CTA Data Management Quick-Look and Real-Time (On-Site) Analysis Detailed User Requirement Document

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List of Abbreviations			
RTA	Real-Time Analysis	GO	Guest Observer
SAM	Science Alert Monitoring	GUI	Graphical User Interface
SAG	Science Alert Generation	SPM	Science Performance Monitoring
SM	Science Monitoring	FOV	Filed of View

History		
Version	Date	Observation
0.1	2012-04-16	First issue
0.2	2012-05-02	Some modification and new document layout
0.3	2012-07-20	New version after the RTA EVO Progress Meeting 2 (2012-05-08), Amsterdam General meeting (14-18/5/2012) and comments from Massimo Trifoglio, Gino Tosti, Jose Luis Contreras, Karl Kosack, Phil Evans, Gernot Maier, Saverio Lombardi and many others. Added the "delayed analysis" concept, a more strong division in sub-units. Added a glossary of terms.
0.4	2012-10-10	New version including comments from Gernot Maier, Phil Evans, Alejandro Lorca, Jose Luis Contreras. Added new introduction, use case details, flow of events, test procedures, traceability matrices between use cases and user requirements
0.5	2012-11-14	Traceability matrix between High Level and RTA Use Cases (TBD) Comments to DM URD Comments from Jose Luis Contreras Some changes to fit the science monitoring into PBS products

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1. INTRODUCTION

In the context of DM WP of the CTA observatory a Detailed User Requirement document (URD) for the CTA Data Management Quick-Look and Real-Time Analysis [R1] (called **Science Monitoring subsystems)** has been proposed [R4].

1.1 Purpose of the document

This document addresses the detailed user requirements for the Science Monitoring subsystem of the CTA observatory.
The purpose of this document is to serve as a tool to gather the user requirements that will drive the development of software of this subsystem. In addition, it could be used as a guide to select and re-use existing software, to be identified at a later stage.
The use cases are classified in two levels: user and sub-function. The use cases at user level are use cases of the system that are connected directly with user action; the use cases at sub-function level are use cases at system level that are part of a most general use case at user level: they are put in evidence to better understand the use of the system and the classification of requirements.
For some use cases the flow of events and related test procedure are reported. Tables with links between use cases and functional requirements are reported.
It is important to indicate that the requirements in this document are just aimed at the software development process. This document describes what the software should be able to do but not how it will be implemented; this is the aim of the software requirement document. Instrumental characteristics and observatory performance requirements are analysed in the Performance Requirements document [R3] and will not be considered here.
The general requirements of the DM WP are reported in [R4].

1.2 Scope of the software

The scope of this subsystem is related to the activities and products of the DM work package, as defined in the Product Breakdown Structure [R1] of the project.

From [R1], the Real-Time Analysis aims are the following:

- 2.1 **Quick-look (on-site analysis):** on-site reconstruction pipeline software aimed to be a reduced and fast version of the off-site reconstruction aiming to a **scientific quality assessment** (by quick look) of the scheduled observations.
- 2.3 **Real-time analysis:** software components for **quick alerts follow-up** and assess and distribute a notification of a VHE alert (i.e. a “flaring” event).

Both are on-site analysis. The overall system is called Science Monitoring system.

1.3 Definitions, acronyms and abbreviations

To better clarify the content of this document, a glossary of terms is present in this section.

1.4 Reference documents

R1: “CTA-DATA MANAGEMET PBS & WBS”, OPS.1.2011, V13, 5/6/2012

R2: “CTA Operational Concept”, C. Farnier, R. Walter, S. Schlenstedt. 11 July 2011

R3: “Level A: Preliminary CTA System Performance Requirements”, G. Hermann et al. TPC-SPECS/110331a, 7 June 2011

R4: "CTA Data Management User Requirement Document", J.D. Ponz, R. Walter, Edition 0.5, 2012-05-10

R5: “Science requirements and expectations of the Cherenkov Telescope Array (CTA)”, D.F.Torres et al., April / June 2012,

R6: “Guide to applying the ESA software engineering standards to small software projects
”, BSSC(96)2 Issue 1 May 1996

1.5 Overview of the document

In Section 2 we report the general description of the system, without the specification of requirements.
In Section 3 we report the use cases and the capability requirement of the system. A matrix of use cases versus requirements is reported.
In Section 4 we report the constraint requirements.
In Appendix we report the use case details, flow of event and test procedures of use cases reported in Section 3.

2. GENERAL DESCRIPTION

This chapter describes the general factors that affect the product and its requirements. This chapter does not state specific requirements but makes those requirements easier to understand.

The main purpose of the RTA sub-WP is to design a system (**Science Monitoring**) that realizes a first scientific analysis of CTA data in order to

(i) check the **performance of current observation** (data quality); in the following we call this *Science Performance Monitoring (SPM) subsystem*. This corresponds with the PBS [R1] quick-look system.

(ii) detect new, transient or highly variable sources in the data and generate **self scientific alerts**; in the following we call this *Science Alert Monitoring (SAM) subsystem*. This correspond with the PBS [R1] real-time analysis.

Science Performance and Science Alert Monitoring are called **Science Monitoring.**

To detect transients or variable sources the first step of the system is to provide a fast analysis of data coming from telescopes (*data processing*). The second step is to use standard or blind search methods to detect known or serendipitous astrophysical sources in high or unexpected state. The third step of this system is to analyse the output of the data processing in order to select the best transient candidates and generate scientific alerts to provide a fast and automatic communication to CTA people and/or to an automated system and/or to astrophysical community.

To check the performance of current observation the first step of the system is to provide a fast analysis of data coming from telescopes (*data processing*). The second step is to perform standard checks of known sources with the data of current observation. At the end standard report about the current observation or alerts to science alert monitoring subsystem are generated: these alerts should stop the science alert monitoring if some problems occurs.

The first step may be the same in both sub-systems, or there may be some differences that depend on the specific objectives of two sub-system. These aspects are not covered in this document. Also the second step could share some procedures.

The Science Monitoring subsystem works with two **analysis modes (**with respect to the data processing):

a. ***on-line analysis mode***: data processing trigger-by-trigger **during telescope data acquisition**. The main purpose is the speed of analysis.
    a. **Real-time** is a constraint and means that the rate of the data reconstruction and analysis of incoming events is at the same rate of data acquisition and the results are produced within a well define time. A fast analysis with a simplified reconstruction pipeline (e.g. using a reduced set of calibration data) is performed.

b. ***delayed analysis mode***: data processing observation-by-observation with a more refined (but slow) event reconstruction methods performed **after the telescope data acquisition** (*delayed data processing*).

[NOTE FOR EXPERTS BUT OUT SIDE THE VIEW OF AN URD]
Note that this functional decomposition does not mean that will be developed a software module for each function.

Due to network constraints that affect the data transfer time the Science Monitoring subsystem is performed on-site with the telescopes (**on-site analysis**).

The Science Monitoring subsystem is important for different reasons because this subsystem is the only instrument that will enable CTA to [see R5]:

- generate real-time scientific alert to other instruments;
- provide real-time feedbacks to external received alerts;
- generate CTA alerts in case of
  - GRB
  - serendipity discoveries in the FOV
  - particularly interesting state about a given source under observation, with the consequent extension of the current observation if considered appropriate
- generate intra-night-light-curves that may be essential to decide to continue the observation of the given source and/or extend the observation to the day immediately following
- monitor the quality of data taken in "real-time" for a fast reaction to problems

To better understand the importance of this analysis subsystem we must keep in mind that:

- CTA will be about a factor of 10 more sensitive than any existing instrument, opening a window to new phenomena;
- with its large detection area, CTA will resolve flaring and time-variable emission on sub-minute time scales;
- consisting of a large number of individual telescopes, CTA can be operated in a wide range of configurations, enhancing the survey capability with respect to current instruments.

For some kinds of alert (e.g. GRB) speed is crucial, and requires a system with reliable automated trigger system, that can issue alerts immediately upon detection. Human refined analysis follow only for communication to astronomical community like Astronomical Telegram.

The policy and the procedures of the CTA observatory are not well defined at time of writing: this could have a big impact on the scenarios and user requirements of the Science Monitoring subsystem. In any case the scenarios and requirements defined in this document are based on current understanding of the general context in which this software subsystem will operates (see [R1]-[R5]). There is a very important requirements of the external system that is not defined now but has a strong impact on the science monitoring requirements: the CTA observatory reacts to self triggered events by means of an operator or automatically? In this document the alerts are sent to an Array Operator that decide to change the schedule; from our point of view the Array Operator should be a human or an automated system.

The CTA observatory should react to two kinds of scientific alerts:

a. **self scientific alert**: scientific alert generated by the CTA telescope;
b. **external scientific alert**: scientific alert that comes from other telescopes (e.g. GRBs detected by other telescopes).

In both cases, the reaction to these alerts follows predefined procedures (e.g. schedule change, automatic repointing).

With scientific alerts it should be possible to change the schedule or to repoint the telescopes to follow transient events (see [R5]). In any case the schedule management and the repointing of CTA telescope are outside the purpose of the RTA sub-WP.

2.1 Product perspective

This section puts the product into perspective with other related systems.

The system has relation with the following units (see [R4] for more details) in the context of the Data Management WP:

Operations Planning – The SAM affects the planning of the telescope to react to unexpected events. With the SPM it is possible to check the result of the current observation.

Telescope Operation – The SAM could affects the telescope operations to react to unexpected events.

Data Acquisition – The products of the SAM pipeline are stored on-site using the data acquisition tools

On-site Analysis – The SPM and SAM must run on-site.

