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INSTRUMENTATION DIVISION

New General detector Controller

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1 Introduction

1.1 Purpose of the Document

This document describes the operational and functional requirements of the NGC Software (NGCSW) which is the software in charge of handling NGC, the New General detector Controller of ESO.

1.2 Scope of the Document

The requirements described in this document shall apply to the detector controller only. Interfaces to external subsystems are also defined but their specific requirements may be treated in separate documents.

NGC is the successor of the two ESO controllers FIERA and IRACE. Its controlling software therefore combines the requirements for both infrared and visual exposures.

Requirements concerning external tools (e.g. the tool for sequencer programming) will be summarized here and described in detail in separate TBD documents.

These requirements specifications are derived from [AD6] and extended in order to cover the full software domain.

The guidelines for the software are described in [AD26].

While every precaution has been taken in the development of the software and in the preparation of this documentation, ESO assumes no responsibility for errors or omissions, or for damage resulting from the use of the software or of the information contained herein.

The software described in this manual is intended to be used in the ESO VLT project by ESO and authorized external contractors only.

1.3 Overview of the Document

A mixture of functional requirements and use cases is used. Use cases are meant to give a general overview of the different scenarios NGC will tackle while functional specifications will add some detail as well as aspects of requirements that cannot be easily included in use case descriptions. DOORS is the tools used to manage these requirements, and Word documents shall be generated from the DOORS version. As the document has been written directly in DOORS, it is advisable to examine it using DOORS itself. The printed (Word) version looses some of the dynamicity of the document.

This requirement document will take advantage of DOORS functionalities and shall be updated iteratively with new requirements, if accepted, in order to have a real match between requirements and final product.

Software requirements described in [AD6] are part of this document. Where needed, for clarity, a reference (DOORS link when viewed in DOORS) is explicitly written.

The template of this document is based on IEEE Standard 12207.

1.4 Applicable and reference documents

Applicable and reference documents are listed in the "NGC Project Documentation" document, VLT-LIS-ESO-13660-3906.

1.5 Acronyms

The acronyms used within the NGC project are listed in the "NGC Project Acronyms" document, VLT-LIS-13660-3908.

1.6 Glossary

The terms used within the NGC project are explained in the "NGC Project Glossary" document, VLT-LIS-13660-3907.

2 General Description

2.1 Product Perspective

NGC controller shall handle both visual (e.g. CCD) and Infrared (e.g. CMOS) detectors. Therefore NGC software shall handle both Infrared and Visual exposures and this document will describe requirements for both scenarios.

As NGC is the successor of FIERA and IRACE controllers, its functionalities will comprehend functionalities of both predecessors (see [RD13], [RD15] and [RD16]) but no backward compatibility shall be guaranteed

NGC will be the ESO standard controller and will be used in all ESO instruments, it is straightforward consequence that NGC software shall use and follow ESO software standards.

In particular, NGC platforms will use Linux as Operating System, in the flavour supported by the VLTSW.

NGC and NGCSW shall interface with other VLT telescope/instrument subsytems like TCS and AO and possibly others which, at present, are not foreseeable. NGCSW will therefore be flexible enough (e.g. shall not depend on non standard features of operating systems) to take into account new technological developments and or subsystems to interact with. Use of plugins will be explored [AD6].

NGCSW will have a specific focus on performance issue to cope with a trend that points towards increased data flows (e.g. big mosaics) and reduced computing times (e.g. AO applications) for what concerns ESO applications. Scalability is therefore a strong requirement as well as adaptation to ESO standards.

2.2 Product Functions

The NGC Controller will acquire the data coming from the detector(s) and will deliver them either to the RTD or to a FITS file or to both. It will accept commands and will be configured through an ESO standard database. The format of the FITS file is described in [AD37].

NGCSW shall be made of two main functional blocks: the NGC supervisory software (NGCSSW) and the NGC control software (NGCCSW). Together they will be defined as the NGCSW.

NGCSSW will be the interface towards higher level software using standard communication tools as defined in [AD26]. It will coordinate the action of NGCCSW subsystems and will determine the overall state of the system as a combination of states of all subsystems.

States as well as transitions between them are defined and described in [AD29].

NGCSSW will mark the end and the completion of exposures and will be in charge of delivering the final FITS file with all FITS keywords which are of pertinence of the detector system (see [AD37]).

NGCCSW will handle control and communication to and from NGC hardware subsystems (telemetry) as well as shutter subsystem, if the latter is present.

The NGCSW handles single exposures with one or more detector systems (single chip or mosaic) in all phases, from the preparation to the image data storage on disk and/or real-time display.

The NGCSW shall also handle the case where different cameras share the same set of electronics (e.g. X-Shooter [RD47] or Omegacam Autoguider/Image Analyzer [RD48]).

It will be able to repeat the same exposure as many times as specified by the user (***repeated exposure***).

An exposure can start before the previous one is completed provided integrity of data is guaranteed

It will not handle sequences of different exposures; this will be done using higher level software.

