SKA PHASE 1 SYSTEM REQUIREMENTS SPECIFICATION

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DOCUMENT HISTORY

Revision	Date Of Issue	Engineering Change Number	Comments
01 -03	**2013-11-03** **2014-01-24** **2014-02-20**	-	**Initial issues including comments from SKA Community: Jama Contour Baseline Set: System Requirements > SKA-OFF.SE.ARC-SKO-SRS-001-3 Rev 3**
04	**2014-09-09**	ECP-140042	**Document number changed from SKA-OFF.SE.ARC-SKO-SRS-001 to SKA-TEL-SKO-0000008. ECP-140008**
05	**2014-12-11**	ECP-140044	**Correct direction of L0 L1 traceability arrow in figure 1 to indicate L0 are traceable to L1. Appendix F updated**
06	**2015-04-09**	ECP-150001	**Update for rebase-lining with respect to SKA-BD-17-13a and SKA-BD-17-13c. For detailed change history see Appendix F**
06A	**2015-05-18**	ECP-150002	**Remove process requirements. See Appendix F**
06B	**2015-05-19**	ECP-150003	**Create/ update requirements to include: ECP-140009, ECP-140010, ECP-140011, ECP-140012, ECP-140015, ECP-140024, ECP-140029, ECP-140041, ECP-150004**
06C	**2015-06-03**	ECP-150025	**Address consortia comments received against rev 4 and rev 5 release of this document. Detailed change history in Appendix F**
07	**2015-12-11**	ECP-150039	**Address consortia review comments and update to include: ECP-140025, ECP-140026, ECP-140040,** **ECP-150008, ECP-150012, ECP-150016, ECP-150020, ECP-150030, ECP-150033, ECP-150037**
08	**2016-07-01**	ECP-160024	**Address consortia and internal review comments and update to include: ECP-150011,** **ECP-160014, ECP-160015, ECP-160018, ECP-160020**
09	**2016-09-05**	ECP-160030	**Address consortia and internal review comments and update to include:** **ECP-150009, ECP-160008, ECP-160029**
10	**2016-11-21**	ECP-160066	**Address consortia and internal review comments and update to include:** **ECP-160011, ECP-160012, ECP-160025, ECP-160037, ECP-160047, ECP-160057, ECP-160070**
11	**2017-07-31**	ECP-170027	**Create/ update/ delete requirements to implement: ECP-160022, ECP-160038, ECP-160040, ECP-160041, ECP-160042, ECP-160043, ECP-160045, ECP-160046, ECP-160048, ECP-160068, ECP-170002, ECP-170017, ECP-170022, ECP-170026, CN-170003**

DOCUMENT SOFTWARE

	Package	Version	Filename
Wordprocessor	MsWord	Word 2007	SKA-TEL-SKO-0000008-Rev11_SKA1SystemRequirementSpecification
Block diagrams			
Other			

ORGANISATION DETAILS

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ADC...............................Analogue to Digital Converter
AIP................................Advanced Instrumentation Programme
AIV................................Assembly Integration and Verification
API................................Application Program Interface
APM..............................Astrometric Performance Metric
AUS...............................Australia
CDR...............................Critical Design Review
CISPR ....Comité International Spécial des Perturbations Radioélectriques
CPU...............................Central Processor Unit
CSP...............................Central Signal Processing
DAA...............................Dense Aperture Array
DDBH............................Digital Data Backhaul
DDE...............................Direction Dependent Effects
DOI................................Document Object Identifier
DRM..............................Design Reference Mission
DSH...............................Dish
ECSS.............................European Committee on Space Standardisation
EIA................................Environmental Impact Assessment
EMC..............................Electromagnetic Compatibility
EMI................................Electromagnetic Interference
EPA...............................Environmental Protection Agency
EPBC.............................Environment Protection and Biodiversity Conservation
ESD...............................Electrostatic Discharge
ESOH............................Environmental Safety and Occupational Health
EVLA.............................Expanded Very Large Array
EWP..............................Elevating Work Platform
FLD................................Folder (i.e. not a requirement)
FLOPS...........................Floating Point Operations
FMEA............................Failure Mode and Effects Analysis
GASS............................General Assembly and Scientific Symposium
GHQ..............................Global Head Quarters
GPS...............................Global Positioning System
GSM..............................Global System for Mobile Communications
HMG..............................Her Majesty's Government
HPBW............................Half Power Bandwidth
HPC...............................High Performance Computing
ICD................................Interface Control Document
IEC................................International Electrotechnical Commission

IEEE .... Institute of Electrical and Electronics Engineers
IPR .... Intellectual Property Rights
IPS............................ Ionospheric Prediction Service
ISO .... International Standards Organisation
IVOA............................ International Virtual Observatory Alliance
IXR .... Intrinsic cross polarisation ratio
LFAA .... Low Frequency Aperture Array
LNA .... Low Noise Amplifier
LOFAR .... Low Frequency Array
LRU .... Line Replaceable Unit
MHZ............................ Mega Hertz
MIL .... Military
MRO .... Murchison Radio Observatory
MTBF............................ Mean Time Before Failure
MTBM............................ Mean Time Between Maintenance
MTTR .... Mean Time to Repair
NEMA .... National Environmental Management Act
NOHSC .... National Occupational Health and Safety Commission
NZS .... New Zealand Standard
OHS............................ Occupational Health and Safety
PAF .... Phased Array Feed
PDR............................ Preliminary Design Review
PPM............................ Photometric Performance Metric
PSF .... Point Spread Function
RAM .... Reliability, Availability, Maintainability
RFI............................ Radio Frequency Interference
RPM .... Radiometric Performance Metric
SADT............................ Signal and Data Transport (includes Synchronisation and Timing)
SANS............................ South African National Standard
SDP .... Science Data Processor
SIMBAD............................ Set of Identifications, Measurements and Bibliography for Astronomical Data (Astronomical Database)
SKA .... Square Kilometre Array
SKADS .... Square Kilometre Array Design Study
SKAO .... Square Kilometre Array Organisation (or Office)
SMS............................ Short Message Service
SPF .... Single Pixel Feed
SPM............................ Spectrometric Performance Metric
SPO............................ Office of the Square Kilometre Array Organisation
SSHA............................ Subsystem Hazard Analysis

TAT................................Turnaround Time

TBC ....To Be Confirmed

TBD ....To be Determined

TBJ ....To Be Justified

TEC ....Total Electron Content

TOO...............................Target of Opportunity

URSI ....l'Union Radio-Scientifique Internationale

UTC ....Universal Time Co-ordinated

VLBI...............................Very Long Baseline Interferometry

WBSPF..........................Wideband Single Pixel Feed

1 Introduction

1.1 Purpose of the Document

This document serves as a vehicle to communicate the high-level quantitative and qualitative characteristics of the SKA Phase 1 System in the form of formal requirements that are to be allocated to each of its constituent elements.

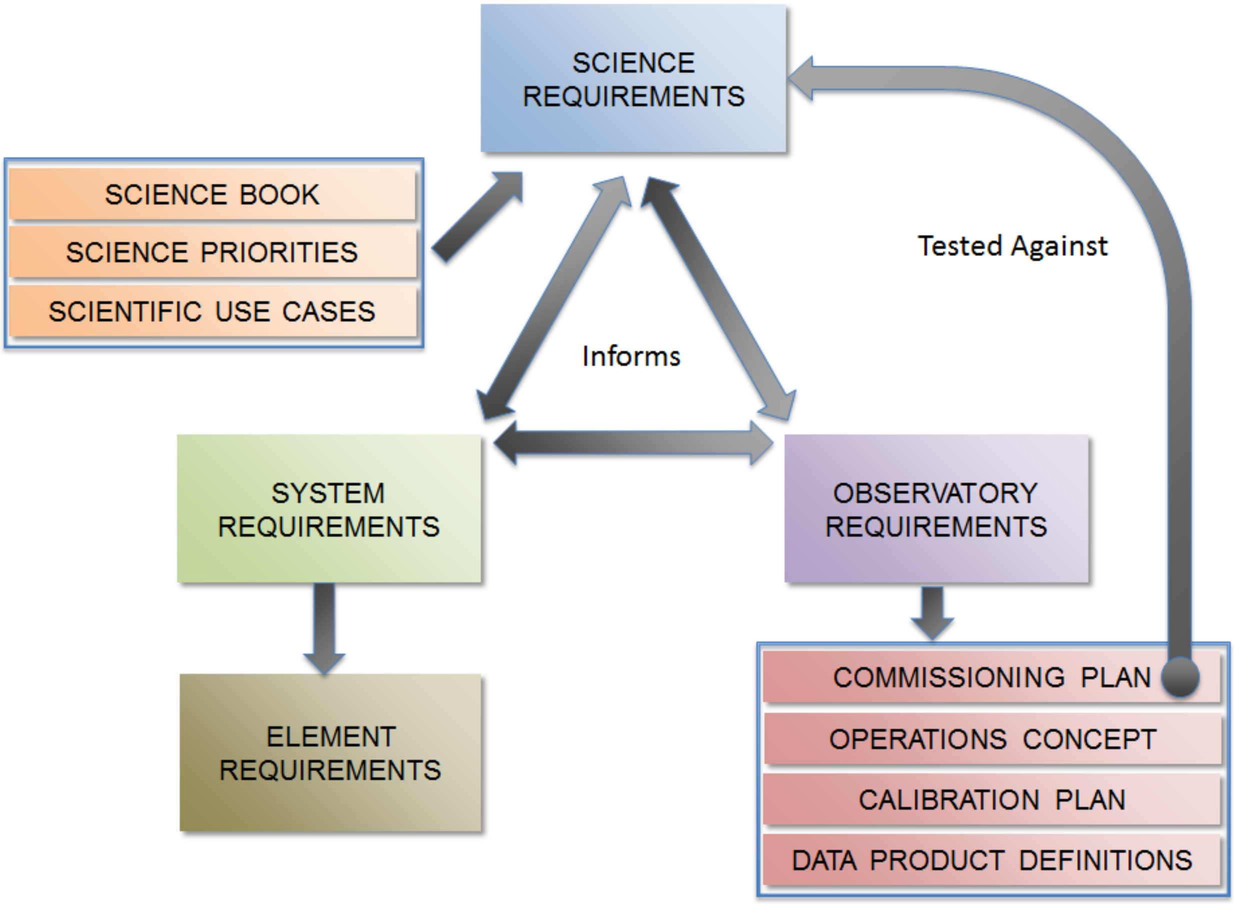

Figure 1 SKA Phase 1 System Requirements Specification Context

Figure 1 provides an initial simplified context assumed for this document in relation to other SKA documentation. There may be changes to the figure as the system engineering process progresses.

There are no security, intellectual property, or privacy considerations attached to the use or distribution of this document.

1.1.1 Approach

This document will reside within a requirements capture tool (Jama Contour) and for each requirement statement will include relational links back to the Science Requirements.

This document is a living document that will converge on the requirements for the SKA1 system. The convergence process is an iterative one between the SKA Office and the consortia involved with the Element design work.

At present, some requirement statements have no traceability link available back to higher level source documents. These will usually be identified as TBJ (to be justified). However, if no link is identified then it is to be assumed that this is the case. If the requirement cannot be justified it will be removed.

Each requirement identified within this document will have a unique four digit identifier preceded by a short hand prefix of "SYS_REQ_". The identifier is a truncation of the "SKA1-SYS_REQ_" that is generated by the requirements capture tool. It provides a useful reference tag and indicates where in the system hierarchy the requirement resides.

Each requirement will identify the type of verification method.

The priority of each requirement will be identified.

The allocation of requirements to Elements is provided too.

The latest issued document will take precedence over the contents of the requirements capture tool. However, an issued Level 1 Requirement document represents a requirements capture tool baseline. The data-base baseline identifier will be referenced in the document history.

Amendments to the document will be via change control. If accepted, amendments will be via the requirements capture tool. Up issue of this document will require a new baseline and export from the requirements tool and subsequent submission and approval via the Document Management System.

1.1.2 Verb Convention

"Shall" is used whenever a statement expresses a convention that is binding. The verbs "should" and "may" express non-mandatory provisions. "Will" is used to express a declaration of purpose on the part of the design activity.

1.1.3 For but not with

"For but not with" in a requirement denotes that provision is to be made for a sub-assembly in the design but that such a sub-assembly is not necessarily to be delivered. An example would be mount positions for feeds at the focal plane of a dish that are not necessarily all to be immediately filled with feeds.

1.1.4 Parent Requirements

Parent Requirements: The Parent Requirement field denotes the source of information providing justification. The allowed values or types of value are:

- "Root": No further justification is considered to be necessary. Rarely used.
- "Established Precedent": There is a known precedent such as an existing computing centre at a given location.

1.1.5 Other requirement: Another requirement acts as justification

- Baselined SKA document: for example ConOps or Baseline design.
- SKA document in preparation.
- SKA ECP.
- Publically available document with established naming conventions such as standard, academic papers, DOIs.

Within this definition, we will provide a parent requirement for all requirements.

1.2 Scope of the Document

The Square Kilometre Array Phase 1 (SKA1) Level 1 Requirements Specification ultimately aims to provide:

- A complete set of traceable system requirements for the SKA1 Telescopes allocated to each Element at the next level down in the system hierarchy.
- Identify the verification method for each requirement presented.
- Allocate each requirement to the appropriate Element in the next level of the system hierarchy.

1.2.1 Identification

The SKA Observatory is assumed to include all of the associated equipment, facilities, material, software, hardware, policy, technical documentation, services, and personnel required for its operation.

This document covers the SKA1_System aspects of the Observatory and as such specifies the following products:

- SKA1 Low Telescope (product 100-000000)
- SKA1 Mid Telescope (product 300-000000)
- SKA1 Common (product 600-000000)

The product tree from an SKA1_System perspective is detailed in Figure 2.

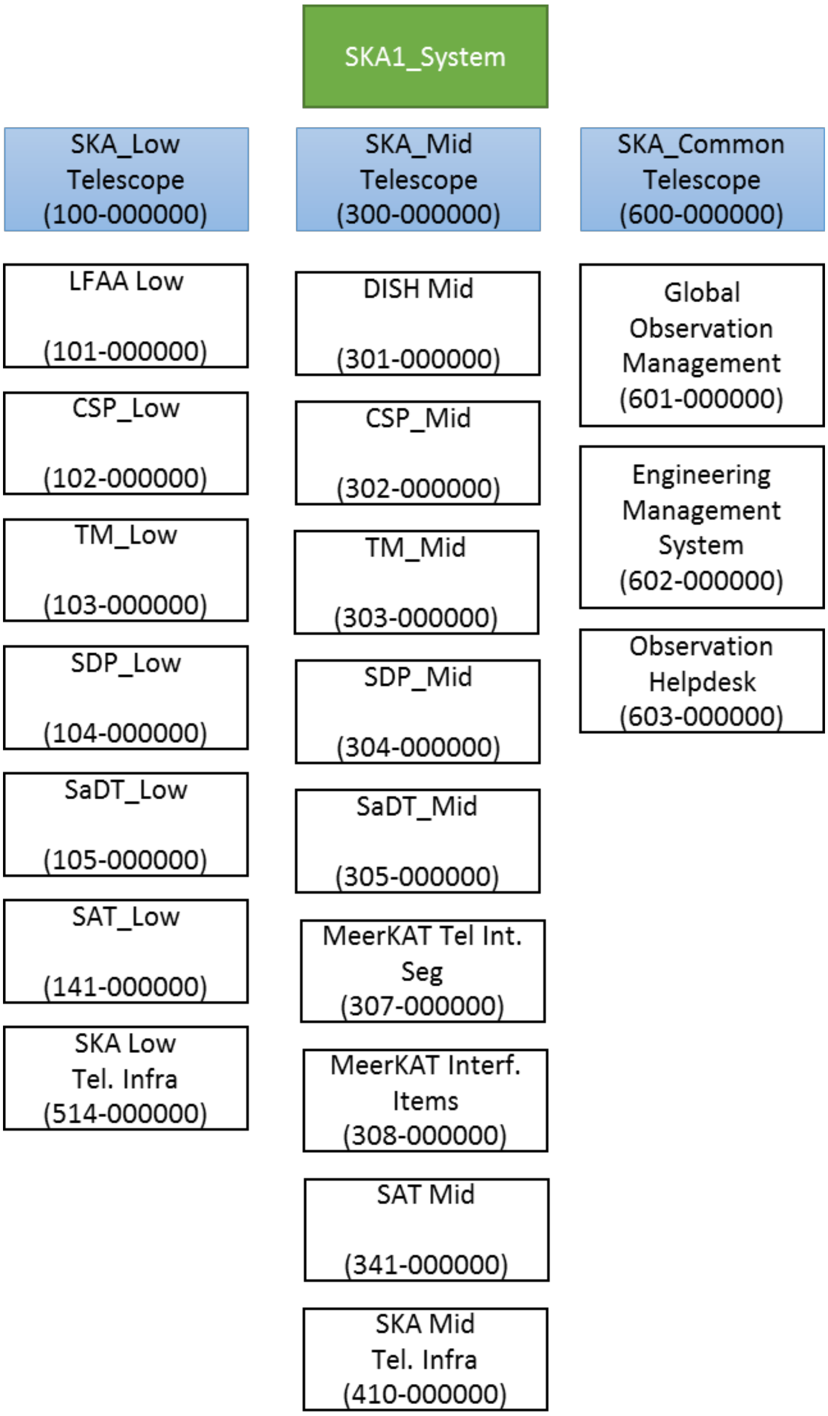

Figure 2 SKA1_System Product Tree

Within this document the terminology used for requirement allocation maps to products as defined in the following table:

Allocation	Target products
LFAA	LFAA LOW (101-000000)
DSH	DSH MID (301-000000)
SADT	SaDT LOW (105-000000) SAT LOW (141-000000) SaDT MID (305-000000) SAT MID (341-000000)
CSP	CSP LOW (102-000000) CSP MID (302-000000)
SDP	SDP LOW (104-000000) SDP MID (104-000000)
TM	TM LOW (103-000000) TM MID (303-000000)
OMS	Observation Management System (601-000000)
EMS	Engineering Management System (602-000000)
OPS	Observation Helpdesk (603-000000)
INFRA	INFRA LOW (514-000000)[1] INFRA MID (410-000000)[2]

Table 1 Allocation Terms

1.2.2 Context

1.2.2.1 SKA1_System

The context diagram for the SKA1_System is detailed below. It defines the boundaries and external interfaces.

[1] 500-000000 SKA INAU LOW can also be subject to allocations for some requirements.

[2] 400-000000 SKA INSA MID can also be subject to allocations for some requirements.

