions (IRFs):
   a. required for the data analysis of a particular set of observations (i.e., the SBs belonging to the same OP acquired during the same observation night);
   b. for a well defined observing mode and instrument configuration.
2. The **Data Processing System** software queries the **CALDB** for the availability of global IRFs:
   a. The query to CALDB was successful. The **Cherenkov Data Selection** module of the DPS generates high-level observation-related IRFs, in the defined standard formats, from the global IRFs. Skip all following points and directly go to the data release point.
   b. The query to the **CALDB** was not or only partially successful. A request for the production of global IRFs is issued in this case to the **Simulation System** and the **Data Processing System**.
3. The newly produced Observation-related IRFs, along with the high-level observation-related event list, are made available to the **Science User** through the **Science Archive** (ASTRI-UC-0-110).

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

An error report is issued describing the reasons why no LUTs and/or IRFs could be produced or provided.

SUCCESS GUARANTEE

A complete set of LUTs and IRFs with the required properties is provided. This is a precondition for ASTRI-UC-0-090 and ASTRI-UC-0-120.

4.13. ASTRI-UC-0-110: Release data

Summary and Scope: Allow a **Science User** to get high-level validated science-ready data and IRFs related to his/her Observing Project, intended for final analysis and publication of scientific results. Moreover, it provides the **Operator** and the **AoD** with preliminary science products produced by the short-term standard analysis executed during the observing run. In addition, allow an **Expert Science User** who has made a request for raw and low-level data, for well-motivated and agreed scientific and technical purposes, to get the requested data.

Authors: F. Lucarelli, S. Lombardi, S. Gallozzi

Version: 1.0

Trigger: Ingestion high-level science-ready data, IRFs and ASTRI MA system science-products, related to an accepted Observing Project, into the **Science Archive**.

Frequency: Every time that the data processing of an accepted Observing Project is considered to be complete.

Phase: Production phase.

Assumptions:

PRE-CONDITION CONSTRAINTS
The ASTRI MA System has executed the observations related to an accepted Observing Project.
SCENARIOS
Basic Path. Main Scenario 1. The ASTRI MA system produces and validates high-level science-ready data, IRFs and ASTRI MA System science-products related to an Observing Project (ASTRI-UC-0-090). 2. The ASTRI MA system archives science-ready data, IRFs and MA System science-products in the **Science Archive** (ASTRI-UC-0-200). 3. The **Science Support System** informs via mail notification the **Science User** about the availability of data. Alternate: *3a, The **Science User** connects to the **Science Gateway** using his/her user credentials.* (See details below). Rejoins Main Scenario at End. Alternate: *3b, An **Expert Science User** requests for raw and low-level data.* Exception: *3a, The **Science User** lost the email notification.* (See details below). Rejoins Main Scenario at End. Exception: *3b, The **Science User** lost his/her **Science Gateway** access credentials.* (See details below). Rejoins Main Scenario at End. 4. The **Science User** downloads the validated high-level data from the **Science Gateway** web pages. **Basic Path. During the observation night.** 1. During observations, the **Science Support System** provides the **Operator** and the **AoD** with preliminary high-level science products produced by the short-term standard analysis (UC-MA-090: Perform data reduction and analysis). These preliminary products shall be retrieved through the ***Science Gateway***.

Alternate. *The **Science User** connects to the **Science Gateway** using his/her user credentials.* 1. The **Science User** selects for the download of all data related to his/her Observing Project.
Alternate. *An Expert Science User requests for raw and low-level data* 1. **Expert Science User's** requests for raw and low-level data are made directly to the **Archive**. Such access should be granted only in some specific cases, for well-motivated and agreed scientific and technical purposes, like the development of new calibration and reconstruction algorithms. 2. No high-level scientific products derived from these raw and/or low level data shall be considered validated from the **MA Science Team** unless produced with the official data reduction and analysis tools provided by the **Data Processing System** and approved by the **Data Processing Manager**.
Exception. *The **Science User** lost the email notification.* 1. The **Science User** contacts the ASTRI MA Science Team to retrieve a copy of the email notification.
Exception. *The **Science User** lost his/her **Science Gateway** access credentials.* 1. The **Science User** requests new user credentials from the **Science Gateway**.
POST CONDITION CONSTRAINT
MINIMAL GUARANTEE
SUCCESS GUARANTEE
Data are downloaded and analysed by the **Science User**. The **Science User** gets validated high-level science-ready data, IRFs and ASTRI MA System science-products related to his/her Observing Project. This is a precondition for: ASTRI-UC-0-120).