This software can run with both of the following possible configurations, where the detector system is considered as a complete ***stand-alone*** instrument (typical test configuration in a laboratory or at a telescope) or just the data acquisition device of a more complex instrument (typical observing configuration at a telescope).

2.3 User Characteristics

NGC and its software shall have two types of users. Hardware engineers in the development of detector systems and observatory ESO personnel when in operation. Members of consortia will be considered as the latter.

2.4 General Constraints

The NGCSW shall be limited to use on ESO instruments as they are foreseen. Its usage in different environments may be considered but it is not a requirement.

2.5 Assumptions and Dependencies

NGCSW shall depend on ESO software environment and its tools [AD6], [AD24], [AD39], [AD30].

All programmatic interfaces (messaging, error, logging, data transfer) shall be developed according to VLT standards [AD6], [AD26], [AD28].

Specifications defined in [AD28] for what concerns DCS will be followed.

The NGCSW shall be kept under version control using VLT standard tools [AD6], [AD25].

Appropriate modular, regressions and system tests will be developed. See [RD41].

The online database will be implemented following specifications found in [RD32], [RD33], [RD34], [RD35]

A graphical user interface shall be developed both for normal and maintenance operations according to [AD38] and [AD39]. See below.

Code will be developed following specifications and guidelines as specified in [AD24], [AD71] and [AD26]. It is possible that different specifications can be followed, in the framework of the development by ESO of new software procedures. If so, this document will be updated.

3 Specific Requirements

3.1 Functional Requirements

3.1.1 Common Requirements

Limits on number of clocks, biases and channels are described in [AD8].

Pixels read out from detector(s) shall be reordered before transferring to the IWS. Delivered images will not need further reordering.

NGCSW will implement, as a minimum, the commands already used by FIERA and IRACE and described in their CDTs with an interface which will allow backward compatibility [AD6]. See also [RD15] and [RD16].

The ONLINE status requires that all voltages are loaded and switches closed as well as telemetry is acquired and checked.

NGCSW will be able to handle multiple independent detectors.

It shall be possible to read any number of windows limited only by detector properties [AD6].

Windows shall be read either in hardware through sequences or in software. In the former case the dimensions of the window shall be parameters of the windowing sequence. The latter case, on the other hand, implies that a full frame is read out and then a window of data is computed in memory.

Binning shall be implemented to an arbitrary value and with independent values in x and y [AD6].

Telemetry shall be available at all times, with the possibility to have a separate period for logging on the VLT logMonitor.

NGCSW shall transfer all computed results to display (RTD) and/or to FITS-file:

DIT (result frame after one integration)

INT (average of NDIT integrations)

STDEV (standard deviation of NDIT integrations)

HCYCLE (intermediate results after half chopping period)

Display visualization is done in parallel to all other data transfers (i.e. one may look at the DIT frame while storing the INT frame to disk and while the next data is already being processed). See [AD6].

If processing- or data-transfer-bandwidth exceeds the capacity of one single computer, the task is split up to N computing units.

In order to test the image data path, NGC must be able to produce pre-defined data.

3.1.2 Visual Specific Requirements

An exposure should not start before the completion of the previous exposure, i.e., before the image data have been saved on the Instrument Workstation in FITS file. This must be the default behavior.

If needed, more than one exposure can be executed at a given time, staring the new integration as soon as the transfer to the Instrument Workstation is completed. This option must be explicitly requested.

In any case, at the start on an exposure there must not be more than one FITS file waiting for completion.

NGCSW will handle exposures with and without shutter operation (e.g. Normal or Dark) and will also implement the possibility of driving an external light source (e.g. LED exposures on HARPS).

It shall be possible to execute sequences during the integration.

Periodic wiping will be possible.

Temperatures and pressures will be controlled by NGCSW. As a minimun interface to Pulpo and PULPO2 shall be provided ([RD18] and [RD19]).

3.1.3 Infrared Specific Requirements

Each Pixel can be read out N times and an average is computed.

Subsampling and digital filtering of individual pixels shall be possible as required in [AD6].

The ONLINE status requires that the system also starts readout. Data are may be displayed but not transferred to the IWS nor saved.

In case reference values on special channels are read out (e.g. Hawaii2RG), NGC shall be able to interpolate through rows or columns.

Chopping mode (average on A-beam minus average on B-beam) shall be implemented.

NGCSW shall be able to transfer bursts of raw data to FITS files.

TBD: BEAMPIX, FLUX??? Joerg?

