CTA Generic Telescope State Machine

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Change Log

Issue	Revision Index	Date	Section / Page affected	Reason / Remarks
1	a-f	09-04-2018	All	Initial versions discussed by the authors
1	g	12-04-2018	All	Added telescope top-level functional decomposition
1	h	10-05-2018	All	Added sub-states and additional transitions to fault
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1	l	04-07-2019	All	Minor editorial polishing. Updated telescope decomposition diagram.
1	m	29.10.2019	All	Update to new template
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2	c	3.12.2019	• Fig .4 (typo) • Tabs 1, 2, 3 (obsolete info)	Address CTA-N review RIXes.
2	d	23.1.2020	• Remove „mode“ in the document. • Updated statechart diagrams and state/transition details. • Added some missing definitions	Address Nick Whyborn’s comments.
2	e	17.3.2020	all	Feedback from LST, NectarCam, FlashCam amd SST added.
2	f	21.4.2020	all	Further feedback by LST

Issue	Revision Index	Date	Section / Page affected	Reason / Remarks
2	g	2021-10-20	Camera State Machine: Added Standby.PointingAssisOn and Standby.PointingAssitOff as substates of Standby. Corresponding transitions were added. Minor wording polishing. Added a note in each transition table to indicate which transitions are are not in the scope of ACADA	Request by LST team (CTA-CRE-TEL-000000-0001) Discussions with FlashCam, NectarCAM, and SST, and additional feedback from them.
2	h	2021-11-11	Changed document ownership and number	Correct an erroneous number and move to telescope group.

List of Abbreviations

ACADA	Array Control and Data Acquisition System
BIT	Built-in tests
COTS	Commercial off-the-shelf
CTA	Cherenkov Telescope Array
CTAO	Cherenkov Telescope Array Observatory
CTA-N	CTA Northern Array
CTA-S	CTA Southern Array
DPPS	Data Processing and Preservation System
IPS	Integrated Protection System
LST	Large-Sized Telescope
MST	Medium-Sized Telescope
OSS	Operations Support System
SDMC	Science Data Management Center
SOSS	Science Operations Support System
SST	Small-Sized Telescope
SUSS	Science User Support System
TCS	Telescope Control System
TOO	Target of Opportunity
TOSS	Technical Operations Support System
UML	Unified Modelling Language

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1 INTRODUCTION

1.1 Scope of the document

This document describes the finite-state machine for a generic CTA Cherenkov Telescope and its two sub-systems, the Structure[1], and the Camera. Any CTA telescope must implement the transitions and states presented in this document.

1.2 Definitions

This sub-section describes the main definitions used through this document. See the CTA Glossary [AD2] and Control Concept document [RD1] for further definitions.

- **State**. A State represents a situation where some invariant conditions hold; this condition can be static (waiting for an event) or dynamic (performing a set of activities). The behaviour of a system can be described through its state at different points in time. When a system is in a given state, it can perform different actions or do a transition to another state so that other actions can be performed.
- **Sub-state.** A state within another state, where transitions can be managed and triggered internally by the system according to external conditions (e.g. available time inside the current state).
- **Machine state:** A state that is intrinsic to the hardware state. These states and their transitions are not managed via the ACADA
- **Operational State:** A logical state of the element with respect to the operations the element is performing. These are the states and their transitions that ACADA is managing to perform the telescope operations.
- **Transition:** A Transition defines the logical movement from one State to another.
- **Event** is an external input to the system that induces the system to perform some actions. The event that determines a transition from State A to State B (e.g. goToStandby) is a **Trigger Event**.
- **Event Data** (input data) that must be provided together with the event.
- **Guard.** Conditions that must be true in order for a transition to happen. The Guard conditions are evaluated after an Event is dispatched, but before the corresponding Transition is triggered. If the guard is true at that time, the Transition is enabled; otherwise, it is disabled.
- **Actions**: When the State machine receives an event, it will perform actions (e.g. reading or setting hardware I/O, etc.). An action can be a method of a class or a function. These actions are internal to the system and not visible externally to the system.
- **Cherenkov Telescope:** A system composed of a Cherenkov Camera and Telescope Structure that is used to collect and image Cherenkov light from Air Showers.
- **Structure:** All of the hardware and software associated with a single optical telescope capable of pointing to different parts of the sky and collecting light on to a Cherenkov Camera. A Telescope Structure forms part of a Cherenkov Telescope System. Telescope Structure may be abbreviated as 'Structure'.
- **Camera:** All of the hardware and software associated with Cherenkov image detection, digitisation, transmission and pre-processing. A Cherenkov Camera forms part of a Cherenkov Telescope System and has as its principle elements a Camera Unit and camera software running

1 In this document, structure refers to a functional unit in the Telescope managing the behaviour all those elements that are not the Cherenkov Camera.

on a camera server deployed at the central computing cluster near the array site. Cherenkov Camera may be abbreviated as 'Camera'.

- **Software Component:** A software component (referred to as “component” in this document) is a software package, service, resource, or module that encapsulates a set of related functions or data. A software component can be deployed independently and is subject to composition by third parties.
- **Telescope Control System (TCS)**: Software deployed at the central computing cluster providing the high-level control interface to the ACADA for an individual Cherenkov Telescope (see [RD1]).
- **Telescope Manager**: The highest-level component in the TCS, responsible of receiving commands from ACADA and distributing them to other components in the TCS.