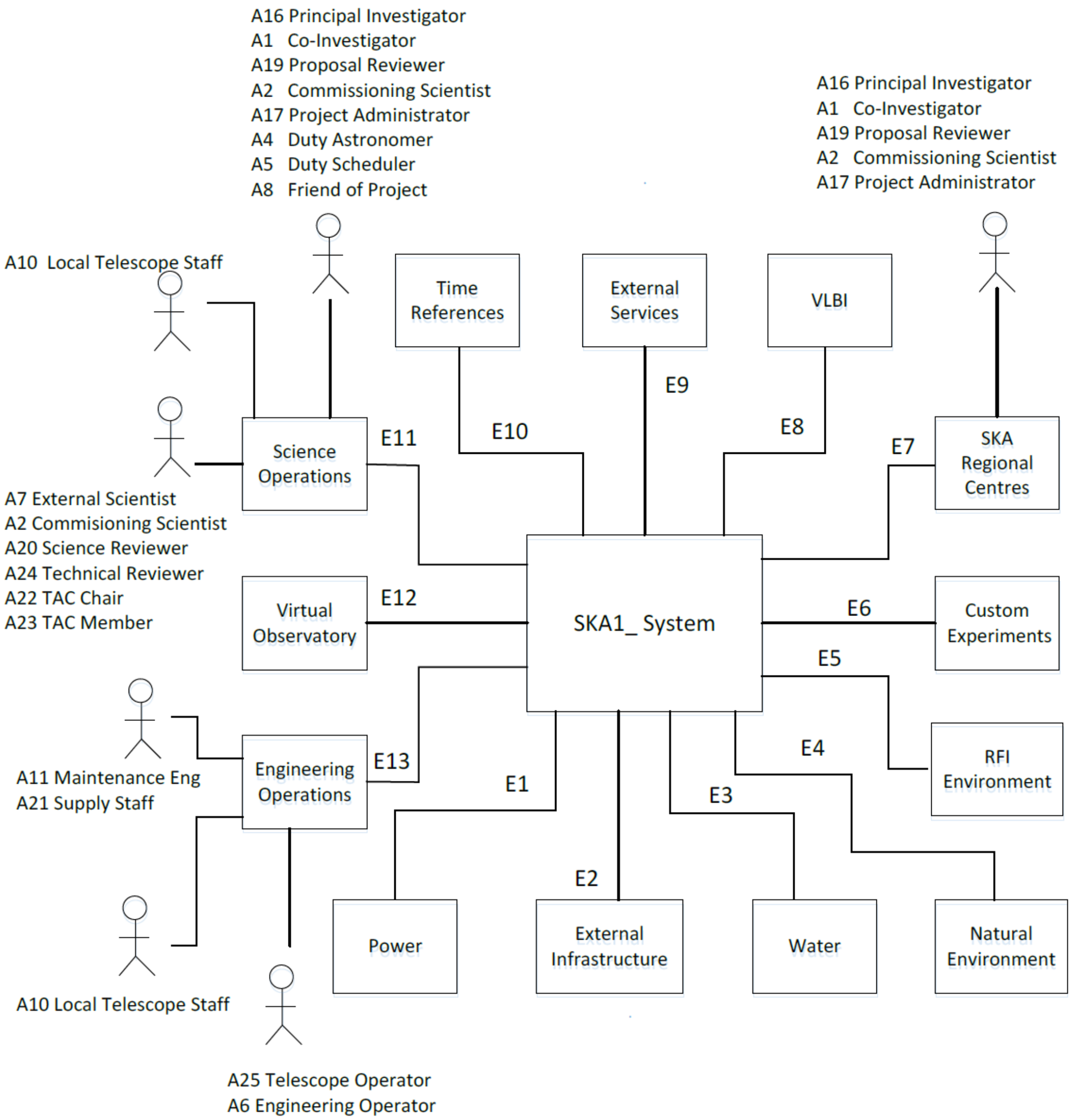

Figure 3 SKA1_System Context Diagram

Interface Number	**Interface name**	**Interface Documents**
E1	Power	Document References to be allocated
E2	External Infrastructure	Document References to be allocated
E3	Water	Document References to be allocated
E4	Natural Environment	{AD7] Environmental Conditions for the SKA1 Mid Site in South Africa 301-000000-009
E5	RFI Environment	[AD2] SKA EMI/EMC standards SKA EMI/EMC Standards and Procedures SKA-TEL-SKO-0000202
E6	Custom Experiments	Document References to be allocated

Interface Number	Interface name	Interface Documents
E7	SKA Regional Centres	Document References to be allocated
E8	VLBI	Document References to be allocated
E9	External Services	Document References to be allocated
E10	Time References	Document References to be allocated
E11	Science Operations	Document References to be allocated
E12	Virtual Observatory	Document References to be allocated
E13	Engineering Operations	Document References to be allocated

Table 2 SKA1_Systems External Interfaces

Table 2 tabulates the external interface groupings identified in the context diagrams against the Interface document sets. These will include Interface Control Documents and Data Exchange Specifications. Due to the distributed nature of the SKA1_System, interfaces will differ depending on geographic location. For example, external infrastructure, power, water interfaces will differ between that defined for the site compared with that required for the Science Processing Centres.

1.2.2.1.1 SKA1_Low

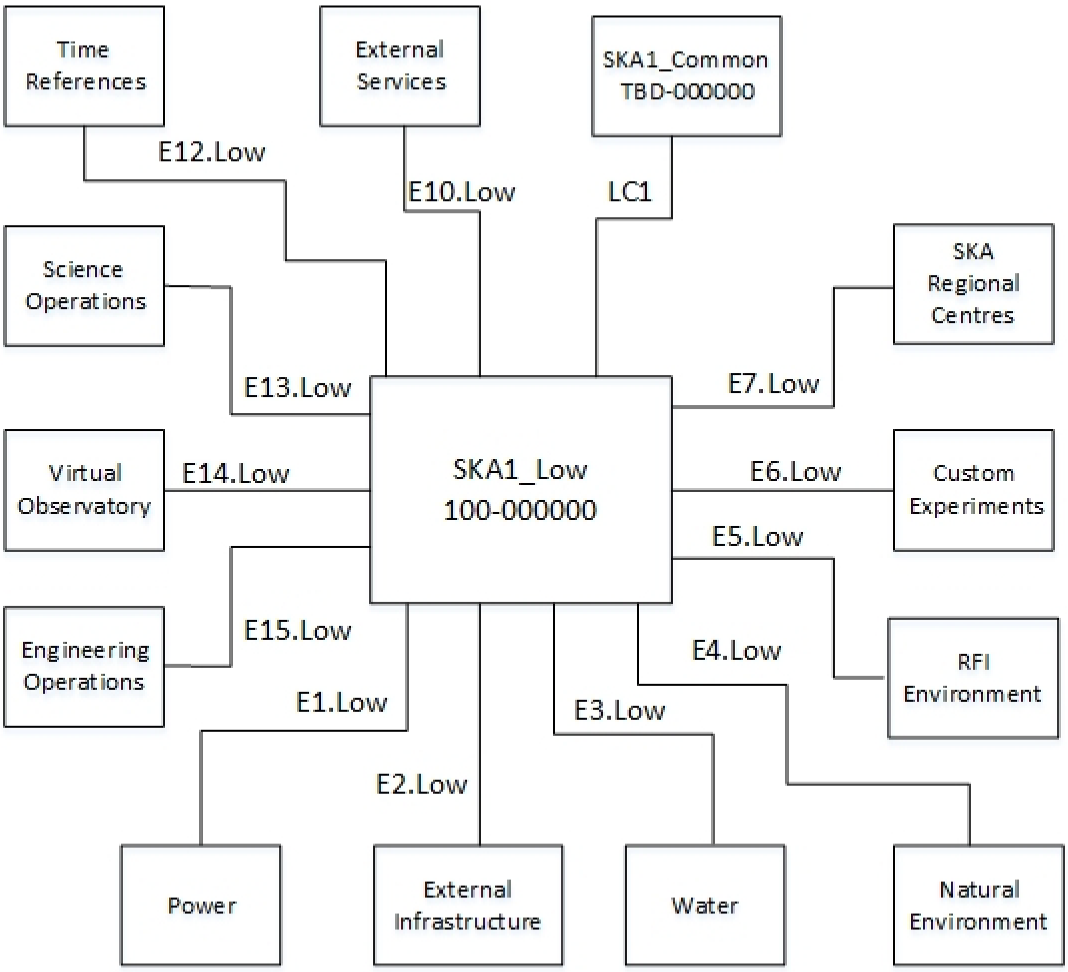

Figure 4 SKA1_Low Context Diagram

Interface Number	Interface name	Interface Documents
E1.Low	Power	Document References to be allocated
E2.Low	External Infrastructure	Document References to be allocated
E3.Low	Water	Document References to be allocated
E4.Low	Natural Environment	Document References to be allocated
E5.Low	RFI Environment	[AD2] SKA EMI/EMC standards SKA EMI/EMC Standards and Procedures SKA-TEL-SKO-0000202
E6.Low	Custom Experiments	Document References to be allocated
E7.Low	SKA Regional Centres	Document References to be allocated
E9.Low	External Services	Document References to be allocated
E10.Low	Time References	Document References to be allocated
E11.Low	Science Operations	Document References to be allocated
E12.Low	Virtual Observatory	
E13.Low	Engineering Operations	Document References to be allocated
LC1	SKA1_Low to SKA1 Common	Document References to be allocated

Table 3 SKA1_Low External Interfaces

1.2.2.1.2 *SKA1_Mid*

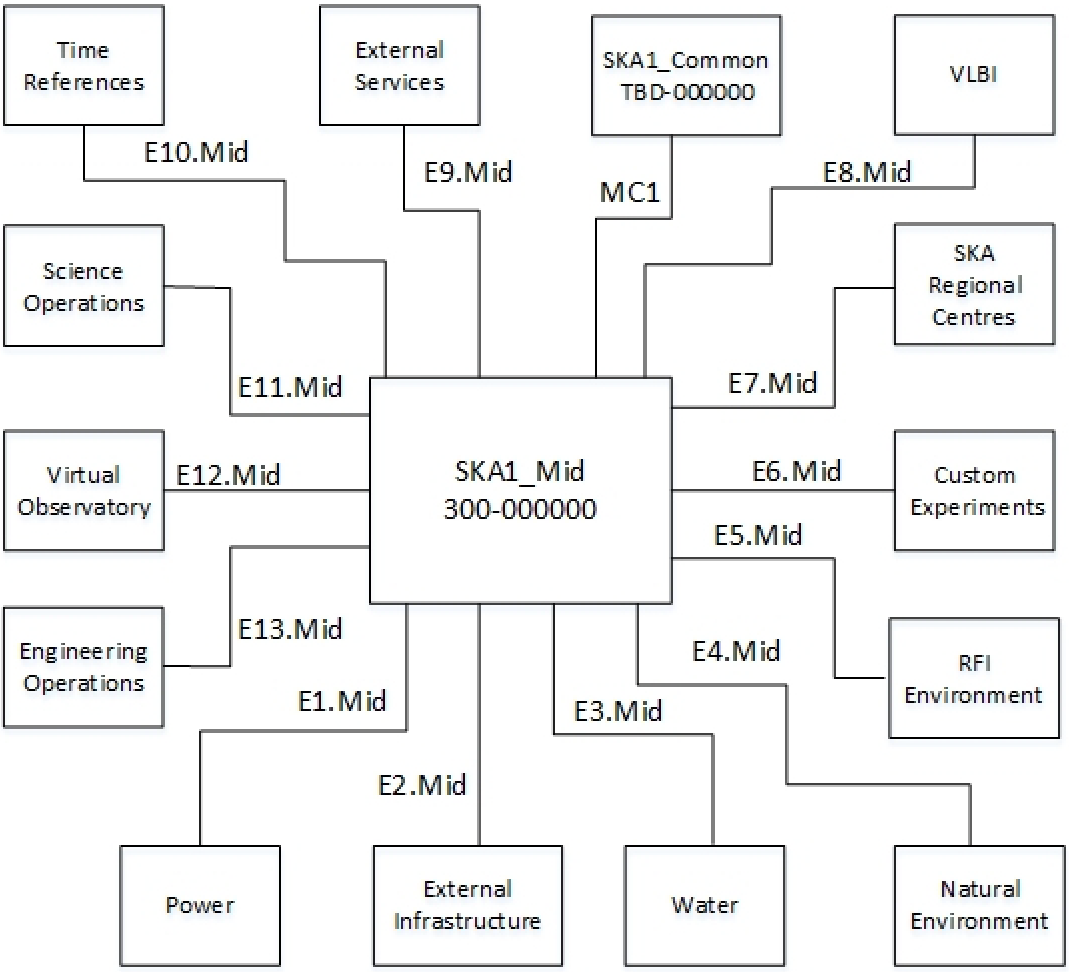

Figure 5 SKA1_Mid Context Diagram

Interface Number	Interface Name	Interface Documents
E1.Mid	SKA1_Mid Power	Document References to be allocated
E2.Mid	SKA1_Mid External Infrastructure	Document References to be allocated
E3.Mid	SKA1_Mid Water	Document References to be allocated
E4.Mid	SKA1_Mid Natural Environment	{AD7] Environmental Conditions for the SKA1 Mid Site in South Africa 301-000000-009
E5.Mid	SKA1_Mid RFI Environment	
E6.Mid	SKA1_Mid Custom Experiments	Document References to be allocated
E7.Mid	SKA1_Mid SKA Regional Centres	Document References to be allocated
E8.Mid	SKA1_Mid VLBI	Document References to be allocated
E9.Mid	SKA1_Mid External Services	Document References to be allocated

Interface Number	Interface Name	Interface Documents
E10.Mid	SKA1_Mid Time References	Document References to be allocated
E11.Mid	SKA1_Mid Science Operations	Document References to be allocated
E12.Mid	SKA1_Mid Virtual Observatory	
E13.Mid	SKA1_Mid Engineering Operations	Document References to be allocated
MC1	SKA1_Mid to SKA1 Common	Document References to be allocated

Table 4 SKA1_Mid External Interfaces

1.2.2.1.3 SKA1_Common

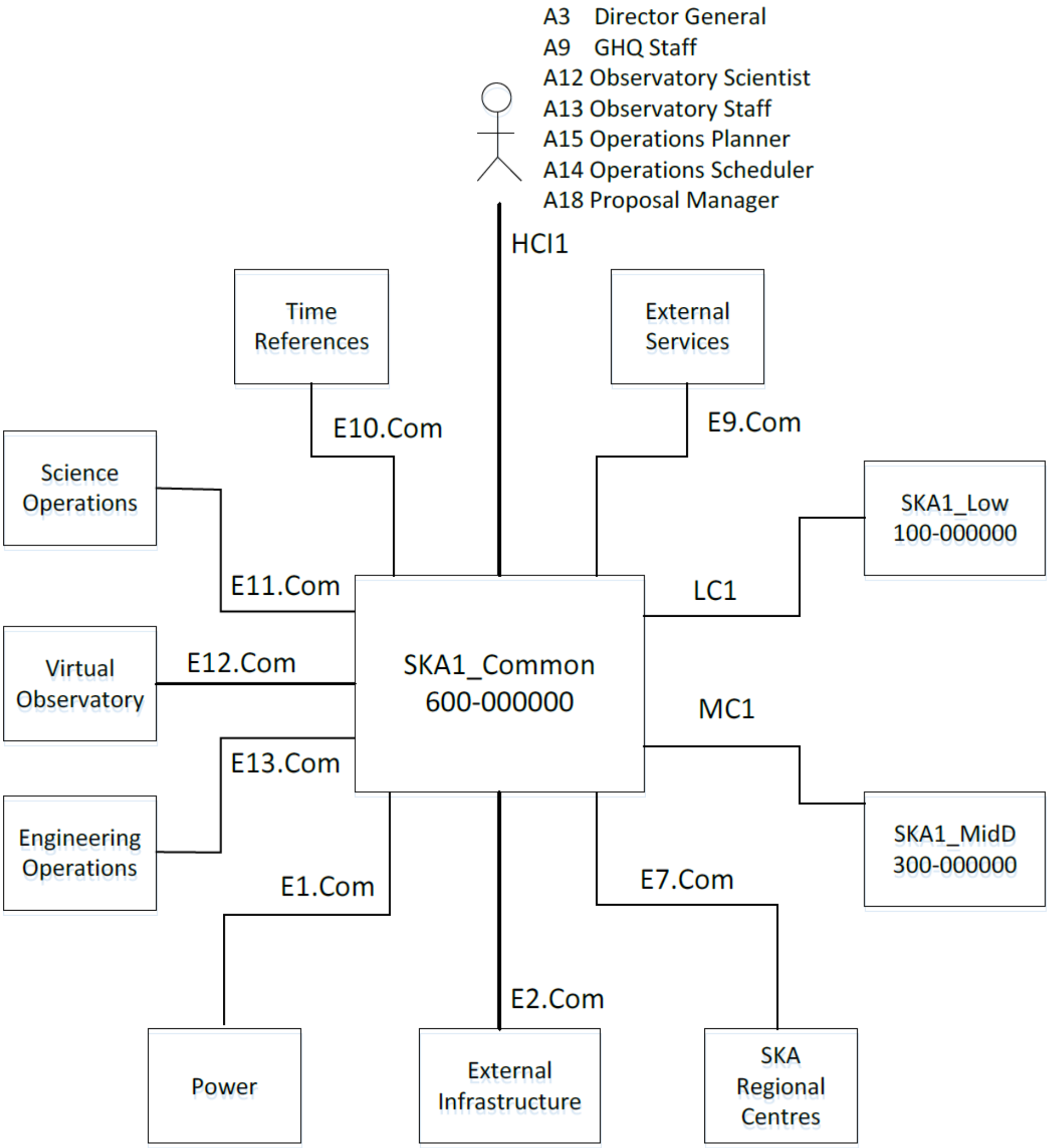

Figure 6 SKA1_Common Context Diagram

Interface Number	Interface name	Interface Document Reference
E1.Com	SKA1_Mid Power	Document References to be allocated
E2.Com	SKA1_Mid External Infrastructure	Document References to be allocated
E7.Mid	SKA Regional Centres	Document References to be allocated
E9.Com	External Services	Document References to be allocated
E10.Com	Time References	Document References to be allocated
E11.Com	Science Operations	Document References to be allocated
E12.Com	Virtual Observatory	
E13.Com	Engineering Operations	Document References to be allocated
MC1	SKA1_Mid to SKA1_Common	Document References to be allocated
LC1	SKA1_Low to SKA1_Common	Document References to be allocated
HC1	SKA1_Common Human Computer Interface	Document References to be allocated

Table 5 SKA1_Common External Interfaces

1.2.3 States and Modes

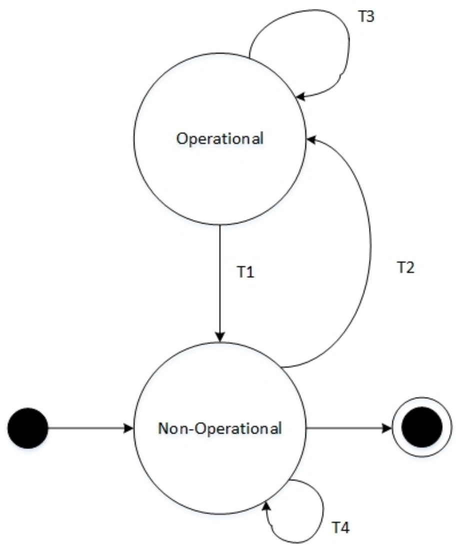

Figure 7 System States

Availability Level		Definition
Operational	Observing	At least one sub-array is in use for science observations, either in Observing or Calibrating mode.
	Standby	At least one sub-array is available for science observations (sub-array could be Configuring or Standby), but no sub-arrays are used for science observing.
Non-Operational	Weather	Observing is not possible due to poor weather (e.g. wind stow conditions).
	Utility	Observing is not possible due to utility problems (e.g. power failure). "Utility" relates to all items that are external to the Telescope item boundary, but are inputs/outputs to the item, needed for the telescope to operate. Mainly power.
	Engineering/ Maintenance	System is not available for any science observations, due to upgrades, scheduled maintenance, off-line calibration, observations for engineering/commissioning, software updates or testing.
	System Fault	System is not available for any science observations, due to a critical system fault and is undergoing critical repair or awaiting for a critical support item (i.e. delay for personnel or spares).