NGC shall implement at least the following readout modes for infrared exposures:

- Uncorrelated (simple adding up):

$$\underline{\mathbf{y}} = \underline{\mathbf{y}} + \underline{\mathbf{d}}$$

- Double Correlated (reset-read-read)

  Reset whole array, read array, read array again after integration time:

$$\underline{\mathbf{y}} = \underline{\mathbf{y}} + (\underline{\mathbf{d}}_2 - \underline{\mathbf{d}}_1)$$

- Double Correlated (reset-read-read)

  Read one row, reset the row, read the row again. The values which are read after resetting the row have to be stored in a temporary array and are subtracted when the next frame is read (after integration time). The first read must be skipped:

$$\underline{\mathbf{y}}_n = \underline{\mathbf{y}}_n + (\underline{\mathbf{d}}_{1n} - \underline{\mathbf{s}}_{n-1})$$
$$\underline{\mathbf{s}}_n = \underline{\mathbf{d}}_{2n}$$

- Least Square Fit

  The detector is read out several times during integration time and a least square fit is computed for each pixel to approximate the integration ramp:

$$\underline{\mathbf{y}} = c_1 \sum_{i=1}^{N} \underline{\mathbf{d}}_i - c_2 \sum_{i=1}^{N} \sum_{j=1}^{i} \underline{\mathbf{d}}_j$$

$$c_1 = \frac{6}{N}$$

$$c_2 = \frac{12}{N(N+1)}$$

  In this read-out mode optionally a saturation check is done. The saturation threshold is set via parameter. If pixel readings are above the threshold, the slope until saturation is extrapolated.

- Fowler Sampling

  The detector is read out N times at the beginning and N times at the end of the integration ramp. An average is computed at both times:

$$\underline{\mathbf{y}} = \underline{\mathbf{y}} + \left(\sum_{N} \underline{\mathbf{d}}_2 - \sum_{N} \underline{\mathbf{d}}_1 \right)$$

The non-destructive read-out modes (*Least-Square-Fit* and *Fowler-Sampling*) are usually combined with sub-pixel sampling

3.2 External Interface Requirements

3.2.1 User Interfaces

NGCSW user interfaces will be developed following rules described in [AD38] and [AD39].

The user interface for telescope operations will merge functionalities of current FIERA and IRACE user interfaces [AD6]. See [RD15] and [RD16].

Specific graphical interfaces may be developed in order to ease engineers' work in the laboratory. These interfaces may be developed not following the standards if their use is confined to the laboratory.

3.2.2 Hardware Interfaces

Hardware interfaces do not apply to this document. See [AD8].

3.2.3 Software Interfaces

3.2.3.1 Shutter Controller

NGCSW will be able to control shutters both using Pulpo and Pulpo2 or using directly

NGC hardware (see [AD8].

In the optical case, backward compatibility to Pulpo and Pulpo2 must be guaranteed.

The software shall support, as a minimum, shutters already used on VLT/ESO instruments. In the optical case these shutters are the ones supported by Pulpo and Pulpo2. See also [AD6].

The software will log all information coming from the shutter and will store it in the relevant FITS keywords. See NGC dictionary.

3.2.3.2 Telemetry/Temperatures/Pressures (optical systems)

The software shall interface to Pulpo and Pulpo2. Other controllers may be taken into consideration ([AD6]).

Interface to new controllers shall be defined in a separate ICD document.

Temperatures and pressures shall be made available through the database.

On request these values will also be reported in the FITS header.

3.2.3.3 AO / RTC

Interface between AO/RTC and NGCSW is defined in [AD41].

3.2.3.4 VLTI

Interface between NGCSW and VLTI applications is defined in [AD8].

3.2.3.5 Sequencer Programming

Sequencer programming shall be implemented using a scripting language, to be chosen among those supported by ESO if the following requirements are satisfied

The scripting language will allow evaluation of arithmetic formulas at run-time

As the script evaluation may need to be done frequently, the startup-overhead of the script must be as short as possible. The script evaluation may not be required by all applications. In particular this is a main difference between optical and infrared applications. Where no script is required a simple parsing can be done.

A graphical tool shall be implemented in order to have also the possibility to program and visualize the sequences [AD6].

The format on disk of the sequences shall be ASCII. Other formats, non ASCII, for ancillary data (e.g for graphics) could be used but must not be required for running the system.

The sequence programming will allow free use of setup parameters (DIT, NDIT, etc.) in sequencer clock pattern descriptions.

The chopper frequency may be input-parameter or output parameter of the sequencer program.

Free placement of synchronization points with external trigger (for chopping mode) must be guaranteed.

Read-out of multiple windows shall be configurable in programming.

Sub-pixel sampling (N samples per pixel) shall also be possible.

The sequencer programming tool will also allow to emulate the real sequencer so that check on the consistency of the sequences can be obtained also without hardware available.

3.2.3.6 RTD

Interface to standard RTD shall be provided (see [AD6]).

The Interface and the library to be used are defined in [RD40].

3.2.3.7 Pixel Processor

Requirements on the Pixel processor are given in [AD6].

3.2.3.8 TCS

NGCSW shall deliver centroiding data to TCS. The interface, i.e. the parameters needed by TCS, are described in [AD43]. If needed (i.e. infrared exposure) flat-field frame and bad pixels mask shall be downloaded to NGCSW which will then distribute them to the relevant subsystem.

3.2.4 Communications Interfaces

Communication between internal subsystems of NGCSW (e.g NGCSSW and NGCCSW) shall be implemented using VLTSW standard messaging tools as well as CCS database. Whenever not otherwise specified, the same standards will be used for all other communication interfaces. See 2.5.

3.3 Performance Requirements

3.3.1 Timing

General timing requirements on SW are given in [AD6].

