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CONTROL AND MONITORING (CAM)

REQUIREMENT SPECIFICATION

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DOCUMENT APPROVAL

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Diagrams	PowerPoint	Mac 2011	https://katfs.kat.ac.za/svnSystemEngineering/MeerKAT/7%20Subsystems/1500%20CAM
Diagrams	Visio		https://katfs.kat.ac.za/svnSystemEngineering/MeerKAT/4%20System%20Level5/2%20Preliminary%20design/14%20CAM/

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LIST OF ABBREVIATIONS

BMS	Building Management System
CAM	Control and Monitoring
CFI	Client Furnished Item
EMC	Electromagnetic Compatibility
ILS	Integrated Logistics System
KAPB	Karoo Array Processor Building
NRF	National Research Foundation
OPT	Observation Planning Tool
RF	Radio Frequency
RFI	Radio Frequency Interference
SP	Science Processor
TBC	To Be Confirmed
TBD	To Be Determined
TFR	Time and Frequency Reference
VDS	Video Display System
VEX	Very Long Baseline Interferometry Experiment
VLBI	Very Long Baseline Interferometry

TERMINOLOGY

May	Indicates a non-mandatory suggestion or permission.
Must	“Must” shall never be used, since it is synonymous with ought and should.
Should	Non-mandatory desire, preference or recommendation.
Shall	Mandatory requirement.
Will	Declaration of purpose or expression of simple futurity.

1 SCOPE

This document defines the requirements for the Control and Monitoring (CAM) for MeerKAT Phase 1 and 2. This document uses "CAM" throughout to refer to the CAM subsystem for MeerKAT, and "MeerKAT" to refer to the MeerKAT telescope system.

1.1 Identification

Level 0: MeerKAT System: - M0000-0000
Level 1: MeerKAT Telescope: - M1000-0000
Level 2: Control and Monitoring: - M1500-0000

1.2 Intended Use of this Document

This requirements specification:

- Forms part of the Control and Monitoring systems engineering baseline, as defined in the MeerKAT SEMP [1].
- Defines performance, interface, environmental, physical, services, safety, logistic support, regulatory (legal), special design, construction and commissioning requirements which are an input to the engineering and development of the item.
- A future version will describe the methods that will be used to verify that these requirements have been met when the item is submitted for acceptance.

1.3 Notes

1.3.1 CORE model

This document currently contains the most recent requirements and diagrams of the CAM Subsystem. Subsequent to the CAM requirements review the CORE model will be updated to align with this document. The intention is to ensure that the CORE model contains the full set of updated CAM requirements as described in this document at the moment, including a high-level functional and component breakdown and allocation of requirements to functions. These CORE updates will be completed at the latest by CAM PDR, planned for April 2013.

To update the CORE model the following steps are envisaged:

- Update CAM requirements in CORE to align with this document
- Capture the high-level CAM functional breakdown in CORE
- Capture the high level CAM component breakdown in CORE
- Allocate CAM requirements to functions in CORE
- Capture verification requirements against the CAM requirements in CORE

1.3.2 Incorporating ECP-36

This document does not yet reflect ECP-36 "Proposal to change the location of the Receiver Controller" motivating to combine the L-, X-, UHF- and S-Band Receivers into a single Receivers Controller as the acceptance of this ECP is imminent. This affects the following functional interfaces I.TE.CM.1, I.TE.CM.10, I.TE.CM.9, I.TE.CM.6.

Version 1 of this document will be updated correctly to reflect the final status of this ECP.

1.3.3 Notation used

R.CM.FC.C.22 – A requirement noted in CYAN has not been in the CORE requirements when we started this document and has to be added

~~R.CM.FC.C.22~~ - A requirement number that is striked through is not a CAM requirement any more and will be deleted from the CORE model or allocated to a different subsystem as appropriate.

TBD – Items that still need to be resolved have been marked with TBD (To Be Determined) and in purple.

~~Strikethrough~~ requirements text - Some requirements (e.g. R.CM.FC.12) have some text ~~striked through~~. The strikethrough text will be deleted after this review, but was left in this revision of the document to show how the requirements text has changed (in cases where the change might need discussion).

1.4 System Description

1.4.1 CAM Overview

The CAM subsystem is responsible for Control and Monitoring of the MeerKAT telescope and presentation of the CAM user interfaces for operators, engineers and science users.

The CAM subsystem shall monitor all monitoring points for health, state and alarms, archive history of all monitoring points and allow easy interrogation of the monitoring archive.

The CAM subsystem shall provide a Proposal Management Tool that will support the proposal process from application submission through to final approval, as well as provide mechanisms required by the Observation Planning Tool whichw will support the observer in preparing the program and scheduling blocks for an approved proposal.

The CAM subsystem shall control the telescope during observations including scheduling, configuring and controlling other subsystems, monitoring execution of programs, noting the data products produced and preparing an observation report on completion of each program.

1.4.2 Context

Figure 1 shows CAM in its physical environment. It shows a circle for each set of CAM equipment:

- The Receptor Switch, which is part of the equipment supplied by CAM, but is integrated into the Receptor.
- A set of 19” racks, containing CAM processing equipment in the Losberg Karoo Array Processor Building (KAPB).
- A set of 19” racks, containing CAM processing equipment in Cape Town (CPT).
- And CAM operator workstations at Klerefontein and in the Cape Town control room. Refer to par. 7.1.2.

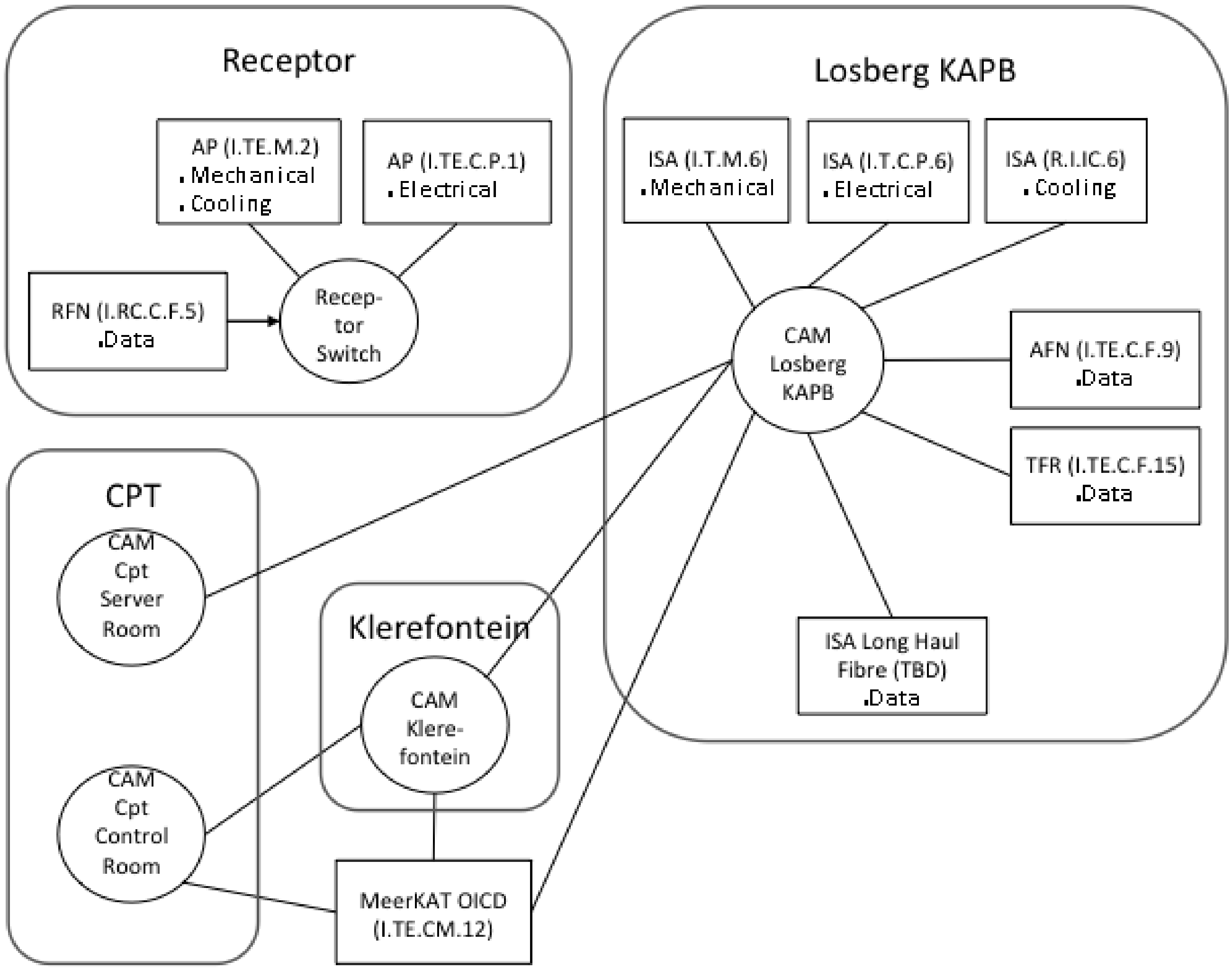

Figure 1. CAM Subsystem Physical Context Diagram

Figure 2 shows the functional interfaces of the CAM. Functional interfaces are discussed in 7.1.2.

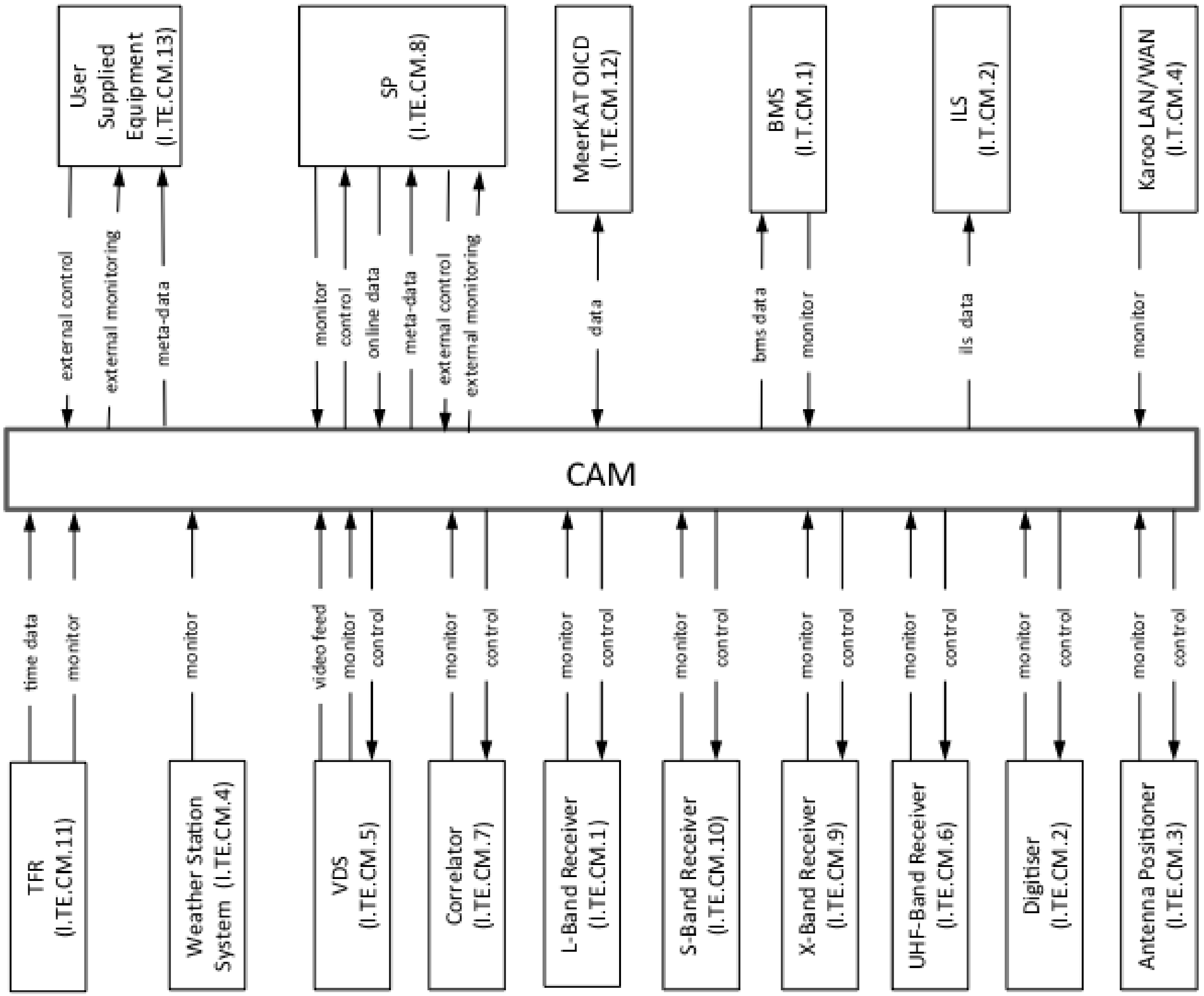

Figure 2. CAM Subsystem Functional Context Diagram

1.4.3 Functional Breakdown

The CAM shall implement the following primary functions:

- Control Subsystems
  - Control Antenna Positioner
    - Apply pointing model (structural and gravity)
    - Apply thermal model
    - Apply wind loading model
    - Apply refraction correction
    - Pointing correction from reference pointing calibration data
  - Control Receivers
  - Control Digitiser
  - Control Correlator
  - Control SP
  - Control VDS
  - Remote subsystem control
- Monitoring
  - Monitor Subsystems – monitor each subsystem periodically for health, status and fault detection
  - Monitor System - monitor the state of the system in real time and implement actions when necessary. It is also required to enable maintainers to identify faulty components for preventive and scheduled maintenance.
    - Manage Alarms – monitor the system for error and critical conditions and alert operators and trigger automated actions as per the requirements
    - ILS interaction – monitor the system and report relevant sensors and errors to the ILS
    - BMS interaction – monitor the power at the receptor and report as a sensor to the BMS, and monitor the BMS
  - Monitor Logs – gather and monitor system and user logs during observations
- Archiving CAM data - store monitoring data for future use and ensure that stored data is available and accessible to all relevant data users
  - Archive monitored data
  - Archive observation data
  - Archive user and system logs
  - Archive configuration data
- Provide MeerKAT CAM interface
  - Condition monitoring data and provide meta-data for augmentation of data products
  - Provide external control interface (i.e. external triggers for targets of opportunity and pulsars)
  - Provide external monitoring interface (for ad hoc monitoring of selected sensors)
- Manage Operations
  - Implement Access control - provide the correct level of access control to authorised users
  - Manage Operator Shifts and User Logs – Manage hand over between lead operators, shift reports and user logs

    - Implement Emergency operator actions - Support operator actions in emergency/critical conditions
    - Implement Automated control – Monitor the system for critical conditions and implement automated actions as per the requirements
- Provide System Displays
  To enable users to assess in real time the state of system settings, the health of the system, and the quality of the data being captured, and to control the system as required (note: signal displays are allocated to the SP subsystem)
    - Provide System Status displays
    - Provide System Health displays
    - Provide System Monitoring displays
    - Provide System Alarms displays
    - Provide System Control displays
    - Provide Observation Control & Scheduling displays
    - Provide Log displays
    - Provide CAM Archive displays
    - Provide Webcam displays
- Manage Observations
    - Provide Manual control - to allow expert users low-level control of the system components.
    - Implement Scheduling - Manual, Queue and Automatic scheduling - to enable the operators to schedule and control one or more observations
    - Provide Observation Control framework – provide the observation control framework that manages program and schedule blocks, define and execute observations
    - Provide Observation feedback - to give the PI feedback on the progress status of observations and the quality of the captured data, to produce an observation report including logs relevant to the observation
    - Manage Resources and Sub-arrays – manage allocation of available resources to sub-arrays for observations
    - Provide Management Reports - to give managers of the facility an overview of observation status, observation quality and system utilisation efficiency
- Manage Instrumental Configuration
    - Manage the instrumental configuration data of the system at all times and match the observations with the appropriate instrumental configuration data
- Manage Proposals
  To help facility operators and science users with the generation, evaluation, approval and storage of proposals
    - Provide Proposal Management displays
    - Provide Proposal Management tools

The primary and derived functions of the CAM are shown in the functional diagram in Figure 3 and functional flow diagram in Figure 4.