1.3 Telescope functional decomposition

For the purpose of this document, a CTA Telescope is a system composed of both a Camera and a Structure functional unit comprising each the corresponding software and hardware elements, both units coordinated by a Telescope Manager component (See Figure 1). The Telescope Manager is responsible for managing the Telescope system as a whole, delegating to Camera and Structure subsystems the implementation of associated operations. In the remaining of the document, it is assumed that the Telescope finite-state machine is implemented at Telescope Manager level, and Camera (resp. Structure) finite-state machine at the Camera (resp. Structure) subsystem. See [AD4] for further details on Telescope and CTA system design.

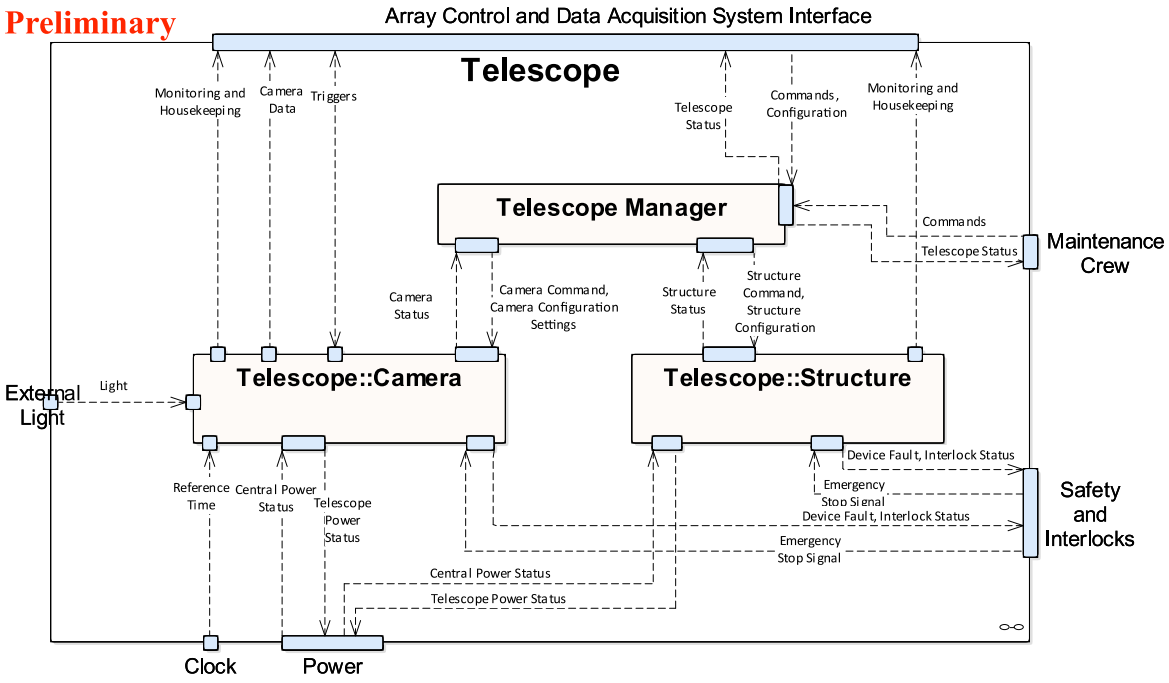

Figure 1: Decomposition of a CTA Telescope in functional units. See [AD4] for notation description and further details. Note that some Telescope-specific low level data flow items may be missing in the diagram.

1.4 Notation

The diagrams in this document use standard UML 2.5 convention for finite-state machine diagrams. States are represented as rounded squares, transitions as solid arrows, and transition guards are depicted within brackets ("[ ]"). See [2] for further details.

1.5 Applicable documentation

- [AD1] CTA Telescope and Common On-site level B requirements at Jama
- [AD2] CTA Glossary at Jama
- [AD3] Generic Telescope Use Cases document, Doc. Num. CTA-TRE-SEI-000000-0015 Issue 2 Rev I, 4.12.2019
- [AD4] CTA System Architecture document v1.0 14.04.2018

1.6 Reference documentation

- [RD1] CTAO System Control Concept, Doc. Num. CTA-TRE-SEI-000000-0016 (In Prep)
- [RD2] CTAO System Control Standard, Doc. Num. CTA-STD-SEI-000000-0004 (In Prep)
- [RD3] CTAO System Control Development Guidelines, Doc. Num. CTA-TRE-SEI-000000-0017 (In Prep)

2 DEFINITION OF STATES

This subsection describes the states that are used through this document. The states below are applicable (except for the Technical state) to the Telescope as a whole but also to the Camera and Structure subsystems. The following list defines[2] these states, where for simplicity *Element* refers to Telescope, Structure or Camera.

Machine states:

- **Off:** Beyond the Telescope Control System reach, without electrical power.
- **On:** *Element* is switched on, and available to operate under the operational states described below.
- **Maintenance:** *Element* is in a state designed to perform maintenance activities and is unavailable for scientific operations or any kind of remote control. Monitoring information is still, in general, available for ACADA.

Operational states (On state sub-states):