Synchronization requirements are given in [AD6].

3.3.2 Data Transfer

Data transfer rate to the IWS shall be limited only by the readout speed. An overhead of max. 5 seconds will be considered acceptable.

3.3.3 Post Processing

Centroiding performance requirements are specified in [AD6].

3.4 Design Constraints

3.4.1 Standards Compliance

NGCSW shall be compliant to ESO/VLT software standards (see "Assumptions and Dependencies" above). UML 2.0 shall be used for diagrams. Description of UML 2.0 specifications can be retrieved on www.uml.org,

3.4.2 Hardware Limitations

See [AD8]

3.5 Attributes

3.5.1 Availability

3.5.2 Security

3.5.3 Maintainability

3.5.4 Transferability/Conversion

3.6 Other Requirements

3.6.1 Operations

3.6.2 Site Adaptation

4 Use Cases

This chapter lists use case diagrams. Use Case names included in the text and underlined can be navigated automatically.

4.1 Actors

This section lists human and other actors with roles in the use cases.

4.1.1 Engineer

It's the person who will interact with the system. He/she can be both a software or a hardware engineer but in any case is supposed to have a deep understanding of the system and will have access to all functionalities.

4.1.2 Operator

It's the person who will interact with the system e.g. at the telescope. He/she is not required to have a full understanding of the system and may not be allowed to have access to all functionalities.

4.1.3 Observing Software

It's the software that will interact with the system. It may not have access to all functionalities.

4.2 Basic interaction with NGC

This section represents one use case diagram. It lists use cases with associated information.

4.2.1 Startup System

4.2.1.1 Context

This is the normal operation after a system complete or partial power-up or reboot. The only variation foreseen is when the engineer explicitly ask for no hardware initialization, relying thus on the current state of the hardware (supposedly shut down without powering down the hardware). This option is strictly allowed to engineers **ONLY**.

4.2.1.2 Primary Scenario

1. NGCSW startup script is executed

    Exception Course: Command failed

2. NGCSW puts in state LOADED all subsystems. All processes are started and the database is loaded

    Exception Course: Some subsystems failed to go to LOADED state

    Post conditions: all subsystems are in state LOADED

3. NGCSW puts all subsystems in state STANDBY Software and Hardware interfaces

are initialized:

4. Data transfer channel is initialized

5. Hardware is verified

   Exception Course: Some subsystems failed to go to STANDBY state

   Post conditions: all subsystems are in STANDBY state

6. NGCSS puts in ONLINE state all subsystems

   Exception Course: Some subsystems failed to go to ONLINE state

Post conditions: all subsystems are in ONLINE state

7. NGCSW performs **<u>Update Global System State</u>**

   Post conditions: NGCSW in state ONLINE, sub state IDLE

8. NGCSW sends final OK reply

4.2.1.3 Variations

4.2.1.3.1 Startup without hardware initialization

1. NGCSW startup script is executed is executed with option "no HW initialization"

   Exception Course: Command failed

2. NGCSW puts in state LOADED all subsystems. All processes are started and the database is loaded

   Exception Course: Some subsystems failed to go to LOADED state

   Post conditions: all subsystems are in state LOADED

3. NGCSW puts all subsystems in state STANDBY Software only is initialized:

4. Data transfer channel is initialized

5. Hardware is verified to be consistently ONLINE

   Exception Course: Some subsystems failed to go to STANDBY state

   Exception Course: Hardware is in a inconsistent state

   Post conditions: all SW subsystems are in STANDBY state HW is ignored.

6. NGCSS puts in ONLINE state all SW subsystems

   Exception Course: Some subsystems failed to go to ONLINE state

Post conditions: all subsystems are in ONLINE state

7. NGCSW performs **<u>Update Global System State</u>**

   Post conditions: NGCSW in state ONLINE, sub state IDLE

8. NGCSW sends final OK reply

4.2.1.4 Exceptions

4.2.1.4.1 Command failed

1. **Update Global System State**

   Post conditions: NGCSW in state OFF, sub state FAILURE

2. NGCSSW sends final ERROR reply

4.2.1.4.2 Some subsystem failed to change state

1. NGCSW puts all subsystems in OFF state

   Post conditions: NGCSW in state OFF, sub state FAILURE

2. NGCSW performs **Update Global System State**
3. NGCSW sends final ERROR reply

4.2.1.4.3 Hardware is in a inconsistent state

1. NGCSW puts all subsystems in OFF state

   Post conditions: NGCSW in state OFF, sub state FAILURE

2. NGCSW performs **Update Global System State**
3. NGCSW sends final ERROR reply

4.2.1.5 Trigger

4.2.1.6 Preconditions

The system must be correctly configured.

4.2.1.7 Stakeholders and Interests

4.2.1.8 Minimal Guarantees

The system is guaranteed to be left in a consistent state even after a failure in startup.

4.2.1.9 Success Guarantees

1. NGCSW is in state ONLINE, sub state IDLE
2. All subsystems are initialized and in state ONLINE
3. The system will be ready to take exposures.