Table 6 System States

1.2.3.1 Definition of States and Modes

The definition of the terms "States" and "Modes" is very diverse in the SE and software communities and it is generally accepted that States and Modes can be used interchangeably, and that there is no clearly defined difference. The strict definition of States and Modes is therefore considered to be not important in this document, and the terms are used quite loosely.

However, they are generally used in the following sense:

- **Modes**: refer to sets of behaviour or functionality that are needed to control an item.
- **States**: refer to sets of characteristics that are needed for reporting of an item's condition.

1.2.3.2 SKA1_Mid observing modes

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3547	Observing modes (SKA1_Mid telescope) The SKA1_Mid telescope, when commanded, shall operate simultaneously with any combination of the following observing modes: • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search • VLBI	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-150011	CSP, SDP, TM	Demonstration

Simultaneous observation across the telescope is achieved through the use of subarrays.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3549	SKA1_Mid observing modes (subarrays) SKA1_Mid subarrays, when commanded, shall operate simultaneously with any combination of observing modes within each of the following configurations: Configuration 1 • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search Configuration 2 • Imaging (in support of VLBI) • Transient Search • VLBI	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-150011	CSP, SDP, TM	Demonstration

1.2.3.3 SKA1_Low observing modes

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3548	Observing modes (SKA1_Low telescope) The SKA1_Low telescope, when commanded, shall operate simultaneously with any combination of the following observing modes: • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search • VLBI	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-150011, ECP-160040	CSP, SDP, TM	Demonstration

Simultaneous observation across the SKA_Low telescope is achieved through the use of subarrays.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3550	SKA1_Low observing modes (subarrays) SKA1_Low subarrays, when commanded, shall operate simultaneously with any combination of the following observing modes: • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-150011	CSP,SDP, TM	Demonstration

1.2.3.4 System States

The possible states at system level are illustrated in Figure 7.

- Observing
- Standby
- Weather
- Utility

- Engineering Maintenance
- System Fault

1.2.3.5 Subarray modes

Sub-array modes are shown in the following modes transition diagram, and are defined in the following table.

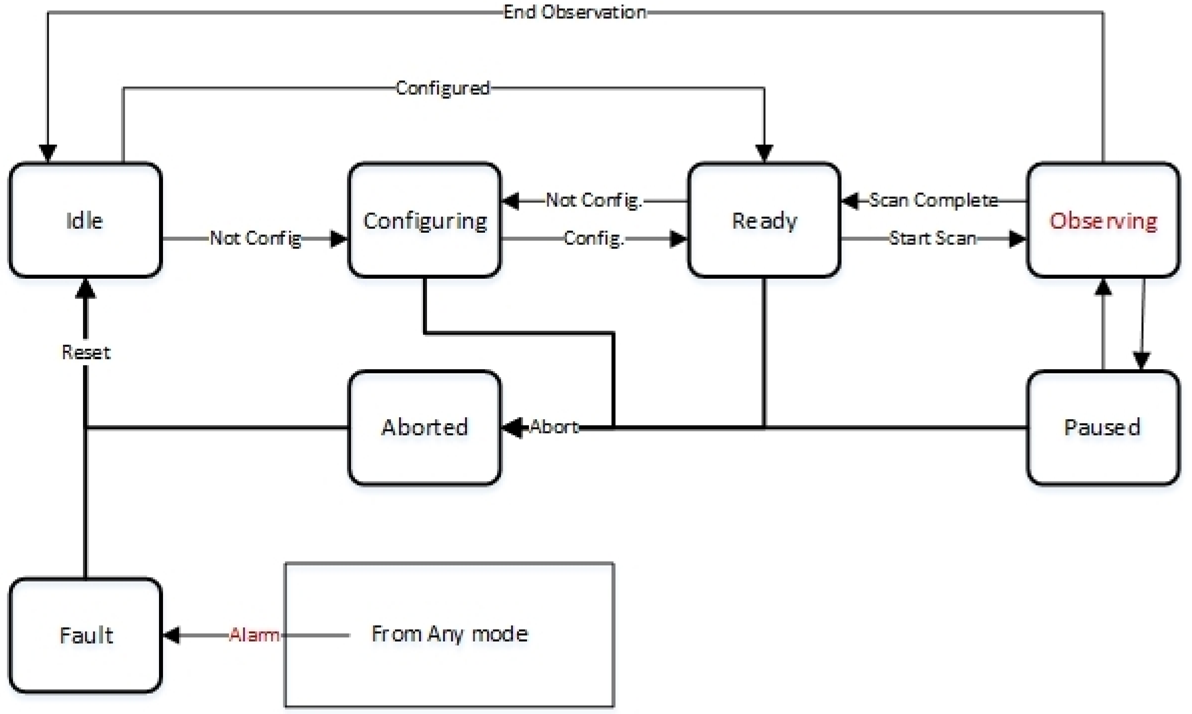

Figure 8 Sub-Array Mode Diagram

Mode	Description
Idle	Sub-array is ready to observe, but is in an undefined configuration.
Configuring	System is being prepared for a specific scan. On entry to the state no assumptions can be made about the previous conditions. It is a transient state and will automatically transition to **Ready** when it completes normally.
Ready	System is fully prepared for the next scan, but not actually taking data or moving relative to the observed coordinate system.
Observing	System is taking data and, if needed, and all components are synchronously moving in the observed coordinate system. Any changes to the sub-systems are happening automatically.
Paused	System is fully prepared for the next observation, but not actually taking data or moving relative to the observed system. Similar to **Ready** state.
Aborted	System has had previous state interrupted by controller and is in an undefined state.
Fault	System has detected a critical functional internal error making it is impossible to remain in the previous state.

Table 7 SKA1_System Subarray Modes

2 References

The revisions of applicable and reference documents are included in the Configuration Management Baseline in eB. The presiding document will always be the 'latest approved' document.

2.1 Applicable Documents

In the event of conflict between the contents of the applicable documents and this SKA1 System Requirement Specification (SRS) document, the applicable documents shall take precedence.

[AD1] SKA1 Operational Concept Document SKA-TEL-SKO-0000307

[AD2] SKA EMI/EMC standards SKA EMI/EMC Standards and Procedures SKA-TEL-SKO-0000202

[AD4] SKA1_Low Configuration Coordinates SKA-TEL-SKO-0000422

[AD5] SKA1_Mid Configuration Coordinates SKA-TEL-INSA-0000537

[AD6] SKA Project Safety Management Plan SKA-TEL-SKO-0000740

[AD7] Environmental Conditions for the SKA1 Mid Site in South Africa 301-000000-009

[AD8] Quality Assurance Plan SKA-OFF.PAQA-SKO-QP-001

2.2 Interface Control Documents

[ICD1] SKA1 LOW SDP to CSP Interface Control Document 100-000000-002

[ICD2] SKA1 LOW LFAA to Infrastructure Australia Interface Control Document 100-000000-003

[ICD3] SKA1 LOW LFAA to CSP Interface Control Document 100-000000-004

[ICD4] SKA1 LOW CSP to Infrastructure Australia Interface Control Document 100-000000-020

[ICD5] SKA1 LOW CSP to TM Interface Control Document 100-000000-021

[ICD6] SKA1 LOW TM to Infrastructure Australia Interface Control Document 100-000000-022

[ICD7] SKA1 LOW SADT to CSP Interface Control Document 100-000000-023

[ICD8] SKA1 LOW SADT to INFRA AUS Interface Control Document 100-000000-024

[ICD9] SKA1 LOW SADT to SDP Interface Control Document 100-000000-025

[ICD10] SKA1 LOW SADT to LFAA Interface Control Document 100-000000-026

[ICD11] SKA1 LOW TM to SADT Interface Control Document 100-000000-027[3]

[ICD12] SKA1 LOW TM to LFAA Interface Control Document 100-000000-028

[ICD13] SKA1 LOW SDP to TM Interface Control Document 100-000000-029

[ICD14] SKA1 MID SDP to CSP Interface Control Document 300-000000-002

[ICD15] SKA1 MID CSP to INFRA SA Interface Control Document 300-000000-020

[ICD16] SKA1 MID CSP to TM Interface Control Document 300-000000-021

[ICD17] SKA1 MID SADT to CSP Interface Control Document 300-000000-023

[ICD18] SKA1 MID SADT to INFRA SA Interface Control Document 300-000000-024

[ICD19] SKA1 MID SADT to SDP Interface Control Document 300-000000-025

[3] Refer to SKA-TEL-SKO-0000153.

[ICD20] SKA1 MID SADT to DSH Interface Control Document 300-000000-026

[ICD21] SKA1 MID TM to SADT Interface Control Document 100-000000-027[4]

[ICD22] SKA1 MID SDP to TM Interface Control Document 300-000000-029

[ICD23] MeerKAT to SKA1 MID CSP Interface Control Document SKA-TEL-AIV-2310001

[ICD24] Interface Control Document - AIV to INFRA-SA SKA-TEL-AIV-2310002

[ICD25] MeerKAT to SKA1 MID SaDT Interface Control Document SKA-TEL-AIV-2310003

[ICD26] MeerKAT to SKA1 MID TM Interface Control Document SKA-TEL-AIV-2310004

[ICD27] MeerKAT to SKA1_MID DISH Interface Control Document SKA-TEL-AIV-2310005

[ICD28] SKA1 Dish to Infrastructure Interface Control Document SKA-TEL-SKO-0000115

[ICD29] SKA1 to VLBI External Interface SKA-TEL-SKO-0000116

[ICD30] SKA1 Dish to CSP Interface Control Document SKA-TEL-SKO-0000124

[ICD31] SKA1 TM to Dish Interface Control Document SKA-TEL-SKO-0000150

[ICD32] SKA1 TM to SaDT Interface Control Document SKA-TEL-SKO-0000153

[ICD33] SKA1 SDP to INFRA-AUS and SKA SA Interface Control Document SKA-TEL-SKO-0000484

2.3 Reference Documents

The following documents are referenced in this document. In the event of conflict between the contents of the referenced documents and this document, this document shall take precedence.

[R1] SKA1 Product Dictionary 000-000000-001

[R2] SKA1 System Baseline Design SKA-TEL-SKO-0000002

[R3] Removed

[R4] P. Hamaker, J. D. Bregman, and R. J. Sault, "Understanding radio polarimetry: I. Mathematical foundations," Astron. Astrophys. Suppl. Ser., vol. 117, pp. 137–147, May 1996.

[R5] U. Rau and T. J. Cornwell, A multi-scale multi-frequency deconvolution algorithm for synthesis imaging in radio interferometry A&A 532, A71 (2011)

[R6] S.J. Wijnholds, J.D. Bregman and A.van Ardenne, Calibratability and its impact on configuration design for LOFAR and SKA phased array radio telescopes, Radio Science, vol. 46, No. RS0F07, 8 November 2011

[R7] C.J. Lonsdale, D. Oberoi, A.J Coster and P.J Erickson, The Effects of Variable Ionospheric and Plasmaspheric Faraday Rotation on Low Frequency Radio Arrays, Proceedings of the XXXth General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS), Istanbul (Turkey), 13 - 20 August 2011

[R8] SKA1 Power Budget SKA-TEL-SKO-0000035

[R9] SKA1 Configuration Management Plan SKA-TEL-SKO-0000120

[R10] SKA Integrated Logistics Support Plan (ILSP) SKA-TEL-SKO-0000104

[R11] ILSP Support spreadsheet

[4] Refer to SKA-TEL-SKO-0000153.

[R12] SKA1 RAM Allocations SKA-TEL-SKO-0000102

[R13] SKA1 Support Concept SKA-TEL-SKO-0000103

[R14] Removed

[R15] SKA Low Telescope Functional Architecture 100-000000-001

[R16] SKA Mid Telescope Functional Architecture 300-000000-001

[R17] Dish Pointing, Motion Behaviour and Control SKA-TEL-SKO-0000438

[R18] SKA1 Error Budgets SKA-TEL-SKO-0000641

[R20] Rau, U., Bhatnagar, S., Voronkov, M.A., and Cornwell, T.J., "Advances in Calibration and Imaging Techniques in Radio Interferometry", Proc IEEEE, 97, 1472-1481, (2008)

[R21] RFI Characterisation and SKA1 Signal Chain Design Consideration SKA-TEL-SKO-0000492

[R22] SKA1 - Mid Fast Noise Injection Resolution Team Report SKA-TEL-SKO-0000663

[R23] SKA1 to VLBI External Interface SKA-TEL-SKO-0000116

[R24] SKA Phase 1 VLBI Clarification ECP-140008 Analysis Document SKA-TEL-SKO-0000044

[R25] SKA System Budget - MID Interferometric Array Sensitivity Budget SKA-TEL-SKO-0000633

[R26] SKA1 System Budget - MID Complex Gain Stability SKA-TEL-SKO-0000675

[R27] SKA System Budget - MID Coherence Budget SKA-TEL-SKO-0000632

[R28] SKA System Budget - LOW System Timing Budget SKA-TEL-SKO-0000637

[R29] SKA1 System Budget - Mid System Timing Budget SKA-TEL-SKO-0000786

[R30] SKA Electrical Installation Standard SKA-TEL.OFF.SE-SKO-ST-001

2.4 Reference Standards

[RS1] IEEE Guide for Developing Systems Specifications IEEE Std 1233 1998 Edition

[RS2] MIL-HDBK-520A Specification Practices

[RS3] IEEE Systems and Software engineering – System life cycle processes ISO/IEC 15288-2008

[RS4] Occupational Health and Safety [OHS] Act, No. 181 1993 (General Machinery regulations 1988, Construction regulation 2003)

[RS5] National Environmental Management Act [NEMA] Act No. 107 1998

[RS6] Occupational Health and Safety (Commonwealth Employment) Act 1991

[RS7] Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems IEC 61508

[RS8] Safety of machinery. Electrical equipment of machines general requirements IEC EN 60204-1

[RS9] Low voltage switchgear and controller gear IEC EN 60947-5-5

[RS10] Safety of machinery. Safety-related parts of control systems general principles for design ISO 13849-1

[RS11] Generic Requirements for Network Equipment in the Outside Plant (OSP) GR-3108-Core Iss 3.

[RS12] SKA1 Power Quality Standard SKA-TEL-SKO-0000293

[RS13] Equipment Engineering Environmental conditions and environmental tests for telecommunications equipment Part 1-2: Classification of environmental conditions Transportation ETS 300 019-1-2

[RS14] Safety of machinery -- General principles for design -- Risk assessment and risk reduction ISO 1200-2 clause 5

[RS15] Equipment Engineering Environmental conditions and environmental tests for telecommunications equipment Part 1-1: Classification of environmental conditions Storage ETS 300 019-1-1

[RS16] Fundamental SKA Software and Hardware Description Language Standards SKA-TEL-SKO-0000661

[RS17] Removed

2.5 Science Requirement References

The following documents are referenced in the traceability to Science requirements in the Appendix A of this document. In the event of conflict between the contents of the referenced documents and this document, **the science requirements document** shall take precedence.

[RD1] Advancing Astrophysics with the SKA, R. Braun et al. eds., 2015

[RD2] SKA-TEL-SKO-0000122 -Appendix A, SKA1 Science Priority Outcomes

[RD10] Removed

[RD11] SKA1 Array Configurations SKA-TEL-SKO-0000005

[RD12] SKA1 Level 0 Science Requirements SKA-TEL-SKO-0000007

3 Organizational Standards

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3563	SKA1 Systems Software quality All software and hardware description language related deliverables shall comply with the "Fundamental SKA Software and Hardware Description Language Standards" (SKA-TEL-SKO-0000661) [RS16]	ECP-160047	DSH, LFAA, SADT, CSP, SDP, TM	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3091	SKA1 Mid and SKA1_Low Power quality standard The SKA1_Mid and SKA1_Power quality shall be compliant with the SKA1 Power Quality Standard Specification : SKA-TEL-SKO-00000293 [RS12]	ECP-150033	INFRA	Test

The specification includes the criteria applicable to the SKA1_Mid and SKA1_Low as consumers of power for:

- Power factor
- Voltage Flicker
- Current Harmonics
- Current Unbalance

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3564	SKA1 Mid and SKA1_Low RFI quality standard SK1_MID and SKA1_Low shall be compliant with SKA EMI/EMC Standards and Procedures SKA-TEL-SKO-0000202 [AD2]		DSH, LFAA, CSP, SaDT, INFRA	Inspection

4 Structure

4.1 Functions

The hierarchical functional analysis have been described for both SKA1 Telescopes in [R15] and [R16].

4.2 Global Headquarters

The SKA Global Headquarters (GHQ) will have overall responsibility for the SKA Observatory.

4.3 Site Location

The SKA1 Antenna systems and digital signal chain will be located within radio quiet zones provided by the Host Countries of South Africa and Australia.

4.4 Distribution and Deployment

4.4.1 Australia

4.4.1.1 Australian Science Operations Centre

The Australian Science Operations Centre will be in Perth.

4.4.1.2 Australian Engineering Operations Centre

The Australian Engineering Operations Centre will be in Geraldton.

4.4.1.3 Australian Science Processing Centre

The Australian Science Processing Centre will make use of floor space, power, cooling, and other infrastructure in Perth.

4.4.1.4 SKA1_Low array

The SKA1_Low array will be located within the legal boundary of the Boolardy station.

4.4.1.5 SKA1_Low Central Processing Facility

The facility housing the station beamformers for the inner area of the SKA1_Low and the central signal processing for SKA1_Low will be at a distance of the order of 1 km South West of the centre of the SKA1_Low array. The precise positioning will be a result of a trade study to minimise RFI and access road impact.

4.4.1.6 SKA1_Low central frequency reference

The SKA1_Low central frequency reference will be located in the SKA1_low Central Processing Facility.

4.4.2 South Africa

4.4.2.1 South African Science Operations Centre

The South African Science Operations Centre will be located in Cape Town.

4.4.2.2 South African Engineering Operations Centre

The South African Engineering Operations Centre will be located at Klerefontein.

4.4.2.3 South African Science Processing Centre

The South African Science Processing centre will be located in Cape Town

4.4.2.4 SKA1_Mid array

The SKA1_Mid dish array will be located in the Karoo Central Astronomy Advantage Area.