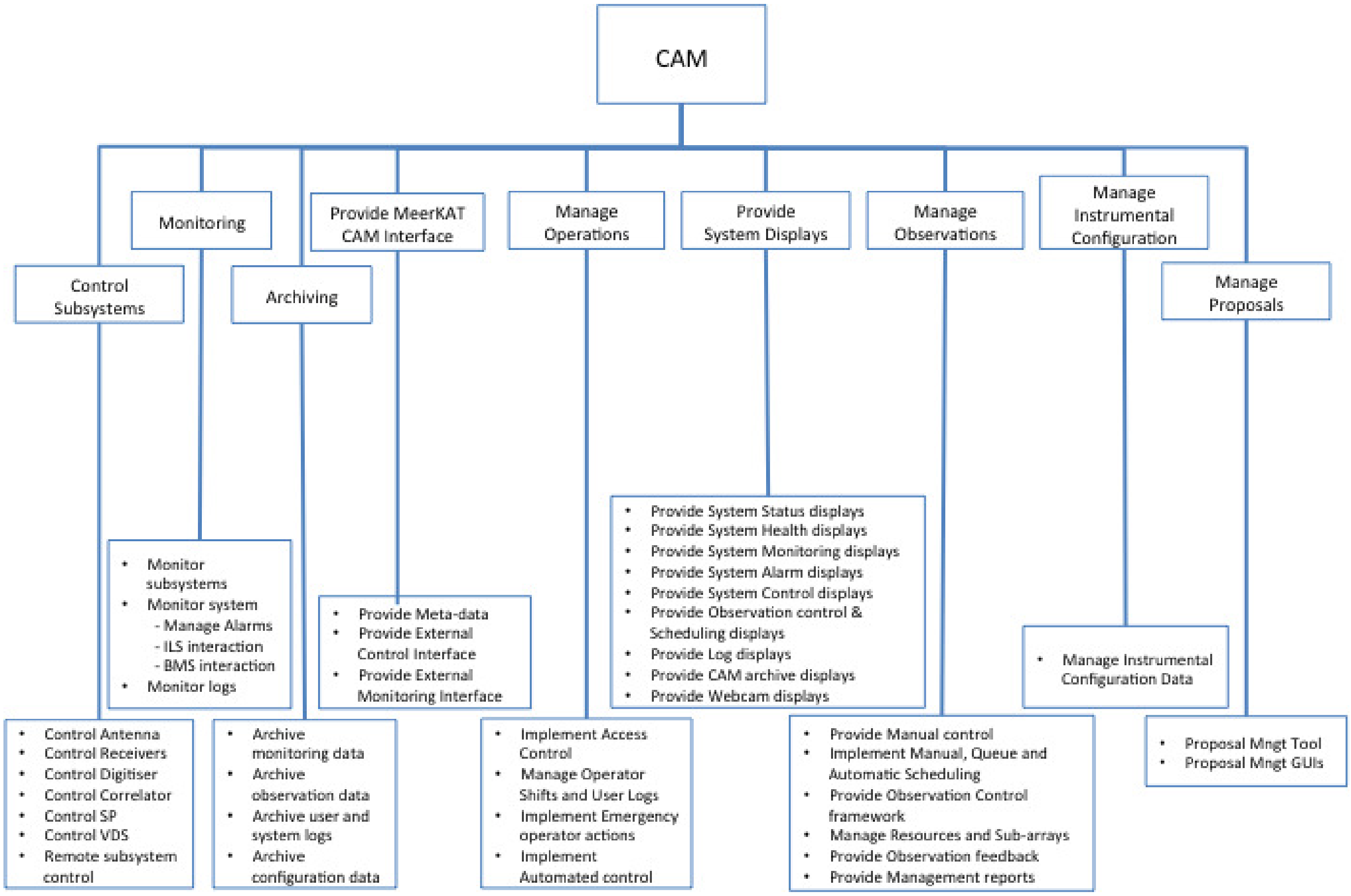

Figure 3. CAM Functional Breakdown

The diagram shown in Figure 4 identifies how the external interfaces connect to major CAM functions.

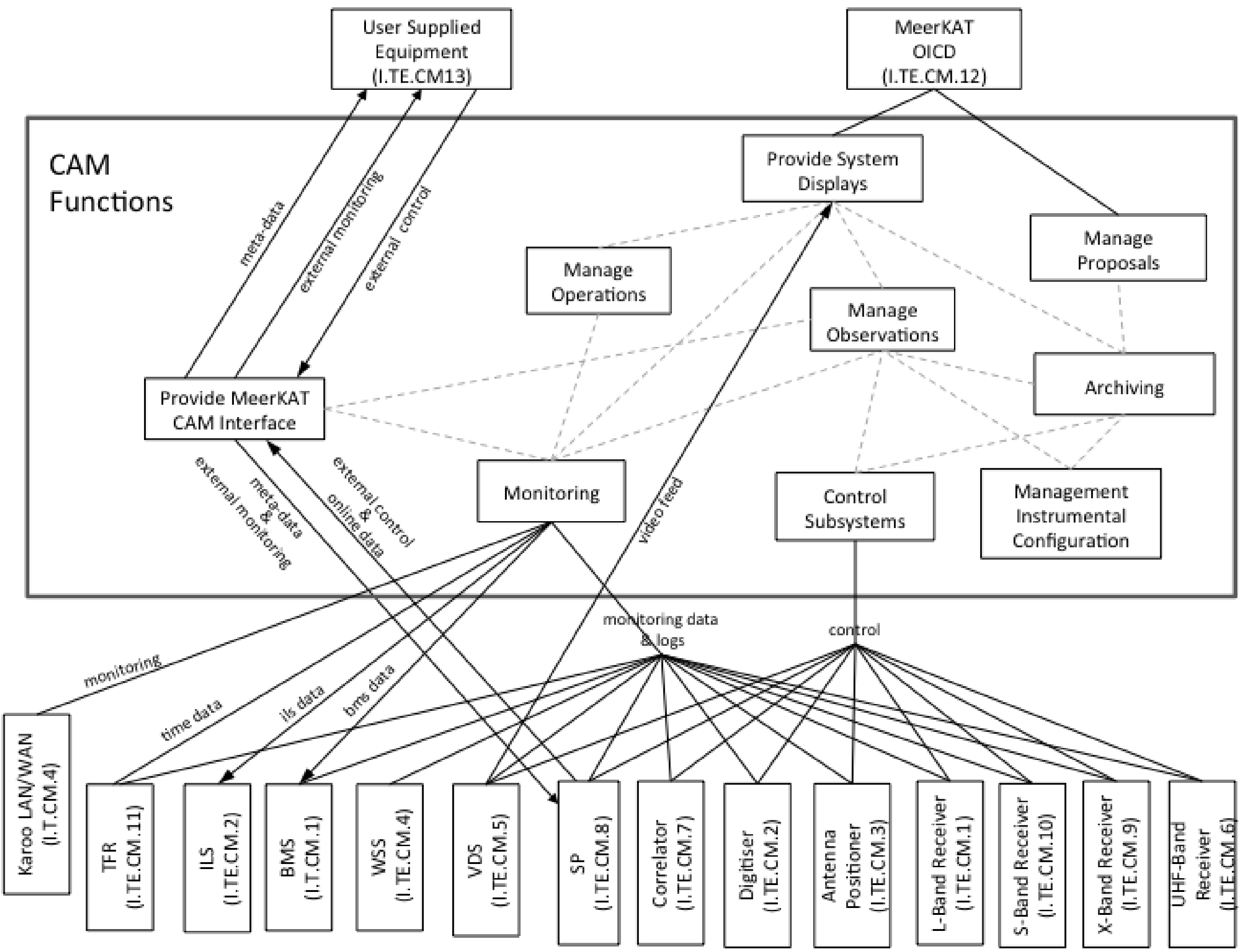

Figure 4. CAM Functional Flow Diagram

1.4.4 External Interfaces Identification

1.4.4.1 Mechanical Interfaces

The CAM's mechanical interfaces are described in [12] and [13], and its interface numbers are listed below:

1. I.TE.M.2
2. I.T.M.6

1.4.4.2 Cooling Interfaces

The CAM's cooling interfaces are described in [12] and [13], and its interface numbers are listed below:

1. I.TE.M.2

2. R.I.IC.6

1.4.4.3 Electrical Interfaces

The CAM's electrical interfaces are described in [12] and [13], and its interface numbers are listed below:

1. I.TE.C.P.1
2. I.T.C.P.6

1.4.4.4 Human Interfaces

The CAM's human interfaces are described in [17], and its interface number is listed below:

1. TBD

1.4.4.5 Functional Interfaces

External interface requirements will be documented in the Interface Control Documents as indicated below. The interfaces that require formal interface control are identified in [13], and are listed in Table 1 for convenience.

Table 1 – CAM External Functional Interfaces

Interface Number	Description	ICD
I.TE.CM.1	L-Band Receiver CAM interface	[27]
I.TE.CM.10	S-Band Receiver CAM interface	[26]
I.TE.CM.9	X-Band Receiver CAM interface	[25]
I.TE.CM.6	UHF-Band receiver CAM interface	[24]
I.TE.CM.2	Digitiser CAM interface	[18]
I.TE.CM.3	Antenna Positioner CAM interface	[19]
I.TE.CM.4	Weather Station System CAM interface	[20]
I.TE.CM.5	VDS CAM interface	[21]
I.TE.CM.7	Correlator CAM interface	[22]
I.TE.CM.11	TFR CAM interface	[28]
I.TE.CM.8	SP CAM interface	[23]
I.T.CM.1	Building Management System (BMS) CAM interface	[15]
I.T.CM.2	ILS CAM interface	[16]
I.T.CM.4	Karoo LAN/WAN CAM interface	[14]
I.TE.CM.12	User Supplied Equipment CAM Interface	[29]
I.TE.CM.13	MeerKAT OICD	[17]

1.4.5 Product Breakdown Structure

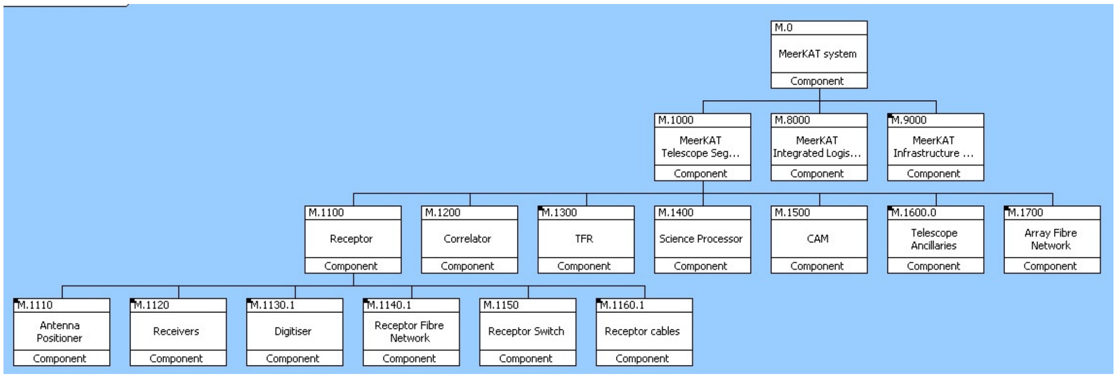

Figure 5. MeerKAT Product Breakdown.

The CAM product consists of the major physical components shown in the diagram below. The figure below was generated with CORE.

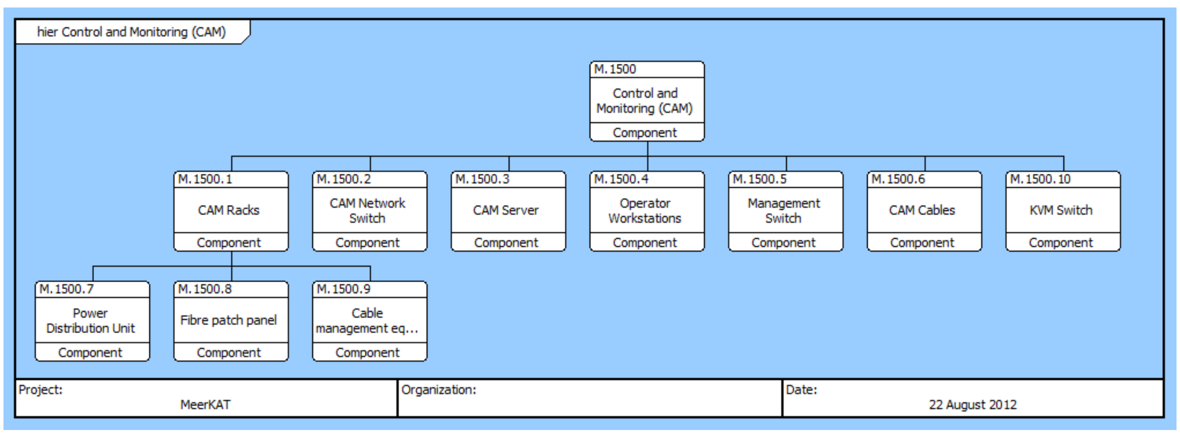

Figure 6. CAM Physical Product Breakdown

2 Applicable and Reference Documents

2.1 Applicable Documents

The following documents are applicable to the extent specified herein. In the event of conflict between the contents of the applicable documents and this document, this document shall take precedence. Nothing in this document supersedes applicable laws and regulations.

[1] MeerKAT System Engineering Management Plan. Document Number: M2000-0000V1-01 MP, Rev 1.

[2] Logistic Engineering Management Plan. Document Number: M2000-0000V1-02 MP, Rev 2.

2.2 Referenced Documents

The following documents are referenced in this document and are merely listed for convenience.

[3] MeerKAT System Support Concept. Document number: M0000-0000V1-01 DD Rev 1

[4] T. Kusel, D. Liebenberg, C. vd Merwe, "MeerKAT Design Description: RAM and Logistical Requirements", NRF, M0000-0000V1-28 TM, Rev 1.

[5] R. Lord, "MeerKAT Design Description: RFI requirements allocation", NRF, M0000-0000V1-30 TM, Rev 1.

[6] T. Kusel, "MeerKAT Design Description: Environmental Requirements Allocation", NRF, M0000-0000V1-34 TM, Rev 1.

[7] T. Kusel, "MeerKAT Design Description: Safety Requirements Allocation", NRF, M0000-0000V1-35 TM, Rev 1.

[8] T. Kusel, C. Gumede, "MeerKAT Design Description: Internal Interface Identification", NRF, M0000-0000V1-32 TM, Rev 1.

[9] P. Herselman, T. Kusel, "MeerKAT Design Description: Digitiser Description and Requirements", NRF, M0000-0000V1-37 TM, Rev 1.

[10] P. Herselman, T. Kusel, F. Kapp, "MeerKAT Design Description: Correlator Description and Requirements", NRF, M0000-0000V1-39 TM, Rev 1.

[11] J. Horrell, T. Kusel, "MeerKAT Design Description: Science Processing Description and Requirements", NRF, M0000-0000V1-41 TM, Rev 1.

2.3 Interface Documents

The following documents are applicable to the extent specified herein. In the event of conflict between the contents of the applicable documents and this document, this document shall take precedence. Nothing in this document supersedes applicable laws and regulations.