4.2.1.10 Non-Functional Requirements

4.2.1.11 Business Rules

4.2.1.12 Process Changes

4.2.1.13 Training Changes

4.2.2 Shutdown the System

4.2.2.1 Context

This is the normal operation before a system complete or partial power-down or reboot. Each required subsystem is brought from its current state to state OFF. The only variation foreseen is when the engineer explicitly ask for no hardware poweroff, relying thus on the current state of the hardware. The hardware will be left in the current state. This option is strictly allowed to engineers **ONLY**.

4.2.2.2 Primary Scenario

1. Execute command to shutdown NGCSW

    Exception Course: Command failed

Post conditions: all subsystems in OFF state

2. NGCSSW sends STOP command and puts in OFF state all subsystems

    Exception Course: Command failed

    Post conditions: all subsystems in OFF state

3. **Update Global System State**

    Post conditions: NGCSW in state OFF, sub state IDLE

4. NGCSSW sends final OK reply

4.2.2.3 Variations

4.2.2.3.1 Shutdown without hardware poweroff

1. Execute command to shutdown NGCSW with "no poweroff" option

    Exception Course: Command failed

Post conditions: all subsystems in OFF state

2. NGCSSW sends STOP command and puts in OFF state all subsystems but the HW subsytems

    Exception Course: Command failed

    Post conditions: all SW subsystems in OFF state

3. **Update Global System State**

Post conditions: NGCSW in state OFF, sub state IDLE

4. NGCSSW sends final OK reply

4.2.2.4 Exceptions

4.2.2.4.1 Command failed

1. **Update Global System State**

   Post conditions: NGCSW in state OFF, sub state FAILURE

2. NGCSSW sends final ERROR reply

4.2.2.5 Trigger

4.2.2.6 Preconditions

4.2.2.7 Stakeholders and Interests

4.2.2.8 Minimal Guarantees

All subsystems in state OFF.

4.2.2.9 Success Guarantees

All HW (unless expicitly not required) and SW subsystems in state OFF.

4.2.2.10 Non-Functional Requirements

4.2.2.11 Business Rules

4.2.2.12 Process Changes

4.2.2.13 Training Changes

4.2.3 Update Global System State

4.2.3.1 Context

The current state of each subsystem is monitored to detect any change and to update immediately:

1. The global system state (OFF, LOADED, STANDBY, ONLINE)

2. The global system sub state (STARTING, IDLE, STOPPING, INTEGRATING, READING, TRANSFERRING, FAILURE, UNDEFINED)

4.2.3.2 Primary Scenario

1. Any sub-system changes state

   Exception Course: States cannot be retrieved

2. NGCSW evaluates global system state as combination of the states of all sub-systems.

   Exception Course: State cannot be evaluated

3. NGCSW evaluates global system sub state as combination of the sub states of all sub-systems.

   Exception Course: State cannot be evaluated

4.2.3.3 Variations

4.2.3.3.1 Unnamed Variation

Undefined Step

4.2.3.4 Exceptions

4.2.3.4.1 State cannot be retrieved

1. NGCSW put in lowest state that can be retrieved

2. NGCSW put in FAILURE sub state

Post conditions: NGCSW in sub state FAILURE

4.2.3.4.2 State cannot be evaluated

1. NGCSW put in lowest state that can be evaluated

2. NGCSW put in FAILURE sub state

4.2.3.5 Trigger

4.2.3.6 Preconditions

NGCSW in any state

4.2.3.7 Stakeholders and Interests

4.2.3.8 Minimal Guarantees

4.2.3.9 Success Guarantees

NGCSW global state consistent with subsystem states.

4.2.3.10 Non-Functional Requirements

4.2.3.11 Business Rules

4.2.3.12 Process Changes

4.2.3.13 Training Changes

4.3 Exposures Diagrams

4.3.1 Visible Exposure

4.3.1.1 Context

A (or a loop of) exposure(s) is/are taken. The detector may have a shutter connected and controlled through Shutter Controller. A STOP command will end the exposure or the loop allowing for completion of current exposure. The ABORT command will interrupt the use case with loss of data.

4.3.1.2 Primary Scenario

1. SETUP command is sent to NGCSS

2. SETUP is verified by NGCCS against current configuration and rules

3. Requested sequences are loaded (if not already loaded by previous exposures) to the NGC electronics

    Exception Course: Command failure

4. OK answer is sent back

5. START command is sent to NGCSS

    Variation: Previous exposure still ongoing

6. NGCCS starts wiping sequence (if requested), optionally executes use case **Synchronize**

7. Sub state set to WIPING

8. **Update Global System State**

    Exception Course: Command failure

9. NGCCS starts integration sequence, optionally executes use case **Synchronize**

10. Shutter Controller opens shutter with due integration time.

11. Shutter state set to OPEN

12. NGCSW sub state set to INTEGRATING

13. **Update Global System State**

    Exception Course: Shutter Controller failure

    Variation: No shutter required

14. During integration actions, if any, are created if necessary (e.g. to accommodate repetition factor for the integration time) and executed (e.g. charge shift). If a PAUSE command is received **Pause Exposure** use case is executed.