4.4.2.5 SKA1_Mid Central Processing Facility

The Central Processing facility for SKA1_Mid will be located entirely within the existing Karoo Array Processor Building.

4.4.2.6 SKA1_Mid central frequency reference

The SKA1_Mid central frequency reference will be located in the Central Processing Facility located in the KAPB

5 Telescopes

5.1 SKA1_Low

5.1.1 SKA1_Low Configuration and Performance

5.1.1.1 Receptor type

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2671	Receptor type The SKA1_Low shall utilise dual, orthogonally polarised antenna elements.		LFAA	Analysis

5.1.1.2 Antenna spacing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3340	Antenna spacing The SKA1_Low average spacing between antenna elements within a station shall be the same for each of the stations.	ECP-160015	LFAA, INFRA	Inspection

5.1.1.3 Array resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2673	Array configuration spatial performance The SKA1_Low configuration shall maintain a sensitivity within a factor of 2 TBC over 2 orders of magnitude of spatial resolution		LFAA	Analysis

The beam performance curves at 140MHz for a single frequency and for wide-band observation are detailed in Figure 23 of [R2].

5.1.1.4 Station beam bandpass stability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2621	Station beam bandpass stability On a maximum time scale of 600 seconds, and within the envelope of the listed spline points with TBD frequency smoothness, SKA1_Low shall have a station beam bandpass stability, post calibration and RFI mitigation, of: • 0.05 % at 50 MHz • 0.02 % at 110 MHz • 0.03 % at 160 MHz • 0.03 % at 220 MHz • 0.05 % at 280 MHz • 0.08 % at 350 MHz compared to the full polarization parameterized beam model.	SKA Error Budget [RD18]	LFAA, CSP, SDP	Test

Bandpass stability is defined here as the residual fractional error in the brightness, ΔI/I, as function of frequency for a specified frequency interval over a specified time. Sufficient bandpass stability must be realised to permit a calibration strategy that provides the specified Spectral Dynamic Range.

5.1.1.5 Station operation range

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3407	Station Operation Range: The SKA1_Low station shall operate at all possible azimuth and elevation angles.		LFAA, TM	Test

5.1.1.6 Sub-stations

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3368	Maximum number of stations and substations The SKA1_Low shall be configurable for one of the following:. 1. 1024 sub-stations randomly distributed within stations. o Stations are populated with 4 randomly-located substations in the core and 4 randomly-located substations in one of the 6 stations at each cluster location. o 75 MHz of bandwidth is available. 2. 1024 sub-stations regularly distributed within stations. o Stations are populated with 6 substations in the core and 4 substations in one of the 6 stations at each cluster location. o 75 MHz of bandwidth is available. 3. 2048 sub-stations randomly distributed within stations. o Stations are populated with 4 randomly located substations in all of the 512 stations. o 19 MHz of bandwidth is available. 4. 2048 sub-stations regularly distributed within stations. o Stations are populated with 6 substations in the core and 6 substations in 3 of the 6 stations at each cluster location. o 19 MHz of bandwidth is available.	ECP-160015	TM, CSP, LFAA, SDP	Test

The available bandwidth may be partitioned further to provide Multi beam capability as specified in requirement SYS_REQ-3039.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3358	Sub-station beams The SKA1_Low, when commanded, shall form dual polarisation beams from up to six sub-stations for any station.	ECP-160015	TM, LFAA	Test

A substation is an array of adjacent antenna elements contained within a station which can be beam-formed to produce a data-stream that can be correlated.

(Note that there are restrictions on the total number of correlatable elements and on the bandwidth which will be in separate requirements. This is simply a statement on the capability of the beam-former, not on the selection of antenna elements. Also, it says for 'any station', not all or pre-specified subset.)

5.1.1.7 SKA1_Low cross polarisation purity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2964	SKA1_Low cross polarisation purity The SKA1_Low intrinsic cross polarisation ratio shall be at least 15 dB over the whole observing band within the half power beam width up to observing angles of 45 degrees.	ECP-150004	LFAA	Test

Note the calibrated polarisation dynamic range is given in SYS_REQ-2966, 3073.and 3074 for imaging, Pulsar Search and Pulsar Timing respectively. This requirement is the geometric IXR ref the antenna.

5.1.1.8 SKA1_Low array sensitivity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2135	SKA1_Low array sensitivity Assuming a sky noise temperature defined in the definitions section of this system requirements specification document, the SKA1_Low array shall have sensitivity per polarization at zenith corresponding to the following values interpolated by a 'not-a-knot' cubic spline function and not deviating by more than +/-5% from the spline interpolation spanning the following points: • 68 m2K-1 at 50MHz • 70 m2K-1 at 55 MHz • 232 m2 K-1 at 80 MHz • 531 m2K-1 at 110MHz • 588 m2 K-1at 140 MHz • 610 m2K-1 at 160MHz • 614 m2K-1 at 220 MHz • 576 m2K-1 at 280 MHz • 522 m2K-1 at 340 MHz • 515 m2K-1 at 345 MHz • 516 m2K-1 at 350 MHz	Science Requirements SKA-TEL-SKO-0000007 Appendix A	LFAA	Test

The model for the sky noise temperature is provided in the Appendix section of this document under the Definitions section. This require changes to the L0 figure 2.

5.1.1.9 Sensitivity for off zenith angles

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2622	Sensitivity for off zenith angles SKA1_Low shall have a degradation of peak sensitivity of less than 30% at local elevation angle of 60 deg and less than 50% degradation at local elevation angle of 45 deg for all local azimuthal angles, 0 – 360 deg.		LFAA	Test

5.1.1.10 Distribution of collecting area within stations

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3339	Distribution of collecting area within stations Placement of Antenna within each SKA1_Low station shall be independently randomised in two dimensions (within the constraints of antenna and station size) so as not to form a regular grid. Polarisations of antenna elements should be aligned for all antennas.	ECP-160015	LFAA, INFRA	Inspection

5.1.1.11 SKA1_Low antennas per station

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2139	SKA1_Low antennas per station. Each station of the SKA1_Low shall be made up of 256 antennas which are in randomised positions.		LFAA, INFRA	Analysis

5.1.1.12 SKA1_Low station diameter

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2140	SKA1_Low station diameter. The maximum distance between any two antennas contributing to a SKA1_Low station shall be the same for each station being less than or equal to 45 metres. The optimal value is less than 35 metres.		LFAA, INFRA	Inspection

The maximum antenna separation of 35 metres is consistent with being able to provide a single, circularly symmetric, beam of 5 degrees at the half-power points at 100 MHz (centre of the EoR frequency range) while meeting the sensitivity requirements with 256 antennas per station evenly distributed in an irregular-random configuration. However, sufficient distance to accommodate the size of antennas is included with 45 metres being considered an upper bound acceptable for the science.

5.1.1.13 SKA1_Low number of stations

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2142	SKA1_Low number of stations. The SKA1_Low shall be composed of 512 stations.		LFAA, SADT, CSP, SDP, TM, INFRA	Inspection

The array sensitivity is set by the total number of antennas and their apparent density, not the number of stations; the fact that the antennas are divided into 512 groups (stations) is a consequence of the economic trades that lead to summing 256 antennas into a station and the desire to have a 5-degree hpbw at ~100 MHz, not the sensitivity.

5.1.1.14 SKA1_Low configuration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2143	SKA1_Low configuration The SKA1_Low station and antenna placement will be as specified in the SKA1_Low Configuration Coordinates document [AD4].	SKA1_Low Configuration Coordinates document [AD4].	LFAA, SADT, INFRA	Inspection

5.1.1.15 Station Identification

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3331	Station identification Each station of the SKA1_Low shall be uniquely identifiable. This will include both the identity of the cluster and the individual station as defined in SKA-TEL-SKO-0000422 SKA1_Low Configuration Co-ordinates document [AD4].	ECP-160015	LFAA, INFRA	Inspection

This isn't a requirement but is of utility until the SoW and the labelling standard are in place. These should include unique identifications for lower level entities such as signal flows, antennas etc.

5.1.1.16 SKA1_Low maximum baseline length between stations

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2817	SKA1_Low maximum baseline length between stations. The maximum distance between station centres of SKA1_Low shall be 65 km.	SKA1_Low Configuration Coordinates document [AD4].	LFAA, CSP, SDP, SADT	Inspection

5.1.1.17 SKA1_Low Instantaneous Bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2147	Instantaneous bandwidth. The SKA1_Low, when commanded, shall process 300 MHz of aggregate bandwidth per polarisation.		LFAA, SADT, CSP, SDP, TM	Test

300MHz of bandwidth is available when the SKA1_Low is producing just a single beam per station. Multiple beams have an aggregate B/W of 300MHz. Even if the beam(s) are sparsely populated with receive channels.

5.1.1.18 Digitisation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2674	Digitisation Digitisation of SKA1_Low antenna signals shall be to at least 8 bits.		LFAA	Demonstration

5.1.1.19 Clipping

Clipping shall occur when the range of the input signal voltages to the ADC is larger than the ADC voltage range.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2639	Clipping SKA1_Low data acquisition shall clip less than 5% of the time for the RFI levels specified within the SKA EMI/EMC standards [AD2].	Operational requirement to meet availability.	LFAA	Test

5.1.1.20 Clipped data flagging

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2640	Clipped data flagging SKA1_Low and SKA1_Mid shall flag clipped data within the data stream.	Operational requirement to meet availability.	LFAA, CSP, DSH, SDP	Demonstration

5.1.1.21 Linearity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2653	Linearity The level of spurious products generated by the SKA1_Low, in the presence of signals representative of the expected RFI environment [AD2], shall degrade the expected thermal noise floor of a 1000 hour integration by no more than 10%.	Related to Signal Chain dynamic range, ECP-160045	LFAA, SDP	Analysis

Originated from Signal Chain dynamic range analysis, and SDP must not contribute to degradation of the noise floor. Sizing of SDP will not be dominated by 1000h integration time.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3621	Direct sun observation SKA1_Low shall perform observations of the Sun. During these observations the instrument response shall be linear.	ECP-170026	LFAA, CSP, SDP, TM	Test

5.1.1.22 Absolute flux scale

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2824	Absolute flux density scale The SKA1_Low shall have an absolute flux density scale with an accuracy better than 5% across the band.	Established Precedent	LFAA, SDP	Test and analysis

It is envisioned test at several distributed points across the band with an analysis to interpolate across the full band.

5.1.1.23 SKA1_Low Polarisation dynamic range: Imaging

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2966	SKA1_Low Polarisation dynamic range: Imaging SKA1_Low shall provide 45 dB polarisation dynamic range for imaging, after calibration, at all spatial and at all fractional bandwidths across the full band.	Science requirements SKA-TEL-SKO-0000007 Appendix A	CSP, LFAA, SDP	Analysis

Polarisation dynamic range is defined here as the ratio of peak Stokes I brightness to the residual instrumental polarised response, I/ΔP, at the source location. Specified values apply to both the target pointing direction as well as everywhere within the half power point of the dish or station beam.

This requirement is driven principally by EoR.

5.1.1.24 SKA1_Low Polarisation dynamic range: Pulsar Search

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3073	SKA1_Low Polarisation dynamic range: Pulsar Search SKA1_Low, when performing calibration imaging in support of Pulsar Search, shall provide better than 25 dB polarisation dynamic range for the configured bandwidth.	Science Requirements Appendix A	SDP, CSP, TM, LFAA	Test

5.1.1.25 SKA1_Low Polarisation dynamic range: Pulsar Timing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3074	SKA1_Low Polarisation dynamic range: Pulsar Timing SKA1_Low, when performing Pulsar Timing, shall provide better than 40 dB polarisation dynamic range across each Pulsar Timing tied array at their bore sight for the configured bandwidth/ time resolution. This implies 40 dB out to the HPBW for the station primary beam as a pulsar timing tied array beam can be located anywhere in that area.	Science Requirements SKA-TEL-SKO-0000007 Appendix A	SDP, CSP, TM, LFAA	Test

5.1.1.26 SKA1_Low Common Delay Centre Time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3294	SKA1_Low common delay centre time Each SKA1_Low subarray shall have a common delay centre at or near its centre with a time accurate to the SKA timescale and a precision of better than 2ns (1σ) over periods of one observation and at least 10 years.	ECP-160043	CSP, SaDT, TM	Test

5.1.1.27 SKA1_Low Brightness dynamic range

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3459	SKA1_Low brightness dynamic range SKA1_Low shall provide at least 50 dB brightness dynamic range at 300 arcsec spatial and 1 MHz spectral resolution.		CSP, SDP, LFAA, TM	Test

5.1.1.28 SKA1_Low calibration transfer

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3542	SKA1_Low calibration transfer When commanded, SKA1_Low shall transfer calibration seamlessly across frequency changes, band changes, and/or source changes, such that the any change in calibration due to the telescope (as compared to the environment or the source) shall be less than 0.1% in amplitude and 0.001 radians in phase.		DSH, LFAA, SADT, SDP, CSP	Test

5.1.2 SKA1_Low station beamforming

5.1.2.1 Station beam spatial stability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2629	Station beam spatial stability On a maximum time scale of 600 seconds, for each SKA1_Low station beam at zenith angles less than 45 degrees, the rms difference between the parameterized model and the actual station beam, relative to the main beam peak power, after calibration, shall remain smaller than the envelope of the listed spline points to a frequency smoothness of TBD: • 0.07 % at 50 MHz • 0.03 % at 110MHz • 0.04 % at 160MHz • 0.05% at 220MHz • 0.07 % at 280MHz • 0.1 % at 350MHz	SKA Error Budgets [R18]	LFAA, SDP	Test

5.1.2.2 Calibration update rate

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2634	Calibration update period The SKA1_Low shall provide calibration update calculation cycle rates of up to once every correlator dump time.	References [R2], [AD1]	LFAA, TM, SDP	Demonstration

5.1.2.3 Real time calibration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2635	Real time calibration The SKA1_Low shall provide on-line station beam calibration functions with an update period of 10 minutes or faster.	Derived from DRM	LFAA	Demonstration

[R6] By exploiting the electronic stability of the system, we can perform the instrumental calibration online (as opposed to real-time) with an update rate of 10 minutes. The feasibility of such an approach is demonstrated with LOFAR, which is currently even using fixed calibration tables, which are only regularly updated during system maintenance.

5.1.2.4 Multi-beam capability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3039	SKA1_Low multiple beam capability SKA1_Low shall process up to 8 independent beams from each station within a subarray, each with potentially independent pointings, such that the sum of bandwidths over these beams is at most 300 MHz.	ECP-150015, ECP-160043	CSP, SDP, LFAA, TM	Test

Multi-beam capability provides support for exoplanet detection. Note that the LFAA has the capability of forming beams with different pointings for each of its coarse channels within each sub-array. With ~ 1MHz coarse channels this corresponds to potentially ~ 300 beams. The pointing can also be co-incident. However, TM and SDP have to deal with the control and data products respectively from the telescope and it is this aspect that introduces constraint of processing 8 or less separate pointings over all. The frequency coverage within a beam does not have to be continuous or contiguous.

Additionally, the bandwidth available for these beams will reduce if sub-stations are configured: (75MHz for 1024 sub-stations, and 18.75MHz for 2048 sub-stations. 300MHz is available if no substations are instantiated).

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3040	SKA1_Low beam steering SKA1_Low, when forming station beams, shall steer them independently in both azimuth and elevation to an accuracy of better than 1/1000 of the half power beam width.	SKA Error Budgets [R18]	LFAA,TM, SDP,CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3041	SKA1_Low multiple beam bandwidths SKA1_Low, when commanded, shall form multiple station beams that have bandwidths independent of each other (where independence allows identical, overlapping or non-overlapping). The independence allows each of one of the 8 beams to have non-contiguous bandwidth and divergent pointing.	ECP-140015	CSP,SDP, TM, LFAA	Demonstration

5.1.2.5 Synchronous time stamping

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3400	SKA1_Low synchronous time stamping Each station beam shall provide to the correlator-beamformer a time stamp, synchronous with and locked to the sample clock and 1PPS.	ECP-160068	LFAA	Test

The number of samples between 1PPS is deterministic.

5.1.3 SKA1_Low Correlation

5.1.3.1 Auto-correlation spectra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3035	SKA1_Low autocorrelation spectra For all stations belonging to a given subarray,SKA1_Low, when commanded, shall deliver full-polarisation autocorrelation spectra, with frequency coverage, spectral resolution, and spectral and temporal response matching that of the cross-correlation spectra from that subarray.	ECP-140010	CSP, SDP, LFAA, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3047	SKA1_Low autocorrelation calibration The SKA1_Low, when commanded, shall generate calibrated autocorrelation spectra. Cross-correlation spectra may be used as part of this calibration.	ECP-140010	SDP	Demonstration

Performance needs to be appended to the requirement when available.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3037	SKA1_Low continuum imaging. SKA1_Low, when commanded, shall provide full Stokes polarisation products (I, Q, U, V) as part of all observing modes including continuum imaging.	ECP-140011	SDP, TM	Test

5.1.3.2 SKA1_Low channelisation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2149	SKA1_Low channelisation transition band for adjacent frequency channels. The SKA1_Low shall have a transition band for adjacent visibility spectra frequency channels that is monotonically decreasing from -3.01 (+/- 0.01) dB at the channel edge, to -60 dB or better at the next adjacent channel centre frequency.	ECP-140012	CSP, LFAA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2810	SKA1_Low channelisation maximum leakage for non-adjacent frequency channels The upper envelope of the noise leakage power for non-adjacent visibility spectra frequency channels for SKA1_Low shall fall off as 1/f or better as a function of frequency offset from the centre of a given frequency channel, for frequency offsets up to half the input bandwidth.	ECP-140012	CSP, LFAA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2811	SKA1_Low channelisation frequency channel amplitude variation The post-calibration amplitude response of SKA1_Low imaging shall vary by at most +/-0.01 dB across the band.	SKA Error Budgets [R18]	CSP, LFAA, SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3296	SKA1_Low channelization stability The spectral and temporal response of the individual SKA1_Low visibility spectra frequency channels shall not change by more than 1% as a function of time, unless explicitly commanded to do so.		CSP, TM, SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3565	SKA1_Low channalization configuration For each subarray, SKA1_Low, when commanded, shall produce correlated visibilities and autocorrelations for all polarization products, in full bandwidth resolution or in higher spectral resolution over limited bandwidth.		LFAA, CSP, SDP	Demonstration

5.1.3.2.1 Full bandwidth resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2148	SKA1_Low spectral channels SKA1_Low, when performing spectral line imaging, shall form a fixed number of least 52,500 and no more than 65,536, dependent on implementation, linearly spaced frequency channels across the frequency band in total normal fine spectral channels.		LFAA, CSP, SDP	Test

5.1.3.2.2 *Higher Spectral Resolution over limited bandwidth*

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2975	SKA1_Low zoom windows. For each subarray, SKA1_Low, when commanded, shall produce correlated visibilities and autocorrelations for all polarization products, for up to four zoom windows, each with bandwidth selected independently from values within 10% of 4 MHz, 8 MHz, 16 MHz, 32, 64, 128 and 256 MHz , such that the entire zoom window lies entirely within the processed observing band.	ECP-140012	CSP, SDP	Test

The zoom windows need to have boundary alignment with coarse channels. The sample rate and oversampling determine the coarse channel boundaries. Consequently tolerance is required on the selectable bandwidths.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2976	SKA1_Low zoom window centre frequency Zoom windows for SKA1_Low shall have centre frequencies independently selectable from each other with a step size within that is 10% of 781kHz such that the full window is contained within the available processed frequency band and with the option of overlapping any or all windows.	ECP-140012	CSP, SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2977	SKA1_Low zoom window channels. When generating zoom windows, SKA1_Low shall on command provide, for each zoom window, 16384 (+/- 10%) linearly spaced frequency channels fully covering the zoom windows.	ECP-140012	CSP, SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3048	SKA1_Low zoom window noise leakage power The maximum noise leakage from a non adjacent channel into SKA1_Low zoom window channels from all frequencies outside the window shall be less than 60dB.	ECP-140012	CSP, LFAA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3049	SKA1_Low overlapped window amplitude response The SKA1_Low post-calibration amplitude response variation across the full (concatenated) frequency range covered by overlapped zoom windows of the same frequency resolution shall be within +/-0.01 dB of the nominal.	ECP-140012	CSP,SDP, LFAA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3462	SKA1_Low zoom windows and subarrays SKA1_Low shall, when commanded, configure zoom windows, and generate the corresponding data products, completely independently, for any and all subarrays.		CSP, SDP, TM	Demonstration

May be superseded by proposed new requirement from subarray RT.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3543	SKA1_Low calibration transfer: zoom windows to/from standard spectral channels When commanded, for each subarray individually, SKA1_Low shall transfer calibration between zoom windows and standard (non-zoom) spectral channels which are observed commensally, without introducing additional errors (beyond those of transferring calibration between different frequencies and/or times) above 0.1% in amplitude and 0.001 radians in phase.		CSP, SDP, TM	Test

Intended to allow "seamless" calibration transfer between zoom windows and "standard" spectral channels, to allow effective transfer of calibration between spectral line and continuum observations. Note that this should allow calibration transfer both for simultaneous observations (e.g., imaging a weak galaxy with a very strong maser) and calibration transfer (e.g., using a maser source to calibrate continuum imaging of a nearby weak YSO).