Data Reduction – Some software of the data reduction could be shared with these pipelines. For the implementation of the science monitoring a "reduce reconstruction (RECO) pipeline" (for a fast processing of the events) is foreseen. The **"reduced RECO (R-RECO)" sub-unit** is related to the reconstruction (generation of event list) and should be a subset of the standard pipeline. Two versions of R-RECO will be presents

a. R-RECO OL: reconstruction pipeline for a fast event reconstruction
b. R-RECO DEL: reconstruction pipeline with a more refined event reconstruction method

Monte Carlo Simulations **–** To configure the analysis pipeline, inputs from MC group are mandatory.

In addition, a link with the following WP is necessary: PHYS (for scientific requirements), interface with DAQ/ACTL framework should be considered.

Scheduling

This is just a note but do not affect the requirements of the real-time analysis.
Alerts generate by the real-time analysis can change the short-term schedule. The reaction to an external alert is the repointing of the array (some or all telescopes); the reaction to alerts generated by real-time science alert monitoring system will be

- continue the current observation without repointing, if the flaring source is well positioned within the FOV (within TBD degree off-axis) – see the definition of a *real-time observation*
- change the current pointing if the flaring source is positioned more than TBD degree off-axis
- reschedule the subsequent observations to follow the source for TBD hours

Based on the results of the delayed analysis, it should be possible to continue the observation also in the following night.

2.2 General capabilities

This section describes the main capabilities and why they are needed. This section describes the process to be supported by the software, indicating those parts of the process where it is used.

To better clarify the user requirements we use the following classification of some functionality that should be performed on-site and a short description of the main capabilities:

1) **Science Performance Monitoring** means processing and evaluation of the observations for a data quality check where some steps of elaboration are performed (gamma/hadron separation, energy and direction reconstruction, \theta^2 plots and sky maps generation). It checks the correct execution of the observations. The main purposes are:

a. Scientific quality assessment of the current observation
   i. When the observation is open
   ii. Final report at the end of an observation
b. Used as input to the Science Alert Monitoring to check the quality of the real-time science alerts (to avoid fake science alerts)

This subsystem generates *data quality reports and alerts.*

2) **Science Alert Monitoring**: *scientific alert* generation of unexpected event from astrophysical sources. The system produce also reports about data analysis.

3) **Engineering Performance Monitoring (including Health Monitoring)** means
   a. Check the status of the telescopes (e.g. status of the camera, voltage, temperature, weather condition, calibration parameters, pixels charge, arrival time, etc.) and related alert generation. The subsystem that generates *engineering alerts* is the **Engineering Alert Monitoring.**
   b. Used as input to the Science Alert Monitoring to check the quality of the real-time science alerts (to avoid fake science alerts)

In this context the subsystems described in this document are the Science Performance Monitoring and the Science Alert Monitoring.

The **Engineering Performance Monitoring** is outside the purpose of the RTA sub-WG, but there is a close relation between engineering performance and science performance monitoring, because many useful plots for engineering performance can be extracted after L2 or L3 phase is reached. For example: uniformity plots (of center of gravity in the camera, of core position in the array) are a clear example. It is not clear at this stage of work the boundary between two systems: more interactions with ACTL are necessary to clarify this point.

2.3 General constraint

This section describes any items that will limit the developer's options for building the software. This section is not used to impose specific requirements or specific design constraints, but should state the reasons why certain requirements or constraints exist.

The most important constraint that we need to keep into account is the alert generation in real-time and the real-time check of the data quality of current observation. It means that we perform a real-time (on-the-fly) analysis of triggers acquired from a sub-arrays or the array of CTA telescopes and immediate alert generation if some conditions occur.

The large amount of data generated by CTA can put additional constraints. Given the large amounts of data recorded by the instrument and produced by computer simulations of the experiment, substantial efforts in e-science and grid computing are envisaged to enable efficient data processing, but this approach require the data transfer from telescope sites to Science Data Center. An on-site analysis has the advantages **to save the data transfer time:** the on-site Analysis eliminates the time necessary to transmit the raw data from the Array Operation Centres to the SDC (Science Data Center), thus minimizing the reaction time. **On-site** means that the elaboration will be done in the on-site facilities (hardware and software infrastructure co-located with the telescopes) but the on-site analysis **requires additional computing hardware and infrastructure.**

In addition, the link between the Array Operation and the Science Data Center can be interrupted; we want to run CTA on days with interrupted network connected (to the outside). This means that the real-time analysis must be on-site.

2.4 Users characteristics

This section should describe those general characteristics of the users affecting the specific requirements.

The user profiles that will provide the requirements for this document are identified in the [R4]. In this context the following user profiles will participate in the science monitoring use cases:

CTA calibration scientist: member of the CTA project with privileged access to project calibration and observation data to generate and verify calibration data and data processing procedures. The calibration scientist is also responsible for the quality of the Monte Carlo software.

CTA array operator: member of the CTA project that generates the short-term schedule to operate the telescope array at each site and monitors the real-time quality of the telescope array. In addition, the array operator manages the detections generated by real-time science alert pipeline and the external triggered repointing.

CTA data processing engineer: member of the CTA project that supervises and operates the processing pipeline to calibrate the observations at each site. S/he is also responsible for the quality of the data processing software.

Guest Observer

Flare Advocate (?) *supply a first and prompt human outlook service to the scientific alerts generated by Science Monitoring and communicate basic and relevant news on the CTA sky to the external astrophysical community*

2.5 Operational environment

This section describe the real world the software is to operate in. This description is supported by a ***context diagram****, to summarize external interfaces. The nature of the exchanges with external systems is specified.*

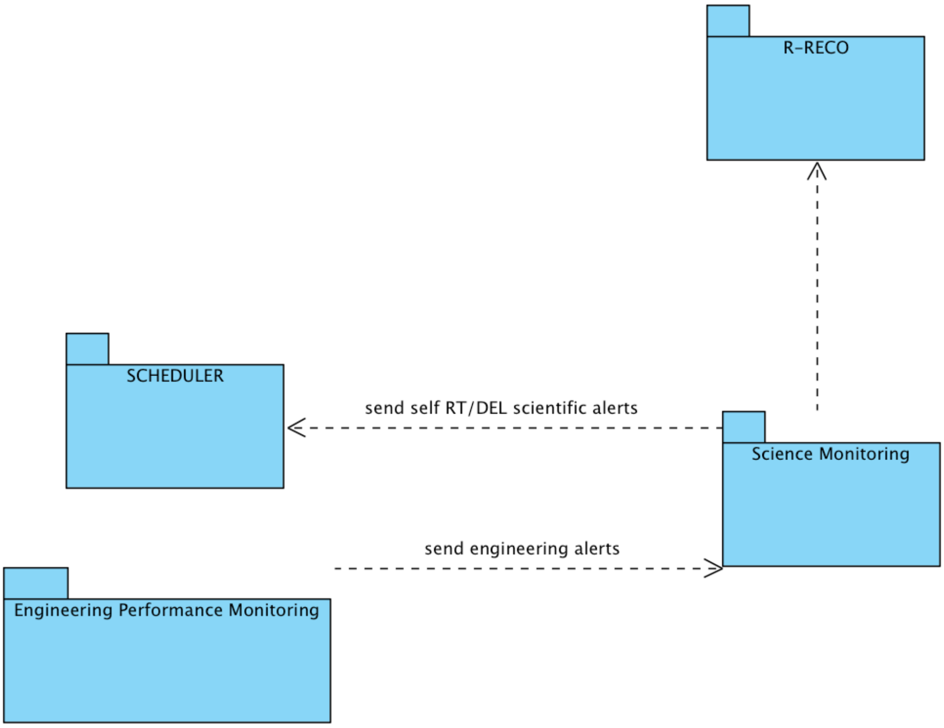


Figure 1 : Science Monitoring context diagram. The Science Monitoring interacts with the RECO subsystem optimized for a fast data analysis of the events acquired by CTA telescope to get data; the Science Monitoring also interacts with the scheduler to send scientific alerts. The Engineering Performance Monitoring also generates engineering alerts to Science Monitoring.

CTA will consist of two arrays (one in the north, one in the south) for full sky coverage; the main site will be in the southern hemisphere, to study the central region of our Galaxy. In addition each of the two arrays can operate as independent sub-arrays. The Science Monitoring analysis pipeline can work with different sub-sets of telescope arrays.

CTA will be operated as open observatory with a Science Data Centre providing access to data, analysis tools and user training. In addition, CTA should react to external alerts. The Science Monitoring analysis pipeline should be independent by ToO, user proposal or external alerts: the Science Monitoring analyzes the acquired data and generates alerts based on well-defined criteria.