    Exception Course: Command failure

15. Shutter Controller closes shutter unless in drift-scanning mode

16. Shutter state set to CLOSED

17. **Update Global System State**

    Exception Course: Shutter Controller failure

    Variation: No shutter required

18. NGCCS starts readout sequence, optionally executes use case Synchronize.

19. If necessary data are reordered or windows are extracted. Possibly **User Defined Processing During Readout** use case is executed.

20. NGCSW sub state is set to READING

21. **Update Global System State.**

    Exception Course: Command failure

22. Data are transferred to IWS and the image is displayed and saved if required. If saved, FITS format is used. If required, image post processing (e.g. rotation of the image) is performed. NGCSW sub state is set to READING & TRANSFERRING until READOUT is completed, then to TRANSFERRING only.

23. **Update Global System State**

    Variation: **Adaptive optics processing**

    Variation: **Auto Guider Process**

    Variation: **Drift scanning**

    Exception Course: Transfer failure

24. NGCSW sub state set to COMPLETED

25. **Update Global System State**

    Variation: Next exposure in a loop

26. Final OK answer to START

Undefined Step

4.3.1.3 Variations

4.3.1.3.1 Previous exposure still ongoing

1. Warning message logged

2. Command is queued until previous exposure finishes and main course continues or timeout expires.

Exception Course: *Error in queue*

4.3.1.3.2 Next exposure in a loop

1. Increment loop counter

2. Go to step 6 of Main Course

4.3.1.3.3 No shutter required

The exposure is either a Dark or a Bias or the shutter is controlled by another system. The exposure time is controlled inside the NGCCS.

4.3.1.4 Exceptions

4.3.1.4.1 Command failure

1. Sub state set to FAILURE

2. Error message logged

3. **Update Global System State**

FAILURE answer to command is sent and the use case ends

4.3.1.4.2 Shutter controller failure

1. Sub state set to FAILURE

2. Error message logged

3. **Update Global System State**

4. FAILURE answer to command is sent and the use case ends.

4.3.1.4.3 Transfer failure

1. An attempt to re-establish the connection is made. If successful, the use case continues with its main course and the event is logged. If fails:

2. Sub state set to FAILURE

3. Error message logged

4. Update Global System State

5. FAILURE answer to command is sent and the use case ends

4.3.1.4.4 Error in queue

1. If the commands queued exceed limit or the timeout expires a FAILURE answer is sent back and the main course continues.

4.3.1.5 Trigger

4.3.1.6 Preconditions

All NGC subsystems ONLINE.

4.3.1.7 Stakeholders and Interests

4.3.1.8 Minimal Guarantees

No data is lost and the system is in a known state.

4.3.1.9 Success Guarantees

The system is in state ONLINE sub state COMPLETED. An exposure has been made and a FITS file (if requested) is stored on disk and image data (if requested) are shown on the RTD. The system is ready for the next exposure.

4.3.1.10 Non-Functional Requirements

4.3.1.11 Business Rules

4.3.1.12 Process Changes

4.3.1.13 Training Changes

4.3.2 Synchronize

4.3.2.1 Context

The exposure is synchronized by an external trigger, e.g. a time delivered by the TIM sub system or by a TTL signal.

4.3.2.2 Primary Scenario

The system suspends itself until an event (time or signal) is delivered to it by another sub system (e.g. TIM module)

Exception Course: Timeout

4.3.2.3 Variations

4.3.2.3.1 Unnamed Variation

Undefined Step

4.3.2.4 Exceptions

4.3.2.4.1 Timeout

1. The event is not delivered in due time. Sub state is set to FAILURE and the use case ends

2. **Update Global System State**

Post Conditions: State ONLINE, sub state FAILURE

4.3.2.5 Trigger

The setup for the exposure requires synchronization

4.3.2.6 Preconditions

NGCSW in state ONLINE, sub state different from FAILURE

4.3.2.7 Stakeholders and Interests

4.3.2.8 Minimal Guarantees

System is left in a consistent state, able to run another exposure.

4.3.2.9 Success Guarantees

Action (e.g. readout) is synchronized to the external signal.

4.3.2.10 Non-Functional Requirements

4.3.2.11 Business Rules

4.3.2.12 Process Changes

4.3.2.13 Training Changes

4.3.3 Pause Exposure

4.3.3.1 Context

A PAUSE command is received by NGCSW

4.3.3.2 Primary Scenario

1. Shutter is closed and system suspends until a CONTINUE command is received

   Exception Course: System not in INTEGRATING substate

2. Once the CONTINUE command is received the shutter is opened and use case ends.

   Variation: Change Integration time during PAUSE

4.3.3.3 Variations

4.3.3.3.1 Change Integration Time during PAUSE

3. If the time requested is valid (> than elapsed integration time) exposure time is changed

   Exception Course: Invalid value for change exposure time request

4.3.3.3.2 CONTINUE command received while not in PAUSED substate

The command is rejected

4.3.3.4 Exceptions

4.3.3.4.1 Timeout

1. The event is not delivered in due time. Sub state is set to FAILURE and the use case ends
2. **<u>Update Global System State</u>**

Post Conditions: State ONLINE, sub state FAILURE

4.3.3.4.2 System not in INTEGRATING substate

The command is rejected

4.3.3.4.3 Invalid value for change exposure time request

The request is rejected

4.3.3.5 Trigger

PAUSE command

4.3.3.6 Preconditions

NGCSW in state ONLINE, sub state INTEGRATING.