- **Initializing:** *Element* just transitioned to the ON machine state and is initializing all its internal components in order to arrive at the Initialized state.
- **Initialized:** *Element* is in a configuration suitable for survival in extreme environmental conditions, minimising the use of power whilst still providing basic status monitoring and maximising the instrument lifetime.
- **Standby:** *Element* is in a state, which is still safe with respect to adverse conditions, but has all components activated, with preparations for Observation initiated. Structure has all internal systems on and is unpark, and Camera is warmed up, but not yet ready for observations (e.g. lids are closed). An exception to this definition occurs with the Camera Standby.PointingAssistOn substate. This substate is not safe with respect to adverse conditions. Instead, the Standby.PointingAssistOn substate requires the same environmental conditions as those required by the Ready and Observing states.
- **Ready:** *Element* is prepared for a rapid transition to the Observing State. Internal calibration activities may take place.
- **Observing***: Element* is in a state associated with observatory data taking, with configuration dictated by performance requirements. Data are being taken by Camera, Structure is tracking (or pointing to) the target, calibration activities may take place.
- **Fault:** *Element* has encountered a serious problem which means it is currently unable to reach one of the standard states or is unable to continue to maintain the current status. For errors that permit to continue the operation of the corresponding state within requirements, the Element should stay in its correct state while such error is solved (the error is to be logged). Whenever the Element enters in the Fault state, an Alarm shall be raised to IPS and/or ACADA depending on the nature of the Alarm. safety-related. (Safety-related alarms are to be managed by IPS, and operations-related by ACADA.) The transition to this state is automatically performed by the system.
- **Technical:** A logical state where the Telescope allows ACADA to get an extended interface in order to execute special calibration and testing procedures. This state is only applicable to Telescope and not to Structure or Camera.

2 Glossary[AD2] definitions will supersede the previous definitions in case of conflict.

3 FINITE-STATE MACHINE FOR A CTA TELESCOPE

Figure 2 shows the top view of the generic finite-state machine applicable for the Camera, the Structure and the Telescope as a whole. At the first level of detail, Telescope, Structure, and Camera implement the same states and transitions, and in a usual night cycle Structure and Camera are at the same operational state (e.g. when the Telescope is in Standby Camera and Structure are in the Standby state).

The transitions of the Telescope from Off to On and to Maintenance Telescope are triggered by a manual switch. The details of such transitions and states are outside the scope of this document, which is focused on the operational states.

Note that the transition from *Initializing* to *Fault* represents a failed attempt of the Telescope Control System to bring up a sub-system, the failure of which is reported as a Fault state. This applies analogously to Structure and Camera.

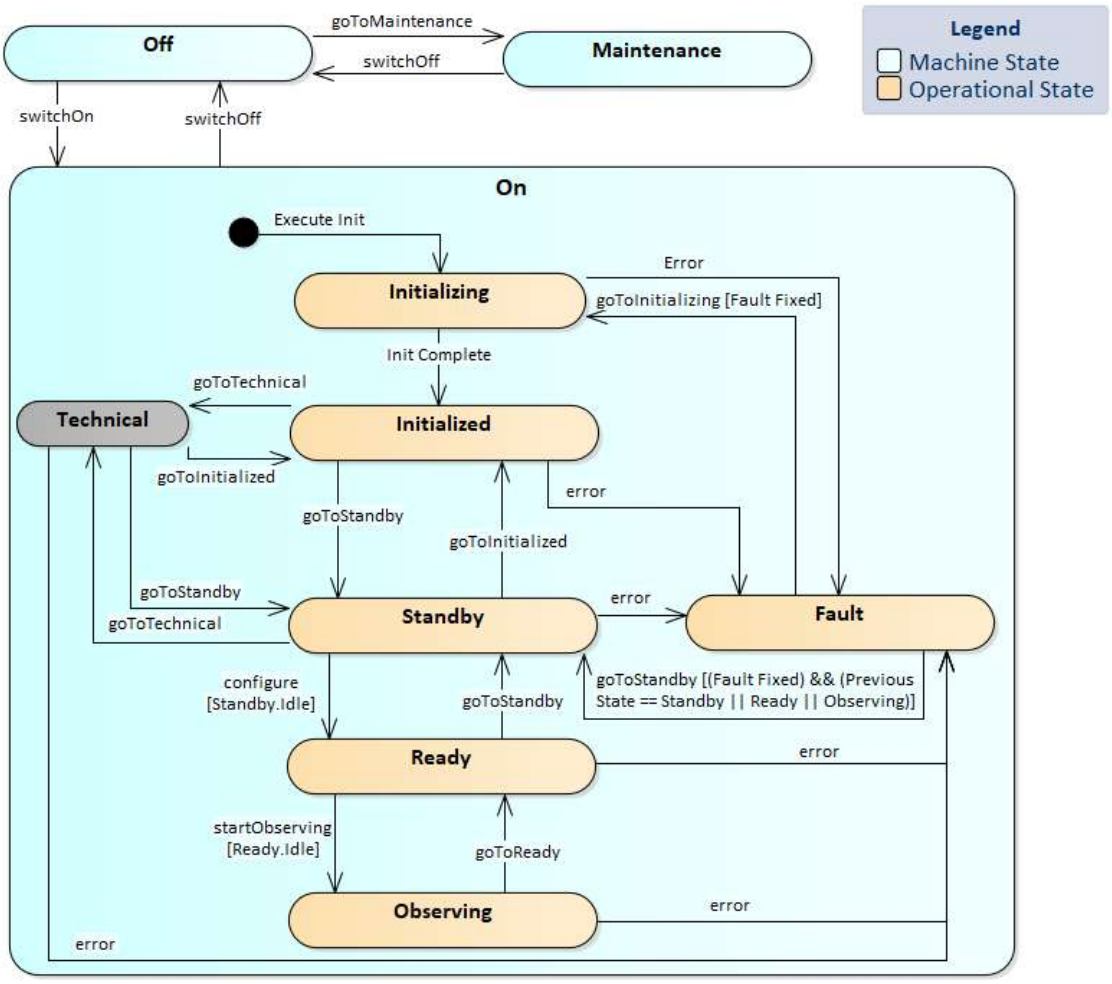

Figure 2: Generic Finite-State Machine for a CTA Telescope Element. Machine states are represented in cyan colour, while operational states are depicted in an orange colour.