3. SPECIFIC REQUIREMENTS – CAPABILITY REQUIREMENTS

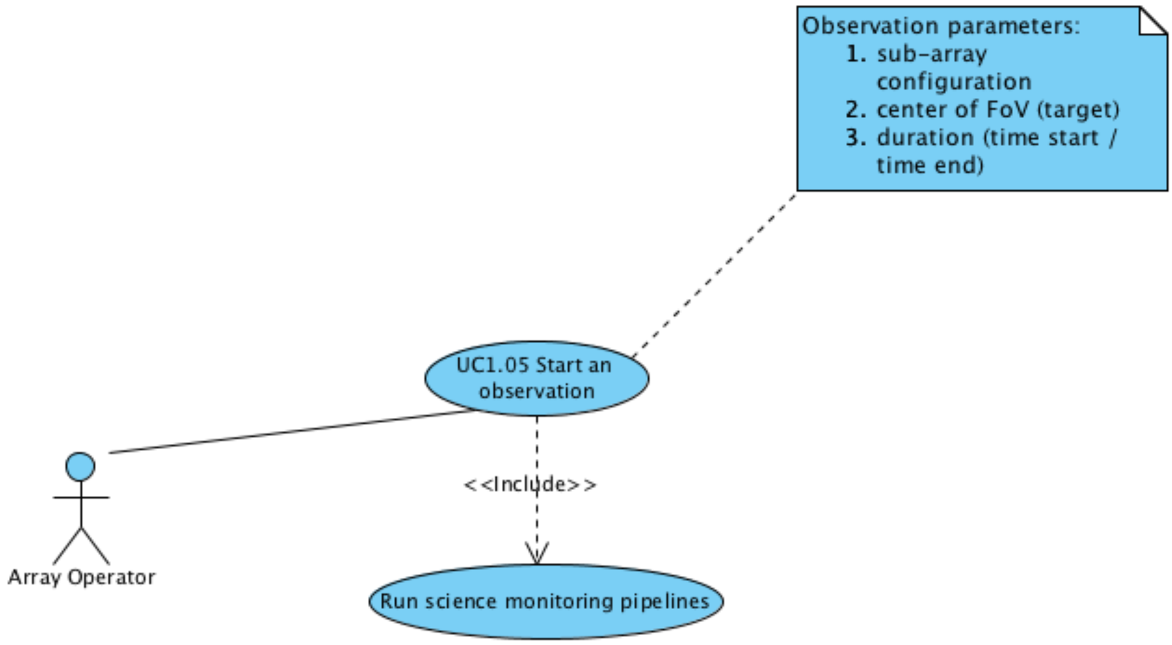
3.1 General requirements

3.1.1 Description and objectives

This section covers general requirements, applicable to the overall system. The main task of the system are: (i) the monitoring of the correct execution of the observations (science performance monitoring), (ii) the monitoring of the scientific data in order to detect high-level activity of sources and generate alerts for transient events (science alert monitoring). Both the systems are called *science monitoring systems*.

3.1.2 Use cases

D-OS-UC1.05 The **Array Operator** starts an observation. When an observation start all the science monitoring systems are launched automatically and configured according with current observation parameters (sub-array configuration, weather conditions, time start and stop of the observation, center of FOV).

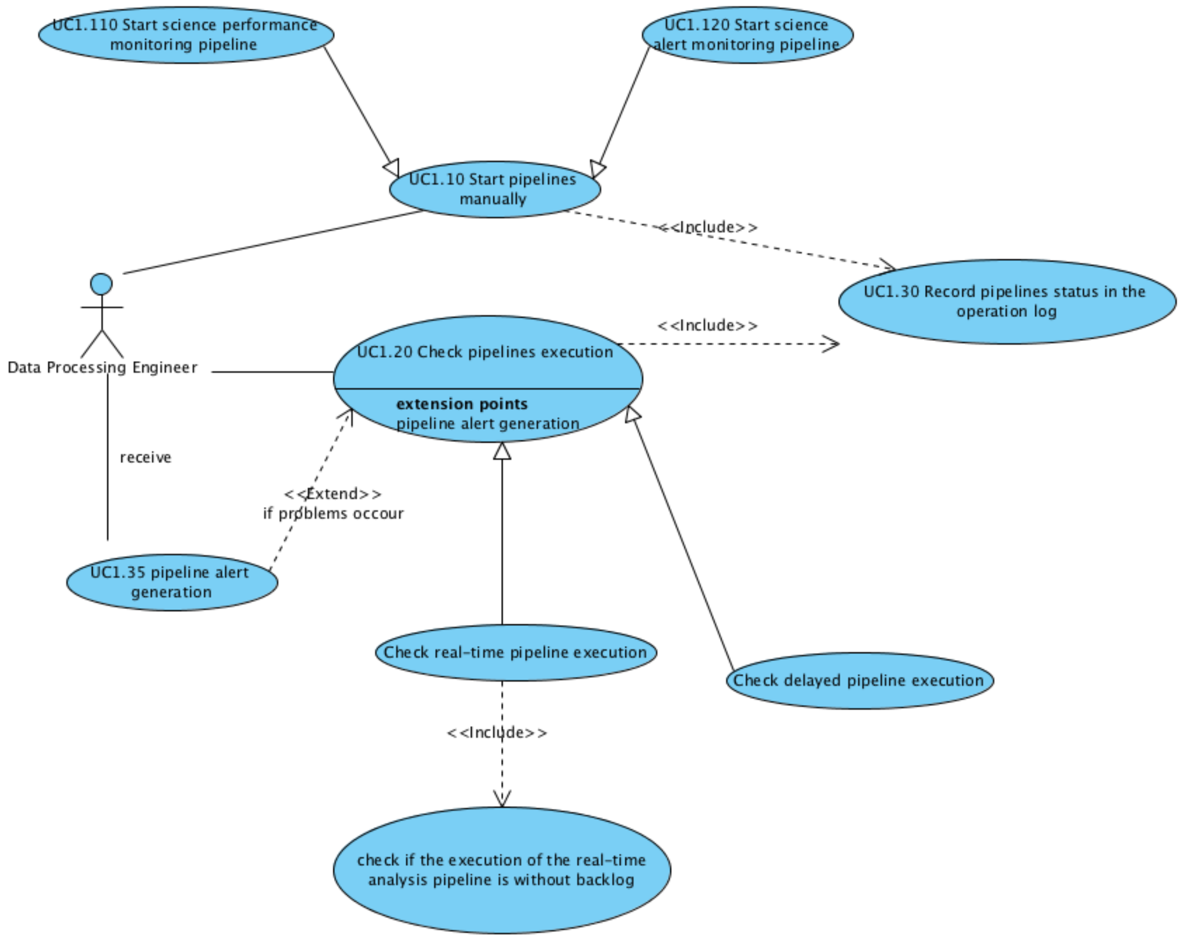


D-OS-UC1.10 The **Data Processing Engineer** starts the monitoring systems (science performance monitoring and science alert monitoring) manually when some problems occur. The monitoring systems are configured according with current observation parameters

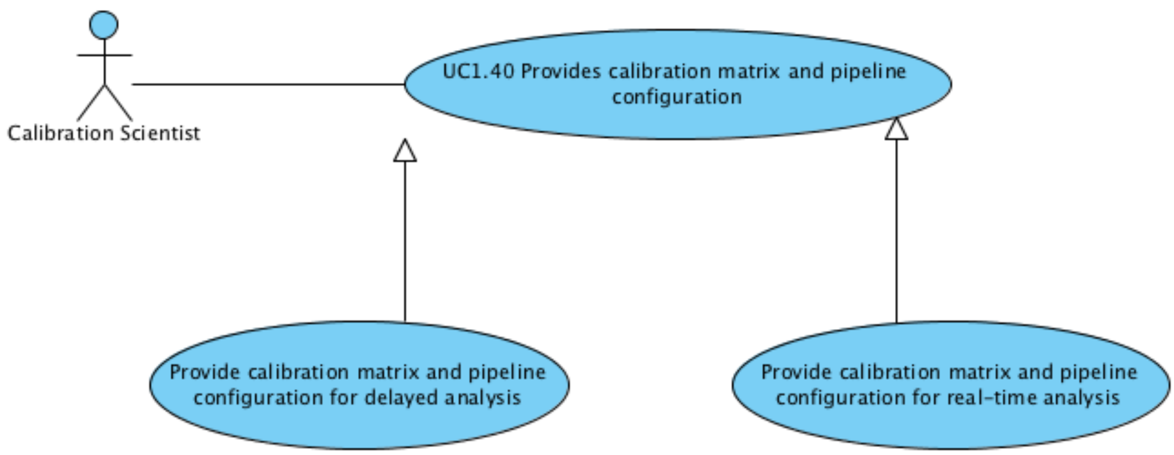
D-OS-UC1.20 The **Data Processing Engineer** check if the execution of the monitoring systems is nominal.

D-OS-UC1.30 The **Data Processing Engineer** records the status of the monitoring systems in the operations log.

D-OS-UC1.35 The **Data Processing Engineer** receive monitoring systems alerts



D-OS-UC1.40 The **Calibration Scientist** provides the last available calibration matrix for the purposes of the real-time and delayed analysis for all the foreseen sub-array configuration.



3.1.3 Requirements

D-OS-UR1.010 There are two On-site Analysis Units associated to each Telescope Array (one in the north, one in the south of the Earth) to perform data analysis and science performance and alert monitoring.
Motivated by C-DATA-8.010

D-OS-UR1.015 Each On-Site Analysis Unit runs different science monitoring systems, one for each sub-array configurations

D-OS-UR1.018 The *science monitoring system* should work in two analysis modes

1. real-time analysis mode (RT) also called real-time monitoring system
2. delayed analysis mode (DEL) also called delayed monitoring system

with different reconstruction methods (a more refined or full reconstruction method is used for the delayed analysis mode).
Motivated by C-DATA-7.030, C-DATA-8.020, C-DATA-8.040, C-DATA-8.041

D-OS-UR1.021 Each monitoring subsystems is a pipeline that automatically should generate alerts and reports.
Motivated by C-DATA-6.070, C-DATA-6.073, C-DATA-7.030, C-DATA-8.045

D-OS-UR1.025 The real-time pipelines process the data trigger-by-trigger continuously, receiving a flow of triggers from CTA telescopes. The data are processed at the same rate of the maximum allowed trigger rate of CTA for different sub-arrays configurations.
Motivated by C-DATA-7.170, C-DATA-8.041

D-OS-UR1.030 The delayed pipelines can process the data observation-by-observation, starting at the end of an observation
Motivated by C-DATA-8.040

D-OS-UR1.050 A reduced reconstruction (R-RECO) subsystem process the data from L0 (raw) to L3 (reduced event-list)

D-OS-UR1.060 The local data storage stores the last TBD months L3 data (reduced event-list) for both RT and DEL pipelines. For Science Alert System the stored L3 data are used to integrate triggers from different observations.