[12] C Gumede, C van der Merwe, "Interfaces for Telescope Equipment inside the KAPB", M1000-0001-028 ICD, Rev 1

[13] C Gumede, "MeerKAT System Level Interfaces Identification", M0000-0000-004 ICD

[14] ISA, "Karoo LAN/WAN data CAM Interface Control Document", originally F4600-0000V1-011, will become M1000-0001-016 ICD

[15] ISA, "BMS CAM Interface Control Document", M0000-0000-015 ICD

[16] ILS, "ILS CAM Interface Control Document", M0000-0000-016 ICD

[17] TBD, "MeerKAT Operator Interface Control Document" , M1000-0001-013 ICD

[18] S. Malan, "Digitiser CAM Interface Control Document", M1000-0001-001 ICD

[19] AP, "Antenna Positioner CAM Interface Control Document", M1000-0001-030 ICD

[20] P. Kotze, "Weather Station CAM Interface Control Document", M1000-0001-007 ICD

[21] P Kotze, "VDS CAM Interface Control Document", M1000-0001-008 ICD

[22] Correlator, "Correlator CAM Interface Control Document", M1000-0001-002 ICD

[23] SP, "SP CAM Interface Control Document", M1000-0001-009 ICD

[24] Receiver, "UHF-Band receiver CAM Interface Control Document", will be merged into M1000-001-005 ICD with ECP-36

[25] Receiver, "X-Band Receiver CAM Interface Control Document", will be merged into M1000-001-005 ICD with ECP-36

[26] Receiver, "S-Band Receiver CAM Interface Control Document", will be merged into M1000-001-005 ICD with ECP-36

[27] Receiver, "L-Band Receiver CAM interface Control Document", M1000-0001-005 ICD

[28] TFR, "TFR CAM Interface Control Document", M1000-0001-012 ICD

[29] CAM, "User Supplied Equipment CAM Interface Control Document", M1000-0001-004 ICD

3 Definitions

The following definitions apply in the use of terminology for requirements:

Observation constraints	*"Observation constraints" shall include the following:* • *whether the source is up (within the elevation limits of the system);* • *whether the source is within the specified proximity of objects of avoidance (strong radiators, sun, etc.);* • *whether the environmental conditions are within specified bounds for the observation (e.g. low wind speeds for high dynamic range imaging observations);* • *specific observation requirements (e.g. only night observing; observation has to be performed at a specific time).*
System resources	*"System resources" shall include the following:* • *availability and good health of all critical system components to enable the execution of a schedule block;* • *minimum number of antennas;* • *specific antennas (e.g. specific baselines required);* • *array processor resources and constraints (e.g. frequency bands);* • *data storage resources.*
Ready Schedule Block	*A "ready" schedule block is a schedule block for which all system resoruces and observation constraint are met, i.e. the schedule block can successfully start execution immediately.*
Instrumental Configuration Data	*"Instrumental Configuration Data" is configuration data, which may influence the data capture and on-line processing of data. To the current best knowledge, Instrumental Configuration Data includes, and is limited to:* • *On-line software configurations: Science Processing on-line processing configurations;* • *Long-term system calibrations: Antenna pointing models (including wind load, thermal, etc);* • *Tied-array reference coordinates;* • *UT1 and Leap seconds for UT1;* • *Satellite catalogues;* • *Source catalogues.*
Instrumental Configuration Data Repository	*A persistent store of versions of Instrumental Configuration Data. This will be part of the Archive.*
Monitoring Data	*Monitoring Data includes:* *a) Failure detections, based on a FMECA analysis, including:* *i. Overall "fit for use" for the device to indicate that it is operating within its specified performance and functional requirements.* *ii. Communication with CAM OK.* *b) Sensor values used for failure prediction by the ILS (where applicable)* *c) Sensors required to identify faults (fault finding)* *d) Sensors that may indicate that the quality of the data being captured may be negatively impacted.*

	e) *Sensors required to determine resource availability for observation planning and scheduling* f) *Sensors that identify the installed configuration of the subsystem.* g) *Sensors that indicate safety-critical conditions.* h) *Subsystem logs.*
Meta data	*Subset of Monitoring Data augmented to a raw data product to complete the data product.*
Augment	*The process of extracting the appropriate meta data from the monitor store/stream to complete the data product.*
Archive	*Permanent storage of data, including proposals, program and scheduling blocks, data products, Monitor Data, Instrumental Configuration Data. Note that the term Archive includes ALL system data, including operational and engineering data, and not only archived data products.*
Sensor	*Each monitoring point on a hardware device or software component is represented as a katcp sensor. A sensor update always include a value and status. The status can be one of nominal, warning, error or failure (where failure indicates that the sensor value could not be read). A sensor also has a description, units of measure and absolute ranges (min/ max values) that are reported on introspection.*
Sensor Strategy	*Every katcp sensor supports different sensor strategies that can be set by each client. This is the sampling rate/update rate at which the sensor updates will be sent to the client. A variety of sensor strategies are supported, for example: periodic, event, periodic with a rate limit, event with a period, auto (underlying update rate of the hardware).*
Request	*Each command on a hardware device or software component is represented as a katcp request . The response to a request is an optional number of katcp informs messages and finally a katcp reply (or timeout).*
Configure & Control	*The term "configure" is used to indicate a setting that is typically done once and remains the same throughout a scheduling block.* *The term "control" is used to indicate a setting that should be updated periodically and changes during a scheduling block*

3.1 Sub-array Related Definitions

The following sub-array related definitions apply in the use of terminology for requirements:

Create *a sub-array*	*shorthand term to describe the process of the lead operator assigning free resources to the resource pool of a sub-array as per the sub-array spec of the Program Block/Schedule Block for which the sub-array is being created*
Free *a sub-array*	*shorthand term to describe the process the delegated control authority freeing the resource pool of the sub-array and thereby releasing control of the sub-array so that a new sub-array can be created for the next PB, as well as unassigning the SBs assigned to that sub-array*
Delegate *a sub-array*	*the lead operator delegating control of a specific sub-array to a specific user (the sub-array's control authority)*
Revoke control *of a sub-array*	*the lead operator autonomously revoking control of a specific sub-array*

	from its delegated control authority (in cases where the control authority does not ***free*** *the sub-array by agreement). The lead operator can then free the sub-array for the next PB.*
Delegated sub-array	*any sub-array for which the lead operator has delegated control to a specific user (i.e. the sub-array's control authority)*
Centralised sub-arrays	*all the sub-arrays for which the lead operator is the control authority, (i.e. all sub-arrays for which control has not been delegated)*
Assign *a resource*	*moving a free resources to the resource pool of a sub-array*
Free *a resource*	*removing an assigned resource from the resource pool of a sub-array to the free resource pool*
Put into *maintenance*	*shorthand term to describe the process when the lead operator or control authority removes a resource from the resource pool of a sub-array to the maintenance resource pool, or a free resource to the maintenance resource pool*
Take out of *maintenance*	*shorthand term to describe the process when the lead operator moves a resource from the maintenance resource pool to the free resource pool, ready to be used in normal observations and sub-arrays again*
Assign *a program block*	*assigning a DEFINED PB to a specific sub-array (i.e adding all SBs of the PB to the sub-array's Observation Schedule)*
Remove *a program block*	*removing all SBs of a specific PB from a specific sub-array's Observation Schedule (can only be done if none of the PB's SBs are currently executing), removing all SBs of the PB from the sub-array's Observation Schedule*
Assign *schedule blocks*	*assigning any selection of schedule blocks from the Program Schedule to a specific sub-array, adding the SBs to the sub-array's Observation Schedule*
Remove *a schedule block*	*removing an idle schedule block from specific sub-array's Observation Schedule*
Observation Schedule	*List of scheduling blocks assigned to a sub-array - in Queue scheduling the list is manually ordered by the control authority, in Automatics scheduling the order is determined by the sub-array scheduler.*
Program Schedule	*The scheduling blocks on DEFINED PBs that are available to be assigned to sub-arrays for scheduling. The system will order this list in order of priority and start time to support the lead operator in identifying the next sub-array to create.*

4 MeerKAT Sub-array Concept

The objective of this paragraph is to ensure that every reader interprets the specific requirements below with a common understanding of the MeerKAT sub-arraying concept and should be read as background to the specific requirements below.

4.1 MeerKAT Sub-array Overview

This overview paragraph describes the sub-arraying concept without going into all the possible edge cases and exceptions. These are handled in a following paragraph below.

4.1.1 4 Sub-arrays

The MeerKAT correlator can be divided into 4 sub-divisions that each can be configured and operated independently with a dedicated data capture chain. To support this the MeerKAT telescope will be operated through 4 independent sub-arrays. Each sub-array will have a resource pool with controlled resources exclusively assigned to that sub-array. The resource pool of a sub-array will typically be a selection of antennas, one sub-division of the correlator and one sub-division of science processing. It will be possible (and often will be the case) that a single sub-array will be in use with all the available antennas assigned to it, with the remaining sub-arrays being unused at that point in time. In addition to the 4 resource pools of the 4 sub-arrays there will also be a pool for **free resources** (controlled resources that are available but not assigned to any of the 4 sub-arrays) and a pool for **maintenance resources** (resources that are in maintenance and cannot be used for normal observations).

The lead operator will create sub-arrays and assign appropriate resources as required for the next scheduling block(s) that needs to be executed. Each sub-array will have its own scheduler that will independently be in Manual, Queue or Automatic Scheduling mode. And each sub-array will have its own resource manager that will allocate resources from the sub-array's resource pool for scheduling blocks in the sub-array. Each sub-array can have MANUAL schedule blocks (for manual control) and OBSERVATION schedule blocks (for prepared scripts). Each sub-array can have concurrent executing SBs as allowed by the resources available in its resource pool and the definition of its SBs.

4.1.2 Sub-array Control Authority

By default the lead operator will be each sub-array's control authority. But the lead operator can delegate control of that sub-array to a specific user who then becomes the delegated control authority for that sub-array. The control authority of the sub-array will manage the Observation Schedule of the sub-array (and can perform observations or manual control of resources in that sub-array).

On completion of his/her observations or when his/her allocated time has expired, the delegated control authority must free the sub-array. Freeing the sub-array cancels any executing SBs and also frees the resources in the sub-array's resource pool. In cases where the delegated control authority does not free the sub-array by mutual consent, the lead operator will be able to revoke control of the sub-array autonomously.

4.1.3 Program Blocks and Schedule Blocks

Each accepted proposal will be defined as Program Blocks containing one or more Schedule Blocks. A Program Block is just a parent grouping a set of independent Schedule Blocks. Mostly each Schedule Block is independent, but in some cases:

- SBs may have desired start times (not earlier) or exact start times
- SBs within a Program Block may be ordered for sequential execution, (but they can still be scheduled at any time with breaks in between, just the order in which they are executed has to be as specified)
- SBs may be linked for synchronised execution (in a sub-array) in Automatic Scheduling. (NOTE: If synchronised executions is needed across sub-arrays it will be done manually by giving the SBs the same exact start time).
- SBs may have a breakpoint defined on completion of a specific SB in an ordered list of Schedule Blocks (at which the PI is notified of completion of the SB and further execution is only continued after manual go-ahead is given by the PI).
- SBs within a Program Block will/may each have their own resource specifications.

Program Blocks will be created as DRAFT, and once all its parameters and Schedule Blocks are fully defined the owner will change the Program Block to DEFINED. The system may perform validation to ensure the Program Block is fully DEFINED. All SBs of DEFINED PBs will be presented in the "Available Schedule" for operators to select from and assign SBs to sub-arrays for scheduling.

A Schedule Block is the uninterruptable unit of execution (i.e. it cannot be paused and resumed, but can be stopped or cancelled) in the MeerKAT system and it will be relatively short (usually less than 30 min, but for Mosaicing may be something like 4 hrs). Scheduling is performed on Schedule Blocks independently. Assigning a complete Program Block to a sub-array is only a convenience function for the control authority (and simply assigns all SBs in that PB to the sub-array).

As the unit of execution a Schedule Block cannot be paused or resumed. A Schedule Block can:

- run to completion (with success or failure),
- be stopped (gracefully exiting and storing data),
- be cancelled (immediately exiting and discarding data, or faster response time, or when data is really bad and should not take up space in the archive)
- be restarted (from the front, capturing new data).

4.1.4 Breakpoints

If breakpoints are defined within the SBs of a PB, all SBs up to the next breakpoint will be available in the "Program Schedule". When a SB is identified as a breakpoint, the PI will be notified once that SB has completed. Only once the PI has given the go-ahead, the next set of SBs up to the next breakpoint will be added to the "Program Schedule". To support the control authority, the "Program Schedule" will be presented in an ordered list taking PB priority, start times, etc into account.

4.1.5 VLBI

VLBI observations will be a special case in that they need to be interruptable and then resume at the correct point in time, and not at the last point in the observation. It is envisaged that this will be achieved within the current concept by the OPT dividing the VLBI scans into SBs with exact start times. SBs for which the exact start time has passed while the VLBI observation was interrupted will then be skipped (as they cannot be executed at the correct time anymore) and the next SB in time will be selected for execution at its exact time.

4.1.6 Targets of Opportunity

TOO functionality is a Timeframe D requirement and will be clarified and reviewed in a subsequent MeerKAT CAM Requirements Review closer to implementation. Some initial thoughts are noted here:

There are various possibilities to define the resources to be used for transient intervention:

- The Lead Operator can be responsible to have a specific sub-array identified for use in transient intervention at all times. If only one sub-array exists it will by default be that sub-array. However, if the only sub-array that exists is being delegated the Lead Operator can be prompted to select/create another sub-array,
- Alternatively transient intervention could be done on all non-delegated sub-arrays,
- Or sub-arrays can be interrupted for transient intervention, unless specifically identified to be non-interruptable. Sub-arrays by default will be interruptable. (This can be controlled by the lead operator.)
- Or SBs may be marked as interruptable for transient intervention, unless specifically identified to be non-interruptable. SBs by default will be interruptable. (But then this will be done by the PI creating the SBs and he might not be the authority that can make that decision. Also possible that the Time Allocation Committee can decide if an observation should be non-interruptable.)

MeerKAT will receive a TOO trigger from external user equipment and respond on the external events with the resources available (according to one of the schemes above). The transient intervention will interrupt the sub-array(s) by cancelling their currently executing scheduling blocks and freeing the sub-array (thereby releasing their resources for transient intervention). If no resources are available for transient intervention, a critical alert may be raised to the operator.

Transient schedule blocks may be “pre-defined” with a sub-array spec and when the TOO trigger arrives, this schedule block will be started on a sub-array created with the resources that was identified to be used for transient intervention.

4.1.7 Typical operations

- Approved proposals are created as (one or more) DRAFT PBs
- DRAFT Schedule blocks (each with a sub-array specification) will be prepared for DRAFT PBs

- DRAFT PBs that are ready for observation is set to **DEFINED** state (some verification checks to ensure all SBs are correctly defined?) . SBs in DEFINED PBs will be presented in the "Program Schedule" to be assigned to sub-arrays.
- The SBs in the "Program Schedule" will be ordered by the system according to start time and priority to support the Lead Operator in identifying the next sub-array to be created.
- Lead operator creates sub-array for next SB in the "Program Schedule" as per the SB sub-array spec.
- The Sub-array Scheduler of a newly created sub-array starts off in Manual Scheduling mode.
- If required the Lead operator can assign selected SB(s) or a full PB (all SBs in the PB) from the "Program Block" to the newly created sub-array. All selected SBs are added to the Observation Schedule of the sub-array.
- The Lead operator delegates control of the sub-array (if required).
- Control authority selects (additional) SBs from the "Program Schedule" and assign to his sub-array (as required).
- Control authority manages/orders Observation Schedule of the sub-array, setting sub-array scheduler to Queue or Automatic Scheduling or continue in Manual Scheduling, executing SBs manually.
- In Manual Scheduling the Sub-array Scheduler executes SBs as manually instructed by the Control Authority.
- In Queue Scheduling the Sub-array Scheduler executes SBs in the sub-array's Observation Schedule in order as they become ready.
- In Automatic Scheduling the Sub-array Scheduler dynamically selects and executes SBs in the sub-array's Observation Schedule.
- The Delegated Control Authority frees sub-array - this frees all assigned resources and puts it back into the Free resource pool. Also unassigns the SBs from the sub-array.

4.1.8 Maintenance operations

A resource will be put into Maintenance by assigning it to the Maintenance Resource Pool.
When physical maintenance has completed it may be assigned (with other non-maintenance resources) to one of the 4 available sub-arrays for engineering/acceptance tests.
Available resources may be added to the sub-array to test the resource under maintenance before taking the resource out of maintenance.
Control of this sub-array can be delegated to the maintainer/engineer to perform the final tests.
The sub-array functions exactly as in any other case with Manual, Queue and Automatic scheduling modes and MANUAL and OBSERVATION scheduling blocks.

5 MeerKAT Users, Roles and Actors

The objective of this paragraph is to ensure that every reader interprets the specific requirements below with a common understanding of the human “actors” that are part of the MeerKAT Telescope system, and roles that actors assume when interacting with the MeerKAT CAM. This paragraph should be read as background to the specific requirements below. For the purpose of the CAM Requirement Specification, it is sufficient to limit categorisation of users to roles and tasks.

5.1 Actors

Users are categorised with regards to their “job” responsibility in MeerKAT.

- **Operator** - Personnel that primarily monitor the health of MeerKAT. One of the operators will be the responsible telescope controller at all times and are referred to as the “lead operator”.
- **Principle Investigator (PI)** - PIs (or the project representative) are informed when a breakpoint has been reached in a sequence of SBs and gives the go-ahead to continue with the rest of the SBs. This is an “offline process” and no additional role is required. Pis are involved in science projects.
- **On-duty Astronomer** - Scientists that take part in MeerKAT commissioning, science verification or science. The On-duty Astronomer is principally responsible for science based decisions and may be involved in verification of schedule blocks, and quality assurance of data products produced. On-duty astronomers are involved in science projects.
- **Engineer** - Engineers, technicians, technologists, etc. that are primarily involved in MeerKAT development (including engineering verification) and fault-finding.
- **Maintainer** - Technicians, artisans, etc. that are responsible for maintaining MeerKAT equipment.

5.2 Roles

Users are categorised with regards to their responsibilities and tasks allowed when interacting with CAM.

5.2.1 Control Authority (Sub-array Controller)

The control authority of a sub-array fully controls the observations performed with that sub-array (e.g. scheduling and executing observations for that sub-array, preparing the observation queue to be executed, deciding the scheduling mode for that sub-array, doing manual control of the sub-array). The control authority however cannot add resources to the resource pool of the sub-array, this is always done by the lead operator. The control authority can remove a resource that is causing trouble from the sub-array by putting it into maintenance. The control authority can also do manual control of the resources in that sub-array. On completion of the observations the control authority frees the sub-array which releases control of the sub-array and its resource for use by other observations.

<u>**Tasks**</u>

- Control observations in sub-array
- Manually Schedule observations in sub-array
- Select Scheduling mode in sub-array

- Monitor sub-array
- Diagnose faults in sub-array
- Data quality assessment level 1 and 2

Actors
- Operator
- PI (or Project representative)
- On-duty Astronomer (during MeerKAT science phase)
- Engineer
- Maintainer

5.2.2 Lead Operator

The lead operator is overall responsible for telescope operations. Lead operator will be handed over between operators so that there is always one responsible lead operator. Lead operator is responsible for creating sub-array by assigning resources to the sub-array resource pools and can intervene in telescope operations in emergencies (e.g. stow antennas, stop antennas, shutdown the system). Lead operator Is the default control authority of a sub-array if control was not delegated to someone else.