4.14. ASTRI-UC-0-115: Provide scientific analysis S/W

Summary and Scope: The **MA Science Team** provides suitable software instruments (the **Science Tools**) used to perform the scientific analysis of the ASTRI MA high-level science-ready data produced during the execution of an Observing Project. **Science Tools** are used by a **Science User** to produce detection plots, images, light-curves and/or spectra of gamma-ray sources (ASTRI-UC-0-120). They can also be used by an **Expert Science User** to assess the ASTRI MA scientific performance. The **Science Tools** can be downloaded from the **Science Gateway**.

Authors: F. Lucarelli, S. Lombardi

Version: 1.0

Trigger:

Frequency: Each major software release of the **Science Tools** for the high-level scientific analysis of the data.

Phase: Production phase.

Assumptions:

PRE-CONDITION CONSTRAINTS
High-level ASTRI MA science-ready data products (event lists, observation-related IRFs, GTI) have been produced in agreement with the data format and content commonly accepted within the imaging Cherenkov gamma-ray astronomy community (ASTRI-UC-0-090).
SCENARIOS
Basic Path. 1. The **MA Science Team** develops and validates *in-house* software tools (the **Science Tools**) for the scientific analysis of the high-level ASTRI MA data. Alternate: *1a*, ***Science Tools** package already developed for the analysis of imaging Cherenkov data can be used for the analysis of the ASTRI MA high-level data.* (See details below). Rejoins Main Scenario at End. 2. The **MA Science Team** validates the **Science Tools** using real and simulated data generated by Monte Carlo simulations (ASTRI-UC-0-120). 3. The **MA Science Team** releases a stable version of the **Science Tools** through the **Science Gateway**. 4. The **Science User** downloads the **Science Tools** from the **Science Gateway** web pages and installs the software on his local computing infrastructure. Alternate: *4a*, *Known **Science Tools** package (ctools* [RD4]*, gammapy* [RD5]*) can be downloaded from their respective home repositories.* (See details below). Rejoins Main Scenario at End. Exception: *4a*, *Problems with the **Science Tools** download and installation.* (See details below). Rejoins Main Scenario at End.

Alternate. The Science Tools package already developed for the analysis of imaging Cherenkov data can be used for the analysis of the ASTRI MA data. 1. **Science Tools** like the *ctools* package [RD4] or the *gammapy* software libraries [RD5] can be used to analyse the high-level data produced by the ASTRI MA system.
Alternate. Known Science Tools package (ctools, gammapy) can be downloaded from their respective home repository. 1. *ctools* package and the *gammapy* software libraries can be downloaded from their respective home repository [RD4, RD5].
Exception. Problems with the Science Tools downloading and installation. 1. The **Science User** requests support to the **Archive Manager** and the **Archive Scientist** for problems with the download and s/w installation.
POST CONDITION CONSTRAINT
MINIMAL GUARANTEE
SUCCESS GUARANTEE
The **Science User** has suitable s/w instruments to perform the scientific analysis of the high-level science-ready data related to his/her Observing Project. This is a precondition for: ASTRI-UC-0-120).

4.15. ASTRI-UC-0-120: Perform a scientific analysis

Summary and Scope: The main goal of this Use Case is to extract science results from high-level ASTRI scientific data. The Science Tools will operate on science-ready calibrated and background subtracted event-lists (ASTRI-UC-0-090), and will make use of high-level Instrument Response Functions (ASTRI-UC-0-100), that describe the response of the ASTRI MA over the relevant period of time, and of monitoring data, such as, e.g., pointing information. The main functionalities of the software will cover science products, i.e. generation of sky images, extraction of source spectra, and determination of light curves. The adjustment of parametric source models to the data will also be possible.

Authors: F. Lucarelli, S. Lombardi

Version: 1.0

Trigger:
- Automatically, by the ASTRI MA Data Processing System, whenever an acquisition Run (or list of runs) is archived and reduced up to the production of science-ready event-list data by the *short*- or *long-term* Cherenkov data processing.
- Manually, by the **Science User**, whenever a new data release has become available to the **Science Archive** and downloaded locally.

Frequency: For every science analysis.

Phase: This use case covers the production phase.