D-OS-UR1.070 The analysis steps should contain at least stereo reconstruction (shower core and direction) and gamma/hadron separation

D-OS-UR1.080 A GUI interface is provided to display the scientific results (reports and alerts) of all the pipelines
Motivated by C-DATA-8.040

D-OS-UR1.090 It is possible the check the status of the pipelines.

D-OS-UR1.095 The running pipelines can generate alerts when there are some problems in the execution (e.g. no calibration matrix are available for a particular array configuration, a sub-task is not running, etc).
Motivated by C-DATA-6.072

D-OS-UR1.100 The system should work with different versions of calibration matrix and configurations that should be configured and selected before the start of the pipeline. The selection depends by

1. array configuration
2. analysis mode
3. weather conditions

D-OS-UR1.110 All the pipeline operations, configurations, anomaly and alerts are stored in a log system (pipelines log system). The operator can add additional comments and notes for a particular observation.
Motivated by C-DATA-5.060

D-OS-UR1.120 A GUI interface provide access to pipeline log system and pipeline alerts
Motivated by C-DATA-5.060

D-OS-UR1.200 At the start of each observation the correct pipeline configuration is loaded automatically. If the science monitoring pipelines are not running, it is launched automatically.
Motivated by C-DATA-8.045

D-OS-UR1.300 The monitoring system is able to manage different changes in schedule due to

1. changes in short term planning due to science alerts and external triggers
2. severe anomaly due to instrument or weather conditions
3. reaction to GRB or ToO alerts

	UR1.010 There are two On-site Analysis Units associated to each Telescope Array (one in the north, one in the south of the Earth) to perform data analysis and science performance and alert	UR1.015 Each On-Site Analysis Unit should work with different sub-array configurations	UR1.021 Each monitoring subsystems is a pipeline that should generate alerts and reports automatically	UR1.018 The system should work in two analysis modes 1. real-time analysis mode (RT) 2. delayed analysis mode (DEL) with different reconstruction methods (a more refined	UR1.019 There are four monitoring subsystem running at the same time (for each array configuration) 1. Science Performance Monitoring in real-time analysis mode 2.	UR1.025 The real-time pipelines process the data trigger-by-trigger continuously, receiving a flow of triggers from CTA telescopes. The data are processed at the same rate of the maximum	UR1.030 The delayed pipelines can process the data 1. observation-by-observation, at the end of an observation 2. trigger-by-trigger, as the RT pipeline but without constraint on processing	UR1.050 A R-RECO subsystem process the data from L0 (raw) to L3 (reduced event-list)	UR1.060 The local data storage stores the last TBD days L3 data (reduced event-list) for both RT and DEL pipelines. It is not necessary to store the L0-L2C data locally. The stored L3	UR1.070 The analysis steps should contain at least stereo reconstruction (shower core and direction) and gamma/hadron separation	UR1.080 A GUI interface is provided to display the scientific results (reports and alerts) of all the pipelines
UC1.05 Start an observation	✓	✓	✓	✓	✓				✓		✓
UC1.10 Start pipelines manually											
UC1.20 Check pipelines execution											
UC1.30 Record pipelines status in the operation log											
UC1.35 pipeline alert generation											
UC1.40 Provides calibration matrix and pipeline configuration	✓	✓								✓	
UC1.110 Start science performance monitoring pipeline						✓					
UC1.120 Start science alert monitoring pipeline							✓				
UC1.200 Event reconstruction analysis								✓		✓	

	UR1.090 It is possible the check the status of the pipelines	UR1.100 The system should work with different versions of calibration matrix and configurations that should be configured and selected before the start of the pipeline. The selection depends by 1	UR1.110 All the pipeline operations, configurations, anomaly and alerts are stored in a log system (pipelines log system). The operator can add additional comments and notes	UR1.120 A GUI interface provide access to pipeline log system	UR1.200 At the start of each observation the correct pipeline configuration is loaded automatically. If the science monitoring pipeline is not running, it is launched automatically	UR1.095 The running pipelines can generate alerts when there are some problems in the execution (e.g. no calibration matrix are available, a sub-task is not running, etc)
UC1.05 Start an observation					✓	
UC1.10 Start pipelines manually						
UC1.20 Check pipelines execution	✓		✓	✓		
UC1.30 Record pipelines status in the operation log			✓	✓		
UC1.35 pipeline alert generation			✓	✓		✓
UC1.40 Provides calibration matrix and pipeline configuration		✓				
UC1.110 Start science performance monitoring pipeline						
UC1.120 Start science alert monitoring pipeline						
UC1.200 Event reconstruction analysis		✓				

3.2 Science Performance Monitoring

3.2.1 Description and objectives

The main task of the Science Performance Monitoring is to check the correct execution of the observations.

3.2.2 Use cases

D-OS-UC2.10 The **Array Operator/Flare Advocate** receive an automated *RT data quality report* to check the data quality during the observation itself.

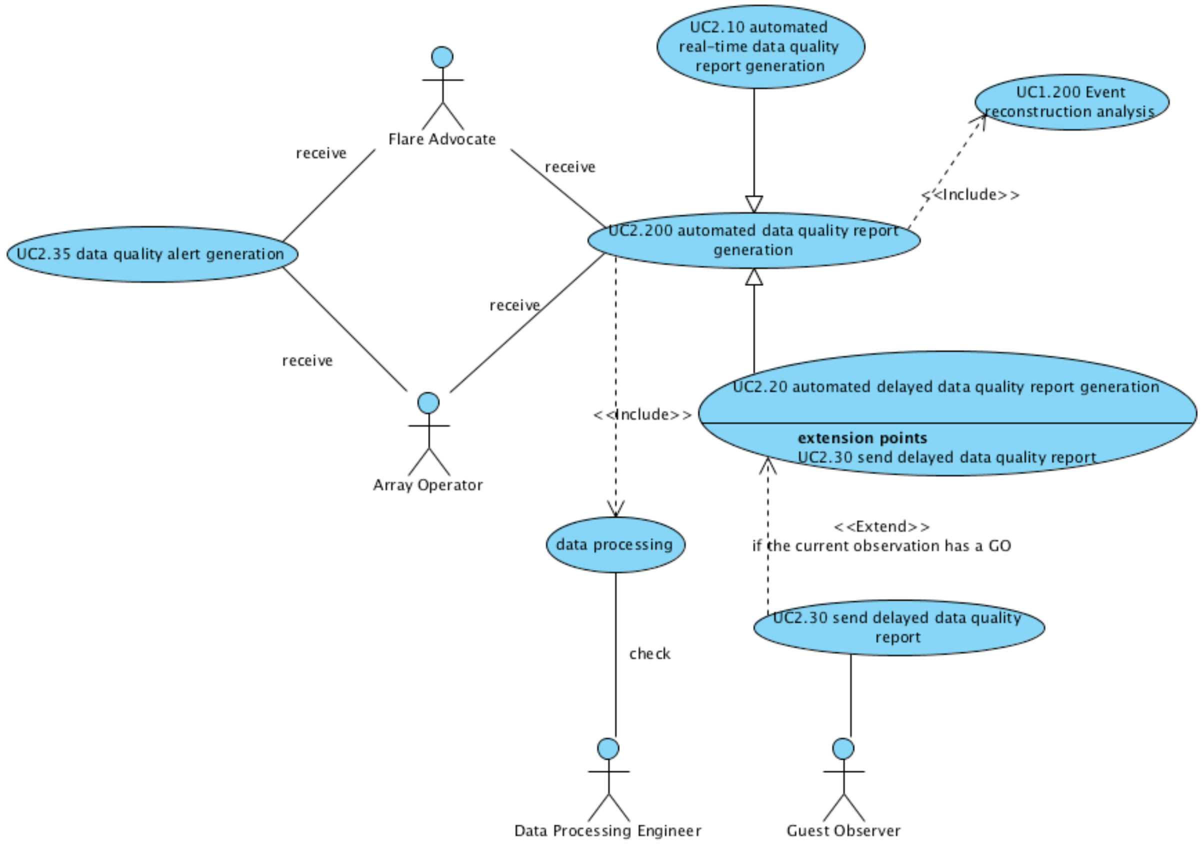
D-OS-UC2.20 The **Array Operator/Flare Advocate** receive an automated *DEL data quality report* to check the data quality at the end of the observation itself.

D-OS-UC2.30 The **Guest Observer** receive an automated *DEL data quality report* to check the data quality of the planned observation at the end of the observation itself.

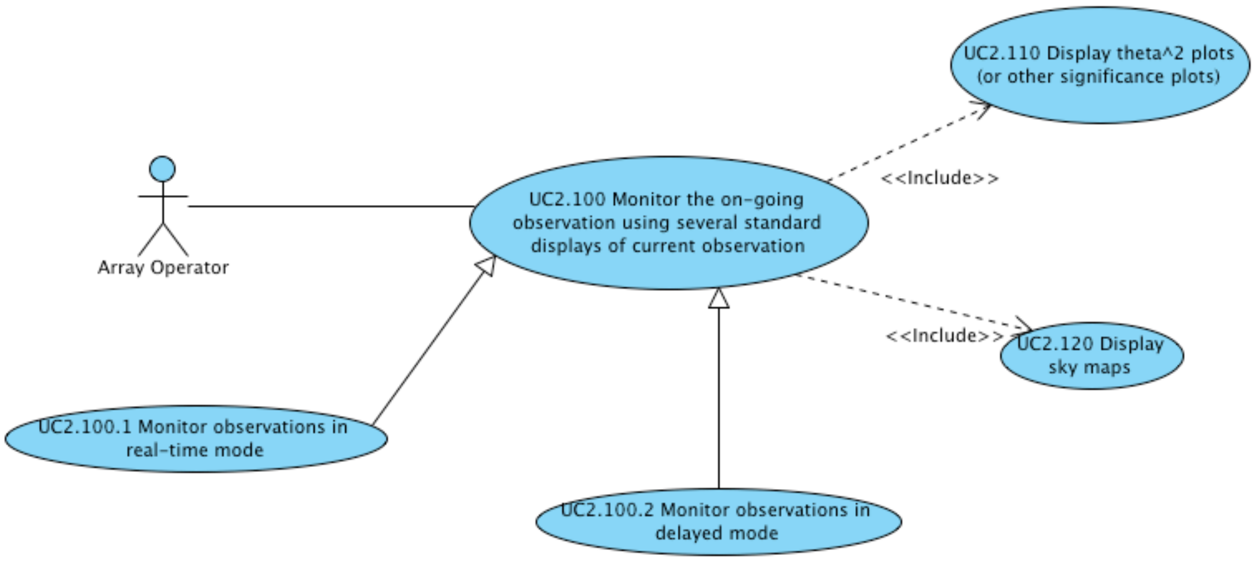
D-OS-UR2.35 The **Array Operator/Flare Advocate** receive a data quality alert when some problems occur during the data acquisition.