5.1.3.3 SKA1_Low Correlation signal to noise

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2678	SKA1_Low correlation signal to noise SKA1_Low correlation shall not degrade the Signal to Noise ratio by more than 2 % compared to ideal analogue correlation for the same inputs.		CSP	Analysis

For the purposes of this requirement, "correlation" includes channelization but not initial quantization (ADC) losses.

5.1.3.4 SKA1_Low polarisation flags

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3454	SKA1_Low polarization flags: visibilities When flagging on timescales shorter than the correlation integration time, SKA1_Low shall flag all polarizations and polarization products if any are found to be bad.		CSP	Demonstration

This allows the use of a single TCI (time centroid) for each such integration.

5.1.3.5 SKA1_Low visibility integration time

The visibility integration time is derived from the level of acceptable image smearing. This is nominally identified as < 2%. However the applicable field of view needs to be specified. A factor of 2 over and above the half power beam width is assumed.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2150	SKA1_Low visibility integration period The visibility integration period for each SKA1_Low subarray shall be independently configurable, with allowed values being an integer multiple of 0.25 seconds (±2%) to a maximum of 36 seconds (±2%).	ECP-160043	CSP, TM, SDP	Demonstration, Inspection

Note from Michael Ripen: that EVLA observers frequently "tune" their integration time to match expected weather conditions and data rate limits.

5.1.4 SKA1_Low tied array beamforming

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3539	Polarization flags: beamforming inputs SKA1_Mid shall flag both polarizations of any beamforming input for which one polarization is flagged (or marked invalid).		CSP	Demonstration

This doesn`t read like a Level 1 but the derivation is not obvious below that level.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3540	Coherence of SKA1_Low tied-array beams When commanded, SKA1_Low shall form pulsar search, pulsar timing, and VLBI tied-array beams that each have a coherence within 5% of that allowed by the current atmospheric conditions.	ECP-160040	SDP, TM, CSP	Test

Requirement that the tied-array beams be "well-formed", that is, be derived by a coherent rather than an incoherent sum. The "when commanded" here allows observers to specify that they really want incoherent beams, or to sacrifice coherence for observing efficiency; the idea is to require that we be able to achieve very good coherence, e.g., through real-time calibration.

5.1.5 SKA1_Low Pulsar Search

5.1.5.1 SKA1_Low Pulsar search spectral purity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3472	SKA1_Low Pulsar search: spectral purity The spectral distortion of pulsar search beams, compared to an ideal analogue beamformer provided with the same inputs, shall be less than • -40 dB in amplitude • 0.01 radians in phase.		CSP	Test

5.1.5.2 Pulsar search processing bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2890	SKA1_Low Pulsar search bandwidth SKA1_Low shall have a continuous Pulsar Search bandwidth of no less than 96 MHz per beam.	ECP-150004	CSP	Demonstration

5.1.5.3 Dispersion Measure

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2942	SKA1_Low Dispersion Measure SKA1_Low, when performing Pulsar Search for unaccelerated pulsars with dispersion measures within the range 0 to 500 pc cm^{-3}, shall space dispersion measure trials such that the recovered signal-to-noise ratio of any signal lying between trials are more than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	ECP-150004	CSP	Demonstration

5.1.5.4 Time Resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2944	SKA1_Low Pulsar Search time resolution SKA1_Low shall retain time resolution in the Pulsar Search such that any increase in sampling interval at high dispersion measure trials does not degrade the signal-to-noise ratio below 95% relative to the configured time resolution.	ECP-150004	CSP	Analysis

5.1.5.5 Pulsar search observation time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2946	SKA1_Low Pulsar search observation time SKA1_Low, when commanded, shall perform the Pulsar Search with an observation time configurable between 180 and 1800 seconds. The SKA1_Low will restrict the observing time to be the same for all beams in a subarray in fixed multiples of the sampling interval.	ECP-150004	CSP, TM	Demonstration

5.1.5.6 Single pulse searches

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2948	SKA1_Low Single Pulse Searches SKA1_Low, when performing Pulsar Search for individual pulses with dispersion measures in the range 0 to 3000 pc cm^{-3} and with widths 100 microseconds to 1 second, shall space dispersion measure trials such that the recovered the signal-to-noise ratio of any signal lying between trials shall be more than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	ECP-150004	CSP	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3241	SKA1_Low Single Pulse Search Signal to Noise ratio SKA1_Low shall obtain a signal-to-noise ratio for a pulse in a de-dispersed time-series that is more than 85% compared to using a Gaussian matched filter of the correct width.	ECP-150004	CSP	Analysis

5.1.5.7 Binary search

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2936	SKA1_Low Binary Pulsar search When commanded, for each pulsar search beam with pulsar search duration less than 600s, SKA1_Low shall perform acceleration correction as part of the pulsar search, over a configurable range of acceleration values from 0 to no less than 350 m/s^2, for no fewer than 500 configurable dispersion measure trials, such that the degradation in signal-to-noise ratio due to coarse acceleration sampling is less than 34% everywhere in the acceleration range.	ECP-150004	CSP, SDP	Analysis

5.1.5.8 Pulsar search array diameter

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2885	SKA1_Low Pulsar search array diameter Each SKA1_Low subarray, when performing Pulsar Search, shall form Pulsar Search beams using any or all stations within that subarray, which are separated by up to 20 km.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.1.5.9 Pulsar search beamforming centre frequency

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2888	SKA1_Low Pulsar search frequency SKA1_Low, when commanded, shall perform the Pulsar Search on a contiguous bandwidth located anywhere within the SKA1_Low band.	ECP-150004	CSP	Demonstration

5.1.5.10 SKA1_Low co-located Pulsar search beams

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3476	SKA1_Low co-located Pulsar search beams SKA1_Low, when commanded, shall form multiple Pulsar Search beams at the same sky coordinates, within a single subarray.		CSP, TM	Demonstration

5.1.5.11 Pulsar search beamformer bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2892	SKA1_Low Pulsar search beams and bandwidth The SKA1_Low, when commanded, shall offset the centre frequency of the Pulsar Search of specified beams by a specified multiple of the Pulsar Search bandwidth, provided that the entire frequency range lies within the current SKA1_Low band.	ECP-150004	CSP	Demonstration

5.1.5.12 SKA1_Low Pulsar Search: number of beams

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2894	SKA1_Low Pulsar Search: Number of beams SKA1_Low, shall concurrently perform the Pulsar Search function in a total of up to 500 independently steerable beams, each of which may be assigned to any sub-array which is configured for Pulsar Search.	ECP-150004	CSP	Demonstration

5.1.5.13 Pulsar Search: beamforming signal-to-noise ratio

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2896	SKA1_Low Beamforming signal-to-noise ratio: Pulsar Search The SKA1_Low, when forming beams for the Pulsar Search, shall achieve a signal-to-noise of more than 97% relative to an ideal analogue beam-forming for the same inputs.	ECP-150004	CSP, LFAA	Analysis

5.1.5.14 Pulsar search output

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2898	SKA1_Low Pulsar Search Candidates SKA1_Low, when performing the Pulsar Search, shall generate Pulsar Candidates and Non-imaging Transient Candidates as defined in TBD.	ECP-150004	CSP, SDP	Demonstration

5.1.5.15 Pulsar search sampling interval

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2917	SKA1_Low Pulsar search sampling interval SKA1_Low shall perform Pulsar Search and Single Pulse Search with on spectral channels with an effective time resolution shorter than 100 microseconds. (effective time resolution - full width at 10% maximum of the channeliser power response).	ECP-150004	CSP	Demonstration

5.1.5.16 SKA1_Low Pulsar search configurability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2918	SKA1_Low Pulsar Search Configurability 1 SKA1_Low, when commanded, shall perform the Pulsar Search with a configurable sampling interval that is 1, 2, 3 or 4 times the minimum sampling interval.	ECP-150004	CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2919	SKA1_Low Pulsar Search Configurability 2 SKA1_Low, when commanded, shall perform the Pulsar Search for a Pulsar Search beam with a configurable bandwidth from the full pulsar search bandwidth for that beam, down to 0.25 times that bandwidth.	ECP-150004	CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2920	SKA1_Low Pulsar Search Configurability 3 SKA1_Low shall restrict the choices of the sampling rate and bandwidth for Pulsar Search to integer sub-multiples of a the fundamental sampling rate.	ECP-150004	CSP, TM	Demonstration

This requirement is allow for natural bandwidths and sampling rates assuming some original digitisation rate.

5.1.6 SKA1_Low Pulsar Timing

5.1.6.1 SKA1_Low Pulsar timing spectral purity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3473	SKA1_Low Pulsar timing: spectral purity The spectral distortion of SKA1_Low Pulsar timing beams, compared to an ideal analogue beamformer provided with the same inputs, shall be no more than -60 dB in amplitude and 0.001 radians in phase.		CSP	Test

5.1.6.2 Pulsar timing subarray diameter

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2922	SKA1_Low Pulsar timing array diameter Each SKA1_Low subarray, when configured for Pulsar Timing, shall form pulsar timing beams using all stations within that sub-array, which are separated by at most 20 km.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.1.6.3 Pulsar timing observing band

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2924	SKA1_Low Pulsar timing observing band The SKA1_Low, when commanded, shall form beams for each of the Pulsar timing subarrays with a selectable observing band for each subarray anywhere in the SKA1_Low band.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.1.6.4 Pulsar timing bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2926	SKA1_Low Pulsar timing bandwidth The SKA1_Low, when performing Pulsar Timing, shall for each pulsar timing beam process a bandwidth which is independently selectable to a fixed granularity of *1 MHz ± 25%, up to the full bandwidth of the entire SKA1_Low band.*	ECP-150004	CSP	Test

5.1.6.5 Pulsar timing beamforming signal-to-noise performance

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2930	SKA1_Low Beamforming signal-to-noise ratio: Pulsar timing. The SKA1_Low, when forming pulsar timing beams, shall have a Signal to Noise ratio greater than or equal to 98% TBC of an ideal beam former, given the same digitized inputs and calibration.	ECP-150004	CSP, LFAA	Analysis

5.1.6.6 SKA1_Low pulsar timing beams: spatial offsets.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3530	SKA1_Low pulsar timing beams: spatial offsets. The spatial offset of each SKA1_Low pulsar timing beam from the imaging delay centre of the corresponding subarray shall be at most half of the half-power beam width of the corresponding station beam of that subarray, evaluated at the highest observing frequency used by the pulsar timing beam.		CSP,SDP	Analysis

5.1.6.7 Pulsar timing observation time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2954	SKA1_Low Pulsar timing observation time The observation duration for each SKA1_Low Pulsar timing subarray shall be set independently with a value between 10 seconds and 300 minutes with a granularity of 10 seconds.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.1.6.8 Pulsar timing time stamp

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2956	SKA1_Low: Pulsar timing time stamping Each SKA1_Low pulsar timing and dynamic spectrum measurement shall be directly traceable to the time at the common delay centre of the SKA1_Low telescope, with an accuracy of better than 2 nanoseconds (TBC).	ECP-150004	CSP, SADT, LFAA	Demonstration

5.1.6.9 Multiple simultaneous timings

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2940	SKA1_Low Pulsar timing beams The SKA1_Low pulsar timing beamformer shall be capable of forming multiple tied array beams within the same subarray, with the same sky coordinates and contiguous bandwidth.	ECP-150004, ECP-160043	CSP, TM	Analysis

To allow timing of multiple pulsars nominally at the same location/beam, for example within a globular cluster.

5.1.6.10 Pulsar timing dispersion measure

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2958	SKA1_Low Pulsar timing Dispersion Measure. The SKA1_Low, when commanded, shall time Pulsars with dispersion measures between 0 to 3000 pc cm $^{-3}$ such that residual dispersive smearing is less than 500 ns or as limited by the precision of the supplied dispersion measure.	ECP-150004, ECP-150030	CSP	Analysis

5.1.6.11 SKA1_Low Pulsar timing resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2962	SKA1_Low Pulsar Timing Resolution The SKA1_Low, when commanded to time a pulsar, shall resolve that pulsar's pulse profile with up to 2048 equal-width, contiguous phase bins with the minimum possible phase bin width being no longer than 2.5 micro sec.	ECP-150004, ECP-150030	CSP, LFAA	Test

Rationale in support document for ECP 150030: "SKA1 Pulsar Timing Resolutions - Ewan Barr & Willem van Straten -Nov 4th 2015"

5.1.6.12 SKA1_Low Pulsar timing Pulsar period

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3546	SKA1_Low Pulsar timing: pulsar period. The SKA1_Low, when commanded, shall time Pulsars with periods between 0.4 milliseconds and 20 seconds.		CSP	Test

Rationale provided in support document for ECP-150030 "SKA1 Pulsar Timing Resolutions - Ewan Barr, Willem van Straten- Nov 4th 2015"

5.1.6.13 Dynamic Spectrum

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3196	SKA1_Low Dynamic spectrum. The SKA1_Low, when commanded, shall produce a dynamic spectrum for one or more pulsar timing beams, recording the amplitude of the signal as a function of time, frequency, and polarisation.	ECP-150011	SDP, CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3202	SKA1_Low Dynamic spectrum and Pulsar timing total beams. SKA1_Low, when commanded, shall simultaneously form and process data from up to a total of16 dual-polarization pulsar timing beams for pulsar timing and dynamic spectrum processing.	ECP-150011	SDP, CSP, TM, SADT	Test

This constrains the total number of pulsar timing beams, summed across all subarrays, at any given time.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3531	SKA1_Low dynamic spectrum parameterization. The spectral and temporal resolution of each SKA1_Low dynamic spectrum shall be independently selectable, within the limitations imposed jointly by the corresponding pulsar timing beam's spectral and temporal responses.		SDP, CSP, TM	Test

5.1.7 SKA1_Low transient capture

SKA1_Low transient capture are ring buffers that store Station level data. Once a fast transient is detected in the Non-Image Processing single pulse search the transient buffer data will be stored as quickly as is possible. It is imperative that the dumping of the transient buffers occurs as quickly as possible to allow for quick reaction to fast transient events and multi-wavelength and multi-messenger triggers.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3081	SKA1_Low Transient buffer SKA1_Low, when commanded, shall generate and respond to real-time internal triggers by storing digitized voltage data, with 2-bit or better sampling, for at least 300 MHz of contiguous, tuneable observed bandwidth in both polarizations, from every station within the triggering subarray, covering at least 10 seconds before (TBC) and at least 500 seconds after (TBC) the triggering event.	ECP-140026	LFAA, CSP, TM , SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3082	SKA1_Low transient capture latency The SKA1_Low shall have a system latency of at most 900 seconds from the time that the highest frequency component of a transient signal arrives at the telescope to the time when the transient buffer is forwarded for storage.	ECP-140026	LFAA, CSP,SDP, TM SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3083	SKA1_Low transient archiving The SKA1_Low shall have the capacity of archiving at least 150 terabytes of transient buffer data per day.	ECP-140026	SDP, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3524	SKA1_Low transient buffer: single-pulse trigger When commanded, SKA1_Low shall archive all or part of the transient buffer based on the results of single-pulse searches, independently for each subarray.		LFAA, CSP, SDP, TM, SADT	Demonstration

5.1.8 SKA1_Low VLBI

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3578	SKA1_Low VLBI time stamping Each SKA1_Low VLBI data sample shall be directly traceable to the time at the common delay centre of the SKA1_Low telescope, with an accuracy of better than 2 nanoseconds.	ECP-160040	CSP, SADT, LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3579	SKA1_Low S/N Performance The SKA1_Low, when forming VLBI beams, shall have a signal-to-noise performance better than 90% of that achievable by an ideal signal chain, given the same inputs, instrumental calibration and excluding RFI.	ECP-160040	CSP, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3580	SKA1_Low VLBI beams sampling rate SKA1_Low, when forming VLBI beams, shall output them with a sampling rate selectable between Nyquist and at least a factor of two oversampling for the selected bandwidth.	ECP-160040	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3581	SKA1_Low Beamforming weights SKA1_Low, when commanded, shall weight the Field Station beams, which are inputs into the VLBI tied-array sums, based on relative sensitivity and coherence losses.	ECP-160040	CSP, TM, SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3582	SKA1_Low Configurability SKA1_Low, when commanded, shall change the pointing, centre frequency, and bandwidth of each VLBI tied-array beam independently, on scan boundaries.	ECP-160040	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3583	SKA1_Low Independently configurable beams SKA1_Low, when commanded, shall provide, through configuration, 1, 2, 3, or 4 separate VLBI specific beams, each with independently selectable centre frequency, bandwidth, frequency resolution and pointing.	ECP-160040	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3584	SKA1_Low VLBI configurability SKA1_Low shall, when commanded, reconfigure the centre frequency, frequency band, and bandwidth for each VLBI beam, in less than 30 seconds.	ECP-160040	CSP, TM, SADT	Test