4.3.3.7 Stakeholders and Interests

4.3.3.8 Minimal Guarantees

The system is left in a consisten ONLINE state

4.3.3.9 Success Guarantees

The exposure is resumed, possibly with the new integration time.

4.3.3.10 Non-Functional Requirements

4.3.3.11 Business Rules

4.3.3.12 Process Changes

4.3.3.13 Training Changes

4.3.4 User Defined Processing During Readout

4.3.4.1 Context

Some kind of processing, defined by the user, is performed on the data while they are read out. A typical example is centroiding**.**

4.3.4.2 Primary Scenario

Executes a user defined function (e.g. FFT, Centroiding…)

Exception Course: Failure executing function

4.3.4.3 Variations

4.3.4.3.1 Unnamed Variation

Undefined Step

4.3.4.4 Exceptions

4.3.4.4.1 Failure executing function

1. An error is logged
2. Sub state is set to FAILURE and the use case ends

4.3.4.5 Trigger

4.3.4.6 Preconditions

NGCSW in state ONLINE, sub state READING

4.3.4.7 Stakeholders and Interests

4.3.4.8 Minimal Guarantees

Readout is performed regularly and no data is lost. The system is left in a consistent state.

4.3.4.9 Success Guarantees

User requested processing is performed and readout is done. System in substate COMPLETED.

4.3.4.10 Non-Functional Requirements

4.3.4.11 Business Rules

4.3.4.12 Process Changes

4.3.4.13 Training Changes

4.3.5 Adaptive optics processing

4.3.5.1 Context

Data are sent to Real Time Computer for Adaptive Optics computations. The data are sent to the RTC at the highest possible speed until the detector is completely read out. The readout is normally repeated in an infinite loop; however, for testing purposes, it may be executed only once. After completion of readout the use case ends.

4.3.5.2 Primary Scenario

Data are sent to the RTC at the highest possible speed until STOP or ABORT command are received.

Exception Course: Failure communicating to RTC or reading out the detector.

4.3.5.3 Variations

4.3.5.3.1 Unnamed Variation

Undefined Step

4.3.5.4 Exceptions

4.3.5.4.1 Failure in communicating to RTC or in reading out the detector

1. Data communication to the RTC fails.
2. An error is logged
3. Sub state is set to FAILURE and the use case ends
4. **Update Global System State**

   Post Conditions: State ONLINE, sub state FAILURE

4.3.5.5 Trigger

4.3.5.6 Preconditions

NGCSW in state ONLINE, sub state READING

4.3.5.7 Stakeholders and Interests

4.3.5.8 Minimal Guarantees

System left in a consistent state.

4.3.5.9 Success Guarantees

Data sent to the RTC and, possibly, 1 out of n frames sent to the IWS. System ONLINE, substate COMPLETED

4.3.5.10 Non-Functional Requirements

4.3.5.11 Business Rules

4.3.5.12 Process Changes

4.3.5.13 Training Changes

4.3.6 Auto Guider Process

4.3.6.1 Context

Data are sent to TCS for autoguiding.

4.3.6.2 Primary Scenario

Centroiding data of a predefined (in the SETUP) window(s) are computed and sent to TCS according to standard interface protocol. The readout is normally repeated in an infinite loop; however, for testing purposes, it may be executed only once.

> *Exception Course:* Failure (communicating to TCS or in reading out the detector or computing Centroiding data)

4.3.6.3 Variations

4.3.6.3.1 Unnamed Variation

Undefined Step

4.3.6.4 Exceptions

4.3.6.4.1 Failure

1. An error is logged
2. Sub state is set to FAILURE and the use case ends
3. **Update Global System State**

> *Post Conditions:* State ONLINE, sub state FAILURE

4.3.6.5 Trigger

4.3.6.6 Preconditions

4.3.6.7 Stakeholders and Interests

4.3.6.8 Minimal Guarantees

4.3.6.9 Success Guarantees

4.3.6.10 Non-Functional Requirements

4.3.6.11 Business Rules

4.3.6.12 Process Changes

4.3.6.13 Training Changes

4.3.7 Drift scanning

4.3.7.1 Context

Drift scanning data read out

4.3.7.2 Primary Scenario

1. Data are read out and sent to IWS continuously. If required they are displayed and/or saved to disk in FITS format. Readout continues until required number of lines has been read and shutter can be closed.