D-OS-UC2.40 Check data-quality report: the **Data Processing Engineer** check if the standard data product are generated by the pipeline.

D-OS-UC2.50 The **Array Operator** can check all the data quality reports and alerts of the past observations.



D-OS-UC2.100 The Array Operator monitor the on-going observation using several standard displays of current observation both in real-time and in delayed mode. Some useful results are displayed: significance plots and sky maps.



3.2.3 Requirements

D-OS-UR2.001 The science performance monitoring subsystem works both in real-time and delayed analysis mode. In real-time analysis mode the subsystem receive a flow of trigger and process them immediately, in delayed analysis mode the subsystem process the data at the end of the observation.
Motivated by C-DATA-5.020, C-DATA-7.170, C-DATA-8.020

D-OS-UR2.010 In real-time analysis mode a **data quality report** should be generated within TBD minutes from the last acquired trigger.

D-OS-UR2.015 In real-time analysis mode the first X minutes of the observation are used to generate the data quality report.
Motivated by C-DATA-8.020

D-OS-UR2.018 In delayed analysis mode the data quality report should be generated at the end of the observation before the start of the following night of observations (or before the midday?) using all the data of the observation.
Motivated by C-DATA-8.020, C-DATA-8.042

D-OS-UR2.020 Processing of data uses approximate calibrations (or other reconstruction methods like predefine LUT) and standard CTA software.

D-OS-UR2.030 The result of the monitoring is used to verify the quality of the observation. A **data quality report** is generated in real-time and delayed modes.
Motivated by C-DATA-8.020, C-DATA-8.042

D-OS-UR2.035 The engineering performance monitoring is used as input to check the status of the observation.

D-OS-UR2.040 The science performance monitoring generates first quick-look sky maps, \theta^2 plot and source detection(s) significance and flux of current observation. In particular, the analysis is based on
1. standard checks of known sources (based on predefined list)
2. it use the field of view of current observation

Motivated by C-DATA-8.040

D-OS-UR2.060 The L3 data input are used for the science performance monitoring.

D-OS-UR2.070 The final report for each observation contains
- Pointing position
- Instrument configuration for the exposure
- Average event count rates and flux
- Total observing time
- Weather conditions
- Significance of the detected sources
- Position and error box of the detected sources

Motivated by C-DATA-8.042

D-OS-UR2.071 The *final report* of the observation is sent to the Guest Observer and to the Array Operator and Flare Advocate at the end of the observation in an automatic way.
Motivated by C-DATA-8.043

D-OS-UR2.073 During the real-time mode a *data quality alert* is generated if some problems occur. (PROVIDE A LIST)
Motivated by C-DATA-8.015

D-OS-UR2.075 A local database stores all the data quality reports and alerts.
Motivated by C-DATA-6.080

D-OS-UR2.080 A GUI will be used to display processed data to manually check the quality of the current or past observations.
Motivated by C-DATA-8.050

	UR2.001 The science performance monitoring subsystem works both in real-time and delayed analysis mode. In real-time analysis mode the subsystem receive a flow of trigger and process	UR2.010 In real-time analysis mode the data quality report should be generated within TBD minutes from the last acquired trigger, 60% of the time; and shall be processed within TBD	UR2.015 In real-time analysis mode the first X minutes of the observation are used to generate a report.	UR2.018 In delayed analysis mode the data quality report should be generated at the end of the observation before the start of the following night of observations (or before the midday?)	UR2.020 Processing of data uses approximate calibrations (or other reconstruction methods like predefine LUT) and standard CTA software.	UR2.030 The result of the monitoring is used to verify the quality of the observation.	UR2.035 The engineering performance monitoring is used as input to check the status of the observation.	UR2.040 The science performance monitoring generates first quick-look sky maps, \theta^2 plot and source detection(s) significance and flux of current observation. In particular, the	UR2.060 The L3 data input are used for the science performance monitoring	UR2.070 The final report for each observation contains • Pointing position • Instrument configuration for the exposure • Average event count rates and flux • Total observing time •	UR2.071 The final report of the observation is sent to the Guest Observer and to the Array Operator and Flare Advocate at the end of the observation in an automatic way	UR2.073 During the real-time mode a data quality alert is generated if some problems occur. (PROVIDE A LIST)
UC2.10 automated real-time data quality report generation		✓	✓									✓
UC2.20 automated delayed data quality report generation				✓								
UC2.30 send delayed data quality report											✓	
UC2.35 data quality alert generation												✓
UC2.200 automated data quality report generation	✓				✓	✓	✓	✓	✓	✓	✓	

	UR2.075 A local database stores all the data quality reports and alerts.	UR2.080 A GUI will be used to display processed data to manually check the quality of the current or past observations.
UC2.10 automated real-time data quality report generation		
UC2.20 automated delayed data quality report generation		
UC2.30 send delayed data quality report		
UC2.35 data quality alert generation		
UC2.200 automated data quality report generation	✓	✓

3.3 Science Alert Monitoring

3.3.1 Description and objectives

The main task of the Science Alert Monitoring is the monitoring of the CTA science data in order to detect high or unexpected states of Galactic and extra-Galactic sources and react to transient events. This subsystem generates scientific alerts.

For the science alert monitoring we can consider "two (or more) contiguous observations" as the same observation if there are less than TBD degrees (1-2?) of repointing from old to new observation. We call this **real-time observation**. If an alert occur within a real-time observation and there is enough time to follow the flare before the conclusion of the real-time observation, no repointing is needed (how many time?).

Note: To follow a source it is important to have contiguous observation. With this definition it is possible that short observations (if they will foresee by the scheduler) will be viewed as a single long observation. This is a definition only for internal purpose of the Science Alert Monitoring pipeline and has not impact on the definition of the observation outside this context. This definition is important because the start and the end of an observation drive the Science Alert Monitoring pipeline and the definition of the real-time processing run. We can propose that the long and mid-term schedulers take into account this need.

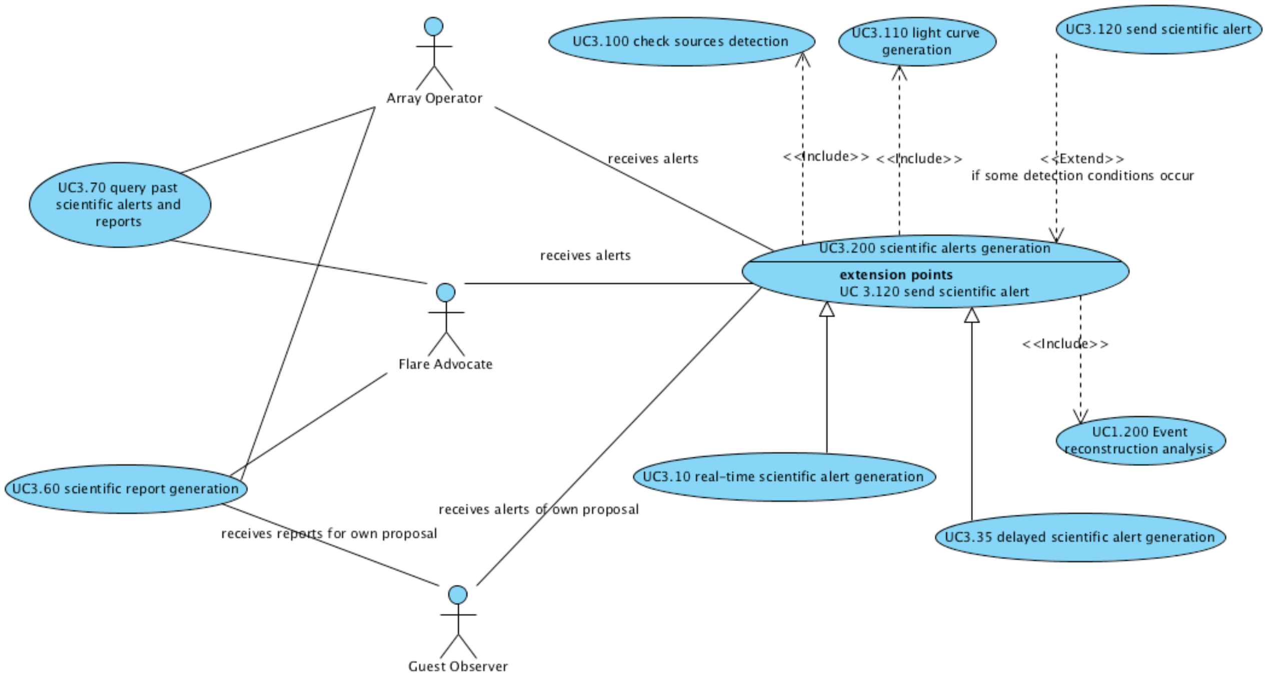
3.3.2 Use cases

D-OS-UC3.10 The **Flare Advocate** and the **Array Operator** receive real-time scientific alerts generated by the system. The **Guest Observer** receives the real-time scientific alert generated by the system if the observation has been planned by a proposal.