Need to specify scan boundaries to avoid the prospect of continual changes during individual scans.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3585	SKA1_Low VLBI spectral resolution SKA1_Low shall, when commanded, generate VLBI beams with a spectral resolution different from the spectral resolution used for imaging within the same subarray.	ECP-160040	CSP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3586	SKA1_Low VLBI channel width SKA1_Low shall be able to generate VLBI beam data with a selectable channel width of: 256, 128, 64, 32, 16, 8, 4, 2, or 1 MHz TBC.	ECP-160040	CSP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3587	SKA1_Low VLBI imaging and beamforming SKA1_Low, when commanded, shall simultaneously generate both VLBI beams and SKA1_Low imaging data for all polarization products and all baselines (including autocorrelations) with a spectral resolution no worse than 1 MHz, covering at least the larger of 100 MHz TBC or the frequency range(s) covered by the VLBI beam(s) within the associated subarray.	ECP-160040	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3588	SKA1_Low VLBI out-of-channel rejection SKA1_Low, when commanded, shall generate VLBI beams with a transition band that is monotonically decreasing from -3dB at the channel edge, to -60dB at a frequency offset from the centre frequency by the channel bandwidth.	ECP-160040	CSP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3589	SKA1_Low VLBI beams and subarrays SKA1_Low shall be able to allocate individual VLBI beams to different subarrays.	ECP-160040	CSP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3590	SKA1_Low VLBI reference position The SKA1_Low VLBI array phase centre shall be within 100km (TBC) of one of the SKA1_Low stations.	ECP-160040	CSP, TM, SDP	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3591	SKA1_Low VLBI: spectral purity Spectral distortion, after calibration, for SKA1_Low VLBI shall be below: • -30dB in amplitude • 0.01 radians in phase.	ECP-160040	CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3606	SKA1_Low VLBI number of beams The SKA1_Low correlator shall have the capability of producing 4 dual polarisation tied-array VLBI beams TBC for one SKA1_Low sub-array.	ECP-160040	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3607	SKA1_Low VLBI array diameter The SKA1_Low correlator shall be capable of forming 4 beams TBC across all stations within the VLBI sub-array to a distance of up to 100,000 TBC metres from the sub-array centre.	ECP-160040	CSP	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3608	SKA1_Low VLBI beam centre frequency The SKA1_Low VLBI beams shall have a centre frequency selectable anywhere within the SKA1_Low observing band.	ECP-160040	CSP	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3609	SKA1_Low VLBI beam bandwidth The SKA1_Low VLBI beams shall have a contiguous processing bandwidth up to the full bandwidth of the SKA1_Low array.	ECP-160040	CSP	Analysis

5.2 Reflector Antennas

5.2.1 Diameter

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2153	Diameter. SKA1 dishes shall have a projected diameter of larger than 15m and smaller than 16.5m.		DSH, CSP, SDP	Inspection

CSP, TM, and SDP will need to know the dish diameter (at minimum) to figure out residual delays and the required update rates for those. SDP presumably has to know the dish diameter (at minimum) to figure out the size of the data processing problem.

5.2.2 Aperture efficiency

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2155	Aperture Efficiency. For SKA1_Mid aperture efficiency, while operating under Precision and Standard environmental conditions, shall be above a lower limit linearly interpolated between the following specification points: • 60% at 350MHz • 65% at 400MHz • 78% from 600MHz to 8000MHz • 70% from 8 to 15 GHz • 65% from 15 to 20 GHz Aperture efficiency is the ratio of the maximum effective area to the physical aperture area (these are terms defined in IEEE Std 145 where the same ratio is referred to as Antenna Efficiency) calculated for a Gaussian feed illumination pattern with taper chosen to maximize aperture efficiency.		DSH	Test

In the context of the requirement, this definition must employ a Gaussian illumination pattern with taper chosen to maximize aperture efficiency.

The topic of environmental conditions needs further attention.

5.2.3 Tracking

All terminology employed here are as defined in [R17] Dish Pointing, Motion Behaviour and Control SKA-TEL-SKO-0000438. In particular, Tracking performance affects the entire **Receptor** (defined term) and not just the reflector antennas in isolation.

5.2.3.1 Allowable Tracking Pointing Error

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3203	SKA1_Mid Receptor Instantaneous Blind Pointing Error Circle In Tracking Precision Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 36 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Precision Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3204	SKA1_Mid Receptor Instantaneous Blind Pointing Error Circle In Tracking Standard Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 72 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Standard Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3205	SKA1_Mid Receptor Instantaneous Blind Pointing Error Circle In Tracking Degraded Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 144 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Degraded Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3206	SKA1_Mid Receptor RMS Blind Pointing Error Circle In Tracking Precision Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 9 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration under Precision Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3207	SKA1_Mid Receptor RMS Blind Pointing Error Circle In Tracking Standard Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 18 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Standard Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3208	SKA1_Mid Receptor RMS Blind Pointing Error Circle In Tracking Degraded Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 36 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Degraded Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3209	SKA1_Mid Receptor Instantaneous Online Pointing Error Circle In Tracking Precision Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 20 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Precision Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Test

From [R17] par 8.2.3: “For the purposes of design, a precise definition of the calibration process for the On-line Pointing Model is required so that the requirements can be verified”. The required calibration process still needs to be developed and proven on L1.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3210	SKA1_Mid Receptor Instantaneous Online Pointing Error Circle In Tracking Standard Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 40 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Standard Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Test

From [R17] par 8.2.3: "For the purposes of design, a precise definition of the calibration process for the On-line Pointing Model is required so that the requirements can be verified". The required calibration process still needs to be developed and proven on L1.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3211	SKA1_Mid Receptor Instantaneous Online Pointing Error Circle In Tracking Degraded Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 80 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Degraded Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Test

From [R17] par 8.2.3: "For the purposes of design, a precise definition of the calibration process for the On-line Pointing Model is required so that the requirements can be verified". The required calibration process still needs to be developed and proven on L1.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3212	SKA1_Mid Receptor RMS Online Pointing Error Circle In Tracking Precision Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 5 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Precision Observing condition.	ECP-160008 [E17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Analysis

From [E17] par 8.2.3: "For the purposes of design, a precise definition of the calibration process for the On-line Pointing Model is required so that the requirements can be verified". The required calibration process still needs to be developed and proven on L1.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3213	SKA1_Mid Receptor RMS Online Pointing Error Circle In Tracking Standard Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 10 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Standard Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Analysis

From [R17] par 8.2.3: "For the purposes of design, a precise definition of the calibration process for the On-line Pointing Model is required so that the requirements can be verified". The required calibration process still needs to be developed and proven on L1.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3214	SKA1_Mid Receptor RMS Online Pointing Error Circle In Tracking Degraded Mode When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 20 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Degraded Observing condition.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	SDP, TM	Analysis

From [R17] par 8.2.3: "For the purposes of design, a precise definition of the calibration process for the On-line Pointing Model is required so that the requirements can be verified". The required calibration process still needs to be developed and proven on L1.

5.2.3.2 Tracking Elevation Range

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3215	SKA1_Mid Receptor elevation motion ranges while tracking While tracking, SKA1_Mid receptor elevation motion range shall be within 15 to 85 degrees.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3216	SKA1_Mid Receptor azimuth motion ranges while tracking While tracking, SKA1_Mid receptor azimuth motion range shall be within -270 to 270 degrees.	ECP-160008 [R17] & par 9 Table 7, 12.1.2.4 Table 20,21	DSH, SDP, TM	Test

5.2.3.3 Relative Pointing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3217	SKA1_Mid Receptor relative Pointing error circle while tracking precision mode The SKA1_Mid Receptor pointing Error Circle diameter, within a time interval of 100 seconds and between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 6.5 (arcsec), under Precision Observing condition.	ECP-160008 [R17] & par 8.6.1 & par 9	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3218	SKA1_Mid Receptor relative Pointing error circle while tracking Standard mode The SKA1_Mid Receptor pointing Error Circle diameter, within a time interval of 100 seconds and between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 13 (arcsec), under Standard Observing condition.	ECP-160008 [R17] & par 8.6.1 & par 9	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3219	SKA1_Mid Receptor relative Pointing error circle while tracking Degraded mode The SKA1_Mid Receptor pointing Error Circle diameter, within a time interval of 100 seconds and between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 26 (arcsec), under Degraded Observing condition.	ECP-160008 [R17] & par 8.6.1 & par 9	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3220	SKA1_Mid Receptor RMS Relative Pointing Error Circle while Tracking Precision Mode The SKA1_Mid Receptor RMS Relative Pointing Error, within a time interval of 100 seconds under Standard conditions and computed between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 1.3 (arcsec) RMS, under Precision Observing condition.	ECP-160008 [R17] & par 8.6.6 & par 9	DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3221	SKA1_Mid Receptor RMS Relative Pointing Error Circle while Tracking Standard Mode The SKA1_Mid Receptor RMS Relative Pointing Error, within a time interval of 100 seconds under Standard conditions and computed between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 2.6 (arcsec) RMS, under Standard Observing condition.	ECP-160008 [R17] & par 8.6.6 & par 9	DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3222	SKA1_Mid Receptor RMS Relative Pointing Error Circle while Tracking Degraded Mode The SKA1_Mid Receptor RMS Relative Pointing Error, within 100 seconds under Degraded conditions and computed between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 5.2 (arcsec) RMS, under Degraded Observing condition.	ECP-160008 [R17] & par 8.6.6 & par 9	DSH	Analysis

5.2.3.4 Tracking Stability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3223	SKA1_Mid Receptor Instantaneous Tracking stability while tracking in precision mode The SKA1_Mid Receptor pointing Error Circle diameter, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 9 (arcsec), under Precision Observing condition.	ECP-160008 [R17] & par 8.2.5 & Table 7	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3224	SKA1_Mid Receptor Instantaneous Tracking stability in Standard mode The SKA1_Mid Receptor pointing Error Circle diameter, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 18 (arcsec), under Standard Observing condition.	ECP-160008 [R17] & par 8.2.5 & Table 7	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3225	SKA1_Mid Receptor Instantaneous Tracking stability in Degraded mode The SKA1_Mid Receptor pointing Error Circle diameter, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 36 (arcsec), under Degraded Observing condition.	ECP-160008 [R17] & par 8.2.5 & Table 7	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3226	SKA1_Mid Receptor RMS Tracking stability in precision mode The SKA1_Mid Receptor RMS Relative Pointing Error, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 2.3 (arcsec) RMS, under Precision Observing condition.	ECP-160008 [R17] & par 8.2.5 & Table 7	DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3227	SKA1_Mid Receptor RMS Tracking stability in Standard mode The SKA1_Mid Receptor RMS Relative Pointing Error, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 4.6 (arcsec) RMS, under Standard Observing condition.	ECP-160008 [R17] & par 8.2.5 & Table 7	DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3228	SKA1_Mid Receptor RMS Tracking stability in Degraded mode The SKA1_Mid Receptor RMS Relative Pointing Error, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 9.2 (arcsec) RMS, under Degraded Observing condition.	ECP-160008 [R17] & par 8.2.5 & Table 7	DSH	Analysis

5.2.3.5 Tracking Speed

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3229	SKA1_Mid Receptor Maximum tracking Speed in Azimuth The SKA1_Mid Receptor maximum Azimuth speed during Tracking shall be 0.3 deg/sec.	ECP-160008 [R17] & par 9 Table 7	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3230	SKA1_Mid Receptor Maximum tracking speed in elevation The SKA1_Mid Receptor maximum elevation speed during Tracking shall be 0.08 deg/sec.	ECP-160008 [R17] & par 9 Table 7	DSH	Test

5.2.4 Slewing

5.2.4.1 Maximum Slew Rates

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3231	SKA1_Mid Receptor Maximum elevation slew speed rate The SKA1_Mid Receptor shall be capable of slewing in elevation at a rate of 1 deg/sec under Precision and Standard Operating Conditions. Degradation of up to 50% will be allowed under Extreme or Degraded Operating Conditions.	ECP-160008 [R17] & par 8.6.3	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3232	SKA1_Mid Receptor Maximum Azimuth slew speed rate The SKA1_Mid Receptor shall be capable of slewing in azimuth at a rate of 3 deg/sec under Precision and Standard Operating Conditions. Degradation of up to 50% will be allowed under Extreme or Degraded Operating Conditions.	ECP-160008 [R17] & par 8.6.3	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3233	SKA1_Mid Receptor Simultaneous slew speed rates The SKA1_Mid Receptor shall be able to achieve maximum azimuth and elevation slew rates simultaneously.	ECP-160008 [R17] & par 8.6.3	DSH	Test

5.2.5 Number of receivers

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2162	Number of feeds. There shall be space at the Gregorian focus of SKA1_Mid dishes for five single pixel feeds (SPF).		DSH	Inspection

5.2.6 Provision for Phase Array Feed, PAF

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3077	SKA1_Mid provision for Phased Array Feed SKA1_Mid DSH shall make mechanical and optical provision on the structure to exchange the SPF Band 1 with a PAF. The PAF shall be constrained to a physical size of a cylindrical volume with of maximum diameter of TBD m and a maximum depth of TBD m and a maximum mass of TBD kg.	Root	DSH	Inspection

5.2.7 Polarisation purity

The polarisation purity of reflector antenna shall be expressed by using the intrinsic polarisation ratio (IXR). It will give coordinate system independent FoM of the polarisation purity and quantify the polarimetric performances even after the calibration.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2165	SKA1_Mid Cross Polarisation Purity The intrinsic cross polarisation ratio, IXR, for SKA1 Mid shall be better than 15 dB over the whole observing bandwidth within the HPBW.	ECP-150004	DSH	Test

This requirement refers to the IXR of the Dish and is pre calibration. A separate downstream post calibration IXR is defined.

5.2.8 Elevation limit

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2170	Elevation limit. The SKA1_Mid shall operate at all elevations greater than 15 degrees.		DSH, TM, SDP	Demonstration

The original objective for this requirement was associated with dish. However elements need to know this information in order to do their job. E.g., the elevation limit determines the approximations that can be used in determining opacity, and for atmospheric refraction. TM must also enforce these limits in software at some level.

5.2.9 Azimuth range

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2171	Azimuth range. The SKA1_Mid shall have a continuous useable azimuth observation range from -270° to +270°, inclusive measured relative to true North defined as 0° and with East defined as +90°.		DSH, TM, SDP	Demonstration

SKA1_Mid SDP and TM need to know this information as well as Dish in order to do their job hence the allocations.

5.3 SKA1_Mid

5.3.1 SKA1_Mid configuration and performance

5.3.1.1 Inclusion of MeerKAT

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2833	SKA1_Mid inclusion of MeerKAT The SKA1_Mid shall incorporate the 64 MeerKAT receptors *so that each one individually may be treated as functionally equivalent to the SKA1_Mid dishes.*		SADT, CSP, SDP, TM, INFRA, AIV	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2173	Monitor and control of MeerKAT SKA1 MID Telescope Manager shall be able to control and Monitor all MeerKAT Receptors independently.		SADT, INFRA, TM. AIV	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3535	Inclusion of MeerKAT in SKA1_Mid tied-array beams SKA1_Mid, when commanded, shall include both MeerKAT and SKA1 dishes in any or all tied-array beam sums.		AIV, CSP	Demonstration

5.3.1.2 Absolute flux scale

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2825	Absolute flux density scale standard weather conditions The SKA1_Mid, under standard weather conditions, shall have an absolute flux density scale accurate to better than 5% across the band.	Established Precedent	DSH, CSP, SDP, TM	Test and analysis

It is envisioned test at several distributed points across the band with an analysis to interpolate across the full band. The **Flux density scale** is transferred from a celestial calibrator to the target source. It includes the atmospheric extinction as well as all receptor-based system temperatures and gains.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2826	Absolute flux density scale under precision weather conditions The SKA1_Mid, under precision weather conditions, shall have an absolute flux density scale accurate to better than 3% across the band. It is envisioned test at several distributed points across the band with an analysis to interpolate across the full band. The **Flux density scale** is transferred from a celestial calibrator to the target source. It includes the atmospheric extinction as well as all receptor-based system temperatures and gains.	Established Precedent	DSH, CSP, SDP, TM	Test and analysis

It is envisioned test at several distributed points across the band with an analysis to interpolate across the full band.

5.3.1.3 SKA1_Mid spectral stability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3458	SKA1_Mid spectral stability The bandpass of SKA1_Mid, on timescales of 600 seconds or less and for all processed bandwidths, post-calibration and RFI mitigation, shall be stable to better than 0.03%.	SKA Error Budgets [R18]	DSH, CSP, SDP	Test

5.3.1.4 SKA1_Mid configuration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2174	Combined SKA1_Mid configuration. The SKA1_Mid shall have the configuration defined in the SKA1_Mid Configuration Co-ordinates document [AD5].	Mid Configuration Co-ordinates Document [AD5]	SADT, INFRA, DSH, SDP	Inspection

5.3.1.5 SKA1_Mid maximum baseline length between dishes

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3072	SKA1_Mid maximum baseline length between dishes The maximum distance between SKA1_Mid (including MeerKAT) Receptors shall be at most 160km.	SKA-TEL-INSA-0000537 [AD7]	INFA, CSP, SDP	Inspection

5.3.1.6 SKA1_Mid sensitivity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3064	SKA1_Mid Sensitivity Band 1 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid array (excluding the MeerKAT array), while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization above a line that increases linearly from 272 m^2/K at 350 MHz to 545 m^2/K at 650 MHz and then stays constant at this level up to 1050 MHz over pointing angles from zenith down to 30° above the horizon. Sky temperature is defined for a feed with boresight directed towards an elevation angle where ground illumination is minimized, observed at a time when no significant sources appear within the beam.		DSH, CSP	Test

Reference to the MID Interferometric Array Sensitivity Budget Document Number SKA-TEL-SKO-0000633.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3065	SKA1_Mid Sensitivity Band 2 Assuming a sky noise temperature defined in the definitions section of this document, Mid Band 2, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 916 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the unweighted average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.		DSH, CSP	Test

Reference to the MID Interferometric Array Sensitivity Budget Document Number SKA-TEL-SKO-0000633.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3066	SKA1_Mid Sensitivity Band 3 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 3, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than916 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the unweighted average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.		DSH, CSP	Test

Reference to the MID Interferometric Array Sensitivity Budget Document Number SKA-TEL-SKO-0000633.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3067	SKA1_Mid Sensitivity Band 4 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 4, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 833 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the unweighted average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.		DSH, CSP	Test

Reference to the MID Interferometric Array Sensitivity Budget Document Number SKA-TEL-SKO-0000633.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3614	SKA1_Mid Sensitivity Band 5a Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 5a, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 1110 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	ECP-160022	DSH, CSP	Test

Reference to the MID Interferometric Array Sensitivity Budget Document Number SKA-TEL-SKO-0000633.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3615	SKA1_Mid Sensitivity Band 5b Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 5b, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 805 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	ECP-160022	DSH, CSP	Test

Reference to the MID Interferometric Array Sensitivity Budget Document Number SKA-TEL-SKO-0000633.