    Exception Course: Transfer failure

2. Shutter Controller closes shutter and shutter state set to CLOSED

3. **Update Global System State**

    Exception Course: Shutter Controller failure

4.3.7.3 Variations

4.3.7.3.1 Unnamed Variation

Undefined Step

4.3.7.4 Exceptions

4.3.7.4.1 Transfer failure

1. An attempt to reestablish the connection is made. If successful, the use case continues with its basic course and the event is logged. If fails:

2. Sub state set to FAILURE

3. Error message logged

4. **Update Global System State**

5. FAILURE answer to command is sent and the use case ends

Post Conditions: State ONLINE, sub state FAILURE

4.3.7.4.2 Shutter Controller Failure

1. Sub state set to FAILURE
2. Error message logged
3. **Update Global System State**
4. ERROR answer to command is sent and the use case ends

Post Conditions: State ONLINE, sub state FAILURE

4.3.7.5 Trigger

4.3.7.6 Preconditions

NGCSW in state ONLINE, sub state READING

4.3.7.7 Stakeholders and Interests

4.3.7.8 Minimal Guarantees

System is left in a consistent state.

4.3.7.9 Success Guarantees

Drift scan data transferred. System in state ONLINE, substate COMPLETED.

4.3.7.10 Non-Functional Requirements

4.3.7.11 Business Rules

4.3.7.12 Process Changes

4.3.7.13 Training Changes

4.3.8 Infrared Exposure

4.3.8.1 Context

A (or a loop of) infrared exposure(s) is/are taken. A STOP command will end the exposure or the loop allowing for completion of current exposure. The ABORT command will interrupt the use case with loss of data.

4.3.8.2 Primary Scenario

1. SETUP command is sent to NGCSS which in turn forward it to NGCCS

2. SETUP is verified by NGCCS against current configuration and rules

3. Requested sequences are loaded (if not already loaded by previous exposures) to the NGC electronics

   Exception Course: Command failure

4. OK answer is sent back

5. START command is sent to NGCSS

   Variation: Previous exposure still ongoing

6. NGCCS starts readout sequence, optionally executes use case **Synchronize.** NGCSW sub state is set to READING.

7. If necessary data are reordered or windows are extracted.

8. Sub-pixel sampling or chopping mode is executed as requested.

9. The step is executed applying then the **Infrared Readout Modes** use case.

10. **Update Global System State.**

    Exception Course: Command failure

11. all requested" data being transferred and stored and displayed. NGCSW sub state set to READING & TRANSFERRING until READOUT is completed, then to TRANSFERRING only.

12. **Update Global System State**

    Variation: **Adaptive optics processing**

    Variation: **User defined processing during Readout**

    Exception Course: Transfer failure

13. NGCSW sub state set to COMPLETED

14. **Update Global System State**

    Variation: Next exposure in a loop

15. Final OK answer to START

4.3.8.3 Variations

4.3.8.3.1 Previous Exposure still Ongoing

1. Warning message logged

2. Command is queued until previous exposure finishes and main course continues or timeout expires.

Exception Course: Error in queue

4.3.8.3.2 Next Exposure in a Loop

1. Increment loop counter
2. Go back to step 5 of Main Course

4.3.8.4 Exceptions

4.3.8.4.1 Command Failure

1. Sub state set to FAILURE
2. Error message logged
3. **Update Global System State**
4. ERROR answer to command is sent and the use case ends

4.3.8.4.2 Transfer Failure

1. An attempt to re-establish the connection is made. If successful, the use case continues with its main course and the event is logged. If fails:
2. Sub state set to FAILURE
3. Error message logged
4. **Update Global System State**
5. ERROR answer to command is sent and the use case ends

4.3.8.5 Trigger

4.3.8.6 Preconditions

4.3.8.7 Stakeholders and Interests

4.3.8.8 Minimal Guarantees

System is left in a consistent state.

4.3.8.9 Success Guarantees

The system is in state ONLINE sub state COMPLETED. Infrared data have been aquired.

4.3.8.10 Non-Functional Requirements

4.3.8.11 Business Rules

4.3.8.12 Process Changes

4.3.8.13 Training Changes

4.3.9 Infrared Readout Modes

4.3.9.1 Context

This use cases tries to take into account the various readout modes involved in infrared exposures.

4.3.9.2 Primary Scenario

Executes one of the following readout modes:

- Uncorrelated (simple adding up)
- Double Correlated (Reset-Read-Read)
- Double Correlated (Read-Reset-Read)
- Least Squares Fit
- Fowler Sampling
- Other: **User Defined Processing During Readout**

Exception Course: Failure

4.3.9.3 Variations

4.3.9.3.1 Unnamed Variation

Undefined Step

4.3.9.4 Exceptions

4.3.9.4.1 Failure

1. An error is logged
2. Sub state is set to ERROR and the use case ends
3. **Update Global System State**

Post Conditions: State ONLINE, sub state ERROR

4.3.9.5 Trigger

4.3.9.6 Preconditions

NGCSW in state ONLINE, sub state READING

4.3.9.7 Stakeholders and Interests

4.3.9.8 Minimal Guarantees

System is left in a consistent state

4.3.9.9 Success Guarantees

Required processing is performed.

4.3.9.10 Non-Functional Requirements

4.3.9.11 Business Rules

4.3.9.12 Process Changes

4.3.9.13 Training Changes

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