Assumptions:

PRE-CONDITION CONSTRAINTS
1. ASTRI science-ready data products (event-lists, observation-related IRFs, GTIs) have been produced and archived into the **Science Archive**. 2. The **Science User** has been informed of the new data release and has locally downloaded the relevant data from the **Science Gateway** provided by the Science Archive (ASTRI-UC-0-110). 3. The **Science User** has locally installed the scientific analysis S/W provided by the **MA Science Team** (ASTRI-UC-0-115).
SCENARIOS

Basic Path. Main Scenario

1. The **Science User** defines the subset of data that he/she wants to analyse from all the data he/she has locally downloaded on disk.
2. The **Science User** selects the data space region of interest that he/she wants to analyse. The selection of the events is based on a variety of filters (GTI, arrival direction selections, event cuts, or any other criterion that relates to the instrument configuration or atmosphere characterisation).
3. All **Science Users** operations are launched either from the command line of a PC terminal or via user-defined scripts. The **Science User** then:
    a. produces an image;
    b. produces a source spectrum;
    c. produces a light curve (eventually folded by pulse period or orbital period);
    d. defines a parametric model and fits that model to the data. The **Science User** may add any additional multiwavelength (MWL) data in this step to constrain the parametric model. Access to additional MWL data might be through services and VO Tools provided by the ASTRI MA **Science Gateway**;
    e. determines the expected MA performance (for **Expert Science User**).

    Alternate: *3a*, *An automated science analysis will be integrated into the ASTRI MA Data Processing Software* (See details below). Rejoins Main Scenario at End.

    Alternate: *3b The Science User may configure and launch the scientific analysis through a remote web service hosted by the **Science Gateway**.*

    Exception: *3a*, *Raise exceptions* (See details below). Rejoins Main Scenario at End.

Exception. Raise exceptions

1. The **Science Tools** software may raise exceptions at any analysis step in case it cannot interpret correctly any input parameter or data provided, or if the processing of a certain analysis step fails. The **Science User** should correct his/her analysis workflow and re-execute the **Science Tools** software until no exception will be raised anymore. In case that the **Science User** does not succeed to build a workflow without exceptions, he/she may contact the **MA Science Team**.

Alternate. An automated science analysis will be integrated into the ASTRI MA Data Processing Software System

1. An automated science analysis will be integrated into the ASTRI software *short*- and *long-term* Cherenkov data analysis pipelines (ASTRI-UC-0-090). The standard scientific analysis will be executed on the high-level science-ready data products (event-lists and IRFs) to produce standard images, spectra and light curves (science products). The results of the short-term pipeline will be displayed during the observations to the **Operator** and **Astronomer on-duty**. The science products produced at the end of the long-term pipeline will be delivered to the **Science User**, along with the data release. Both pipeline products will be ingested into the ASTRI **Science Archive**.

Alternate. The Science User may configure and launch the scientific analysis through a remote web service hosted by the Science Gateway

This is a service that may be developed and implemented in the years immediately after the experiment phase, in case the collaboration also opens the observations to external Guest Observers.

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

During the Observation campaign, the **Science User** has a detection plot and a sky image to evaluate the ongoing observation on a daily-basis.
SUCCESS GUARANTEE
At the end of the Observation campaign, the **Science User** has final scientific results (sky images, spectra, light curves, model fit results, or flux upper limits estimate) ready for science publications.

4.16. ASTRI-UC-0-200: Archive data

Summary and Scope: This Use Case is common to several ASTRI MA Top Level Use Cases. The ASTRI MA System archives data, data products and science products at each step of the observation workflow. Moreover, the ASTRI MA System archives data and data products from Monte Carlo simulations.

Authors: F. Lucarelli, S. Gallozzi

Version: 1.0

Trigger:

Frequency: Every execution of an observation or a special technical data acquisition, calibration or maintenance Observing Projects. Every online and offline data processing. Every generation of Monte Carlo events and Monte Carlo data products (IRFs).

Phase: This use case covers the SVP and the production phase.

Assumptions:

PRE-CONDITION CONSTRAINTS
1. The Archive System is up and running. 2. The ASTRI Software is configured and ready to store data and ingest metadata in the ASTRI data **Archive**. 3. The ASTRI MA System is ready for SVP or for nominal observations and engineering Observing Projects.
SCENARIOS
<u>**Basic Path.**</u> 1. The **Science Support System** archives all the submitted Observing Projects, ready for reviews. Exception: *1a*, *Problems with the proposal archiving.* (See details below). Rejoins Main Scenario at End. 2. The **Science Support System** archives all the information needed to execute the *long-term observation plan*, and *short-term observation plans* (Targets, Scheduling Blocks, ...). Exception: *2a*, *Problems with the observation plans.* (See details below). Rejoins Main Scenario at End. 3. The **SCADA System** provides: ● scientific raw data generated during an observation; ● environmental, atmosphere characterisation and instrument monitoring data (ASTRI-UC-0-025, ASTRI-UC-0-030, ASTRI-UC-0-035); ● array calibrations data (ASTRI-UC-0-050, ASTRI-UC-0-051); ● log and alarm reports. ● reports and data products related to the status of the ongoing observation (ASTRI-UC-0-060). 4. The **Data Processing System** provides: ● the stereo trigger files generated by the Stereo Event Builder; ● data, data products, and data quality reports produced by the *short-term* and *long-term* Cherenkov data analysis pipelines (ASTRI-UC-0-090); ● data, data products, and data quality reports produced by the intensity interferometry data pipeline. ● science data products produced in an automated way (ASTRI-UC-0-120); ● instrument and auxiliary devices monitoring reports on a mid- and long-term basis (TBD).