3.1 Finite-State machine for a CTA Camera

The Cherenkov Camera implements the generic state machine presented in the previous section, except the Technical state. In addition, certain Camera states have internal sub-states that are managed internally by the Camera, and there is an additional *pointingAssist* state that is not present in the generic state machine. Table 1 and Figure 3 show a description of the states, sub-states, transitions and their conditions.

Any CTA Camera needs to report the top-level states to the Telescope Manager which sends this information to ACADA. In the case of a particular sub-state not being applicable for a particular camera type, then that sub-state does not need to be implemented. However, if a camera is able to perform an operation compatible with the description of the sub-state then it must implement that sub-state.

Different types of Camera operations are defined by "dynamic" configuration settings loaded when entering in the Ready state. When the Camera starts Observing, it acquires data according to the operations defined in the provided configuration. See Section 5 for details on how "Calibration" is handled in this scheme.

Table 1: States and sub-states of Camera

State	Sub-state	Description	Exiting Transitions
Machine States			
Off		This is the state that the Telescope Manager can infer when there is no connection to the Local Control System. If an attempt to power up the Camera results in one of its sub-systems not able to be powered up then the Camera will go to the Fault state, via the *Initializing* state.	*switchOn (1), goToMaintenance (1)*
Maintenance		The Camera is in a state designed to perform maintenance activities and is unavailable for scientific operations or any kind of remote control.	*switchOff (1)*
On		The Camera is switched on, and available to operate under the operational state described below.	*switchOn (1.*
Operational States within the On State			
Initializing		Camera just transitioned to the ON machine state and is initializing all its necessary internal components in order to arrive at the initialized state.	*Init Complete (2), error (2)*
Initialized		Camera is in a configuration suitable for survival in extreme environmental conditions, minimising the use of power whilst still providing basic status monitoring and maximising the instrument lifetime.	*warmUp, error (2), enablePointingAssist.*
PointingAssist		Camera is in a state to support dedicated Telescope pointing monitoring measurements (e.g. TPoints). The specific implementation may vary from telescope to telescope type, e.g. for a certain particular telescope type it would mean to prepare a target in which projecting the reflected image from a star.	*disablePointingAssist, warmup, error (2)*
Standby	***Orthogonal region for warming up operations***		
	WarmingUp	Camera starts immediately the warming-up procedure. Pointing Assistance can be activated or deactivated (see *Orthogonal region for pointing assistance operations)* The operation can be externally aborted; then the Camera goes to the Initialized state. Otherwise, Camera will self-transition to the Idle sub-state. If the camera is already warmed up when entering in the state, and then it goes immediately to the idle sub-state. An	*abortWarmingUp (then triggers a goToInitialized transition), error(2)*

		abortWarming command will then trigger a goToInitialized transition.	
	Idle	Camera is warmed up and ready to go to the Ready state. Pointing Assistance can be activated or deactivated (see *Orthogonal region for pointing assistance operations)* Only in this (subsub) state and PointingAssistOff is set a transition to Ready possible.	*goToInitialized, configureCamera, error (2)*
	Orthogonal region for pointing assistance operations		
	PointingAssistOn	Camera is in a state to support dedicated Telescope pointing monitoring measurements Dedicated Telescope pointing monitoring measurements may be performed (e.g. for a certain particular telescope this might mean driving a target on the focal plane in which projecting the reflected image from a star).	*disablePointingAssist, error(2)*
	PointingAssistOff	Pointing Assistance is deactivated. Only in this (subsub) state and Idle (subsub) state is set a transition to Ready possible.	*enablePointingAssist, configureCamera, error*
Ready	**Idle**	Camera is warmed up, lids are open, and ready to go to the Observing state. Dynamic configuration is loaded on entry. A self-transition can be triggered to reconfigure the dynamic configuration, which brings the Camera back to the ready.Idle state or triggers an internal calibration depending on the new configuration and time budget. It is possible to request an enablePointingAssist transition. In that case, the camera goes to the Standby.[Idle, PointingAssist] states.	*startObserving, goToStandby, error (2), reconfigure, startCalibration, enablePointingAssist*
	Calibrating	Camera self-calibrating. It can be triggered internally, according to the time budget provided by ACADA for being ready for observations, but can also be externally triggered to start internal calibrations.	*startCalibration calibrateCamera, error(2), [internal]calComplete.*
Observing		Camera is acquiring data. Depending on the configuration parameters loaded during the ready state, the camera can be acquiring Cherenkov shower data, dedicated calibration data or shower and interleaved calibration data.	*goToReady, error (2)*
Fault	**Fixing**	Camera is trying self-fix the error. After fixing the error, if the Camera was in the Standby, Ready or Observing state and depending on the nature of the error, it will go try to reach to the Standby state. In case the Standby state cannot be reached, of for the other states before the fault. Otherwise, it goes to the Initializing states (which will trigger the transition to go to the Initialized state afterwards). If the cancelTransition command is issued, the interruption of autonomous fixing procedure is attempted, and the Camera will go to the CouldNotFix state.	*goToInitialazing, goToStandby.*
	CouldNotFix	Camera could not self-fix the error and needs human intervention to fix the problems Note: In addition to SwitchOff, other means by manual interventions using the TCS may allow to return the telescope to the Initialized or Standby State directly. A description of such procedures depends on the telescope type and is outside the scope of this document.	*switchOff (1) (manually triggered as a transition from the On state, see "Machine States")*
Notes: *(1) Not managed by ACADA* *(2) Self-triggered by the Camera*			

