SP-1623
As per discussion with the NCRA Team on 21/06/2021

Telescope Operational State

Telescope Operational State as reported by the TMC Central Node. The goal is to define a set of indicators (states and modes) to report the overall status of the telescope. Not an easy task, given that each SKA Telescope supports several observing modes, consists of a large number of components, spread over several locations and comprises computing, networking and other supporting equipment (e.g. clocks, weather stations, RFI detectors), some not under the direct control of TMC.
Several indicators will be required to determine different aspects of the Telescope status. The operational state, as defined by the CS Guidelines, was defined for the SKA Elements, i.e. major subsystems. In a similar manner as the Telescope, most of the subsystems also consist of diverse equipment and software components, determining operational availability is a complex task.
The indicator 'operational state' mostly relates to the availability and consumption of power. Once the power is connected, operational *availability* is reported using other indicators.

Context

It is a level 1 requirement that each Telescope (MID and LOW) implements a low power mode where it consumes less than 5% of the power budget (or nominal power).
From that requirement the equivalent requirements were derived for the major subsystems (TM, DISH, MCCS, CSP, and SDP). Given that TANGO built-in attribute state does not allow for custom values, state=STANDBY is used to identify low-power mode where the Telescope (and each of the major subsystems) use less than 5% of allocated power budget.

The design tabled at CDR assumed that the equipment in the Central Processing Facility(CPF) will be installed so that when power is connected, only a small portion of equipment starts up (each Element/subsystem defined its own set of equipment which consumes less than 5% of total power).

The design assumed that: When power is connected (main switch ON), a portion of the equipment is immediately energized, the switches and servers come up, and software is started. For the DISH, CSP, MCCS, SDP state=STANDBY means that only the servers running the master monitor and control software and the network switches are ON.
For TM it was some rudimentary part of TM software.
Note: transition from OFF (no power) to STANDBY is implemented in hardware and partly software (automatic startup and transition to STANDBY).

The plan was that when the TMC receives a command to transition to state=ON, the full set of ™ hardware and software is started, and when the full ™ is ON, then TMC commands other subsystems, one by one, to transition to state=ON. Subsystems are commanded to

transition to ON one at a time, to keep inrush power below pre-defined limits and to keep the load balance among the phases (CPF power supply provides 3 phases). The details of this procedure will be determined and implemented in software. Each major sub-system (CSP, MCCS) implements its own startup procedure. TMC might have to start some smaller components individually but that's to be determined.

Table 1 ***Telescope Operational State - definition – the correct version (as initially intended and defined for the Telescope as a whole and its subsystems).***

OFF	Power is not connected. When the equipment in the racks installed in the Central Processing Facility (CPF) is not energized, TMC equipment is OFF, TMC software is not up and running, therefore the Telescope state cannot be reported by the Telescope itself; it can be reported by a client which can determine whether the power is connected. The clients, which cannot determine the status of the power switches, can only report that TMC is unresponsive. In order to report the Telescope State, the TMC software must be running, which means that the TMC servers must be ON (or STANDBY) and the software must be running. In other words, the TMC never reports the Telescope state as OFF.
STANDBY	Telescope uses 5% of the total power budget, or less. A subset of equipment and software is on. The TMC Central Node, Leaf Nodes and Subarrays are ON. The Alarm Handler should be ON. The EDA should be ON.
ON	The telescope (or sub-system) uses more than 5% of the total power budget. This does not mean that the Telescope is able to perform observations (capture astronomical data and produce output products).
ALARM	A Telescope-level alarm is an indication that a condition has been detected which requires operator attention. Unlike sub-system alarms, which are not necessarily IEC 62682 alarms (i.e. do not necessarily require operators attention), the telescope alarms are IEC 62682 alarms. Note: Some of the Telescope functionality may be available, the Telescope may be able to carry on (some or all) observations. Additional information may be required to determine which functions, equipment, and/or observations are affected. For each alarm, the operator screens provide additional information regarding availability of the Telescope functionality and suggested action(s).
FAULT	The Telescope entered a failed state; human intervention is required to return to normal. The Telescope monitor and control function, and some of the functions related to observing (calibration, weather stations, timing) may still be available, but the observations cannot continue. See the question below.