5.3.1.7 SKA1_Mid polarisation dynamic range: Imaging

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2965	SKA1_Mid polarisation dynamic range: imaging SKA1_Mid shall provide 40 dB polarisation dynamic range at all fractional bandwidths across the full band for the field of view to the half power band width.	Science Requirements SKA-TEL-SKO-0000007 Appendix A	CSP, SDP, TM, DSH	Test

Polarisation dynamic range is defined here as the ratio of peak Stokes I brightness to the residual instrumental polarised response, I/ΔP, at the source location. Specified values apply to both the target pointing direction as well as everywhere within the half power point of the dish or station beam.

5.3.1.8 SKA1_Mid Polarisation dynamic range: Pulsar Search

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3075	SKA1_Mid Pulsar Search: Polarisation purity SKA1_Mid, when performing Pulsar Search, shall provide better than 25 dB polarisation purity across tied array beams for the configured bandwidth.	Science Requirements SKA-TEL-SKO-0000007 Appendix A	CSP, SDP, TM, DSH	Test

5.3.1.9 SKA1_Mid Polarisation dynamic range: Pulsar Timing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3076	SKA1_Mid Polarisation dynamic range: Pulsar Timing SKA1_Mid, when performing Pulsar Timing, shall provide better than 40 dB polarisation dynamic range across tied array beams for the configured bandwidth.	Science Requirements SKA-TEL-SKO-0000007 Appendix A	DSH, CSP, SDP, TM	Test

5.3.1.10 SKA1_Mid brightness dynamic range

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3460	SKA1_Mid brightness dynamic range SKA1_Mid shall provide at least 60 dB brightness dynamic range at 0.5 arcsec spatial and 1 MHz spectral resolution.		DSH, CSP, TM, SDP	Test

5.3.1.11 Frequency agility

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2224	SKA1_Mid frequency agility. The SKA1_Mid, when commanded, shall change from observing in any frequency band, to observing in any other frequency band in: • Less than 10 s from any band to band 5a or band 5b • Less than 20s between all other bands.	ECP-160008, ECP-160022	CSP, SDP, TM, DSH	Demonstration

5.3.1.12 SKA1_Mid calibration transfer

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3453	SKA1_Mid calibration transfer When commanded, SKA1_Mid shall transfer calibration seamlessly across frequency changes, band changes, and/or source changes, such that the any change in calibration due to the telescope (as compared to the environment or the source) shall be less than 0.1% in amplitude and 0.001 radians in phase on timescales of TBD minutes.		DSH, LFAA, SADT, SDP, CSP	Test

5.3.1.13 SKA1_Mid Common delay centre time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3293	SKA1_Mid common delay centre time Each SKA1_Mid subarray shall have a common delay centre at or near its centre with a time accurate to the SKA timescale and a precision of better than 2ns (1σ) over periods of one observation and at least 10 years.	ECP-160043	CSP, TM, SaDT	Test

5.3.1.14 Excess thermal noise

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3566	Source of excess thermal noise The SKA1_Mid Telescope shall have a source of excess thermal noise (e.g. a noise diode), that is injected into the signal path and can be turned ON and OFF independently for each receptor.	ECP-160038	DSH,TM	Test

Noise injection is used for calibration purposes. The possibility to independently operate it on each receptor introduces a flexibility that allows to implement uncorrelated scheme of injection.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3567	Bandwidth of excess thermal noise sources The SKA1_Mid excess thermal noise signal, when commanded ON for a given Receptor, shall occupy the entire bandwidth of the selected Band.	ECP-160038	DSH	Test

The source must have its power distributed across the observed bandwidth so that proper band calibration can happen.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3568	Periodic switching of excess thermal noise sources The SKA1_Mid excess thermal noise sources, when commanded to do periodic firing, shall support configurable switching cycles with a minimum dwell time of not more than 5 microsec and a maximum dwell time of not less than 5 sec.	ECP-160038	DSH, CSP, TM	Test

The firing frequencies must be able to reach the 100 kHz in order to support the commensality of imaging and pulsar search observations. The seed for the pseudo-random generator must be configurable, so that the pattern can be predicted. See SKA-TEL-SKO-0000663.

Notes:

- dwell time excludes transition periods.
- at 50% duty cycle this achieves 100 kHz if dwell time includes rise & fall time, or 50 kHz if rise & fall time is excluded.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3569	Excess thermal noise phase Imbalance When ON, the unbalance between the signal injected in the SKA1_Mid Telescope Receptors in each polarisation by the excess thermal noise sources shall be less than 1.5 degree in phase, between the coupling points.	ECP-160038	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3570	Excess thermal noise phase stability When operating, the phase unbalance of SKA1_Mid telescope calibration signal, between the two orthogonal polarisations, shall remain stable to < 0.3° RMS, measured over time, at any frequency in the band.	ECP-160038	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3571	Pseudo-random firing of excess thermal noise sources SKA1_Mid, when commanded to do pseudo-random firing, shall inject excess thermal noise following a pseudo-random ON-OFF pattern, with a pattern seed that is independently programmable per receptor.	ECP-160038	DSH, CSP, TM	Test

SKA-TEL-SKO-0000659 establishes that this requirement is needed for commensality of imaging and pulsar observations. The seed for the pseudo-random generator must be configurable, so that the pattern can be predicted.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3572	Frequency resolution of measurement of the excess thermal noise source The SKA1_Mid measurement of the excess thermal noise source signals shall have a frequency resolution of 10 MHz or finer.	ECP-160038	SDP, CSP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3573	Noise source duty cycle The SKA1_Mid excess thermal noise ON as well as the OFF state shall be independently programmed.	ECP-160038	DSH,TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3574	Noise source periodic switching pattern The SKA1_Mid, when commanded to do periodic firing, shall inject excess thermal noise with duty cycles ranging from 5 to 50% that is independently programmable per receptor.	ECP-160038	DSH,TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3575	Noise source transition period None of the transitions (ON-OFF or OFF-ON) of the calibration signal, measured from the edge of the accompanying status flags till the calibration signal reaches within 10% of its final value, shall exceed 5 microsec.	ECP-160038	DSH	Test

Need for a sharp ON to OFF and OFF to ON transition to minimise impact on SNR, and lower impact on calibration.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3576	Excess thermal noise source power level — standard observing When ON, the SKA1_Mid excess thermal noise sources shall contribute between 5 and 15% of Tsys when the noise source is OFF, at all frequencies within the observed bandwidth of the selected Band, averaged over any 1 MHz bandwidth across the specified frequency range and with Tsys computed for Cold sky at the lowest specified elevation angle.	ECP-160038	DSH	Test

Absolute power level of excess thermal noise source. Can't be too high (or it will dominate the system), can't be too low (or the system will not be sensitive to the noise source). The standard observing indicates not extremely bright sources, e.g. the Sun. See SKA-TEL-SKO-0000633.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3577	Excess thermal noise source stability The SKA1_Mid excess thermal noise source output level shall remain stable so that its standard deviation, computed from samples integrated over 10 MHz and 500 milliseconds, shall not exceed 0.05% over intervals extending up to 30 minutes, and 1% on timescales up to 1 week.	ECP-160038	DSH	Test

Introduced in SKA-TEL-SKO-0000675. Essentially a worst case limit which permits the cal signal fluctuations to not beat down as 1/sqrt(time), while still yielding solutions that compare favourably to self-cal on a 10 mJy source (sigma_g/g ~0.1% over 10 MHz & 30 minutes, for MID).

5.3.2 SKA1_Mid antenna

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2712	SKA1_Mid antenna The SKA1_Mid array shall consist of 133 Receptors plus 64 MeerKAT receptors centred in the same location as the MeerKAT array.		SADT, INFRA, DSH	Inspection

5.3.3 Dish RF system

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2179	Dish RF system. Each Receptor of SKA1_Mid shall produce data from at most a single frequency band at any one time.		DSH, TM, CSP, SDP	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3392	SKA1_Mid phase calibration stability against band changes There shall be no change in phase in any band induced by intervening band changes.	ECP-160068	DISH	Test

The telescope is capable to return to previous calibrated states so band changing doesn't require a new calibration.

5.3.3.1 RF system frequency range band 1

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2180	RF system frequency range band 1 The SKA1_Mid Receptors, when the band 1 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 0.35 to 1.050 GHz for each polarisation.		DSH	Test

5.3.3.2 RF system frequency range band 2

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2181	RF system frequency range band 2 The SKA1_Mid receptors, when the band 2 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 0.95 to 1.76 GHz for each polarisation.		DSH	Test

5.3.3.3 RF system frequency range band 3

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2182	RF system frequency range band 3 The SKA1_Mid Receptors, when the band 3 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 1.65 to 3.05 GHz for each polarisation.		DSH	Test

5.3.3.4 RF system frequency range band 4

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2183	RF system frequency range band 4 The SKA1_Mid Receptors, when the band 4 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 2.80 to 5.18 GHz for each polarisation.		DSH	Test

5.3.3.5 RF system frequency range band 5

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3612	RF system frequency range band 5a The SKA1_Mid receptors, when the band 5a capability is selected, shall be able to receive condition and digitise signals over a frequency range from 4.6 to 8.5 GHz for each polarisation.	ECP-160022	DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3613	RF system frequency range band 5b The SKA1_Mid receptors, when the band 5b capability is selected, shall be able to receive condition and digitise signals over a frequency range from 8.3 to 15.4 GHz for each polarisation.	ECP-160022	DSH	Test

5.3.3.6 RF system sampled bandwidth band 1

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2185	RF system sampled bandwidth band 1 The instantaneous sampled bandwidth for SKA1_Mid band 1 shall be 700MHz for each polarisation.		SADT, CSP, SDP, DSH	Test

5.3.3.7 RF system sampled bandwidth band 2

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2186	RF system sampled bandwidth band 2 The instantaneous sampled bandwidth for SKA1_Mid band 2 will be 810 MHz for each polarisation.		SADT, CSP, SDP, DSH	Test

5.3.3.8 RF system sampled bandwidth band 3

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2187	RF system sampled bandwidth band 3 The instantaneous sampled bandwidth for SKA1_Mid band 3 will be 1,400 MHz for each polarisation.		SADT, CSP, SDP, DSH	Test

5.3.3.9 RF system sampled bandwidth band 4

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2188	RF system sampled bandwidth band 4 The instantaneous sampled bandwidth for SKA1_Mid band 4 will be 2,380 MHz for each polarisation.		SADT, CSP, SDP, DSH	Test

5.3.3.10 RF system sampled bandwidth band 5

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2189	RF system sampled bandwidth band 5 The SKA1_Mid band 5a and band 5b, shall each provide two independent bands of 2.5 GHz for each polarisation, tuneable across the whole respective band's RF frequency range.	ECP-160022	SADT, CSP, SDP, DSH	Test

5.3.3.11 RF digitisation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2190	SKA1_Mid RF digitisation Digitisation for each polarisation of SKA1_Mid shall be: • band 1 - 8 effective number of bits • band 2 - 8 effective number of bits • band 3 - 6 effective number of bits • band 4 - at least 4 effective number of bits • band 5a - 2 streams of at least 3 effective number of bits • band 5b - 2 streams of at least 3 effective number of bits ***Where Effective Number of Bits (ENOB)*** is the number of bits that an ideal Analogue-to-Digital Converter provides between full scale input and the input-referred noise floor, excluding harmonic distortion & spurs. This relates to the actual number of bits from the Analogue-to-Digital Converter which may not correspond to the number of bits forwarded.	ECP-160022	SADT, CSP, DSH	Demonstration

The proposed amendment of this requirements aims at a clarification of the performance specification.

5.3.4 SKA1_Mid correlation

5.3.4.1 Auto-correlation spectra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3036	SKA1_Mid autocorrelation spectra SKA1_Mid, when commanded, shall generate full polarisation autocorrelation spectra from all receptors within a subarray, with characteristics matching those of the cross-correlation spectra.	ECP-140010, ECP-160043	CSP, SDP, TM	Demonstration

The statement about polarisation products is intended to allow for pulsar phase binning, where one can trade polarisation products for spectral channels and/or phase bins.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3046	SKA1_Mid autocorrelation calibration The SKA1_Mid, when commanded, shall generate autocorrelation spectra. Crosscorrelation spectra may be used as part of this calibration.	ECP-140010	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3038	SKA1_Mid continuum imaging The SKA1_Mid, when commanded, shall provide full Stokes polarisation products (I, Q, U, V) as part of all observing modes including Continuum Imaging.	ECP-140011	SDP, CSP, TM	Test

5.3.4.2 SKA1_Mid spectral resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2196	SKA1_Mid transition band for adjacent frequency channels The SKA1_Mid shall have a transition band for adjacent visibility spectra frequency channels that is monotonically decreasing from -3.01 dB (or better) at the channel edge, to -60 dB (or better) at the next adjacent channel centre frequency.	ECP-140009	CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2803	SKA1_Mid maximum leakage power for non-adjacent frequency channels The maximum noise leakage power for SKA1_Mid shall be better than -60 dB for non-adjacent fine frequency channels.	ECP-140009	CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2805	SKA1_Mid fine frequency channel amplitude variation The post-calibration amplitude response of SKA1_Mid imaging shall vary by at most +/-0.05 dB across the band.	SKA Error Budgets [R18]	CSP, DSH	Test

This applies to both wideband and narrowband signals. A narrowband signal swept across the band should give the same post-calibration total power regardless of where it appears. +/-0.05 dB is driven by CSP digital filter costs.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3297	SKA1_Mid Channelization Stability The spectral and temporal response of the individual SKA1_Mid visibility spectra frequency channels shall not change by more than 1% as a function of time, unless explicitly commanded to do so.		CSP, SDP	Demonstration

5.3.4.2.1 Full bandwidth resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2195	SKA1_Mid spectral channels For each subarray, SKA1_Mid, when commanded, shall form a fixed (but band-dependent) number of at least 51,180 and at most 65,536, linearly spaced frequency channels across the frequency band in total. For each of band 5a and band 5b, the total sampled bandwidth is 5 GHz (2 * 2.5 GHz).	ECP-140009, ECP-160022	CSP, SDP	Demonstration

Rationale: 51,180 channels for Band 4 allows significant cost savings within CSP.

5.3.4.2.2 Higher spectral resolution over limited bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2968	SKA1_Mid zoom windows. When commanded, for each subarray independently, the SKA1_Mid, shall produce correlated visibilities and autocorrelations for all polarization products for zoom imaging such that: 1. The total bandwidth across Zoom Windows is configurable up to that of the processed band in any variant of contiguous, overlapped or separated frequency coverage. 2. The maximum Zoom window bandwidth is 256 MHz + 35% 3. Zoom windows can each be individually configurable to one of 1, 1/2, 1/4, 1/8, 1/16, 1/32, or 1/64 of the maximum zoom window bandwidth. 4. Each zoom window contains at least between 14,000 and 16,384 linearly spaced frequency channels fully covering the zoom window bandwidth. 5. The number of simultaneously available windows in each sub-array is constrained by the available processing and communication resources within the telescope.	ECP-140009, ECP-170017	CSP, SDP, TM	Test

The available processing and communication resources will be dependent on other simultaneous observation allocations within the telescope with an over-all constraint defined by: standard imaging bandwidth of 5GHz or simultaneous 1500 beams PSS and 8 beams of PST of 2.4 GHz or 4 VLBI beams of 2.4 GHz.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2969	SKA1_Mid zoom window centre frequencies. Zoom windows for SKA1_Mid shall have centre frequencies which are independently selectable from each other with a step size within 0.01MHz, such that the full window is contained within the available frequency band and with the option of overlapping any or all windows. For Band 5 zoom windows are contained within the individual 2.5 GHz streams.	ECP-140009, ECP-160022, ECP-170017	CSP, SDP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2971	SKA1_Mid continuum with zoom windows. Whilst retaining the ability to operate simultaneously within all Bands to the extent that processing and communication resources are available, the SKA1_Mid shall, when commanded, generate up to the full frequency band at continuum resolution simultaneously with the zoom windows to provide a coarse context for the fine resolution.	ECP-140009, ECP-170017	CSP, SDP, TM	Test

The full frequency band at a continuum resolution is required simultaneously with the zoom windows to provide a coarse context for the fine resolution.

Where continuum resolution is configurable to around 10-3 of the imaging bandwidth and is implemented towards the back end of Science Data processing.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3050	SKA1_Mid zoom window noise leakage power. The maximum noise leakage power, for a flat passband and with no RFI, into SKA1_Mid Zoom Window channels from frequencies outside the window shall be less than 60dB.	ECP-140009, ECP-170017	CSP, DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3051	SKA1_Mid overlapped window amplitude response. The SKA1_Mid post-calibration amplitude response variation across the full concatenated bandwidth of overlapped zoom windows of the same frequency resolution shall be within +/-0.05 dB of the nominal.	ECP-140009	CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3463	SKA1_Mid zoom windows and subarrays SKA1_Mid shall, when commanded, configure zoom windows, and generate the corresponding data products, completely independently, for any and all subarrays.		CSP, SDP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3537	SKA1_Mid calibration transfer: zoom windows to/from standard spectral channels When commanded, for each subarray individually, SKA1_Mid shall transfer calibration between zoom windows and standard (non-zoom) spectral channels which are observed commensally, without introducing additional errors (beyond those of transferring calibration between different frequencies and/or times) above 0.1% in amplitude and 0.001 radians in phase.		CSP, SDP, TM	Test

Intended to allow "seamless" calibration transfer between zoom windows and "standard" spectral channels, to allow effective transfer of calibration between spectral line and continuum observations. Note that this should allow calibration transfer both for simultaneous observations (e.g., imaging a weak galaxy with a very strong maser) and calibration transfer (e.g., using a maser source to calibrate continuum imaging of a nearby weak YSO).

5.3.4.3 SKA1_Mid correlation signal to noise

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2679	SKA1_Mid correlation signal to noise The SKA1_Mid correlation shall maintain the Signal to Noise ratio better than 98% for Bands 1, 2, 3 and 4 and at least 96% or better for each of band 5a and band 5b, compared to ideal analogue correlation for the same inputs.	ECP-160022	CSP	Analysis

This is only allocated to CSP, and does not include initial quantization losses in the ADC.

5.3.4.4 SKA1_Mid polarisation flags

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3538	SKA1_Mid Polarization flags: visibilities When flagging on timescales shorter than the correlation integration time, SKA1_Mid shall flag all polarizations and polarization products if any are found to be bad.		CSP	Demonstration

This allows the use of a single TCI (time centroid) for each such integration.