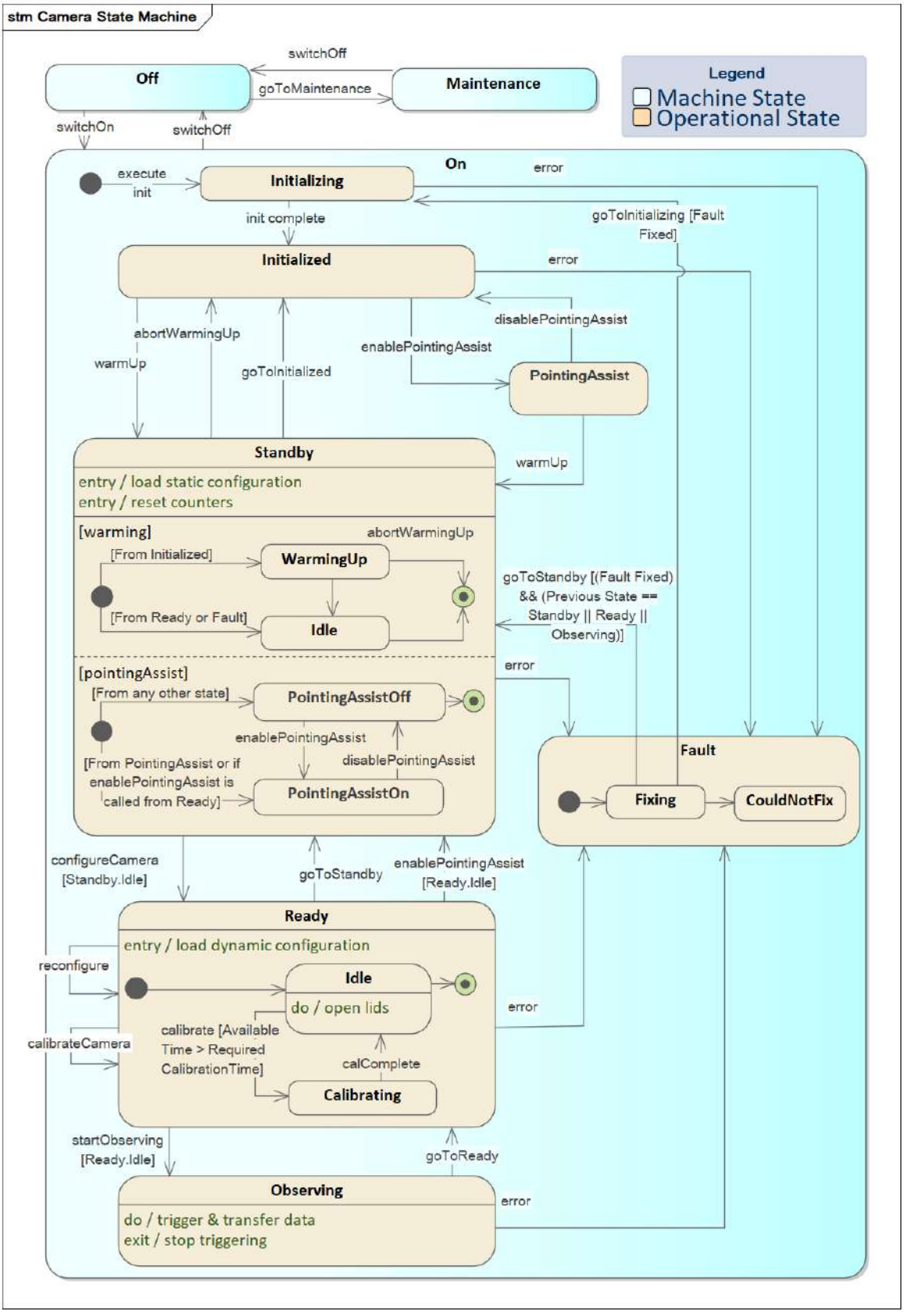

Figure 3: State machine of Camera including the states and their sub-states.

3.2 State machine for a CTA Structure

The state machine of a Telescope Structure implements the generic states presented in the previous section, except the Technical state. In addition, certain states have internal sub-states that are managed internally by the Structure. Figure 4 and Table 2 show a description of the states, sub-states, transitions and their conditions. As in the case of Cameras, any Structure type must implement all the top-level states, and the sub-states when applicable.

Structure can receive an *applyOffset* command while in the Observing state (when in Tracking or FixedPosition sub-states). This typically triggers an internal transition to *Offsetting* and then another internal transition back to the *Tracking* sub-state, while Camera keeps taking data. At a lower level this is likely to be the same operation as "slewing", but the Structure control system software reports it differently.