In preparation for construction, the Telescope Manager software was subdivided to Telescope Monitor & Control (TMC) and OSO. The TM computing infrastructure in pre-

construction provided by the TM Local Infrastructure was discontinued and TM Local Monitor and Control software were discontinued as products (to my knowledge). During the bridging, the SKAO MVP is deployed on existing servers provided by member countries. Those servers are not operated and managed by SKAO.

During the bridging, the approach was adopted that the computing infrastructure is not treated as a part of TMC. The computing infrastructure (equipment and software) is monitored and controlled via other means (off-the-shelf solution).

In this new situation, TMC state=STANDBY does not have the initially intended meaning.

Proposal:
PI11 version of TMC does NOT implement the STANDBY state (See the section on TMC state reporting for details).

Justification: According to the TM L2 requirement, TMC should implement a STANDBY (low-power) state, but the functional requirements are not clear.
Suggestion: update the TMC state machine so that, after initialization, TMC enters ON.
In other words, the reported state should reflect the actual implementation.

TBD1: What about EDA. It would be best that the EDA also becomes active and enters state=ON.

Other subsystems may keep their state machines as-is, and implement what makes sense.

TBD2: With move of CSP to Cape Town and Perth:

- does requirement for the low power mode remain the same?
- does it apply to both locations?

TBD3: What about OSO, OET ?

There are still many unknowns regarding the implementation of the Telescope low-power state.

Here we describe the PI11 implementation related to TMC and Telescope state.

We can keep the simplified version implemented so far, with some changes.

PI11 Implementation

Table 2 Telescope Operational State - PI11 implementation

Telescope	TMC SW	DISH/MCCS	CSP	SDP	Comment
OFF[1] Imaging=not_available PSS=not_available PST=not_available VLBI=not_available	ON	OFF OFF OFF OFF	OFF	OFF	Part of the Telescope is ON (TMC), but Telescope cannot be used for observing.
STANDBY Power: 4.5% Imaging=not_available PSS=not_available PST=not_available VLBI=not_available	ON	STANDBY STANDBY STANDBY STANDBY	STANDBY	STANDBY	Using less than 5% of power.
state=ON Power: 15% Imaging=not_available PSS=not_available PST=not_available VLBI=not_available	ON	ON ON ON STANDBY	STANDBY	STANDBY	Using more than 5% of power.
ON 1 receptor available Imaging=available PSS=not_available PST=not_available VLBI=not_available	ON	ON OFF OFF STANDBY	ON Planned - not implemented: Imaging=available PSS=not_available PST=not_available VLBI=not_available Able to process input from 1 receptor.	ON Does SDP report ability to perform observing modes ?	Also need to report for CSP: how many dishes it can process and portion of BW it can process. Health has also to be considered.
ON 4 receptors available Imaging=available PSS=not_available PST=available VLBI=not_available	ON	ON ON ON ON	ON Planned - not implemented: Imaging=available PSS=not_available PST=available VLBI=not_available	ON	

[1] During the discussion on 21 June agreed that TMC state is not part of the aggregation. Assumed this to be a temporary solution. TMC could/should be treated as a part of the Telescope, in the same manner as the control software in other subsystems. For example if the CSP.LMC software is not rolled-up in the overall CSP state, the TM would have to roll-up the CSP.LMC state and CSP state individually.