Tasks
- Resource Control/Management on Telescope level
- Manage sub-arrays, including creating sub-arrays by assigning resources to the sub-array and delegate sub-array control.
- Control the Telescope, including stop/start the instrument and graceful power-down of equipment, and power down of Correlator and Science Processor equipment in the KAPB remotely.
- Critical and safety actions on the system, including stow antennas and inhibit antenna movement.
- Other Operator tasks (monitor Telescope).

Actors
- One of the Operators

5.2.3 Other Operators

Tasks
- Monitor the health and status of the system and observations
- Monitor QA1 of data being captured
- Enter user logs
- No control or actions on the instrument, except for emergency actions

Actors
- Operator

5.2.4 Engineers

This role provides for in depth analysis of the health of the system for fault finding. For example, this may include commissioning of new components/functionality that may not yet be available to the standard “control authority” for observations (like a new receiver frequency band or a new Correlator mode).

Tasks

- Test sub-array equipment
- Maintain sub-array equipment
- Commissioning using sub-array
- Restart sub-array equipment
- Full, low-level control of sub-array equipment

Actors

- Engineer
- Maintainer
- On-duty Astronomer (during MeerKAT Telescope science verification)

6 Functional Requirements

6.1 Timeframes

A timeframe definition has been included for the allocated requirements, because the software development effort will be ongoing through to full science operations – it is important to understand what functionality is required early in the project so that the development activities can be scheduled appropriately:

- **Timeframe A:** Receptor Test System.
  Receptor 1. Functionality to support:
  - Standalone Receptor Test System required - will be used to accept each dish as it gets delivered
  - Dedicated CAM server
  - Control and Monitoring of Antenna Positioner, Digitiser, Receiver
  - Manual control
  - May include some Control and Monitoring of Correlator, Science Processor
- **Timeframe B:** Start of Array Release 1 integration (for Science commissioning).
  Receptors 3-6. Functionality to support:
  - Interferometric characterisation and calibration (baseline cal, amplitude closure, phase closure…)
  - Continuum imaging
  - Spectral line imaging
  - Pulsar timing
- **Timeframe C:** Start of Array Release 2 integration (for Early science).
  Receptors 7-32. Functionality to support:
  - Queue scheduled Imaging and Pulsar timing observations
  - Limited concurrent transient search
- **Timeframe D:** Start of Array Release 3 integration (for Full science operations).
  Receptors 33-64. Functionality to support:
  - 64 Receptors with all hardware installed and accepted
  - 32 Receptors fully commissioned (science ready)
  - Back-end capable of reliably performing early science in high priority areas (Deep HI and Pulsar Monitoring).

6.2 General Requirements

Due to its remote location, MeerKAT will be designed for remote operation. Careful consideration should be given to the design of the control system to ensure the operator has full situational awareness and is able to control MeerKAT efficiently and safely. CAM should allow the lead operator to gracefully stop the observation in non-critical cases, or to stop immediately in critical situations. CAM should also have built-in checks for critical failures and automatically revert to a safe state.

Req #	*Description*	*Source*	*Time-scale*
~~R.CM.FC.1~~	Deleted. Superceded by R.CM.FC02. ~~Under normal circumstances the observations will be controlled from the Cape Town operational facility.~~	~~R.T.FC.1~~	~~B~~

R.CM.FC.2	CAM shall support control centres in Cape Town, Klerefontein and Losberg. [Note] . *[Note: During development engineering access to the system shall be through delegating control of a sub-array to the engineer so that the operators are at all times aware of engineering activity]*	R.T.FC.2	B
R.CM.FC.3	CAM shall control access to ensure that authorised users can only control those resources delegated to them.	R.T.FC.3	B
R.CM.FC.8	CAM shall ensure that there shall be only one lead operator at any time from one of the control centres, who may delegate control of each sub-array to a control authority.	R.T.FC.8	B
R.CM.FC.9	CAM shall enable transfer of telescope control between lead operators located at different control centres.	R.T.FC.9	B
R.CM.FC.4	For non-critical situations CAM shall enable the lead operator to gracefully stop (wrap up schedule block, archive the data, release resources) all executing schedule blocks at any time.	R.T.FC.4	B
R.CM.FC.5	CAM shall stop observations automatically and revert to a safe state for the relevant components of the system, in at least the following cases: • the 10-minute mean wind speed on site exceeds 40km/h • the gust wind speed on any wind sensor exceeds 61km/h • Failure of Karoo Array Processor cooling system as reported by the BMS • Imminent site power failure as reported by the BMS	R.T.FC.5	A
R.CM.FC.7	If connectivity is lost between CAM and the lead operator (e.g. remote link is down), then CAM shall complete the currently executing schedule block(s) and revert to an idle safe state (no further observations and stow all antennas).	R.T.FC.7	A?
R.CM.FC.6	For critical situations, at any time during observations, any Operator shall be able to initiate any one of the following commands in a very simple, which shall immediately stop the executing schedule blocks, stop the observation schedule and execute the command: - Stow all antennas - Stop movement of all antennas - Graceful power-down of components which are sensitive to power failures or cooling system failures (i.e. manually invoking R.CM.FC05)	R.T.FC.6	A
R.CM.FC.12	The operator interface shall be ~~independently~~ configurable ~~depending on the operator's preference~~ as defined in the MeerKAT Operator Interface Control Document, [17].	R.T.FC.12	C
R.CM.FC.13	When the CAM detects that the primary remote link between the KAPB and Cape Town is down (and the backup link is being used) then CAM must raise an alarm and only send critical information to Cape Town control centre.	R.T.FC.7	B

6.3 Scheduling Requirements

Each sub-array shall be in one of the following modes of scheduling:

a) Manual Scheduling - in which the control authority of a sub-array manually selects schedule blocks for execution. This is useful for things like engineering tests, hot box testing where manual intervention is required and having an "idle" state on the sub-array schedulers for shutdown. The control authority of a sub-array manually arranges the Observation Schedule and manually starts the execution of the schedule blocks.
b) Queue Scheduling - where the control authority of a sub-array manually arranges the order of the schedule blocks in the observation schedule and the sub-array scheduler executes the schedule blocks in the Observation Schedule in order as they become ready. Those schedule blocks that cannot be executed due to constraints not being met, will be skipped. This functionality will be required from science commissioning onwards.
c) Automatic Scheduling - which will be required during full science operations to maximise the science output. In Automatic scheduling the sub-array scheduler will dynamically select schedule blocks for execution by taking into account weather conditions and observation constraints.

Manual Control of resources in a sub-array must also be provided for expert users, maintainers or engineers.

6.3.1 General Scheduling Requirements

Req #	*Description*	*Source*	*Time*
R.CM.FC.10	CAM shall provide a mechanism for the control authority of a sub-array to schedule Schedule Blocks (SB) and control the order and execution of the Observation Schedule for that sub-array.	R.T.FC.10	B
R.CM.FC.11	The Observation Schedule Display, shall include the following for all sub-arrays simultaneously (for use by operators), or for sub-arrays independently (to be used by delegated control authority): - a list of scheduled SBs; - the completion progress status of all listed SBs; - whether sufficient system resources (as per definition) are available for any selected SB in the list; - whether all observation constraints (as per definition) are met for executing any selected SB in the list.	R.T.FC.11	B
R.CM.FC.36	CAM shall enable the control authority of a sub-array to control only that sub-array independently.	R.T.FC.36	C
R.CM.FC.22	CAM shall enable the lead operator to reset or restart components remotely.	R.T.FC.22	A
R.CM.FC.23	CAM shall enable the Control Authority to select a version of Instrumental Configuration Data from the Instrumental Configuration Data Repository to use with a sub-array.	R.T.FC.23	B

R.CM.FC.40	CAM shall allow a VLBI observation to be interrupted and when resuming the CAM shall ensure that local VLBI observation is synchronised with the running global VLBI observation.[Note] *[Note: It is conceivable that, while participating in a Very Long Baseline Interferometry (VLBI) observation, MeerKAT may be caused to exit from the observation before the observation has run to completion.* *When entering a running global VLBI observation, the CAM shall ensure that local observation is synchronised with the running global VLBI observation.* *The schedule block definitions in a VLBI Experiment (VEX) file, defines the exact start time of each scan. These start times are used to synchronise instruments that participate in the observation.* *The VLBI observation should be broken down into multiple schedule blocks, each containing a scan with its specific start time as per the VEX file. This is to ensure that the observation can be resumed in synchronisation with the global observation.]*	R.T.P.77	C
R.CM.FC.32	CAM shall allow parallel execution of ready scheduling blocks in a sub-array to increase utilisation efficiency.	R.T.FC.32	D
R.CM.FC.33	CAM shall schedule scheduling blocks as the uninterruptable unit of execution (i.e. scheduling blocks cannot be paused and resumed, but it can be stopped, cancelled or restarted).	R.T.FC.33	D
R.CM.FC.42	When receiving a valid Target Of Opportunity (TOO) trigger with relevant configuration information as per [29], CAM shall stop the currently executing SB(s) and start executing the required TOO SB. [Note] *[Note: Timeframe C&D requirements will be clarified in more detail at subsequent Requiremennts Reviews resulting in the next revision of the CAM Requirement Specification]*	R.T.FD.56	D

6.3.2 Manual Control

Req #	*Description*	*Source*	*Time*
R.CM.FC.21	CAM shall provide a command-line control interface to the expert user for manual control of a sub-array's resources. The command-line control interface shall give the expert user direct (manual) control over the sub-array's resources through simple scripts in a Command Control Language. The command-line control interface shall only be available to the expert user.	R.T.FC.21	A
R.CM.FC.38	The time delay within CAM between issuing a command and the command being sent to the relevant subsystem should be less than 1s.	R.T.FC.38	B
R.CM.FC.41	The Manual control scripting language shall be the same as the observation scripting language used by the OPT.	R.T.FP.7	A

6.3.3 Manual and Queue scheduling

Req #	*Description*	*Source*	*Time*
R.CM.FC.24	CAM shall provide Manual Scheduling mode and Queue Scheduling mode for each sub-array scheduler that can be selected by the control authority.	R.T.FC.24	B
~~R.CM.FC.39~~	Deleted. Covered by OPT and other requirements ~~The system shall provide tools for users to validate schedule blocks, plan upcoming observations and schedule blocks.~~	~~R.T.FC.39~~	~~C~~

R.CM.FC.25	In the Manual and Queue Scheduling modes, CAM shall enable the control authority to perform the following actions with the scheduling blocks (SBs) of the sub-array: - Assign a scheduling block from the archive to the sub-array (i.e. add the scheduling block to the sub-array's observation - Assign all scheduling blocks of a program block from the archive to a sub-array (i.e. add all the scheduling blocks of the Program Block to the sub-array's observation schedule) - Remove an idle scheduling block from the sub-array's observation schedule - Re-arrange/order the list of scheduling blocks in the sub-array's observation schedule - Start execution of a selected scheduling block (allocating resources from the sub-array's resource pool and start executing the scheduling block) – mostly in Manual Scheduling mode - Stop execution of a selected scheduling block (gracefully wrap up the scheduling block, archive the data, release resources, keeping the scheduling block on the observation schedule, flagged as "stopped"). - Restart execution of a scheduling block (allocating resources from the sub-array resource pool and restart execution of a stopped scheduling block from the start) - Cancel execution of a scheduling block (immediately stop execution of scheduling block, release resources and **discard** the captured data, keeping the scheduling block on the observation schedule, flagged as "cancelled")	R.T.FC.25	B
R.CM.FC.26	In Manual and Queue Scheduling mode, when selecting a SB from the archive, CAM shall display the following information for a selected SB: - whether sufficient system resources are available for the scheduled SB; - whether all observation constraints are met for executing the SB.	R.T.FC.26	B
R.CM.FC.61	In Manual Scheduling mode, the sub-array scheduler will execute scheduling blocks as instructed by the control authority.	R.T.FC.26	B
R.CM.FC.27	In Queue Scheduling mode the sub-array scheduler will perform serial execution of the scheduling blocks in the Observation Schedule in order (subject to Observation Constraints). Scheduling blocks that are not ready will be skipped.	R.T.FC.27	B

6.3.4 Automatic Scheduling

Req #	*Description*	*Source*	*Time*
R.CM.FC.28	CAM shall provide an Automatic Scheduling mode for each sub-array scheduler that can be selected by the control authority.	R.T.FC.28	D
R.CM.FC.29	In the Automatic Scheduling mode, the sub-array scheduler shall dynamically select and schedule scheduling blocks based on - priority, [Note] - available System Resources and - Observation Constraints. (as per definitions) *[Note: Priority of observations is set by the TAC as part of the proposal approval process]*	R.T.FC.29	D
R.CM.FC.30	The control authority shall be able to stop Automatic Scheduling mode and revert back to Manual or Queue scheduling.	R.T.FC.30	D

R.CM.FC.37	In the Automatic scheduling mode, CAM shall enable synchronised execution of scheduling blocks in a sub-array.[Note] *[Note: Synchronised execution may be required for some observations (e.g. performing different processing at the same time while observing a source.) Synchronisation of scheduling blocks across different sub-arrays will be realised manually by giving the scheduling blocks the same exact start time.]*	R.T.FC.37	D

6.3.5 Resource Management

Req #	***Description***	***Source***	***Time***
R.CM.FC.62	CAM shall manage the following resource pools: - free resources (all resources that are available for observations) - maintenance resources (all free resources that should not be used for normal observations) - resource pool per sub-array (all resources assigned to a specific sub-array)	R.T.FC.34	B
R.CM.FC.34	CAM shall enable the control authority to put a resource in the sub-arrays resource pool into maintenance.	R.T.FC.34	B
R.CM.FC.50	CAM shall enable the lead operator to add a resource from the free and maintenance resource pools to the resource pool of any sub-array.	R.T.FC.34	B
R.CM.FC.35	CAM shall enable the lead operator to move antennas from one sub-array to another with ease.	R.T.FC.35	C

6.3.6 Observation concurrency and sub-arraying

Req #	***Description***	***Source***	***Time***
R.CM.FD.40	CAM shall be able to operate up to 4 sub-arrays with completely independent control and data capture.	R.T.FD.40	C
R.CM.FD.41	CAM design shall not be limited to 4 sub-arrays for upgradeability.	R.T.FD.41	D
R.CM.FD.100	CAM shall support Spectral Line Imaging observing mode and Continuum Imaging observing mode concurrently.[Note] *[Note: Observing modes are defined in system requirement R.T.FD.50. Refer to [10], par. 2.2 for more detail on the MeerKAT Telescope Imaging observing mode.]*	R.T.FD.100	D

6.4 Subsystem Control

6.4.1 General

Req #	***Requirement***	***Source***	***Time***
R.CM.FD.54	There shall be nothing in the CAM that prevents the switching between observing modes using the same receiver in less than 3 minutes. Note *[Note: Observing modes is defined in system spec R.T.FD50]*	R.T.FD.54	C
R.CM.FD.55	CAM shall support tracking of solar system objects, medium to high orbit satellites and deep space satellites from source catalogues.	R.T.FD.55	A

6.4.2 Antenna Positioner control

Figure 7 shows a functional block diagram of the antenna control and monitoring functions performed by the different subsystems:

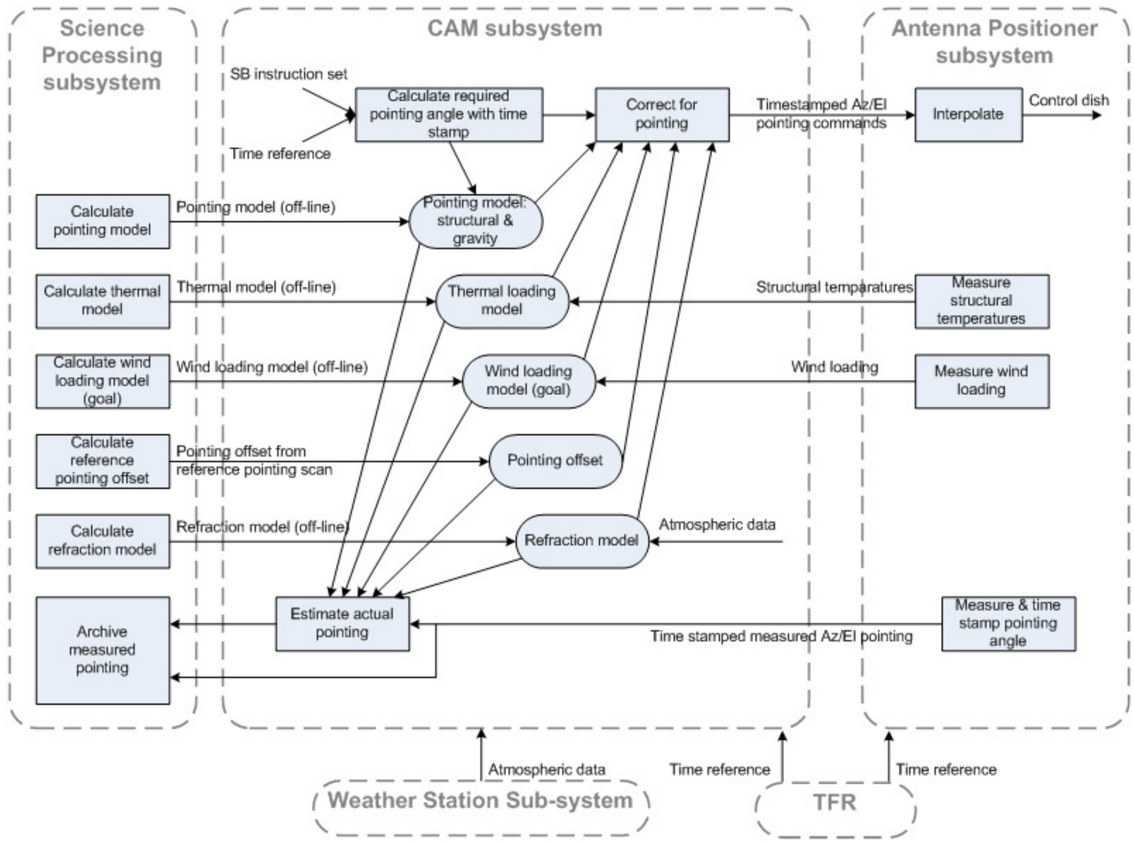

Figure 7: Antenna pointing control and monitoring functions

The following CAM requirements were identified from this functional analysis:

Req #	***Requirement***	***Source***	***Time***
R.CM.FC.A.1	CAM shall apply a pointing model (produced off-line by SP) to mitigate pointing errors caused by structural misalignments and structural deformations due to gravity. [Note] *[Note: Static models to be applied by CAM shall be provided off-line by SP]*	R.A.P.9, 10, 11, 12, 13.	A
R.CM.FC.A.2	CAM shall apply pointing corrections (using a thermal model produced off-line by SP) due to thermal deformations of the antenna structures using data from thermal sensors on the structure, as per [19]. [Note] *[Note: Static models to be applied by CAM shall be provided off-line by SP]*	R.A.P.9, 10, 11, 12, 13.	wasA
R.CM.FC.A.3	CAM shall apply pointing corrections (using a refraction correction model produced off-line by SP) due to refraction, based on current weather data, as per [20]. [Note] *[Note: Static models to be applied by CAM shall be provided off-line by SP]*	R.A.P.9, 10, 11, 12, 13.	A
R.CM.FC.A.4	CAM shall apply pointing corrections (using a wind load model produced off-line by SP) due to deformations from wind loading using sensor data from the antenna positioner (goal) as per [19].[Note] *[Note: Static models to be applied by CAM shall be provided off-line by SP]*	R.A.P.9, 10, 11, 12, 13.	C
R.CM.FC.A.5	CAM shall apply pointing corrections (using a model produced off-line by SP) based on a **reference pointing calibration data,** received from the SP, as per [23]. [Note] *[Note: Static models to be applied by CAM shall be provided off-line by SP]*	R.A.P.9, 10, 11, 12, 13.	C

R.CM.FC.A.6	CAM shall archive raw Az/El measured pointing sensor values as well as estimated actual pointing based on all applied offset pointing corrections (as per Figure 7: Antenna pointing control and monitoring functions).	R.A.P.9, 10, 11, 12, 13.	C
R.CM.FC.A.7	The CAM shall command the Antenna Positioner to stow in the following cases: • the 10-minute mean wind speed on site exceeds 40km/h • the gust wind speed on any wind sensor exceeds 61km/h	R.T.R.6, R.T.S.4	A

The current KAT-7 implementation of the pointing correction is shown in Figure 8. This model will be adapted to include thermal and wind loading effects, as well as reference pointing corrections.

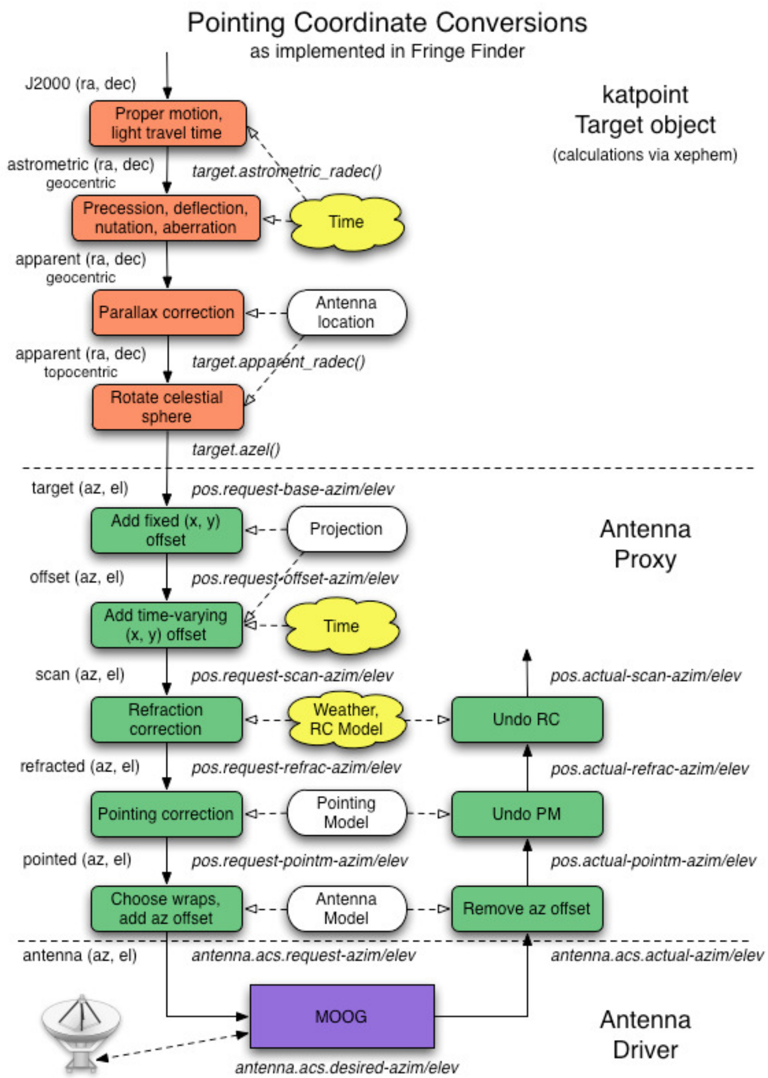

Figure 8: Implementation diagram of antenna pointing correction

6.4.3 Correlator control

The following Correlator observing modes have been identified in the MeerKAT PDR Correlator Description and Requirements [10], par. 2.2:

a) Imaging mode
b) Generic Tied-array mode
c) Pulsar timing mode
d) Transient search mode
e) Fly's eye mode
f) VLBI mode

Each of these modes has different functionality and require different control functions, as shown in Figure 9 to Figure 13.

Refer to [10], par. 2.2 for the mapping of MeerKAT observing modes to Correlator observing modes.

The configuration and control messages required by the Correlator in this paragraph is specified in I.TE.CM.7 Correlator CAM ICD [22].

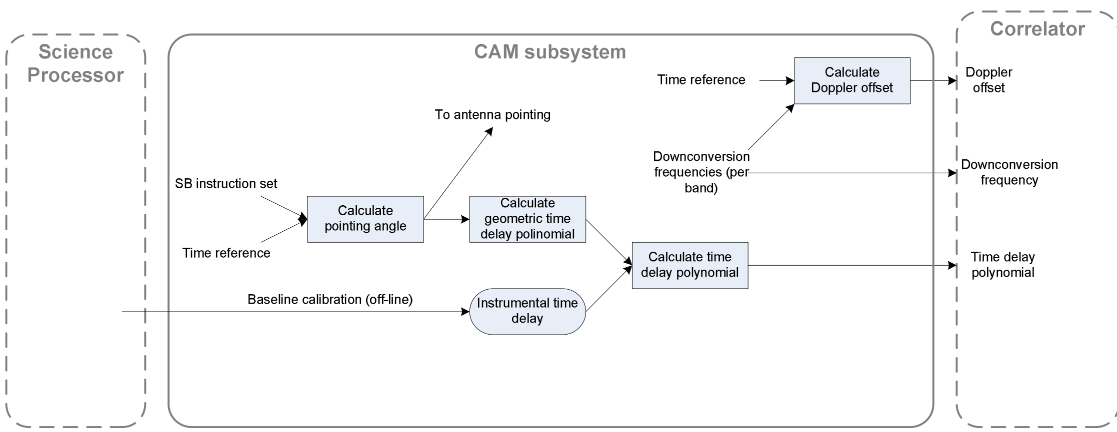

Figure 9: Imaging mode control functions

The following control functions are required for each Correlator sub-division in the Imaging Correlator observing mode:

Req #	*Requirement*	*Source*	*Time*
R.CM.FC.C.1	When a Correlator sub-division is in the Imaging, Tied-array or Pulsar Timing mode, and when the Doppler tracking function is enabled, CAM shall continuously calculate the Doppler offset and control the Doppler offset parameter on the Correlator, updated at a rate of TBD.	R.T.P.114	B
R.CM.FC.C.2	It shall be possible to disable the Doppler tracking function.	R.T.P.72	B
R.CM.FC.C.3	When a Correlator sub-division is in the Imaging, Tied-array or Pulsar Timing mode, CAM shall configure the Correlator downconversion frequency parameter as per [22].	Functional analysis	B
R.CM.FC.C.4	When a Correlator sub-division is in the Imaging observing mode, CAM shall calculate the time delay polynomial at TBD update rate from: a) the instrumental time delay and b) the geometric time delay for the required pointing angle, and control the Correlator time delay polynomial as per [22].	Functional analysis	A

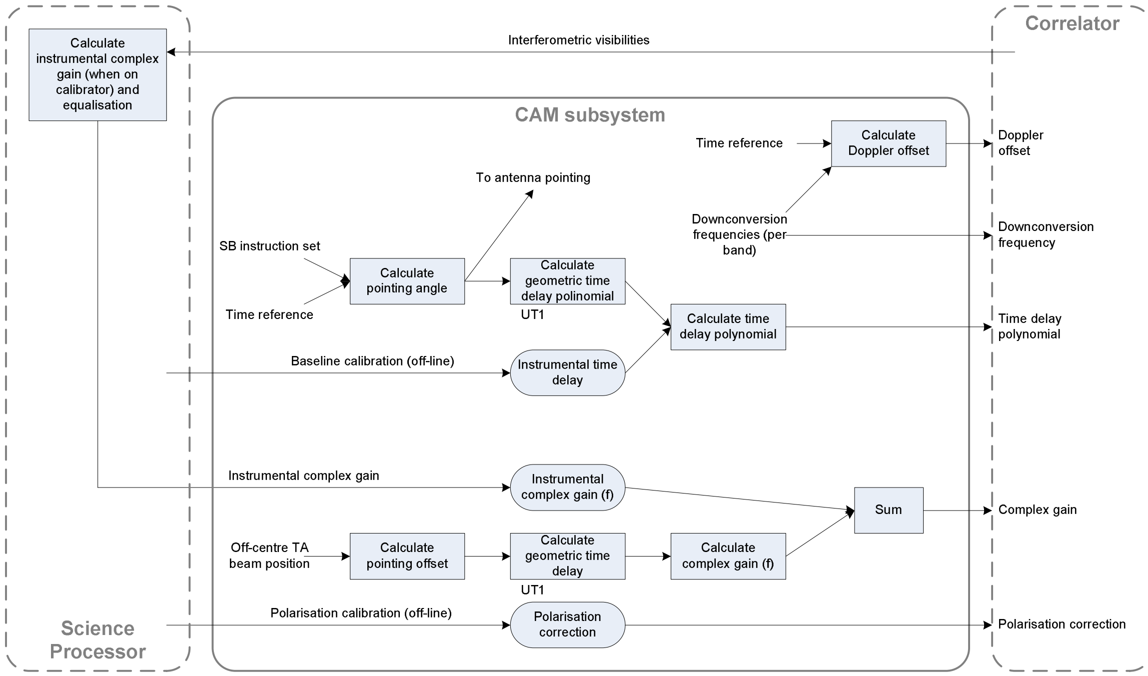

Figure 10: Tied-array mode control functions

The following additional control functions are required for each Correlator sub-division in the Generic Tied-array Correlator observing mode:

Req #	***Requirement***	***Source***	***Time***
R.CM.FC.C.10	When a Correlator sub-division is in the Tied-array mode, CAM shall continuously calculate the time delay polynomial, updated at a rate of TBD, from: a) the instrumental time delay and b) the geometric time delay for the required pointing angle for the reference beam position, using UT1 time to an accuracy of 3ms, and control the Correlator time delay polynomial as per [22].	Functional analysis, R.T.P.66	B
R.CM.FC.C.11	When a Correlator sub-division is in the Tied-array or Pulsar Timing modes, CAM shall continuously calculate the complex gain correction updated at a rate of TBD, from: a) the instrumental complex gain received from the SP subsystem after a complex gain calibration b) the geometric time delay for the required offset pointing angle (from the reference beam position), for up to 4 independent beams, using UT1 time to an accuracy of 3ms, and control the Correlator complex gain values accordingly as per [22].	Functional analysis, R.T.P.66	B
R.CM.FC.C.12	When a Correlator sub-division is in the Tied-array mode, Pulsar Timing and Transient Search modes, CAM shall configure the polarisation correction values, based on the relevant polarisation calibration data from the SP subsystem, as per [22].	Functional analysis, R.T.P.30	B

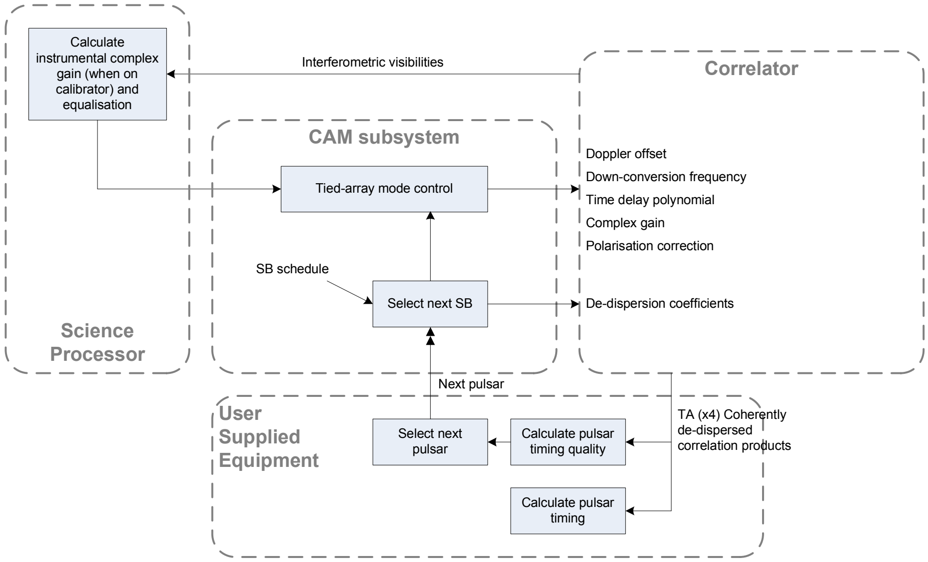

Figure 11: Pulsar timing mode control functions

The following additional control functions are required for each Correlator sub-division in the Pulsar Timing Corrrelator observing mode:

Req #	***Requirement***	***Source***	***Time***
R.CM.FC.C.20	When a Correlator sub-division is in the Pulsar Timing mode, CAM shall receive an external trigger from the user supplied pulsar timing equipment, as per [29], for terminating the current executing scheduling block and starting the next scheduling block in that sub-array.	R.T.P.38	B
R.CM.FC.C.21	When the Correlator sub-division is in the Pulsar Timing mode, CAM shall configure the following parameters as per [22]: a) De-dispersion coefficients for the selected pulsar b) De-dispersed time series dump rate	Functional analysis	B
R.CM.FC.C.22	On receiving the external trigger to move to the next pulsar, the CAM shall stop the currently executing SB and transition to the next scheduling block.	R.T.P.38	B