Table 2: States and sub-states of Structure

State	Sub-state	Description	Transitions
Machine States			
Off		This is the state that the Telescope Manager can infer when there is no connection to the Local Control System. If an attempt to power up the Structure results in one of its sub-systems not able to be powered up then the Structure will go to the Fault state, via the *Initializing* state.	*switchOn(1), goTo-Maintenance (1)*
Maintenance		The Structure is in a state designed to perform maintenance activities and is unavailable for scientific operations or any kind of remote control.	*switchOff (1).*
On		The Structure is switched on, and available to operate under the operational state described below.	*switchOff (1), goTo-Maintenance (1)*
Operational States within the ON State			
Initializing		Structure just transitioned to the On machine state and is initializing all its necessary internal components in order to arrive at the initialized state.	*Init Complete (self-triggered transition), error (2)*
Initialized		Structure is in a configuration suitable for survival in extreme environmental conditions, minimising use of power whilst still providing basic status monitoring and maximising the instrument lifetime.	*goToStandby, error*
Standby	**Idle**	Already unparked and able to start the transition to "Ready". Goes to this state if it is already unparked when entering the Standby state.	*goToInitializedOn, configure), error (2)*
	Parking/Unparking	Structure is parking or unparking. When coming from the Initialized state, the Structure starts the unparking procedure, and when done it automatically transition to idle.	*error (2)*
Ready	**Idle**	Able to go to the Observing state	*goToTarget, goTo-Standby, error(2)*
	Calibrating	Internal telescope calibrations such as when initial mirror alignment for the night happen. Structure cannot be tracking.	*Error(2)*
	Slewing	Going to another pointing position. Goes to Ready.Idle, Observing.FixedPosition, or to Observing.Tracking automatically when done, the latter case being when the telescope is instructed to start tracking an Object in the sky upon arrival. Can be cancelled, in that case it goes to the idle sub-state.	*StartObserving, Error(2), stop*
Observing	**Tracking**	Following a position in the sky, or a proper motion target.	*applyOffset, goToReady, error(2)*
	FixedPosition	Pointed to a particular fixed position in Alt-Az (e.g. drift scan mode).	*applyOffset, goToReady, error(2)*
	Offseting	Moving to a new position in the same field of view. Goes to the previous sub-state (Tracking or FixedPosition) spontaneously when the operation is finished.	*Error(2)*
Fault	**Fixing**	Structure is trying self-fix the error. After fixing the error, if the Structure was in the Standby, Ready or Observing state it will try to reach the Standby state. In case the Standby state cannot be reached, of for the other states before the faultand depending on the nature of the error, it will go to the Standby state. Otherwise it goes to the Initializing states. If the cancelTransition command is issued, the autonomous fixing procedure is interrupted, and the Structure will go to the CouldNotFix state.	*goToInitializing, goToStandby,switch-Off*

	CouldNotFix	Structure could not self-fix the error and needs human intervention to fix the problems Note: In addition to SwitchOff, other means by manual interventions using the TCS may allow to return the telescope to the Initialized or Standby State directly. A description of such procedures depends on the telescope type and is outside the scope of this document.	*switchOff (1) (manually triggered as a transition from the On state, see "Machine States")*
Notes: *(1) Not managed by ACADA* *(2) Self-triggered by the Structure*			

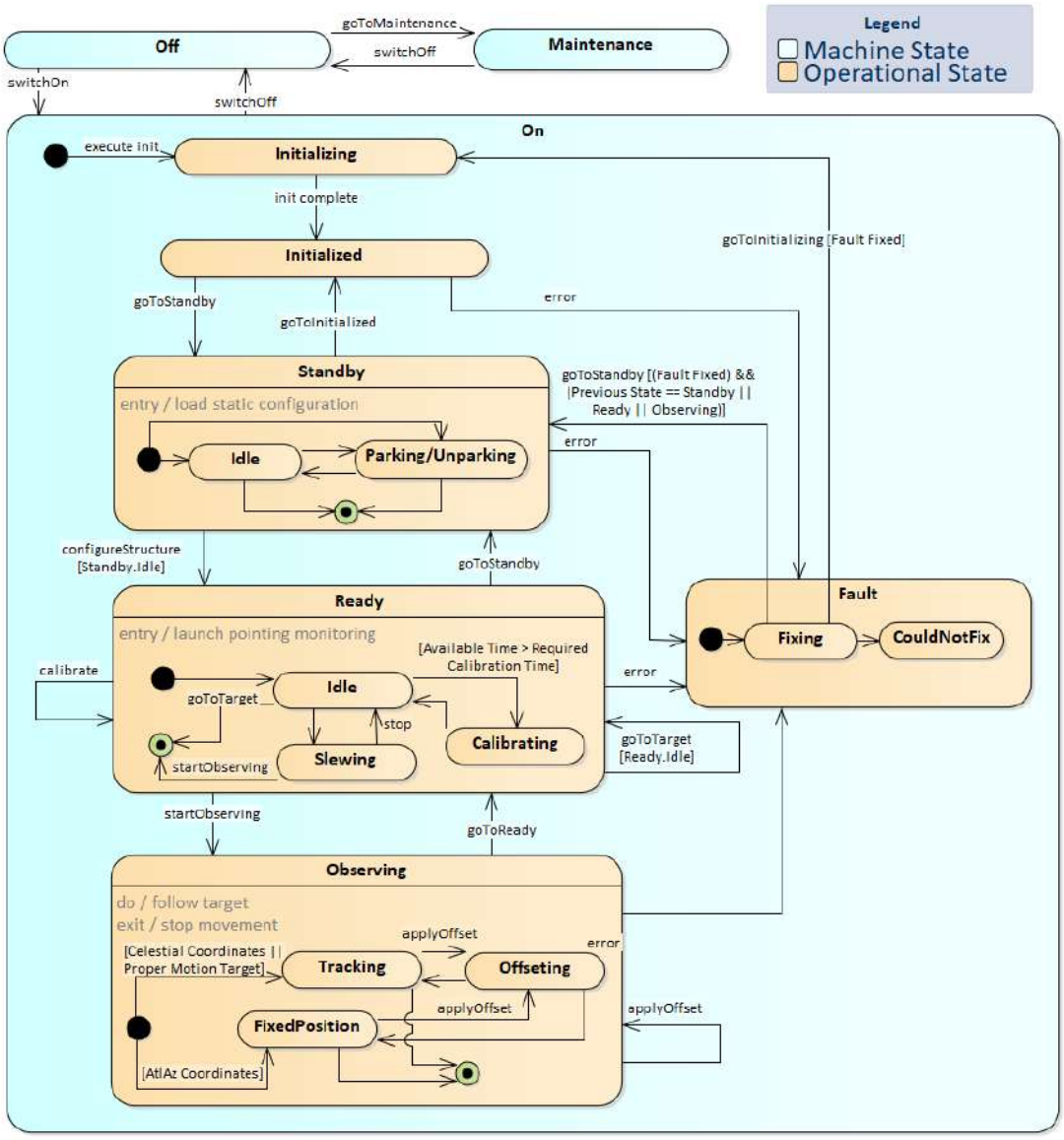

Figure 4: State machine of Structure including the states and their sub-states.