ON Imaging=not_available PSS=not_available PST=not_available VLBI=not_available	ON	STANDBY STANDBY STANDBY STANDBY	ON	OFF	The Telescope uses > 5% of power, but cannot be used for observing.
ON Imaging=not_available PSS=not_available PST=not_available VLBI=not_available	ON	ON ON ON ON	STANDBY	OFF	The Telescope uses > 5% of power, but cannot be used for observing.
ON Imaging=not_available PSS=not_available PST=not_available VLBI=not_available	ON	ON ON ON UNKNOWN	UNKNOWN	ON	The Telescope uses > 5% of power, but cannot be used for observing.
ON 3 receptors available Imaging=available PSS=not_available PST=available VLBI=not_available	ON	ON ON ON ON	ALARM Planned - not implemented: Imaging=available PSS=not_available PST=not_available VLBI=not_available Can process 3 receptors	ON	CSP reported alarm - cannot process input from one of the receptors.

Note: The table does not include the status of supporting systems:
SAT, EDA, RFI detector, weather station, network, etc.
At this time the MVP does not include those but will soon have to.

Note: During discussion on 21 June agreed that in PI11 the TMC will implement attributes: Imaging, PSS, PST and VLBI.
The Imaging indicator is derived from the state of the DISH, CSP and SDP.
PSS, PST and VLBI in this version are always reported as not unavailable.
These 4 indicators (attributes) should be implemented and included in the dashboard as indication of the planned reporting of the functional availability.

In order to declare that observing mode imaging is available:

- At least one dish has to be available (ON).
- CSP has to be ON and able to process input from at least one dish.
- SDP has to be ON.

The availability will be in more detail determined when per subarray (when resources are assigned to the subarray).

Telescope Imaging	Telescope	DISH/MCCS	CSP	SDP	Comment
available	ON	ON OFF OFF OFF	ON	ON	Minimum required to report that observing mode imagining is available.

Commands

When received, the commands: On(), Standby(), Off() have to be intelligently handled.

Example:
If the status of the Telescope and its subsystems is as shown in the 1st row in the table below, if the TMC receives command On() it should forward the command to the dishes and CSP (the SDP is already ON).

If the status of the Telescope and its subsystems is as shown in the 2nd row in the table below, if the TMC receives command On(), it should forward the command to the CSP. When CSP transitions to ON, the TMC shall send command standby to SDP, and when that transition is completed, the command On().

Telescope	TMC SW	DISH/MCCS	CSP	SDP	Comment
ON	ON	STANDBY STANDBY STANDBY STANDBY	STANDBY	ON	
state=ON	ON	ON ON ON ON	STANDBY	OFF	

TMC Operational State

TMC Comprises:

- Telescope TANGO DB
- TMC 'core' software (Central Node, Leaf Nodes, Subarrays, etc)
- Alarm Handler
- EDA

All 4 items listed above must be functional for the TMC, and the Telescope, to be functional.

- Without the Telescope TANGO DB the TMC components cannot communicate with each other nor with other parts of the Telescope, and cannot communicate with the Clients, most importantly with the operator interfaces.
- Without the Alarm Handler and related software components, the Telescope is not able to process and report alarms, which is an unacceptable risk.
- Without EDA (and related software components), the TMC and other Telescope parts cannot log engineering data, which introduces risk (no monitoring of trends) and results in loss of engineering data generated during observations; the telescope cannot be assumed to be operational without EDA.

It was agreed with the NCRA team that in PI11 the EDA status is not taken into consideration when overall TMC status is derived.
The NCRA Team also proposes not to include the Alarm Handler in PI11 version.
The status of the Alarm Handler and EDA should be at least shown on the Taranta dashboard.

NCRA team did not provide justification/reason for not including EDA in the TMC state roll-up. It would be good to add that to the feature.

Questions that remain (require more board discussion):
Q1:
a) Are the operator interfaces, including the Alarm screen, assumed to be part of the TMC?
b) Shall the TMC continue operations (and observations), when the operator clients (interfaces) are not connected?