D-OS-UC3.35 The **Flare Advocate** and the **Array Operator** receive delayed scientific alerts generated by the system and not generated in real-time analysis mode. The **Guest Observer** receives delayed scientific alerts generated by the system and not generated by the real-time analysis mode if the observation has been planned by a proposal.

D-OS-UC3.60 The **Guest Observer**, the **Array Operator** and the **Flare Advocate** receive real-time/delayed scientific reports at the end of the observation.

D-OS-UC3.70 The **Flare Advocate** and the **Array Operator** can query the past scientific alerts for all the time-scale analysed by the system and can query scientific reports.



3.3.3 Requirements

D-OS-UR3.010 The science alert monitoring must be able to process the data to detect any activities requiring the generation of scientific alerts, albeit with reduced sensitivity.
Motivated by C-DATA-8.070

3.4.3.1 Common requirements

D-OS-UR3.030 The science alert monitoring system should be running constantly, receiving a flow of triggers.
Motivated by C-DATA-8.041, C-DATA-8.045

D-OS-UR3.040 The science alert monitoring process the data trigger-by-trigger (event-by-event).
Motivated by C-DATA-8.041

D-OS-UR3.045 A full band analysis is performed.

D-OS-UR3.050 The input of the Science Alert Monitoring is the L3 data level.

D-OS-UR3.070 If the CTA array makes observation with different subset of telescopes, a branch of each analysis pipeline should run (one branch for each subset of telescopes). The system should check if the calibration matrixes are available for each subset of the CTA array.

D-OS-UR3.075 In real-time analysis mode a good estimation of the flux/position of a source is required during the data acquisition TBD seconds after the last trigger used in the analysis. This estimation is improved by science alert monitoring in delayed analysis mode but it is not used for a real-time scientific re-check during the real-time alert management.
Motivated by C-DATA-8.070

D-OS-UR3.080 The science alert monitoring is based on blind search methods and on a list of known sources. Both **methods** are used to **find sources** in high or anomalous state and they run in parallel during the analysis.
Motivated by C-DATA-8.070

D-OS-UR3.090 The list of known sources should be updated taken into account new discoveries performed by CTA itself.
Motivated by C-DATA-8.070

D-OS-UR3.095 The science alert monitoring perform a **variability analysis** using different time integration windows (**multi-time scale analysis in parallel**) for the detection of transient phenomena at different time-scale. The following integration windows are foreseen:

UR4.080.1 1 minute (sub-minutes?)
UR4.080.2 TBD minutes (2, 4, 10, …)
UR4.080.3 TBD hours (1, 2, …)

Provide a final list.
Motivated by C-DATA-8.070

Note about UR above: this is a key point of this pipeline; we can use different time integration windows to search transients on different time scales of integration

D-OS-UR3.096 The system should produce **overlapped light curves** for each time-scale of analysis (e.g. integration of last N minutes every M minutes – for example, for a light curve with a time bin size of 10', we can generate a new bin every 2 minutes). The light curve can contain also past observations.
Motivated by C-DATA-8.070

D-OS-UR3.097 The system should produce **not overlapped light curves** for each time-scale of analysis. The time start of the light curve is the starting point of current real-time observation.
Motivated by C-DATA-8.070

D-OS-UR3.098 The system work with a **full field of view analysis**. If the same sky region has been observed in the last TBD days (2-3?), the sum of these observations is performed by an automated procedure without conditions about significance or flux level.
Motivated by C-DATA-8.070

Note: the analysis subsystem will add the new acquired event into its multi-timescale, full field of view image analysis, i.e. this is a continuous process, not a discrete one. It may then kick of things like source detection periodically rather than continuously. If the system has rolling, multi-timescale images of the field of view, then when a new observation starts, and hence the field of view is redefined, any areas of the image, which are still illuminated in the new field of view, are simply carried over. Indeed, the system may consider keeping a live full sky, rather than full field-of-view image, so that if the system observe areas A, then B, then C, and A&C overlap, the image accumulated in A is then added to when observation B starts.

D-OS-UR3.120 The configuration and the automated analysis performed by science alert monitoring pipeline do not depends by ToO or user proposal but they are optimized only to maximize the detection of flaring events keeping into account the array configuration and the level of confidence of the detection reached by the reconstruction and analysis software.
Motivated by C-DATA-8.080

3.4.3.2 Real-Time Analysis

D-OS-UR3.200 The science alert monitoring processes the data in real-time analysis mode without producing a backlog.
Motivated by C-DATA-8.041

D-OS-UR3.210 The science alert monitoring processes the data in real-time analysis mode producing a real-time scientific report during and at the end of the current observation.
Motivated by C-DATA-8.070, C-DATA-8.090

D-OS-UR3.240 The real-time analysis uses the standard software tools for event reconstruction and gamma/hadron separation.

3.4.3.3 Delayed analysis

D-OS-UR3.400 A delayed analysis reprocesses the data for more accurate scientific results.
Motivated by C-DATA-8.040

D-OS-UR3.415 The processing of data should end before the start of the following night. The scientific alerts and scientific reports should be generated before the start of the following night
Motivated by C-DATA-8.040

D-OS-UR3.420 The delayed analysis can generate scientific alerts performing refined check on acquired data. The duplication of alerts generated within the real-time analysis mode should be avoided.
Motivated by C-DATA-8.015, C-DATA-8.070

D-OS-UR3.430 The delayed analysis should perform a final check of real-time alerts for next night observations. With this more refined analysis should be possible to decide to continue an observation that has generated a scientific alert also in the following night.

D-OS-UR3.440 The delayed analysis uses the standard tools for event reconstruction and gamma/hadron separation

3.4.3.3 Alert and report results

D-OS-UR3.500 An estimation of the flux of a source is required. An estimation of the significance of the observation, its temporal evolution (with different time-scales), a sky map of the current pointing should be some output of the science alert monitoring pipeline.
Motivated by C-DATA-8.070

D-OS-UR3.510 Science alerts should be generated when the results of the science alert monitoring passes predefined conditions (e.g. significance threshold or flux level) in case of increasing or anomalous flux values from known sources or when a new source is detected. *Add more details about condition of alert generation*
Motivated by C-DATA-8.070

D-OS-UR3.512 If the same candidate alert is found with a blind search methods and using the list of known sources, the duplication of alerts are avoided and only one alert is generated.
Motivated by C-DATA-8.070

D-OS-UR3.514 The science alert monitoring can accumulate different observations of the same sky region/source using the L3 locally stored data when a candidate alert is discovered during the variability analysis. This enables the analysis system to find the *flux mean level* of a candidate source of

i. a new source
ii. a known source with an unknown flux.

With this procedure it is possible to check if alerts came from new sources or from an important variation of the flux of known sources.
Motivated by C-DATA-8.070

D-OS-UR3.516 An optional procedure could be activated when a low significance level of detection below TBD sigma for a particular time scale) is found during the variability analysis of current observation and similar detections was generated in the past. The science alert monitoring can accumulate different observations of the same sky region/source using the L3 locally stored data and analyse these data. This should enable the science alert monitoring to discover new periodic or aperiodic flaring sources.
Motivated by C-DATA-8.070

D-OS-UR3.520 The science alert monitoring should be able to generate sky maps using the locally stored data (L3) and light curves using the locally stored detections (L4) at different time scale for each known or new source.
Motivated by C-DATA-8.070

D-OS-UR3.522 The generated alert should contain at least the following information:

1. The analysis method (real-time or delayed)
2. the method used to find the position of the source (blind search (which?) or from a list of known sources) and the position and error box of the detection
3. the position of the source and an error circle (or ellipse) contour level
4. the time-scale bin where the detection is found
5. the time start and the time end of the time bin
6. the significance of the detection
7. the average count rate and the flux of the detection
8. the name of the detected source (if known) or (a list of) a possible association with a TeV source (if unknown or if the localization came from blind search method)
9. a flag that indicate if the detection is associated with a known or unknown source
10. the mean flux level (if calculated by the pipeline itself) – or a warning if the source is unknown and it is not possible to calculate the mean flux level
11. if the light curve that contains the detection is overlapped or not-overlapped and how many trials has been done from the start of current real-time observation (as alternative, it is possible to calculate directly the post-trial significance)
12. the instrument configuration
13. the pointing position

Motivated by C-DATA-8.070

D-OS-UR3.530 The local data storage stores the results of the science alert monitoring pipeline (L4 data).

Note: this local area can be used to store the results of the processing of the science alert monitoring pipeline: it is possible to store each detection, accumulate \theta^2 plots and sky maps, and so on. It depends by the amount of L4 data

D-OS-UR3.540 The real-time science alert monitoring will generate a report for each observation containing

- Pointing position
- Instrument configuration for the exposure
- Average event count rates and flux

- Total observing time
- Weather conditions
- Significance of the detection
- Position and error box of the detection

Motivated by C-DATA-8.090

D-OS-UR3.550 The system store in a local database all the reports and alerts generated by science alert monitoring subsystem

D-OS-UR3.560 Science alerts are sent to Array Operator, to Flare Advocate and to Guest Observer. The GO should be informed only if the sources of his proposal generate alerts.