3.3 State machine for a CTA Telescope

This section describes the state machine that represents a CTA telescope as a whole. These are logical states and are determined by the combination of the states of the Structure and Camera as indicated in Table 3 and in Figure 5.

For the usual operations of a CTA telescope, the overall Telescope state means that both the Structure and the Camera are in the same state. The following exceptions apply:

- **Maintenance**: In addition to the Maintenance state, Camera (resp. Structure) is allowed to be Off and On. When both Camera and Structure are put to their respective On states, the global state of the Telescope can perform the transition to the On state.
- **Observing**: In addition to Observing, the Structure is allowed to be in the Ready state for a short interval when ACADA commands Telescope to acquire data as soon as the target is within the field of view of the Camera. In those cases, the camera can start observing when the target is in the field of view, while the Telescope is still slewing.
- **Technical**: A wide range of combinations is allowed.

In addition to the transitions shown in Figure 5, it is possible in principle to have transitions from Technical and Maintenance states to the Off state, but these are special cases and happen during low-level operations and severe problems, and have been omitted here for the sake of simplicity.

Table 4 describes the possible combinations of Structure and Camera and the global reported state. Note that in some cases, in order to determine the global Telescope state some additional details are needed (e.g. the path from which the state was achieved)

Table 3: Global Telescope Operational states and sub-states description

State	Sub-state		Description & Conditions	Transitions
Initializing			Telescope, including Structure and Camera, is initializing from the Off state.	*Init complete, error (1).*
Initialized	Cam	**Initialized**	Both Structure and Camera must be in the Initialized state	*goToStandby, goToTechnical, error.*
	Struct	**Initialized**		
Standby	Cam	**Standby**	Both Structure and Camera must be in the Standby state	*goToInitialized(1), configure, goToTechnical, error (1)*
	Struct	**Standby**		
Ready	Cam	**Ready**	When both Structure and Camera must be in the Ready	*startObserving, goToTarget, reconfigure, goToStandby, error (1)*
	Struct	**Ready**		
		Observing	When Structure is following a target, but Camera is not observing	
Observing	Cam	**Observing**	Telescope is Observing when Camera is Observing.	*goToReady, applyOffset, error (1)*
	Struct	**Observing**	When Structure is following a target, and Camera is observing	
Fault	Cam	**Fault** OR any state if Structure.Fault*	*Except Camera in Maintenance. If the Camera is in Maintenance the Structure must be in Maintenance, or Off	*goToInitialized , goToStandby.*
	Strcut	**Fault** OR any state if Camera.Fault*	*Except Structure in Maintenance. If the Structure is in Maintenance the Camera must be in Maintenance, or Off	
Technical	Struct	Any except Initializing and Fault	This is a special operation mode that allows ACADA to get control of the Structure and the Camera Controller components. It can be used to perform array-level technical operations such as “pointing runs” and special camera calibration operations.	*goToInitialized, goToStandby, error (1).*
	Cam	Any except Initializing and Fault		
Notes: *(1) Self-triggered by the Telescope Manager*				