- Suggestion: TMC continues operating and continues signal processing and generation of output products using the parameters provided before the contact with the clients was lost.
- What should TMC do if the temperature in the environment crosses the threshold? TMC can end SB / scan, but should TMC shut down equipment? Note: This could result in temperature cycling the equipment due to software bug. Is it better to rely on the monitoring provided by the facility (PSI, ITF, CBF).

Q2:
The Telescope can be functional without Central Log Repository + Elastic Stack.
Are they considered as a part of TMC ?

What to implement in PI11

Does it make sense for TMC to report that TMC state=OFF ?
What does that mean? And why is it needed?
<NCRA> :

- When power is switched on TMC is launched automatically and by default CentralNode.state is set to 'ON' and likewise other TMC devices as well (SubarraNode, SubarrayLeafNodes ?)
- TMC.ON is the state in which TMC is capable of issuing commands to its downstream systems like CSP and SDP
- CentralNode.state attribute is an aggregated TMC state meaning it represents the state of entire TMC devices
- When Central Node is successfully initialised the state attribute is set to 'INIT'.
- When TMC devices (except Central Node) are successfully initialised their state attribute is set to 'ON'.
- When all the TMC devices are up and running the Central Node will aggregate the state of all the TMC devices and it will set its state attribute to 'ON'.
- TMC.Central Node will have a separate On() and Off() commands which will set the state of all other TMC devices to 'ON' and 'OFF' respectively
- TMC.Central Node state attribute will be aggregated, to represent TMC state:
    - All TMC devices need to report ON state for the TMC.Central Node to report ON state
    - TMC will be able to accept other commands, only when TMC is in 'ON' state
    - Downside: If any one of the TMC devices is not ON, then Central Node will be in 'UNKNOWN' state and it will not be able to accept any other command

The CN checks status of other components, and raises alerts and alarms as necessary.
<NCRA> :

- The CN checks status of other components, - Yes
- raises alerts and alarms as necessary. : In general yes, but not for PI11.

Does TMC automatically try to bring on EDA?
<NCRA> :

- We can leave EDA and Alarm Handler out of the scope of PI11.

At this time it can't turn hardware ON/OFF, let's discuss what should we do with software components.
<NCRA> :

- Let's further discuss (beyond PI11 scope when it comes to implementation of this Feature)

When it comes up and enters ON, TMC also checks status of other subsystems (DISH, MCCS, CSP, SDP) but it initiates state transitions only when commanded.

<NCRA> :

- Yes, once TMC goes to “ON” TMC state, it checks the states of other subsystems to derive the “Telescope Operational state”

Note: Command OFF shuts down the TMC.

<NCRA> :

- TMC.CentralNode.Off() command will change the state of TMC devices to ‘OFF’ meaning it will not be able to issue commands to other sub-systems. It will still be able to issue the TMC.CentralNode.On() command internal to TMC. <<TBD what OFF means; maybe tmc shutdown is desired>

Commented [1]: I don't see why is it useful to have a state where TMC does not accept commands. Would prefer that Off() is OFF, meaning TMC software terminates. I understand that this is how TMC is currently implemented and would like to understand reasoning behind the design decisions.

CSP Operational State

CSP	CSP.LMC	CBF	PSS	PST	

Agreed TMC Implementation:
TMC Operational State:

When MVP is deployed TMC devices will be On.
CN On()
CN Off()
CN StandBy()
CN State will represent the overall TMC state.
For State aggregation Subarray and SubarrayLeafNodes to be considered.

Telescope Operational State:

For telescope state aggregation logic based on the discussion:

- TMC State will not be a part of telescopeState aggregation logic
    - If any lower device reports its State as On(i.e. more than 5% power use) then the telescopestate will be On.
- NCRA needs to implement an 'imaging' attribute. It will be derived from CSP , SDP and Dish/mccs state.
    - when CSP + SDP + One of the dish is ON then On
- Attributes for PSS , PST and VBLI will be implemented to Default Value as OFF.

CN telescopeOn()

CN telescopeOff()
CN telescopeStandby()
telescope state aggregation logic : based on the discussion above