	.1 UR3.010 The science alert monitoring must be able to process the data to detect any activities requiring the generation of	.2 UR3.030 The science alert monitoring pipeline should be running constantly, receiving a flow of triggers.	.3 UR3.040 The science alert monitoring process the data trigger-by-trigger (event-by-event).	.4 UR3.045 A full band analysis is performed. No needs for energy determination.	.5 UR3.050 The input of the Science Alert Monitoring is the L3 data level.	.6 UR3.070 If the CTA array makes observation with different subset of telescopes, a branch of each analysis	.7 UR3.075 In real-time analysis mode a good (precise) estimation of the flux/position of a source is required during	.8 UR3.080 The science alert analysis is based on blind search methods and on a list of known sources.	.9 UR3.090 The list of known sources should be updated taken into account new discoveries performed by CTA itself.	.10 UR3.095 The science alert monitoring use different time integration windows (multi-time scale analysis in parallel) for the	.11 UR3.096 The system should produce overlapped light curves for each time-scale of analysis (e.g. integration of last N	.12 UR3.097 The system should produce not overlapped light curves for each time-scale of analysis. The time start of the
UC3.10 real-time scientific alert generation												
UC3.35 delayed scientific alert generation												
UC3.200 scientific alerts generation	✓	✓	✓	✓	✓	✓	✓	✓	✓			
UC3.60 scientific report generation												
UC3.70 query past scientific alerts and reports												
UC3.100 check sources detection												
UC3.110 light curve generation										✓	✓	✓

	.30 UR3.098 The system work with a full field of view analysis. If the same sky region has been observed in the last TBD	.31 UR3.100 The science alert monitoring can accumulate different observations of the same sky region/source, also from	UR3.120 The configuration and the automated analysis performed by science alert monitoring pipeline do not depends	.32 UR3.200 The science alert monitoring processes the data in real-time analysis mode without producing a backlog and	.33 UR3.210 The science alert monitoring processes the data in real-time analysis mode producing a real-time scientific	.34 UR3.240 The real-time analysis uses the standard software tools for event reconstruction and gamma/hadron	.35 UR3.400 A delayed analysis reprocess the data for more accurate scientific results.	.36 UR3.410 The delayed analysis run constantly with a continuous integration of the flow of triggers coming from	.37 UR3.415 The processing of data should end before the start of the following night (before midday?). The scientific alerts and	.38 UR3.420 The delayed analysis can generate scientific alerts performing refined check on acquired data. The	.39 UR3.430 The delayed analysis should perform a final check of real-time alerts for next night observations. With this	.40 UR3.440 The delayed analysis uses the standard tools for event reconstruction and gamma/hadron separation
UC3.10 real-time scientific alert generation				✓	✓	✓						
UC3.35 delayed scientific alert generation							✓	✓	✓	✓	✓	✓
UC3.200 scientific alerts generation	✓	✓	✓									
UC3.60 scientific report generation												
UC3.70 query past scientific alerts and reports												
UC3.100 check sources detection												
UC3.110 light curve generation												

	.59 UR3.500 An estimation of the flux of a source is required to trigger MWL observations. An estimation of the	UR3.540 The real-time science alert monitoring will generate a report for each alert containing • Pointing position •	.60 UR3.550 The system store in a local database all the reports and alerts generated by science alert monitoring
UC3.10 real-time scientific alert generation			
UC3.35 delayed scientific alert generation			
UC3.200 scientific alerts generation			
UC3.60 scientific report generation		✓	
UC3.70 query past scientific alerts and reports			✓
UC3.100 check sources detection	✓		
UC3.110 light curve generation			

4. SPECIFIC REQUIREMENTS – CONSTRAINT REQUIREMENTS

D-OS-CR1 FITS is the recommended format to be used for the final data products

D-OS-CR2 The pipelines in real-time analysis mode process the data at the same rate of the maximum allowed trigger rate of CTA.

5. APPENDIX – USE CASE DETAILS AND TEST PROCEDURES

5.1 General requirements

5.1.1 UC1.40 Provides calibration matrix and pipeline configuration

Name	Value
Testing Setup	- select different CTA sub-array configurations - check if different calibration matrix, pedestal and other inputs for pipeline configuratio are avaliable both for delayed and for real-time analysis pipeline - check if Monte Carlo data are available for at least two sub-array configuration for delayed analysis and two sub-array configuration for real-time analysis
Testing Config	- run the pipeline with for all the available sub-array configuration and time-window - check if the standard data product are generated

5.1.1 UC1.10 Start pipelines manually

Name	Value
Documentation	The Data Processing engineer starts (at the start of each night of observation) the pipelines (science performance monitoring and science alert monitoring)
Testing Setup	- a list of simulated engineering alerts - a list of sub-array configuration and related calibration matrices

5.1.1.1 Flow of Events

5.1.1.2 Main

Steps	Procedures	Expected Results
1.start the execution of the engineering performance monitoring pipeline		
2. SYSTEM acquire data from telescopes and check a set of parameters for each telescope		
3. if one or more telescopes has problems		
3.1. SYSTEM stop the observation		
3.2. SYSTEM send alert to Array Operator and to science monitoring	Simulate different engineering alerts. Check if the science monitoring receives simulated alerts	The science monitoring receives simulated alerts
4. else		
4.1. for each sub-array configuration	Simulated different sub-array configuration	
4.1.1. if calibration matrix are ok	Check if science	The science monitoring

	monitoring pipeline starts correctly if correct calibration matrix are present.	is started correctly
4.1.1.1.start the execution of the science performance monitoring pipeline		
4.1.1.2.start the execution of the science alert monitoring pipeline		
end if		
end for each		
end if		

Extension

Steps	Procedures	Expected Results
4.1.1.a.		
1. if calibration matrix are not present		
1.1.generate pipeline alert	Check if alert is generated	The generated alert
1.2.exit		
end if		

5.1.1.3 Details

Name	Value
Post-conditions	At the end of the execution all the pipelines should run nominal.

5.2 Science Performance Monitoring

5.2.1 Event reconstruction analysis

Name	Value
ID	UC45

5.2.1.1 Flow of Events

1. Telescopes generate a flow of event triggers
2. for each sub-array configuration
2.1.The event triggers are reconstructed
2.1.1.signal extraction

2.1.2.calibration
2.1.3.image cleaning
2.1.4.image parameterization
2.1.5.event classification
2.1.6.(energy estimation)
2.1.7.determination of direction
end for each
3.

5.3 Science Alert Monitoring

5.3.1 UC3.100 check sources detection

5.3.1.1 Flow of Events

1.calculate statistical significance level
2.calculate flux

5.3.2 UC3.110 light curve generation

5.3.2.1 Flow of Events

1. for each time scale
1.1.produce a new bin periodically
1.1.1.add the flow of triggers to new bin
end for each

5.3.3 Event reconstruction analysis

5.3.3.1 Flow of Events

1. Telescopes generate a flow of event triggers
2. for each sub-array configuration
2.1.The event triggers are reconstructed
2.1.1.signal extraction
2.1.2.calibration
2.1.3.image cleaning

2.1.4.image parameterization
2.1.5.event classification
2.1.6.(energy estimation)
2.1.7.determination of direction
end for each

5.3.4 UC3.35 delayed scientific alert generation

5.3.4.1 Flow of Events

1. SYSTEM Event reconstruction analysis in delayed analysis mode
2. UC3.200 scientific alerts generation

5.3.5 UC3.10 real-time scientific alert generation

Name	Value
Documentation	The **Flare Advocate** and the **Array Operator** receive real-time scientific alerts generated by the system.
ID	UC3.10

5.3.5.1 Flow of Events

1. SYSTEM Event reconstruction analysis in real-time analysis mode
2. UC3.200 scientific alerts generation

5.3.6 UC3.200 scientific alerts generation

Name	Value
Testing Setup	1) check if pipeline is running 2) check if Monte Carlo data are available with different scientific cases (runs with known and unknown sources) 2.1) Crab nebula in the center of the FoV 2.2) unknown source off-axs (TBD) 2.3) AGN (select) in the center of the FoV 2.4) AGN (select) off-axis (TBD)

	2.5) Two known sources in the FoV 2.6) ... For each scientific case the simulated data should contains the following test case: TC1) at least one bin for a particular time-scale with a flux level 5 sigma above the expected sensistivity of the science alert monitoring pipeline TC2) X contiguous bins for a particular time scale with a flux level 5 sigma above the expected sensitivitu Also different time-scale for each TC should be simulated. The combination of scientific case with test cases and with different time-scale produces a 3D test matrix. The test procedures described here are only related to the scientific cases. 3) a list of known TeV sources
Testing Config	Each sub-unit of the pipeline should run indipendently

5.3.6.1 Extension Points

UC 3.120 send scientific alert

5.3.6.2 Flow of Events

5.3.6.3 Run with only one known source

Steps	Procedures	Expected Results
1. if data quality is ok		
1.1. for each new acquired event/trigger	Generate a flow of triggers with an average rate of K Hz. K is variable and depends by (i) analysis mode (real-time or delayed) (ii) simulated sub-array configuration	The pipeline acquires and elaborates the flow of triggers
1.1.2. for each known source in the FOV	check if the procedure select the simulated source in the simulated FoV. This is an automated procedure	The known source in the current FoV
1.1.2.1. UC3.110 light curve generation	Generate temporal bins of light curves. This is an automated procedure. Check if the content of the bin is as expected	The expected number of bins of the known simulated source.
1.1.2.2. for each new time-scale bin		
1.1.2.2.1. UC3.100 check sources detection	This is an automated procedure. Check the current flux for each temporal bin and the significance.	The current flux for each temporal bin and the significance is as expected.
1.1.2.2.2. if statistical detection is	The simulated data	The condition is

above TBD sigma or current flux is above TBD	should contains at least one temporal bin that verify these conditions. Check if the conditions are verified for the expected bin. Check if the conditions are passed or not for all the remaining bins	verified for expected simulated bin/bins and it is not passed for the remaining bins
1.1.2.2.2.1. if mean flux level of detected source is unknown	The mean flux level is known.	The condition is verified
1.1.2.2.2.1.1.calculate mean level flux based on past observations		
end if		
1.1.2.2.2.2. if mean flux level is TBD sigma above current flux		The condition is verified
1.1.2.2.2.2.1. UC 3.120 send scientific alert	This is an automated procedure. Check the content of the generated alert.	An alert is generated with the expected content.
end if		
end if		
end for each		
end for each		
1.1.3. for each unknown candidate source found not contained in the list of known sources	Verify if the blind search procedure is able to find the simulated source within the data	A list of sources found with a blind search method and a list of sources found with a blind search method not contained in the list of known sources. In this test the second list is empty. The condition is not passed.
1.1.3.1. UC3.110 light curve generation		
1.1.3.2. for each new time-scale bin		
1.1.3.2.1. UC3.100 check sources detection		
1.1.3.2.2. if statistical detection is above TBD sigma or current flux is above TBD		
1.1.3.2.2.1.calculate mean level flux based on past observations		
1.1.3.2.2.2. if mean flux level is TBD sigma above current flux		