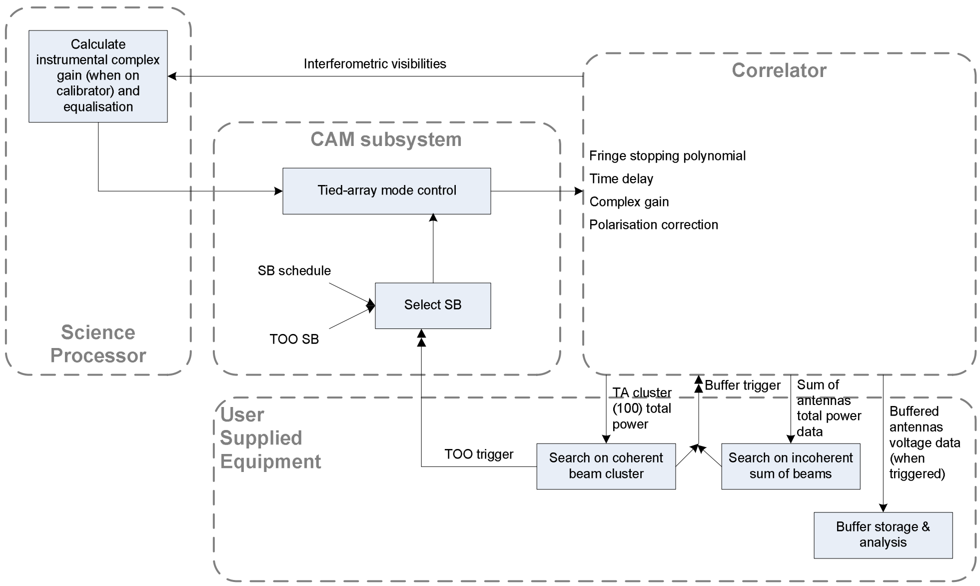

Figure 12: Transient Search mode control functions

The following additional control functions are required in the Transient Search Correlator observing mode:

Req #	*Requirement*	*Source*	*Time*
R.CM.FC.C.30	When the Correlator sub-division is in the Transient Search mode , CAM shall continuously calculate **the complex gain correction,** at a rate of TBD, from: a) the instrumental complex gain received from the SP subsystem after a complex gain calibration b) the geometric time delay for the required offset pointing angle (from the reference beam position), for up to 100 independent beams (goal 500 beams), using UT1 time to an accuracy or 3ms, and control the Correlator complex gain values accordingly as per [22]. [Note] *[Note: Timeframe C&D requirements will be clarified in more detail at subsequent Requiremennts Reviews resulting in the next revision of the CAM Requirement Specification]*	Functional analysis, R.T.P.40 R.T.P.66	C
~~R.CM.FC.C.31~~	Deleted. Moved to General Scheduling. ~~The CAM subsystem, when receiving a valid Target Of Opportunity (TOO) trigger with relevant configuration information, shall stop the currently executing SB and start executing the required TOO SB.~~	~~R.T.FD.56~~	~~D~~

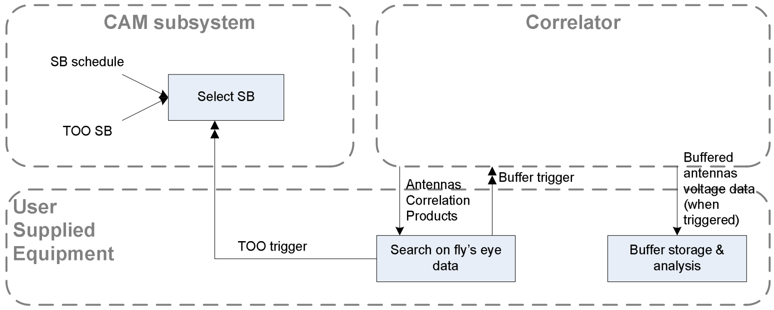

Figure 13: Fly's eye search mode control functions

There are no additional Correlator control requirements for the Fly's Eye Correlator observing mode.

6.4.4 Receivers control

Receivers configuration and control messages required in this section is specified in one of the following interface documents:

1. I.TE.CM.1 L-BAND Receiver CAM ICD
2. I.TE.CM.10 S-Band Receiver CAM ICD
3. I.TE.CM.9 X-Band Receiver CAM ICD
4. I.TE.CM.6 UHF-Band Receiver CAM ICD

NOTE: Due to the Receivers Controller ECP-036 currently being processed, these interfaces may be combined into one.

Req #	*Requirement*	*Source*	*Time*
R.CM.FC.R.1	CAM shall configure the Receiver subsystem over Ethernet using the KATCP protocol as per [24], [25], [26] and [27], including the following parameters: a) Noise diode on/off/digitiser_controlled. b) Vacuum pump on/off (via Antenna controller). c) Compressor on/off (via Antenna controller).	Functional analysis	A

6.4.5 Digitiser control

Digitiser configuration and control messages required in this section is specified in I.TE.CM.2 Digitiser CAM ICD. A functional flow block diagram of the digitiser is given in [18], from which the following control requirements are derived:

Req #	*Requirement*	*Source*	*Time*
R.CM.FC.D.1	CAM shall configure the digitiser over Ethernet using the KATCP protocol as per [18], including the following parameters: a) Variable attenuator settings b) Downconversion frequency c) RFI flagging settings d) RFI excision settings e) Noise switching parameters	Functional analysis	A

6.4.6 Science processor control

Req #	*Requirement*	*Source*	*Time*
R.CM.FC.S.1	CAM shall configure and control the science processor over Ethernet	Functional	B

	using the KATCP protocol as per [23]. [Note] *[Note: The CAM / SP interface will be clarified in more detail as the SP functionality emerges and implementation matures. The goal of this document was to identify the different types of data that will flow between the CAM and SP.]*	analysis	

6.4.7 Video Display Subsystem control

Req #	*Requirement*	*Source*	*Time*
R.CM.FC.V.1	CAM shall control the cameras of the Video Display Subsystem over Ethernet using the KATCP protocol as per [21]. [Note] *[Note: The CAM displays must integrate the zoom, pan, select functionality to control the cameras of the VDS even though standalone control of the VDS may be possible.]*	Functional analysis	B

6.5 Infrastructure control

There are no requirements for the control of infrastructure components from the CAM subsystem.

6.6 Monitoring

Figure 14 gives an overview of the flow of monitoring information from the source (subsystems) to the end users (operators, maintainers and science data users)

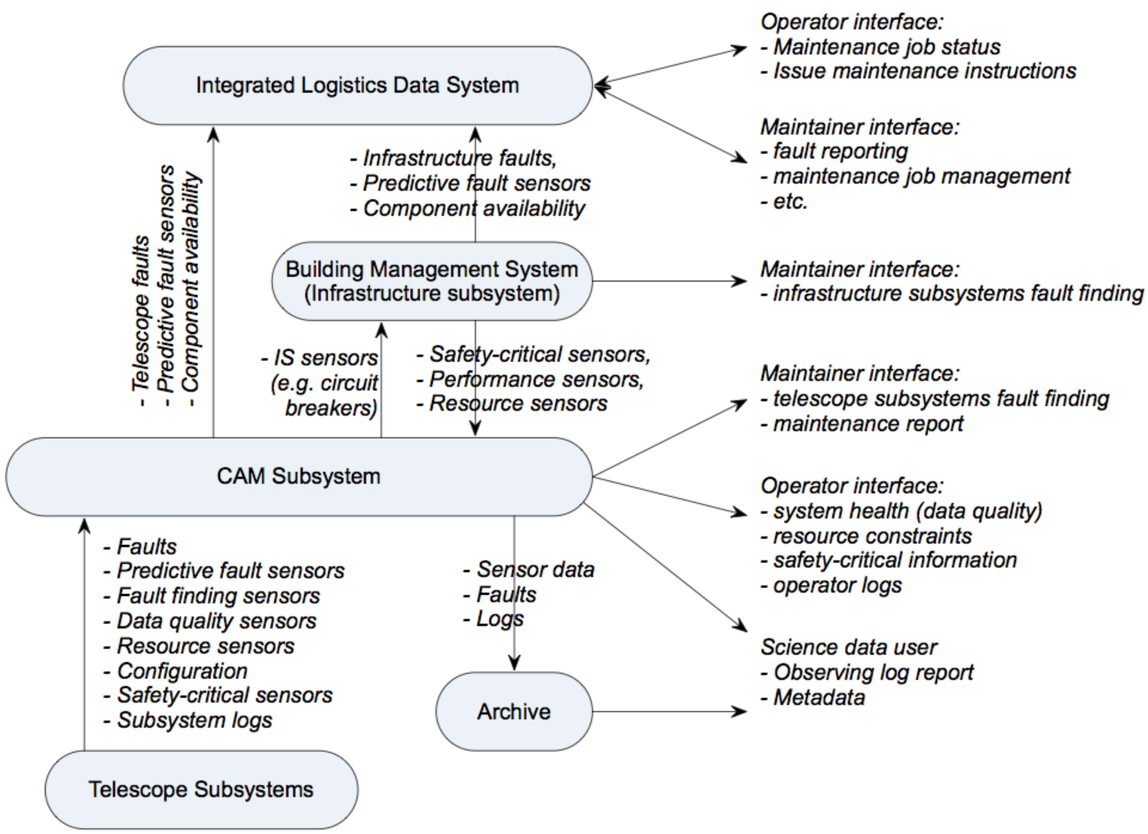

Figure 14: Overview of monitoring information flow

From this analysis, the following high level requirements are derived for the CAM subsystem. Some of these are detailed in the following sections.

Req #	*Requirement*	*Source*	*Time*
R.CM.FM.1	CAM shall provide System Displays to enable a single operator to monitor the state of health of the complete system, irrespective of the sub-arraying configuration.	R.T.FM.300	A
R.CM.FM.2	The System Displays shall enable an operator to evaluate the resource constraints for scheduling.	R.T.FM.300	A
R.CM.FM.3	CAM shall generate alarms in case of safety-critical system conditions, based on safety-related sensors from subsystems.[Note] *[Note: The detail of which sensors should be monitored for which conditions will be clarified in the specification record of the CAM component to which this requirement are allocated]*	R.T.FM.300	A
R.CM.FM.4	The System Displays shall facilitate fault finding.	R.T.FM.300	A
~~R.CM.FM.5~~	Deleted. Covered by R.CM.FM102 ~~CAM shall allow authorised users to create log message entries.~~	~~R.T.FM.101~~	~~B~~

~~R.CM.FM.7~~	Deleted. Covered by R.CM.FM314 below. ~~CAM shall report the following information to the Integrated Logistics System (ILS):~~ ~~a) Telescope faults that require maintenance actions~~ ~~b) Predictive fault sensors~~ ~~c) Component availability[Note]~~ ~~*[Note: Component availability statistics is required by the ILS system to verify and refine the reliability models]*~~	~~Functional analysis~~	~~C~~
~~R.CM.FM.8~~	Deleted. This requirement is split into a requirement per sub-system monitored by CAM. ~~CAM shall receive the following monitoring information from all subsystems:~~ ~~i) Failure detections, based on a FMECA analysis, including:~~ ~~iii. Overall "fit for use" for the device to indicate that it is operating within its specified performance and functional requirements.~~ ~~iv. Communication with CAM OK.~~ ~~j) Sensor values used for failure prediction by the ILS (where applicable)~~ ~~k) Sensors required to identify faults (fault finding)~~ ~~l) Sensors that may indicate that the quality of the data being captured may be negatively impacted.~~ ~~m) Sensors required to determine resource availability for observation planning and scheduling~~ ~~n) Sensors that identify the installed configuration of the subsystem.~~ ~~o) Sensors that indicate safety-critical conditions.~~ ~~p) Subsystem logs.~~	~~Functional analysis~~	~~A~~
R.CM.FM.21	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Weather Station System as per [20].	Functional analysis	A?
R.CM.FM.22	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Correlator as per [22].	Functional analysis	A
R.CM.FM.23	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the SP as per [23].	Functional analysis	A
R.CM.FM.24	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Receivers Controller as per [27].	Functional analysis	A
R.CM.FM.28	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Digitiser as per [18].	Functional analysis	A
R.CM.FM.29	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Antenna Positioner as per [19].	Functional analysis	A
R.CM.FM.30	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Video Display Subsystem as per [19]. [Note] *[Note: This is required because CAM has to report switching on/off of cameras during observations for possible RFI]*	Functional analysis	B
R.CM.FM.31	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the Time Frequency Reference as per [28].	Functional analysis	A
R.CM.FM.32	The CAM shall periodically gather and store Monitoring Data [as per Definition] from the BMS as per [18][28].	Functional analysis	B
R.CM.FM.9	CAM shall be able to generate and archive an observation report for each scheduling block consisting of all relevant system logs, user logs and scheduling block definition information.	R.T.FM.111 R.T.FM.104	B

R.CM.FM.10	CAM shall be able to generate a log report for a specified period of time consisting of all relevant system logs and user logs.	R.T.FM.112	C
~~R.CM.FM.11~~	Deleted. This requirement is not applicable because no dependency exists between serial number item configuration and the processing of data linked to a SB. ~~CAM shall receive configuration changes from the ILS data system and automatically update the Instrumental Configuration Data accordingly.~~	~~Functional analysis~~	~~B~~
R.CM.FM.12	CAM shall report the following infrastructure sensor data to the BMS system as per [15]: a) Receptor power on/off derived from connections to katcp interfaces in the receptor.	Functional analysis	A
R.CM.FM.13	Monitoring displays to support observations shall be accessible via the internet.	R.T.FM.1	B
R.CM.FM.305	CAM shall archive all system Monitoring Data (including health, weather and pointing) for at least a period of 12 months.	R.T.FM.305 R.T.FM.206 R.T.FM.207	A
R.CM.FM.14	CAM shall be allowed to decimate and resample archived Monitoring Data older than that in R.CM.FM305 above.	R.T.FM.305 R.T.FM.206 R.T.FM.207	C
R.CM.FM.306	The frequency of how often monitoring points are stored should be easily configurable.	R.T.FM.306	A
R.CM.FM.310	CAM shall log and archive all reported alarms, warnings and errors.	R.T.FM.310	A
R.CM.FM.15	The CAM design shall allow for Monitoring Data with a total number of sensors across all receptors and subsystems in the order of 100 000, with the following sampling rates: • Not more than 10% of sensors sampled at subsecond rate - ~ 10-500ms • Not more than 25% of sensors sampled at order second rate - ~ 1-5 seconds • Rest of the sensors sampled at an average rate of once every 10s	R.T.FM.306	B
R.CM.FM.16	CAM shall provide meta-data (TBD per sub-array) on-line as per [23], to augment data products	Functional Analysis	B

6.6.1 Health monitoring displays

The health monitoring is performed by a combination of graphical system health displays and alarms. For monitoring functional interfaces during development and for fault finding purposes, it must be possible to display the control and monitoring activities on any selected control interface between subsystems. Monitoring data should be archived and should allow for historical data retrieval and analysis.

For maintenance purposes, the monitoring will initially be performed manually, but eventually the system needs to feed faults directly to the ILS for managing maintenance activities and gathering reliability and availability data.

Req #	*Requirement*	*Source*	*Time*
R.CM.FM.301	CAM shall provide System Display(s) that allows the operator or maintainer to easily track faults down to LRU level.	R.T.FM.301	B

R.CM.FM.302	The System Displays shall enable the operator to easily see when the system health status changes.	R.T.FM.302	B
R.CM.FM.303	When requested by the operator, the System Displays shall show the values of selected monitoring points.	R.T.FM.303	A
R.CM.FM.304	CAM shall be able to plot up to 64 selected current or historical monitoring points as a function of time on a synchronised timescale within a few seconds for time range up to 7 days**.**	R.T.FM.304	B
R.CM.FM.307	CAM shall enable a user to retrieve and view historical monitoring points.	R.T.FM.307 R.T.FM.204	B
R.CM.FM.308	For system faults that require immediate intervention, or which may compromise the integrity of the captured data, CAM shall generate an alarm to the operator as soon as the fault is detected, with sufficient information for the operator to identify the problem and the required corrective action. [Note] *[Note: The detail of this requirement will be clarified in the Specification Record of the component to which this requirement is allocated.]*	R.T.FM.308	B
R.CM.FM.309	CAM shall organise the display of alarms according to severity and time of occurrence.	R.T.FM.309	B
R.CM.FM.313	When requested by a user, CAM shall display the control and/or monitoring activities between CAM and any selected subsystem.	R.T.FM.313	B
~~R.CM.FM.316~~	Deleted. Will be provided by ILS. ~~CAM shall make operator manuals and troubleshooting procedures available on-line~~.	~~R.T.FM.316~~	~~B~~
R.CM.FM.314	CAM shall report the following information to the ILS as per [16]: - Failure detections as defined in the failure modes model of each subsystem. - System parameters required for the purpose of predicting failures. [Note] - Usage sensors as reported by the subsystem to plan preventative maintenance (as identified by the subsystem FMECA process). *[NOTE: Sensors llike high temperatures or currents that indicate failures are imminent.]*	R.T.FM.314	B

6.6.2 System Status displays

The system must display critical in-time status information to enable the operator to assess that the observation is running smoothly. This includes pointing, system settings and status, weather conditions, current time and video from the array. Some system status information (e.g. actual pointing) needs to be archived.