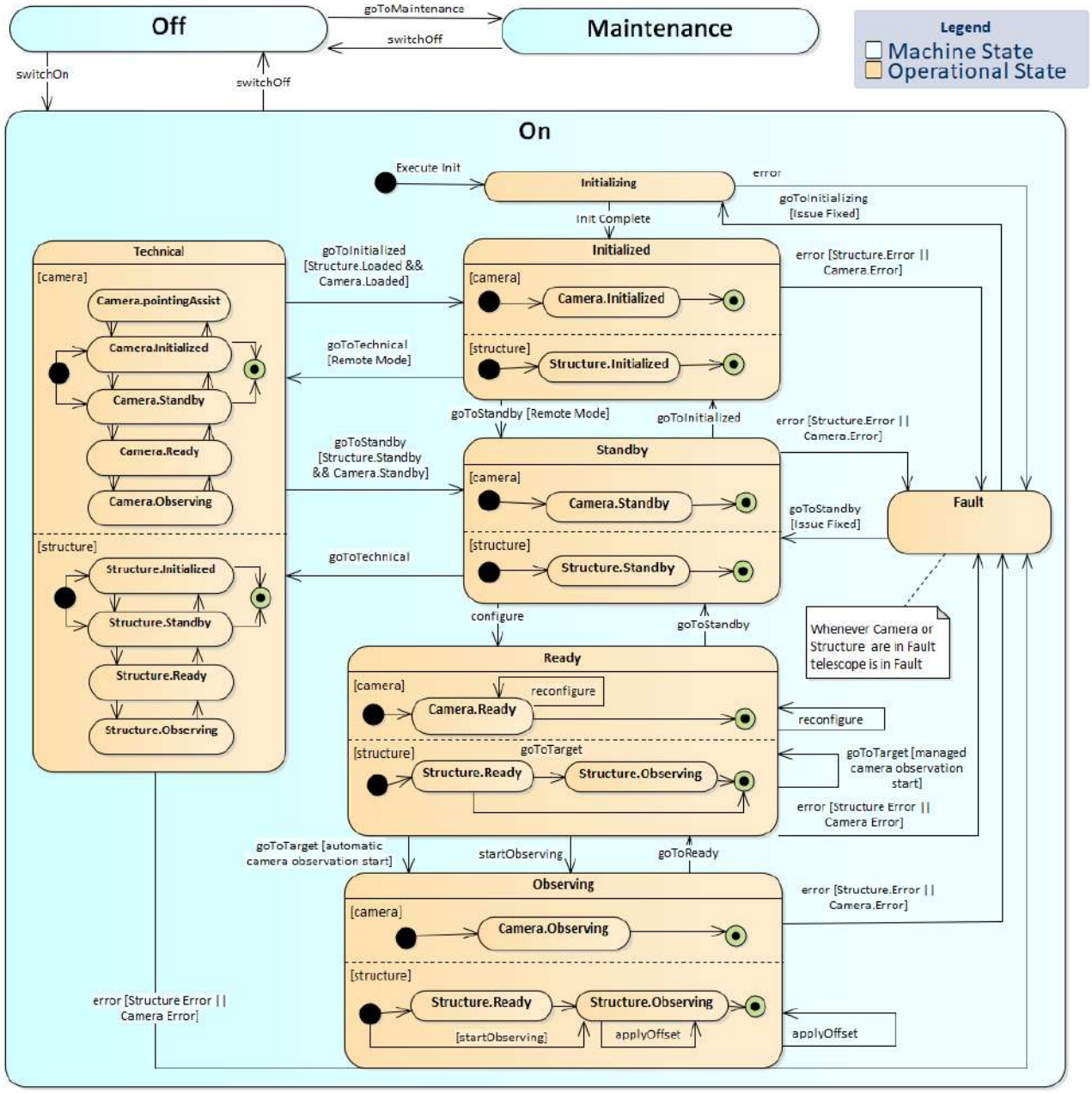

Figure 5: State Machine of a CTA Telescope

Table 4: Possible Combinations of Camera and Structure states together with the corresponding global telescope states

	Structure - Off	Structure - On	Structure - Maintenance	Structure - Initializing	Structure - Initialized	Structure - Standby	Structure - Ready	Structure - Observing	Structure - Fault
Camera - Off	Off	Maintenance	Maintenance						
Camera - On	Maintenance	On	Maintenance						
Camera - Maintenance	Maintenance	Maintenance	Maintenance						
Camera - Initializing				Initializing	Initializing	Not Allowed	Not Allowed	Not Allowed	Fault
Camera - Initialized				Initializing	Initializied	*Technical*	*Technical*	*Technical*	Fault
Camera - Standby				Not Allowed	*Technical*	Standby	*Technical*	*Technical*	Fault
Camera - Ready				Not Allowed	*Technical*	*Technical*	Ready	Ready** */Technical*	Fault
Camera - Observing				Not Allowed	*Technical*	*Technical*	Observing*/ *Technical*	Observing	Fault
Camera - Fault				Fault	Fault	Fault	Fault	Fault	Fault

Notes: * for a short period of time before Structure is Tracking; ** If structure is following a target but camera is not observing

4 ENVIRONMENTAL CONDITIONS AND TRANSITIONS

The conditions to enable any particular transition are specified as requirements in Jama [AD1][3].

5 APPENDIX I: Notes on "Calibration"

The term calibration is used for various different meanings in the CTA project and may cause confusion in the scope of this document. We want to note that we deliberately decided against having a global Telescope or Camera *Calibration state* because of the possible confusion. Here we explain the various calibration procedures and what are the associated states:

- **Camera calibration and calibration data:** Depending on the Camera type and the allowed time budget provided by ACADA before observations, the Camera can decide to perform a calibration while the telescope is in the Ready state. In this case, the Camera is in the Ready.Calibrating state. For the operations happening during the Ready.Calibrating state, the Camera is allowed to close and open the lids if the particular calibration operation requires it. The camera may need to perform dedicated calibration observations before acquiring shower data, or perform that operation according to the loaded configuration; in that case the Camera is in the Ready.Calibrating state. Certain Camera types can acquire interleaved calibration data while observing air showers; in that case there is no special state and the Camera is just in the Observing state.
- **Camera Pedestals:** The Camera can obtain Pedestals/Zero bias image data. It can perform that operation under the Ready.Calibrating state, or in the case of interleaved operations with the acquisition of shower data, Camera just reports Observing state.
- **Special Camera Calibration:** The Technical state allows for special Calibration operations managed remotely by the ACADA when for example it is not needed or possible to unpark the telescope. Lower level calibration operations are performed in the Maintenance state.
- **Pointing calibration operations ("pointing runs") using CCD cameras:** These are performed in the Technical state, by ACADA managing the Structure in the Observing state while Camera

[3] We are aware that not all transitions have yet corresponding requirements in [AD1] in the time of writing this document version. It is planned to finalize these requirements soon.

is, in principle in the On or Standby states (depending on the program for the rest of the night).[4]

- **Mirror alignment calibration**: If this refers to an automatic operation to happen for example at the beginning of the night or regularly at the discretion of the Structure, it happens in the Structure.Ready state. Such operation refers to a special or dedicated but automatically scheduled or at (sub-)array level, not associated with the usual data taking, then it happens and the Technical state. If this refers to a special manual operation by the expert, then it happens in the Maintenance state. If happening all the time while observing: no special state (just observing).
- **Still yet-to-define remote calibration operations managed from ACADA:** These are done in the Technical state.

6 APPENDIX II: Validation of State Machines with respect to Generic Telescope Use Cases

The document Generic Telescope Use Cases [AD3] defines, for each use case, the state or transition of the element for each use case step. We refer to that document for further details.

4 Alternative pointing calibration operation may do done by imaging the sky stars with the Cherenkov Cameras proposed by some SST team members.