1.1.3.2.2.2.1. UC 3.120 send scientific alert		
end if		
end if		
end for each		
end for each		
end for each		
end if		

Extension

Steps	Procedures	Expected Results
1.1.2.2.2.2.a.		
1. if it is not possible to calculate the mean flux level		
1.1. UC 3.120 send scientific alert with warning		
end if		
1.1.3.2.2.1.a.		
1. if it is not possible to calculate the mean flux level		
1.1. UC 3.120 send scientific alert with warning		
end if		

5.3.6.4 Run with serendipitous discovery

Steps	Procedures	Expected Results
1. if data quality is ok		
1.1. for each new acquired event/trigger	Generate a flow of triggers with an average rate of K Hz. K is variable and depends by (i) analysis mode (real-time or delayed) (ii) simulated sub-array configuration	The pipeline acquires and elaborates the flow of triggers
1.1.1.		
1.1.2. for each known source in the FOV	The FoV do not contains known source.	The procedure is not executed
1.1.2.1. UC3.110 light curve		

generation		
1.1.2.2. for each new time-scale bin		
1.1.2.2.1. UC3.100 check sources detection		
1.1.2.2.2. if statistical detection is above TBD sigma or current flux is above TBD		
1.1.2.2.2.1. if mean flux level of detected source is unknown		
1.1.2.2.2.1.1.calculate mean level flux based on past observations		
end if		
1.1.2.2.2.2. if mean flux level is TBD sigma above current flux		
1.1.2.2.2.2.1. UC 3.120 send scientific alert		
end if		
end if		
end for each		
end for each		
1.1.3. for each unknown candidate source found not contained in the list of known sources	Verify if the blind search procedure is able to find the simulated source within the data	A list of sources found with a blind search method and a list of sources found with a blind search method not contained in the list of known sources. In this test the second list should contains (at least) the position of the simulated source. The condition is verified.
1.1.3.1. UC3.110 light curve generation	Generate temporal bins of light curves. This is an automated procedure. Check if the content of the bin is as expected	The expected number of bins of the unknown simulated source.
1.1.3.2. for each new time-scale bin		
1.1.3.2.1. UC3.100 check sources detection	This is an automated procedure. Check the current flux for each temporal bin and the significance.	The current flux for each temporal bin and the significance is as expected.
1.1.3.2.2. if statistical detection is	Check if condition is	The condition is verified (alternative

above TBD sigma or current flux is above TBD	verified	simulation: the condition is not verified)
1.1.3.2.2.1.calculate mean level flux based on past observations		
1.1.3.2.2.2. if mean flux level is TBD sigma above current flux		
1.1.3.2.2.2.1. UC 3.120 send scientific alert	This is an automated procedure. Check the content of the generated alert.	An alert is generated with the expected content.
end if		
end if		
end for each		
end for each		
end for each		
end if		

Extension

Steps	Procedures	Expected Results
1.1.2.2.2.2.a.		
1. if it is not possible to calculate the mean flux level		
1.1. UC 3.120 send scientific alert with warning		
end if		
1.1.3.2.2.1.a.		
1. if it is not possible to calculate the mean flux level		
1.1. UC 3.120 send scientific alert with warning		
end if		

6. APPENDIX – TRACEABILITY MATRIX BETWEEN HIGH LEVEL DATA MANAGEMENT USE CASES AND THE USE CASES OF THIS DOCUMENT

The following table reports the links between the general high level data management use cases (see [R4]) and the most detailed use cases reported in this document.
There following aspect are not covered in [R4] and should be reported in a new version of the cited document :

1) the concept of delayed analysis
2) The Flare Advocate as Actor of the system
3) For D-OS-UC2.30 we have not found coverage with R4.

ID	Name	Primary Actors	Relation between DM and RTA UCs
C-DATA-UC6.4.2.5	C-DATA-UC6.4.2.5 The CTA Array Operator updates the short-term planning with the result of the daily short-term operations, reactions to real-time science alert monitoring and to the external triggers that generate re-pointing.	CTA array operator	RTA should be able to manage changes in short term planning. There are no direct use cases connection between RTA and DM. I have added D-OS-UR1.300 to take into account this changes.
C-DATA-UC6.5.2.1	C-DATA-UC6.5.2.1 The CTA Array Operator monitors the on-going observation using several standard displays of the real-time data. A hierarchy of displays will allow to monitor operational configurations al different complexity levels.	CTA array operator	D-OS-UC2.100.*, D-OS-UC2.110, D-OS-UC2.120
C-DATA-UC6.5.2.2	C-DATA-UC6.5.2.2 The CTA Array Operator enters an anomaly in the observing log.	CTA array operator	The RTA contributes to the realization of this UC with alerts and reports generation to Array Operator
C-DATA-UC6.5.2.3	C-DATA-UC6.5.2.3 The CTA Array Operator generates a new schedule of the observing plan in case of severe anomaly due to instrument or weather conditions.	CTA array operator	RTA should be able to manage changes in short term planning. There are no direct use cases connection between RTA and DM. I have added D-OS-UR1.300 to take into account this changes.
C-DATA-UC6.5.2.4	C-DATA-UC6.5.2.4 The CTA Array Operator collects data on individual telescopes to monitor performances of the individual cameras.	CTA array operator	D-OS-UC2.10, D-OS-UC2.20, D-OS-UC2.35, D-OS-UC2.200
C-DATA-UC6.6.2.1	C-DATA-UC6.6.2.1 The CTA Array Operator interrupts current operations and submits a new schedule	CTA array operator	RTA should be able to manage changes in short term planning. There are no direct use cases connection between

	to operate the CTA array in case of severe anomaly due to instrument or weather condition. The event is recorded automatically in the operations log.		RTA and DM. I have added D-OS-UR1.300 to take into account this changes.
C-DATA-UC6.6.2.2	C-DATA-UC6.6.2.2 The CTA Array Operator interrupts current operations and executes the specific observing procedure in case of ToO alert. The event is recorded automatically in the operations log.	CTA array operator	RTA should be able to manage changes in short term planning. There are no direct use cases connection between RTA and DM. I have added D-OS-UR1.300 to take into account this changes.
C-DATA-UC6.6.2.3	C-DATA-UC6.6.2.3 An automatic re-pointing system interrupts current operations and executes the specific observing procedure in case of external triggered alert and records the event in the operations log.	CTA array operator	RTA should be able to manage changes in short term planning. There are no direct use cases connection between RTA and DM. I have added D-OS-UR1.300 to take into account this changes.
C-DATA-UC6.6.2.4	C-DATA-UC6.6.2.4 When an alert is generated by the real-time science alert monitoring the current observation is continued for TBD hours interrupting the planed observations. It is also possible a re-pointing to put the flaring source in the centre of the FOV. If the alert is generated when the observation that has generated the alert is finished, an automatic re-pointing system interrupts current observation and executes the specific observing procedure to follow the current alert for TBD hours	CTA array operator	D-OS-UC3.120 and all the related UCs (see scenario of D-OS-UC3.120) that participate to the realization of this UC are connected.
C-DATA-UC6.8.2.1	C-DATA-UC6.8.2.1 The CTA Array Operator executes the on-site analysis pipeline using the last available calibration for the site.	CTA array operator	D-OS-UC1.05, D-OS- D-OS-UC1.10, D-OS- D-OS-UC1.20, D-OS- D-OS-UC1.30, D-OS- D-OS-UC1.35, D-OS-UC1.40, D-OS-UC1.110, D-OS-UC1.120 and all the related (and more detailed) use cases details this DM use case.
C-DATA-UC6.8.2.2	C-DATA-UC6.8.2.2 The CTA Array Operator records the quality result of the on-	CTA array operator	RTA sends quality reports. See D-OS-UC2.10, D-OS- D-OS-UC2.20, D-OS- D-OS-

	site analysis in the operations log.		UC2.35, D-OS- D-OS-UC2.50, D-OS-UC2.200
C-DATA-UC6.8.2.3	C-DATA-UC6.8.2.3 The CTA Array Operator submits an anomaly report in the quality control system.	CTA array operator	More details needed. In any case, RTA send reports to Array Opertator (e.g D-OS-UC2.200)
C-DATA-UC6.8.2.4	C-DATA-UC6.8.2.4 The CTA Array Operator records the scientific alerts and the automatic reaction of the telescope array to the real-time analysis/external trigger re-pointing in the operations log.	CTA array operator	RTA send scientific alert to Array Operator (D-OS-UC3.*)
C-DATA-UC6.8.2.5	C-DATA-UC6.8.2.5 The CTA Array Operator updates the short-term planning after the triggers from the real-time science alert monitoring or external triggers.	CTA array operator	Array operator receive scientific alerts (D-OS-UC3.120)