Req #	*Requirement*	*Source*	*Time*
R.CM.FM.200	CAM shall provide a status display for each sub-array independently, which shall include at least the following status information: - Pointing: - Mechanical pointing for a chosen antenna, commanded (ideal) pointing position and known pointing error (difference between desired and reported) - Electronic pointing of the array - Scan reference position	R.T.FM.200	A

	- Horizon mask - Receiver settings - Array processor mode and settings		
R.CM.FM.201	CAM shall display local sidereal time, day of year, date, Modified Julian Day, universal time and South African standard time.	R.T.FM.201	B
R.CM.FM.202	CAM shall display the system build state on request of the operator.	R.T.FM.202	A
R.CM.FM.203	CAM shall provide a Weather Display, showing current conditions and trends on site and warnings if conditions are out of range (e.g. wind speeds require antennas to be stowed)	R.T.FM.203	B
~~R.CM.FM.204~~	Deleted. Covered by R.CM.FM307. ~~CAM shallbe able to show a historical time-plot of selected weather conditions.~~	~~R.T.FM.204~~	~~A~~
R.CM.FM.205	CAM shall display the video feed from the cameras for the VDS on the System Displays.	R.T.FM.205	B

6.6.3 Logging

Logging requirements consist of user logs, system generated logs and reports created from logs. CAM must time stamp and archive all logs, and distribute log messages to relevant users.

Req #	***Requirement***	***Source***	***Time***
R.CM.FM.107	CAM shall time stamp and store all log messages in the archive.	R.T.FM.107	A
R.CM.FM.108	CAM shall include relevant log messages in shift reports and observation reports. ~~CAM shall send specified log messages to relevant users as and when required.~~	R.T.FM.108	B
~~R.CM.FM.109~~	Deleted. This is an operating system level functionality of the workstation. ~~CAM shall enable users to copy from any log to the clipboard.~~	~~R.T.FM.109~~	~~B~~
~~R.CM.FM.110~~	Deleted. Covered by R.CM.FM.102. ~~User logs and system logs shall be associated with one or more relevant users, including PI, operator, maintenance or developer.~~	~~R.T.FM.110~~	~~B~~

6.6.4 User logs

Operators are required to log a wide range of events. Observers, PIs and scientist also need to log conditions or events which may be relevant to the observation.

These user logs will be classified and be included in the shift reports and observation reports. ~~The list below is a catch-all description, work through each real requirement here.~~

~~Operators are required to document a wide range of information:~~

- ~~a) Notify the PI of conditions or events which may have influenced the quality of recorded data (QA level 1).Log conditions or events which may have influenced the quality of recorded data (QA level 1) – for PIs.~~
- ~~b) Log maintenance activities. (REMOVE – In ILS instead, not in CAM?)~~
- ~~c) Create shift notes – for other operators.~~
- ~~d) Notify maintainers of issues which require attention. (REMOVE – In ILS instead, not in CAM?)~~
- ~~e) Create reminders for themselves.~~

~~CAM must be able to facilitate the capturing and viewing distribution of these logs.~~
~~Staff astronomers responsible for QA level 2 activities also want to log data quality messages.~~

Req #	***Requirement***	***Source***	***Time***
R.CM.FM.101	CAM shall allow users to edit their own user log messages.	R.T.FM.101	B
R.CM.FM.102	User logs shall be tagged with a type, the relevant user who made the log entry and optionally with a Scheduling Block and/or System Resource. The types of user logs, shall include: • shift logs (to record something of note for other operators or reminders for themselves) • time-loss logs (duration and reason for loss of observation time) • observation logs (on conditions that may affect data quality logs and general observation log entries) • status logs (logs on the health of system components) • maintenance logs (notes on troubleshooting and maintenance activities) ~~CAM shall enable the creation of different types of user logs, including reminders (i.e. messages to self for later time), operator to operator messages, notes to PIs, data quality logs, notes to maintainers, troubleshooting messages and general observation log entries.~~	R.T.FM.102 R.T.FM.110	B
R.CM.FM.103	CAM shall enable operators to attach files ~~figures~~ to user logs. TBD Confirm this is still a requirement	R.T.FM.103	B
R.CM.FM.104	Authorised users shall be able to generate a shift report associated with a specific shift time span, containing the user logs for that shift classified by type, in open format text and searchable on text keywords.	R.T.FM.104	B
~~R.CM.FM.150~~	Deleted. Covered by R.CM.FM.9. ~~CAM shall be able to generate and archive an observation report with relevant logs and information for that observation.~~	~~R.T.FM.104~~	~~B~~

6.6.5 System logs

CAM must automatically log system level activity (e.g. scheduling events, antenna stowing due to wind) and serious faults.

Req #	***Requirement***	***Source***	***Time***
R.CM.FM.105	CAM shall generate system logs of the following system activity: - Scheduling events (e.g. SB set up, SB started, SB stopped, SB completed) - Wind stow events - Alarms and serious faults	R.T.FM.105	B

6.7 CAM Archiving

CAM is responsible for archiving the following data. The Science processing subsystem is responsible for archiving the observation data products.

Req #	*Requirement*	*Source*	*Time*
R.CM.FDA.1	CAM shall archive the following data: a) Proposals and proposal management information b) Observation instructions, including Program Blocks, Schedule Blocks and other user scripts (e.g. calibration scripts) c) User and system logs d) Monitoring Data e) Instrumental Configuration Data	R.T.FM.107 R.T.FM.206 R.T.FM.207 R.T.FM.305 R.T.FA.1	A
R.CM.FDA.2	The CAM archive shall be mirrored to provide full back up to all data.	R.T.FA.15	B
R.DM.FDA.3	CAM shall use the storage provided by the SP in the Karoo Array Processor Building and in the Cape Town archive, as per [23].	Financial Analysis	B

6.8 Proposal management

Req #	*Requirement*	*Source*	*Time*
R.CM.FP.1	CAM shall provide a web-based Proposal Management Tool with an easy to use graphical user interface. [Note] *[Note: Timeframe C requirements will be clarified in a subsequent requirements review.]*	R.T.FP.1	C
R.CM.FP.2	The Proposal Management Tool shall facilitate the electronic submission, storage, search, modification and evaluation of proposals. [Note] *[Note: Timeframe C requirements will be clarified in a subsequent requirements review].*	R.T.FP.2	C

6.9 Observation planning

Req #	*Requirement*	*Source*	*Time*
Observation Planning : General			
~~R.CM.FP.3~~	Deleted. Moved to SP. ~~The Observation Planning Tool (OPT) shall enable the user to convert an approved proposal to one or more program blocks, each of which shall consist of one or more schedule blocks.~~	~~R.T.FP. 3~~	~~C~~
~~R.CM.FP.4~~	Deleted. Moved to SP. ~~The OPT shall facilitate the creation, storage and modification of program and schedule blocks.~~	~~R.T.FP. 4~~	~~B~~
~~R.CM.FP.24~~	Deleted. Moved to SP. ~~The OPT shall be able to interpret VEX format instructions~~	~~R.T.P.7 5~~	~~C~~
Observation Planning: Output			
~~R.CM.FP.5~~	Deleted. Moved to SP. ~~The OPT shall produce as its output a complete set of schedule blocks for each program block in the form of executable scripts, which contain all information required to schedule and execute the observation.~~	~~R.T.FP.5~~	~~B~~
~~R.CM.FP.6~~	Deleted. Moved to SP.	~~R.T.FP.6~~	~~A~~

	~~Executable scripts shall be in the same human-readable command-line language used for manual control.~~		
~~R.CM.FP.7~~	Deleted. Moved to SP. ~~The scripting language shall support loops, structured conditional tests, parameterized procedures, global variables and arrays.~~	~~R.T.FP.7~~	~~A~~
Observation Planning: Definition			
~~R.CM.FP.8~~	Deleted. Moved to SP. ~~The OPT shall allow the user to easily construct a source list of coordinates and velocities by accessing standard astronomical catalogs.~~	~~R.T.FP08~~	~~B~~
~~R.CM.FP.9~~	Deleted. Moved to SP. ~~The OPT shall assist with the choice of appropriate calibrator sources.~~	~~R.T.FP.9~~	~~C~~
~~R.CM.FP.10~~	Deleted. Moved to SP. ~~The OPT shall enable the user to define a set of Observation Constraints (as per definition above) for the observation or for selected parts of the observation.~~	~~R.T.FP.10~~	~~B~~
~~R.CM.FP.11~~	Deleted. Moved to SP. ~~The OPT shall assist the user in selecting antennas/resources for schedule blocks.~~	~~R.T.FP.11~~	~~C~~
~~R.CM.FP.12~~	Deleted. Moved to SP. ~~The OPT shall assist the user with the choice of appropriate hardware functions and settings (e.g. frequency bands and channelisation).~~	~~R.T.FP.12~~	~~B~~
~~R.CM.FP.13~~	Deleted. Moved to SP. ~~The OPT shall assist the user to divide the proposal into a proper set of program and schedule blocks, which may be ordered for sequential execution.~~	~~R.T.FP.13~~	~~B~~
~~R.CM.FP.14~~	Deleted. Moved to SP. ~~Schedule blocks created by the OPT shall consist of a sequence of standard observing scans and standard calibration scans.~~	~~R.T.FP.14~~	~~B~~
~~R.CM.FP.21~~	Deleted. Moved to SP. ~~Schedule blocks created by the OPT may include calibrations which shall be applied to subsequent scans if required (for example, reference pointings).~~	~~R.T.FP.21~~	~~B~~
~~R.CM.FP.15~~	Deleted. Moved to SP. ~~The system shall enable the proposer to define breakpoints between SBs after which observations shall be stopped and only resumed (possibly in modified form) with the proposer's approval.~~	~~R.T.FP.15~~	~~B~~
~~R.CM.FP.22~~	Deleted. Moved to SP. ~~The OPT shall include a mechanism to apply for director's discretionary time.~~	~~R.T.FP.22~~	~~C~~
~~R.CM.FP.23~~	Deleted. Moved to SP. ~~The OPT shall enable users to update or delete their proposals before it has been officially submitted.~~	~~R.T.FP.23~~	~~C~~
Observation Planning: Help			
~~R.CM.FP.16~~	Deleted. Moved to SP. ~~The design of the OPT and associated documentation shall assume a user with no detailed knowledge of MeerKAT hardware and shall use as far as possible end-user terminology rather than system-specific terminology.~~	~~R.T.FP.16~~	~~D~~

~~R.CM.FP.17~~	Deleted. Moved to SP. ~~Where applicable, the OPT shall offer sensible default values for system parameters.~~	~~R.T.FP.17~~	~~B~~
~~R.CM.FP.20~~	Deleted. Moved to SP. ~~Where applicable, the OPT shall deduce default values for system parameters from science goals.~~	~~R.T.FP20~~	~~C~~
~~R.CM.FP.18~~	Deleted. Moved to SP. ~~The OPT shall verify that the proposed observation parameters are within the valid ranges of the system.~~	~~R.T.FP.18~~	~~C~~
~~R.CM.FP.19~~	Deleted. Moved to SP. ~~Where applicable, the OPT shall offer a simulation capability with system models to enable the proposer to evaluate the effectiveness and limitations of the planned observation.~~	~~R.T.FP.19~~	~~C~~

6.10 Observation management

Req #	***Requirement***	***Source***	***Time***
R.CM.FP.30	CAM shall inform the PI of the following events: - When his/her observation has started for the first time. - When schedule blocks have been completed. - When the SP reports that data from a schedule block has been rejected and has to be re-captured due to data quality problems detected during level 2 quality assurance evaluation. - When a breakpoint has been reached. - When a program block has been completed.	R.T.FP.30	C
R.CM.FP.31	At any time when requested by authorised users, CAM shall provide information on the overall progress and data quality (as reported by the SP) of an executing/executed Program Block.	R.T.FP.31	C
R.CM.FP.32	At any time when requested by authorised users, CAM shall provide information on the data quality of executed Schedule Blocks (as reported by the SP).	R.T.FP.32	C
R.CM.FP.33	CAM shall generate a management report which contains one or more of the following: - Telescope utilisation efficiency (% time used for observation) for a selected period. - Observing time lost and reasons for the loss of time (based on user time-loss logs) - Progress on all approved proposals. - Data quality of all executed and executing proposals.	R.T.FP.33	C
R.CM.FP.34	The CAM observation control framework shall provide a mechanism for breakpoints between SBs after which observations shall be stopped and only continued (possibly in modified form) with the proposer's approval. [Note] *[Note: Timeframe C requirements will be clarified in a subsequent revision and review of this document.]*	R.T.FP.15	C
R.CM.FP.35	The CAM shall provide mechansims to support a simulation capability for the OPT to enable the proposer to evaluate the effectiveness and limitations of the planned observation. .[Note] *[Note: Timeframe C requirements will be clarified in a subsequent revision and review of this document. Responsibility of the simulation capability will be determined then.]*	R.T.FP.19	C

6.11 Configuration management

The Instrumental Configuration must be controlled by the CAM subsystem and the version of this configuration must be linked to all scheduling blocks.

Req #	***Requirement***	*Source*	*Time*
R.CM.FC.51	CAM shall associate each SB with the version of the Instrumental Configuration Data that was valid at the time of executing the SB.	R.T.FC.51	B
R.CM.FC.52	If any changes are made to the Instrumental Configuration Data, CAM shall update the version of the Instrumental Configuration, which will be associated with the data products.	R.T.FC.52	B
R.CM.FC.54	CAM shall enable Operators to manually add long-term system calibrations as a version of the Instrumental Configuration Data to the Instrumental Configuration Data Repository, including: • SP on-line processing configurations; • Antenna pointing models; • Tied-array reference coordinates; • Source catalogues.	R.T.FC.54 R.T.FC.23	B
R.CM.FC.55	CAM shall automatically acquire, and add as a version to the Instrumental Configuration Data Repository, the following instrumental Configuration Data: • UT1; • Leap seconds for UT1; • Satellite catalogues.	R.T.FC.55	B
~~R.CM.FC.56~~	Deleted. This requirement is not applicable because no dependency exists between serial number item configuration and the processing of data linked to a SB. ~~CAM shall update Instrumental Configuration Data automatically based on inputs from the ILS due to hardware and software configuration changes.~~	~~R.T.FC.56~~	~~D~~
~~R.CM.FC.53~~	Deleted. CAM is not a time critical subsystem ~~CAM shall enable the following sequence of activities to be performed without requiring instrumental re-calibration longer than 10 minutes:~~ ~~[Note]~~ ~~a) change between observing modes and/or receivers~~ ~~b) change back to the original observing mode and/or receiver~~ ~~c) continue original observation~~ ~~*[Note: CAM will typically complete schedule block, load calibration files, select different receiver (execute obs) for reference pointing observation.]*~~	~~R.T.FC.53~~	~~C~~
R.CM.FC.57	CAM shall provide a display of all serial numbers reported in sensors by components.	R.T.FC.57	A
R.CM.FC.58	CAM shall enable an operator to easily query all software and firmware versions.	R.T.FC.58	A
R.CM.FC.59	CAM software shall be under configuration control and it shall be possible to revert back to previous versions.	R.T.FC.59	A
R.CM.FC.60	Release notes for CAM software releases shall be easily accessible on-line for operators.	R.T.FC.60	A

7 Non-functional Requirements

7.1 Interfaces Requirements

7.1.1 Client Furnished Item (CFI) Interfaces

There is no CFI in the CAM subsystem, but CAM shall interface to the User Supplied Equipment for pulsar timing and transient searching as defined in [29] which are CFI.

7.1.2 External Interface Requirements

External interfaces are listed in 1.4.4. No additional interface requirements are to be noted at this time, but the Interface Control Document of each interface will capture the detail.

Some notes on specific interfaces are listed in the paragraphs below until the Interface Control Documents are produced.

7.1.3 User Supplied Equipment CAM Interface Notes

This functional interface is elaborated here until ICD [29] is generated for it.

External Control

User Supplied Equipment sends control requests to CAM. Refer to ICD [29].
Items:

- KATCP request, reply, inform and log messages
  - TOO Trigger
  - Next Pulsar Trigger
  - (May be External equipment informs CAM of data QA1 and QA2)

Protocol:

- KATCP

External Monitoring

User Supplied Equipment sends sensor strategies and sensor value requests to CAM. Refer to ICD [29].
Items:

- Selected sensor data

Protocol:

- KATCP

Meta-data

Items:

- Metadata from CAM (conditioned sensor data from monitoring)

Protocol:

- SPEAD

7.1.4 SP CAM Interface Notes

This functional interface is elaborated here until an ICD is generated for it. Note that the OPT and PMT interfaces (required for Timeframe C and D respectively) are not addressed at this point in time.

SP to CAM Static Models

SP provides static antenna positioning models to CAM off-line. The models are used by CAM to apply pointing correction.

Items:

- Structural Pointing Model
- Gravity Pointing Model
- Thermal Loading Model
- Wind-loading Model
- Refraction Correction Model
- Reference Pointing Calibration Model ?

Protocol:

- Off-line

Refer to requirements in par. 6.4.2 Antenna Positioner control.

SP to CAM Online Data Interface

SP provides polarisation calibration data and instrumental complex gain to the CAM after a complex gain calibration.