- log and alarm reports about system execution.

6. The **Simulation System** archives simulated Cherenkov events generated using Monte Carlo methods.

7. The **Data Processing System** archives data and data products (LUTs and IRFs), needed for data reduction and analysis, generated from the analysis of the Monte Carlo simulations (ASTRI-UC-0-100).

6. The **Archive Manager** verifies the successful data archiving and the related metadata ingestion, and it guarantees as well the **Archive System** integrity and long-term preservation of the ASTRI data, data products and science products.

Exception: *6a*, *Problems with data, data products and science products archiving.* (See details below). Rejoins Main Scenario at End.
Exception: *6b*, *Problems with data, data products and science products integrity.* (See details below). Rejoins Main Scenario at End.
Exception: *6c*, *Problems with metadata ingestion.* (See details below). Rejoins Main Scenario at End.

Exception. *Problems with the proposal archiving.*

1. If something goes wrong with the Observing Project archiving, the **Science Support System** informs the **Archive Manager** and the **Science User** submitting the OP.

Exception. *Problems with the observation plans.*

1. If something goes wrong with the short-term and long-term observation plan archiving, the **Science Support System** informs the **Support Astronomer**.

Exception. *Problems with data, data products and science products archiving.*

1. The **Data Processing System** informs the **Archive Manager** and the **Archive Scientist** whenever data, data products and science products, produced during the reduction and analysis of scientific data, are not properly archived.

Exception. *Problems with data, data products and science products integrity.*

1. The **Archive System** informs the **Archive Manager** and the **Archive Scientist** whenever data, data products and science products integrity is not satisfied.

Exception. *Problems with metadata ingestion.*

1. The **Archive System** informs the **Archive Manager** and the **Archive Scientist** whenever metadata ingestion is not successful.

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

An alarm is issued describing the reasons why archiving of data and/or ingestion of related metadata failed. An alarm is also issued describing the reasons why archive integrity was compromised or lost.

SUCCESS GUARANTEE

All data and metadata related to an Observing Project are permanently archived.
Observing Project proposals and observation schedules; Cherenkov and SI^3 data, monitoring data, calibration data, log and alarm data, quality data, data products, and science products generated during the execution of an Observing Project, as well as Monte Carlo simulations and Monte Carlo products produced before the OP

execution, are successfully archived. Moreover metadata and information describing all the above data and data products are properly ingested. This is a precondition for: ASTRI-UC-0-070; ASTRI-UC-0-090; ASTRI-UC-0-100; ASTRI-UC-0-110; ASTRI-UC-0-120.

5. Appendix A: use case template

5.1. ASTRI-UC-0-0XX: Title

Summary and Scope:

Authors:

Version: 1.0

Trigger:

Frequency: Many times

Phase:

Assumptions:

PRE-CONDITION CONSTRAINTS

The ASTRI MA System is ready for SVP or for nominal observations and engineering runs.

SCENARIOS

Basic Path.

1. The **Science User** submits a **Project**. The Science User specifies the Observing Strategy

Note: The MA System checks if the Project/Observing Project is technically feasible, if there are errors in the submitted information.

Exception: *2a*, *Exception path short title* (See details below). Rejoins Main Scenario at End.
Alternate: *2a*, *Alternate path short title* (See details below). Rejoins Main Scenario at End.

Short title of the step

2. The **MA System** performs something

Exception. *Exception path short title*

1. The **MA System** perform the corrective action X

Alternate. *Alternate path short title*

1. The **MA System** perform this action

POST CONDITION CONSTRAINT

MINIMAL GUARANTEE

SUCCESS GUARANTEE
OPEN POINTS
Open points for discussion and to produce a new version of the Use Case.

system
data
observation
astri
science
exception
control
observing
operator
environmental
monitoring
scenario
problems
analysis
scientific
calibration
atmosphere
conditions
central
alarm
archive
rejoins
details
main
user
processing
products
phase
blocks
astronomer
archived
results
basic
night
level
telescope
observations
scheduling
condition
camera
automated
alternate
support
lidar
target
long
errors
short
quality
check
cherenkov
alarms
related
checks
high
ready
guarantee
execution
pointing
version
uvsipm
team
case
path
hmi
block
run
env
tools
scada
software
array
plan
project
perform
term
status
site
event
irfs
sb