Items:

- Polarisation Calibration Data (R.CM.FC.C12);
- Instrumental Complex Gain (R.CM.FC.C11 and R.CM.FC.C30).
- SP informs CAM of data QA1 and QA2 – SBs may be re-scheduled if the observation had failed. (Or could be through sensors on SP Monitoring and Control Interface)

Protocol:

- KATCP

SP Monitoring and Control Interface

CAM controls SP processing. CAM monitors SP health.
Items:

- KATCP request, reply, inform and log messages

Protocol:

- KATCP

External Control

(TBD May not be required from SP – only External User Equipment)
SP sends TOO and Next Pulsar Trigger to CAM. Refer to ICD [29].
Items:

- KATCP request, reply, inform and log messages
    - TOO Trigger
    - Next Pulsar Trigger

Protocol:

- KATCP

External Monitoring

(TBD May not be required from SP – only External User Equipment)
SP sends sensor strategies and sensor value requests to CAM. Refer to ICD [29].
Items:

- KATCP request, reply, inform and log messages

Protocol:

- KATCP

Meta-data

CAM provides metadata interface for SP (per subarray). CAM may be required to match SPEAD metadata stream to be at the same sampling of the captured data (same cadence) by interpolation or extrapolation of sensor samples of CAM monitoring points.
Items:

- Meta-data (conditioned sensors data from monitoring)

Protocol:

- SPEAD

7.2 Environmental Conditions

7.2.1 Operational

Environmental requirements are defined in [6], and are listed below for convenience:

Req #	*Requirement*	*Source*	*Time*
R.CM.E.8.A	All components and spares of the correlator subsystem shall be transported under conditions as defined in “Class 2.2: careful transportation” of the ETSI EN 300 019-1-2 standard [7].	R.T.E8	D
R.CM.E.9	All components and spares of the CAM subsystem shall be stored under conditions as defined in “Class 1.1: Weatherprotected, partly temperature-controlled storage locations” of the ETSI EN 300 019-1-1 standard [6].	R.T.E9	D
R.CM.E.20	Cooling shall be supplied to the racks in the KAPB in the form of a hot/cold isle mechanism.		D
R.CM.E.21	The temperature of air in all areas of the KAPB cold isle sections shall be maintained at a dry bulb temperature between 18°C and 27°C.		D
R.CM.E.22	The humidity of the air in all areas of the KAPB cold isle sections shall have a maximum Relative Humidity of 60% and a maximum dew point temperature of 15°C		D
R.CM.E.23	The air in all areas of the KAPB cold isle sections shall have a minimum dew point temperature of 5.5°C over the entire dry bulb temperature range.		D
R.CM.E.24	The CAM subsystem shall require a cooling capacity of less than 5kW per rack.		D

7.2.2 Electromagnetic Compatibility

CAM will be deployed in a shielded container and thus there are no additional requirements.

7.2.3 Radio Frequency Interference

RFI requirements are defined in [5], and are listed below for convenience:

Req #	*Requirement*	*Source*	*Time*
R.CM.RFI.1	Commercial and non-developmental CAM subsystem electronic items shall be EMC/RFI certified according to the CISPR 22 standard for Class B devices, or a SKA SA approved equivalent.	R.T.RFI.6	D
R.CM.RFI.2	The CAM subsystem design shall comply with the blue highlighted sections	R.T.RFI.7	D

	of the highlighted version of the SANS 61000-5-2 standard on Electromagnetic Compatibility (EMC) as supplied by SKA SA.		
R.CM.RFI.3	The CAM subsystem design shall follow the NRS 083-2 and 083-3 code of practice for the application of Electromagnetic Compatibility standards and guidelines in electricity utility networks.	R.T.RFI.8	D
R.CM.RFI.4	The system shall allow zones of avoidance to be defined. Note *[Note: Zones of avoidance will be applied in (not) selecting schedule blocks for execution.]*	R.T.RFI.116	C
R.CM.WC.1	The CAM subsystem shall warn the operator of an RFI risk if any webcam is powered on during observations.		C

7.3 Physical, Cooling and Power Characteristics

The following CAM subsystem requirements are derived in [12] , and are listed below for convenience:

Req #	***Requirement***	***Source***	***Time***
R.CM.IC.1	The power consumption of racks in the KAPB shall be limited to a maximum of 5kW per rack.		B
R.CM.IM.1	The CAM subsystem shall provide a receptor network switch for installation in the pedestal with the following ports: a) at least 2 single-mode fibre ports; for uplink between KAPB and receptor and 1 spare; max distance 15km; data rate 1Gbps. b) at least 2 single-mode fibre ports; for weather stations/webcams; max distance 100m; data rate 1Gbps. c) at least 4 multi-mode fibre ports; for receivers controller, digitiser and 2 spares; max distance 30m; data rate 1Gbps. d) at least 2 8P8C connector port for cat5 cable connection; for Antenna Positioner and 1 spare; data rate 1Gbps. And LC connectors for all fibre ports.		B
R.CM.IM.2	The receptor network switch shall operate in ambient temperatures up to 50°C, with humidity up to 95%, non-condensing.		B
R.CM.IP.10	The power supplied at all telescope loads shall have a voltage equal to the specified nominal voltage +-1%.		B
R.CM.IP.11	The power supplied at all telescope loads shall have a voltage level variation of no more than +-5% from the nominal level, under conditions of transient load variations of up to 50% in the on-site power network, and during mains power failure.		B
R.CM.IP.12	The power supplied at all telescope loads shall have a frequency tolerance of no more than +-1%, under conditions of transient load variations of up to 50% in the on-site power network.		B
R.CM.IP.13	The power supplied at all telescope loads shall have a total harmonic distortion of less than 2%.		B
R.CM.IP.20	The power consumption of racks in the KAPB shall be limited to a maximum of 6.25kVA per rack.		B
R.CM.IS.3	The CAM shall be limited to 2 racks in the KAPB.		B

7.4 Human Factors

No specific considerations.

7.5 Integrated Logistics Support

RAM and Logistical requirements are defined in [4], and are listed below for convenience:

Req #	*Requirement*	*Source*	*Time*
R.CM.R.1	The CAM shall have a mean time between critical failures of >=8 months	R.T.R.1 R.T.R.2 R.T.R.4	D
R.CM.R.2	The CAM shall have a critical mean time to repair of <=8hours	R.T.R.1 R.T.R.3 R.T.R.4	D
R.CM.R.30	Packaging for LRU's and SRU's shall be provided by the supplier of the LRU's and SRU's.	R.T.R.30	D
R.CM.R.31	All serviceable LRU's and SRU's shall be packaged in such a way that they can be stored in covered facilities, in all applicable weather conditions, for a period of at least 2 years, without incurring any damage.	R.T.R.31	D
R.CM.R.32	All unserviceable LRU's and SRU's shall be packaged in such a way that they can be stored in covered facilities, in all applicable weather conditions, for a period of at least 6 months, without incurring any damage.	R.T.R.32	D
R.CM.R.33	All LRU's and SRU's which are frequently transported shall be packaged in CLIP-LOK containers.(1)	R.T.R.33	D
R.CM.R.34	Packaged LRU's and SRU's where one or more dimension is larger than 1.5m, shall be ISO standard sizes. (2)	R.T.R.34	D
R.CM.R.35	Packaged LRU's and SRU's that require periodic maintenance during storage shall be packaged in red-coloured containers.(3)	R.T.R.35	D
R.CM.R.36	Packaged LRU's and SRU's shall have the following markings securely attached on the outside of the packaging container: -\t"Fragile" label -\tMode of transport "careful transportation" or "very careful transportation" (4) -\t"This side up" label -\t"Fork lift here" label, where applicable -\tCentre of gravity marking, where applicable -\tPackaged Item Identification plate, with identification data completed. Where applicable, tamper proof labels for "wrong way up" and "excessive acceleration"	R.T.R.36	D
R.CM.R.37	Packaged LRUs and SRUs which are frequently transported shall have the following Item Identification plate securely attached on the outside of the packaging container: -\tIdentification "MeerKAT System Component" (SKA SA fabricated or subcontracted items only) -\tLRU/SRU Name (supplied by MeerKAT System team) (SKA SA fabricated or subcontracted items only) -\tLRU/SRU Part Number and Version (supplied by MeerKAT System team) (SKA fabricated or subcontracted items only) -\tLRU/SRU serial number -\tLRU/SRU supplier part number -\tLRU/SRU supplier identification -\tPreferably Bar Code data -\tPackaged weight -\tContainer stackability (where applicable) -\tPreservation date (where applicable) Shelf life (where applicable)	R.T.R.37	D
R.CM.R.38	All LRU's and SRU's with a mass of more than 15 kg and less than 40kg shall have carrying handles.	R.T.R.38	D
R.CM.R.39	All LRU's and SRU's with a mass of more than 40 kg shall have an integral lifting arrangement (e.g. eye-bolts).	R.T.R.39	D
R.CM.R.50	All LRU's and SRU's shall be labelled with the following information, and shall be clearly visible when installed: -\tProduct Supplier Name -\tProduct Name (Supplied by MeerKAT system team for SKA SA fabricated or subcontracted items) -\tProduct Part Number (Supplied by MeerKAT system team for SKA SA fabricated or subcontracted items) -\tProduct Version (Supplied by MeerKAT system team for SKA SA fabricated or subcontracted items) -\tProduct Serial Number Preferably Bar Code	R.T.R.50	D
R.CM.R.51	All component mounted connectors shall be labelled to allow identification during installation and maintenance of the Equipment.		D
R.CM.R.52	Equipment that, when improperly operated or handled, may jeopardise the safety of personnel or result in a hazardous situation, shall be clearly marked to such effect.		D
R.CM.R.53	Switches and controls used by operators or technical personnel shall have their functions clearly marked in the English language.		D
R.CM.R.54	All wiring harnesses and their connectors shall be labelled to allow identification of the harness/connector while the harness is installed.		D
R.CM.R.55	Product Markings shall withstand all environments and conditions to		D

	which the item will be subjected. Product Markings shall be waterproof and not detach or become unreadable with repeated handling.		
R.CM.R.56	Product Markings shall be clearly visible during storage and operations.		D

7.6 Product Assurance

7.6.1 Standardisation

Req #	*Requirement*	*Source*	*Time*
R.CM.ST.1	All items should make maximum use of commercial off the shelf (COTS) equipment, and where possible COTS components with long support life expectancy should be chosen.	R.T.S.5	B

7.6.2 Safety and Security

Safety requirements are defined in [7], and are listed below for convenience.

The following general safety design requirements apply:

Req #	*Requirement*	*Source*	*Time*
R.CM.SG.1	CAM locally fail safe Items shall as far as practically possible, be designed to be locally fail safe, and not rely on external components to operate safely.		B
R.CM.SG.2	CAM safe design Items shall be designed such that they are safe and without risk to the health of all users. In particular: a) Ensuring that the item and its environment are safe during all design, development activities/phases. b) Ensuring that the item and its environment are safe during production, installation, use, handling, storage or transport. c) Ensuring that the item and its environment are safe during operations and maintenance. d) Establish what hazards are related to the use/handling of the item, what precautionary measures are to be taken relating to such use/handling, and provide the necessary means to apply such cautionary measures. e) Provide such information, instructions, training and supervision as may be necessary to ensure the health and safety of all users.		B

The following specific safety requirements were identified from the safety analysis:

Req #	*Requirement*	*Source*	*Time*
R.CM.SA.1	CAM automatic fire suppression system reporting The CAM shall report to the operator when the automatic fire suppression system has been activated in the KAPB as reported by the BMS. TBD – Confirm that this is still a CAM requirement		B

Req #	*Requirement*	*Source*	*Time*
R.CM.SA.2	CAM HVAC failure reporting The CAM shall report a critical failure of the HVAC as reported by the BMS to the operator as an alarm.		B
R.CM.SA.3	CAM KAPB temperature alarm The CAM shall monitor the temperature in the KAPB as reported by the BMS and report temperatures beyond a set threshold to the operator as an alarm. TBD – Confirm that this is still a CAM requirement		B
R.CM.SA.4	CAM Remotely power down The CAM shall enable the lead operator to power down Correlator and Science Processor equipment in the KAPB remotely.		B

7.7 Design Constraints

None

7.8 Precedence and Criticality of Requirements

Timeframe A through to D depicts the precedence and priority of requirements with Timeframe A being the highest priority to be delivered first, through to Timeframe D being the lowest priority. The CAM Development Plan will take the timeframe allocation of the CAM requirements into consideration.

8 VERIFICATION

Note: This revision of the MeerKAT CAM Requirement Specification does not contain verification requirements. The verification requirements will be developed, captured in CORE and included in a subsequent revision of this document. To be completed before the MeerKAT CAM PDR currently planned for April 2013.

8.1 Verification Definitions

Table 2: Verification definitions

A	Analysis	An element of verification that uses established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements are met.
D	Demonstration	An element of verification that involves the actual operation of an item to provide evidence that the required functions are accomplished under specific scenarios. The items may be instrumented and performance monitored.
I	Inspection	An element of verification that is generally non-destructive and typically includes the use of sight, hearing, smell, touch, and taste; simple physical manipulation; and mechanical and electrical gauging and measurement.
T	Test	An element of verification in which scientific principles and procedures are applied to determine the properties or functional capabilities of items.
C	Integrated CAM Test	An element of verification which is Tested as defined above under "T", but for which an automated Integrated CAM Test shall be prepared.

8.2 Verification Cross Reference

This section of the document will be completed later in a subsequent revision.

[This table can be printed directly from CORE]
The traceability between the requirement in section 3 and the verification methods specified in section 4, are shown in Table 3.

Table 3. Verification Cross Reference.

Requirement Number & Name	Verified by:
[Requirement number: requirement description [Core]]	[Core verified by]

Requirement Number & Name	Verified by:

8.3 Verification Requirements

8.3.1 [Core verified by test] – [add Core number]

8.3.2 [Core verified by test] – [add Core number]

9 NOTES

This section contains information of a general or explanatory nature to be helpful but is not mandatory.

9.1 Definitions

See section 3.1 and 3.2 for glossary and definition of terms.

9.2 Explanatory notes

See section 3.2 for notes on MeerKAT Sub-array Concept and section 3.3 for notes on MeerKAT Users, Roles and Actors.

9.3 List of un-resolved issues

Paragraph	Responsibility	Comments
Timeframe C&D	SE/CAM	The detail of timeframe C&D requirements will be clarified in subsequent revisions of this document that will be reviewed later at an appropriate time for timeous delivery of that timeframe's requirements.
Various	SE/CAM	Some requirements currently have TBD values – Timeframe A&B requirements should have their TBD values clarified before PDR. Timeframe C&D requirements may have their TBD values clarified later.
R.CM.FM308 and others	CAM	The detail of this example requirement and some other similar requirements cannot be fully determined at the time of producing this document, but the requirement itself had to be captured. The detail of these requirements will be clarified in the Specification Record of the CAM component to which that requirement is allocated. This procedure is written up in the CAM Development Plan.
6.4.3 Correlator Control	SE	Various update rates are TBD
MeerKAT OICD	SE/CAM	The MeerKAT OICD will be handled as a relatively informal document to mainly capture GUI mockups where applicable and may be used to capture more than just the CAM displays (e.g. signal displays).
7.1.3 User Supplied Equipment CAM interface	SE/CAM	The interface between the User Supplied Equipment and CAM has to be clarified further and has been elaborated here until the ICD is produced by CAM.
7.1.4 SP CAM Interface	SP/CAM	The interface between SP and CAM are on various levels and quite complex and has to be clarified further. It has been elaborated here until the ICD is produced by SP.
OPT	SE/SP	The OPT need to have related requirements for R.CM.FC40 stating that the VLBI scans must be produced as scheduling blocks with exact start times.
Antenna Positioner Control	SE	A discussion with SP/Comm/SE to clarify scope, boundaries and responsibilities of generating models, updating and managing the models CAM should apply should be arranged.
6.6.4 User Logs etc	Comm/CAM/IT	The suggested requirements from CAM for user logs have been listed here in this section, but have not been discussed in full with Lindsay and Rupert. Please use OAR to comment if current user log requirements as captured here are not sufficient. Discuss the roles and responsibilities of current KAT-7 components (like Mantis, e-log, IRC, svn archives) for MeerKAT. Should these be seen as external systems for MeerKAT, or part of IT infrastructure and thus do not need any specific requirements in this RS.

VDS video feed and KATCP interface	SE	R.CM.F205 states that CAM shall display the video feed from the cameras for the VDS. VDS interfaces still needs to be clarified.
TFR CAM Interface	SE/CAM	Confirm that TFR will provide sensors to be monitored by CAM (as in KAT-7)
R.CM.FM.103	Comm/CAM	Confirm attaching files ~~figures~~ in user logs is still a requirement.
R.CM.IM.1 R.CM.IM.2	CAM	Receptor switch requirements to be confirmed.
R.CM.IC.1 R.CM.IP.20	SE/CAM	Confirm these separate power requirements were intended.