5.3.4.5 SKA1_Mid correlation integration time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2197	SKA1_Mid correlation integration period The minimum visibility integration period for each SKA1_Mid subarray shall be independently configurable, with allowed values being an integer multiple of 0.14 seconds to a maximum of 1.4 seconds.	ECP-160043	CSP, SDP	Demonstration

5.3.4.6 SKA1_Mid correlator Pulsar binning

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2616	SKA1_Mid pulsar phase binning The SKA1_Mid, for each subarray, shall allow for pulse phase-resolved observations supporting the product of the number of phase bins, channel and polarisation products up to 262,144 (e.g. 4 x 65,536).	ECP-160043	CSP, SDP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2830	SKA1_Mid Pulsar phase bin width SKA1_Mid, when producing phase-binned correlations, shall provide individual phase bins with widths as small as 1 microsecond.		CSP	Test

Rationale: 256 phase bins for a 0.4 msec period corresponds to 1.6microsec phase bins. Note that the impulse response of the filter may be much longer than the phase bin width, for some choices of channel width.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2831	SKA1_Mid Pulsar phase bin synchronisation The SKA1_Mid shall be capable of synchronising phase bins to the ephemeris to limit drift to less than 10% of the selected bin width within the selected correlator integration period.		CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3464	SKA1_Mid maximum number of phase bins SKA1_Mid, when commanded, shall produce phase-binned visibilities with a maximum of 256 phase bins.		CSP, TM, SDP	Demonstration

Some limit is very helpful here.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3465	SKA1_Mid distribution of phase bins SKA1_Mid shall when commanded produce phase-binned visibilities with equal-temporal-width, contiguous phase bins spaced linearly in pulsar longitude.		CSP, TM, SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3466	SKA1_Mid phase bins: continuous coverage The use of phase bins on SKA1_Mid shall not lead to the loss of any additional time on-source during the phase-binning observations.		CSP	Demonstration

5.3.4.7 Inclusion of MeerKAT into SKA1_Mid Correlation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2740	Inclusion of MeerKAT in SKA1_Mid correlation. SKA1_Mid, when commanded, shall form real-time cross-correlation products between all dishes within the SKA1_Mid combined array, including between MeerKAT and SKA1 dishes.		AIV, CSP	Demonstration

5.3.5 SKA1_Mid VLBI

The VLBI community indicate there should be at least 4 beams generated for VLBI usage: one for target and three for calibrators to establish calibration plane.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3292	SKA1_Mid VLBI time stamping Each SKA1_Mid VLBI data sample shall be directly traceable to the time at the common delay centre of the SKA1_Mid telescope, with an accuracy of better than 2 nanoseconds.		CSP, SADT, DSH	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2689	SKA1_Mid VLBI: number of beams SKA1_Mid, when commanded, shall produce a total of up to four VLBI beams, spread across one or more subarrays.	ECP-140008, ECP-160043	CSP, TM	Analysis, Demonstration, Test

All four VLBI beams could be produced in a single subarray, or one in each of four subarrays. The total number of VLBI beams produced at any given time, across the entire telescope, is limited to four, and those four may be distributed as desired across the subarrays.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2759	SKA1_Mid VLBI: beamforming SKA1_Mid, when commanded, shall generate VLBI beams from any or all receptors within a subarray which are separated by at most 100km.	ECP-140008, ECP-160043	CSP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2760	SKA1_Mid VLBI centre frequency When commanded, for each VLBI beam, SKA1_Mid shall tune the centre frequencies of each of its derived beam channels independently with: 1. Beam channels of 128 MHz bandwidth or less, to an accuracy of 0.01 MHz or better, such that their bandwidth falls entirely within the fixed boundaries of beam channels greater than 128 MHz. 2. Beam channels of greater than 128 MHz bandwidth having fixed offset centre frequencies within the processed bandwidth of the observing Band.	ECP-140008, ECP-170017	CSP, TM	Test

This requirement acknowledges the 512 MHz bandwidth contraints of the Mk 5 VLBI recorders by limiting individual data streams. Note that beams of up to 5GHz can be allocated across multiple recorders.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2761	SKA1_Mid VLBI beam bandwidth The bandwidth for each SKA1_Mid VLBI beam shall be independently configurable, with a contiguous processing bandwidth up to the full bandwidth of the selected Band. For Band 5 this applies to each of the two 2.5 GHz streams, and not across streams -- that is, a single Band 5 VLBI beam can produce two 2.5 GHz -wide outputs.	ECP-140008, ECP-170017	CSP, TM, SADT	Analysis

Within the same sub array up to 4 beams are available for a bandwidth up to 2.5 GHz per beam and up to 2 beams for a bandwidth of 5GHz.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2762	SKA1_Mid VLBI S/N performance The SKA1_Mid, when forming VLBI beams, shall have a signal-to-noise performance better than 90% of that achievable by an ideal signal chain, given the same inputs, instrumental calibration and excluding RFI.	ECP-140008	CSP,SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2847	SKA1_Mid tied-array beams: store time-dependent dish weights SKA1_Mid shall store the time-dependent dish weights used for each tied-array beam sum.	ECP-140008	CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2849	SKA1_Mid VLBI beams sampling rate SKA1_Mid, when forming VLBI beams, shall output them with a sampling rate selectable between Nyquist and at least a factor of two oversampling for the selected bandwidth.	ECP-140008	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2851	SKA1_Mid VLBI beamforming weights SKA1_Mid, when commanded, shall weight the dish inputs into the VLBI tied-array sums based on relative sensitivity and coherence losses.	ECP-140008	CSP, TM, SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2852	SKA1_Mid VLBI configurability SKA1_Mid, when commanded, shall change the pointing, centre frequency, and bandwidth of each VLBI tied-array beam independently, on scan boundaries.	ECP-140008	CSP, TM, SADT	Test

Need to specify scan boundaries to avoid the prospect of continual changes during individual scans.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2853	SKA1_Mid VLBI independently configurable beams. When commanded, SKA1_Mid shall form up to at least 4 separate VLBI tied-array beams up to a beams-bandwidth product of 10 GHz, distributed across one or more subarrays, each beam having independently configurable sky coordinates.	ECP-140008, ECP-170017	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2854	SKA1_Mid VLBI configurability SKA1_Mid shall, when commanded, reconfigure the centre frequency, frequency band, and bandwidth for each tied-array beam, in less than 30 seconds.	ECP-140008	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2855	SKA1_Mid VLBI: spectral resolution SKA1_Mid shall, when commanded, generate VLBI beams with a spectral resolution different from the spectral resolution used for imaging within the same subarray.	ECP-140008, ECP-160043	CSP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2856	SKA1_Mid VLBI beam channel sampled bandwidth. SKA1_Mid, when commanded, shall generate VLBI beam channel data with a selectable channel width of: 128, 64, 32, 16, 8, 4, 2, 1 MHz, or a single wideband option, with channel width greater than (128 + 2n + 2m MHz) and less than or equal to 512MHz. Where n and m are non-negative integers.	ECP-140008, ECP-170017	CSP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2857	SKA1_Mid VLBI: imaging and beamforming SKA1_Mid, when commanded, shall simultaneously generate both VLBI beams and VLBI imaging data for the same subarray. VLBI imaging data shall include all polarization products and all baselines (including autocorrelations), with a spectral resolution no worse than 1 MHz, covering a bandwidth of at least 100 MHz, and spanning the full frequency range(s) covered by the VLBI beam(s) generated within the same subarray.	ECP-140008, ECP-160043	CSP, TM, SaDT, SDP	Test

As written this does NOT require that images actually be made – potentially one might just send the visibilities to the VLBI observer.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2859	SKA1_Mid VLBI out-of-channel rejection SKA1_Mid, when commanded, shall generate VLBI beams with a transition band that is monotonically decreasing from -3dB at the channel edge, to -60dB at a frequency offset from the centre frequency by the channel bandwidth.	ECP-140008	CSP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3469	SKA1_Mid VLBI reference position The SKA1_Mid VLBI array phase centre shall be within 100km of one of the SKA1_Mid receptors.		CSP, TM, SDP	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3474	SKA1_Mid VLBI: spectral purity Spectral distortion, after calibration, for SKA1_Mid VLBI shall be below: • -30dB in amplitude • 0.01 radians in phase.		CSP	Test

5.3.6 SKA1_Mid tied array beamforming

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3470	Off-axis beamforming SKA1_Mid and SKA1_Low, when commanded, shall form tied-array beams for pulsar search and pulsar timing (and VLBI, for SKA1_Mid), whose half-power contour fits entirely within the half-power primary beam width of the largest receptors in use, calculated at the highest frequency within the frequency range covered by the tied-array beam in question.		CSP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3471	Polarization flags: beamforming inputs SKA1_Mid shall flag both polarizations of any beamforming input for which one polarization is flagged (or marked invalid).		CSP	Demonstration

This doesn`t read like a Level 1 but the derivation is not obvious below that level.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3525	Coherence of SKA1_Mid tied-array beams When commanded, SKA1_Mid shall form pulsar search, pulsar timing, and VLBI tied-array beams that each have a coherence within 5% of that allowed by the current atmospheric conditions.		SDP, TM, CSP	Test

Requirement that the tied-array beams be "well-formed", that is, be derived by a coherent rather than an incoherent sum. The "when commanded" here allows observers to specify that they really _want_ incoherent beams, or to sacrifice coherence for observing efficiency; the idea is to require that we be able to achieve very good coherence, e.g., through real-time calibration.

5.3.7 SKA1_Mid Pulsar Search

5.3.7.1 SKA1_Mid Pulsar search spectral purity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3541	SKA1_Mid Pulsar search: spectral purity The spectral distortion of SKA1_Mid pulsar search beams, compared to an ideal analogue beamformer provided with the same inputs, shall be no more than -40 dB in amplitude and 0.01 radians in phase.		CSP	Test

5.3.7.2 Pulsar search processing bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2767	SKA1_Mid Pulsar search bandwidth The maximum pulsar search bandwidth for SKA1_Mid shall be no less than 295MHz.	ECP-150004	CSP	Demonstration

The specified minimum bandwidth is less than 300MHz to allow design headroom for the processing.

5.3.7.3 Dispersion measure

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2212	SKA1_Mid Dispersion Measure SKA1_Mid, when performing Pulsar Search for unaccelerated pulsars with dispersion measures within the range 0 to 3000 pc cm^{-3}, shall space dispersion measure trials such that the recovered signal-to-noise ratio of any signal lying between trials shall be no worse than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	ECP-150004	CSP	Demonstration

5.3.7.4 Time resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2216	SKA1_Mid Pulsar Search time resolution The SKA1_Mid shall retain time resolution in the Pulsar Search such that any increase in sampling interval at high dispersion measure trials does not degrade the signal-to-noise ratio below 95% relative to the maximum time resolution.	ECP-150004	CSP	Analysis

5.3.7.5 Pulsar search observation time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2218	SKA1_Mid Pulsar search observation time SKA1_Mid, when commanded, shall perform the Pulsar Search with an observation time configurable between 180 and 1800 seconds. The SKA1_Mid may restrict the observing time to be the same for all beams in a subarray in fixed multiples of the sampling interval.	ECP-150004	CSP, TM	Demonstration

5.3.7.6 Single pulse searches

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2219	SKA1_Mid Single pulse searches SKA1_Mid, when performing Pulsar Search for individual pulses with dispersion measures in the range 0 to 3000 pc cm^{-3} and with widths 100 microseconds to 1 second, shall space dispersion measure trials such that the recovered the signal-to-noise ratio of any signal lying between trials shall be no worse than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	ECP-150004	CSP	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3289	SKA1_Mid Single Pulse search Signal to Noise Ratio SKA1_Mid shall obtain a signal-to-noise ratio for a pulse in a de-dispersed time-series that is more than 85% compared to using a Gaussian matched filter of the correct width.	ECP-150004	CSP	Analysis

5.3.7.7 Binary search

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2220	SKA1_Mid Binary Pulsar search When commanded, for each pulsar search beam with pulsar search duration less than 600s, SKA1_Mid shall perform acceleration correction as part of the pulsar search, over a configurable range of acceleration values from 0 to no less than 350 m/s^2, for no fewer than 500 configurable dispersion measure trials, such that the degradation in signal-to-noise ratio due to coarse acceleration sampling is less than 34% everywhere in the acceleration range.	ECP-150004	CSP, SDP	Analysis

5.3.7.8 Pulsar search array diameter

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2202	SKA1_Mid pulsar search array diameter Each SKA1_Mid subarray, when performing Pulsar Search, shall form beams using any and all constituent receptors within that subarray, which are separated by up to 20,000 metres.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.3.7.9 Pulsar search frequency

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2755	SKA1_Mid pulsar search frequency SKA1_Mid, when commanded, shall perform the Pulsar Search on an operator configured continuous bandwidth located anywhere within the current subarray band.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.3.7.10 Pulsar search beams and bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2756	SKA1_Mid Pulsar Search tuning For each subarray, the SKA1_Mid, when commanded, shall independently set up to two Search Window centre frequencies of the Pulsar Search such that each Search Window lies entirely within the current subarray Band.	ECP-150004, ECP-160043, ECP-170017	CSP, TM	Demonstration

5.3.7.11 SKA1_Mid co-located Pulsar search beams

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3477	SKA1_Mid co-located Pulsar search beams SKA1_Mid, when commanded, shall form multiple Pulsar Search beams at the same sky coordinates, within a single subarray.		CSP, TM	Demonstration

5.3.7.12 Number of beams: Pulsar survey

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2203	Number of beams: SKA1_Mid Pulsar Search SKA1_Mid, shall concurrently perform the Pulsar Search function in a total of up to 1500 independently steerable beams, each of which may be assigned to any sub-array which is configured for Pulsar Search.	ECP-150004	CSP	Demonstration

5.3.7.13 Beamforming signal-to-noise: Pulsar Search

The signal-to-noise (S/N) performance includes all losses, including --but not limited to-- coherence, quantisation, smearing but not RFI.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2205	SKA1_Mid Beamforming S/N Pulsar Search The SKA1_Mid when forming beams for the Pulsar Search, shall achieve signal-to-noise more than 98% relative to an ideal analogue beam-former for the same inputs.	ECP-150004	CSP	Analysis

5.3.7.14 Pulsar Search output

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2897	SKA1_Mid Pulsar Search output. SKA1_Mid, when performing the Pulsar Search, shall generate Pulsar Candidates and Non-imaging Transient Candidates as defined in TBD.	ECP-150004	CSP, SDP	Demonstration

5.3.7.15 SKA1_Mid Pulsar search sampling interval

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2900	SKA1_Mid Pulsar search sampling interval SKA1_Mid shall perform Pulsar Search and Single Pulse Search with on spectral channels with an effective time resolution shorter than 100 microseconds. (effective time resolution - full width at 10% maximum of the channeliser power response).	ECP-150004	CSP	Demonstration

5.3.7.16 SKA1_Mid Pulsar search configurability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2901	SKA1_Mid Pulsar Search Configurability 1 SKA1_Mid, when commanded, shall perform the Pulsar Search with a configurable sampling interval that is 1, 2, 3 or 4 times the minimum sampling interval.	ECP-150004	CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2902	SKA1_Mid Pulsar Search Configurability 2 SKA1_Mid, when commanded, shall perform the pulsar search for a pulsar search beam, with a configurable bandwidth from the full pulsar search bandwidth for that beam, down to 0.25 times the available bandwidth of the current observing band (if that is less than the full pulsar search bandwidth for the beam).	ECP-150004	CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2903	SKA1_Mid Pulsar Search Configurability 3 SKA1_Mid shall restrict the choices of the sampling rate and bandwidth for Pulsar Search to integer sub-multiples of a the fundamental sampling rate.	ECP-150004	CSP, TM	Demonstration

5.3.8 SKA1_Mid Pulsar Timing

5.3.8.1 SKA1_Mid Pulsar timing spectral purity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3544	SKA1_Mid Pulsar timing: spectral purity The spectral distortion of SKA1_Mid Pulsar timing beams, compared to an ideal analogue beamformer provided with the same inputs, shall be no more than -60 dB in amplitude and 0.001 radians in phase.		CSP	Test

5.3.8.2 Pulsar timing subarray diameter

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2206	SKA1_Mid pulsar timing array diameter Each SKA1_Mid subarray, when configured for Pulsar Timing, shall form pulsar timing beams using all receptors within that sub-array, which are separated by at most 20,000 metres.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.3.8.3 Pulsar timing observing band

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2757	SKA1_Mid pulsar timing observing band The SKA1_Mid, when commanded, shall form beams for each of the Pulsar timing subarrays with a selectable Pulsar timing band for each subarray anywhere in the selected SKA1_Mid band.	ECP-150004, ECP-160043	CSP, TM	Demonstration

It would be very costly to accommodate pulsar timing beams spanning more than a single 2.5 GHz stream in Band 5 (a or b), within a single subarray. Note this does not rule out having two Band 5 (a or b) subarrays, pointed at the same pulsar, to allow simultaneous observations spanning more than a single Band 5 (a or b) data stream; although there is currently no requirement that such data be processed together.

5.3.8.4 Pulsar timing number of beams

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2207	SKA1_Mid number of pulsar timing beams The SKA1_Mid, when commanded, shall form and process the data from a total of up to 16 (dual polarization) pulsar timing beams constrained to a net bandwidth (on sky) of 20 GHz per polarization, independently and concurrently. These pulsar timing beams may be spread across one or more subarrays.	ECP-150004, ECP-160014, ECP-160043	CSP, TM	Demonstration

This means that one can have (for instance) eight Band 5 (a or b) (2.5 GHz) beams, or four Band 5 (a or b) (2.5 GHz) beams and eight Band 1/2/3 beams, or one Band 5 (a or b) (2.5 GHz) beam and fourteen Band 1/2/3 beams, or sixteen Band 1/2/3 beams. This helps limit the size of the beamformer (CSP).

5.3.8.5 Beamforming signal-to-noise performance: Pulsar timing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2208	SKA1_Mid beamforming signal-to-noise ratio: Pulsar timing. The SKA1_Mid, when forming pulsar timing beams, shall have a Signal to Noise ratio greater than or equal to 98% TBC of an ideal beam former, given the same digitized inputs and calibration.	ECP-150004	CSP	Analysis

5.3.8.6 SKA1_Mid pulsar timing beams: spatial offsets.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3532	SKA1_Mid pulsar timing beams: spatial offsets. The spatial offset of each SKA1_Mid pulsar timing beam from the imaging delay centre of the corresponding subarray shall be at most half of the half-power beam width of the largest dish in that subarray, evaluated at the highest observing frequency used by the pulsar timing beam.		CSP,SDP	Analysis

5.3.8.7 Pulsar timing processing bandwidth

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2768	SKA1_Mid pulsar timing processing bandwidth The SKA1_Mid, when performing Pulsar timing, shall have a contiguous processing bandwidth up to the full bandwidth of the selected band limited to a maximum of 2.5 GHz for each timing subarray.	ECP-150004, ECP-160043	CSP	Demonstration

5.3.8.8 Pulsar timing observation time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2766	SKA1_Mid pulsar timing observation time The observation duration for each SKA1_Mid Pulsar timing subarray shall be set independently with a value configurable between 10 seconds and 300 minutes with a granularity of 10 seconds.	ECP-150004, ECP-160043	CSP, TM	Demonstration

5.3.8.9 Time stamping

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2764	SKA1_Mid pulsar timing: time stamping Each SKA1_Mid pulsar timing and dynamic spectrum measurement shall be directly traceable to the time at the common delay centre of the SKA1_Mid telescope, with an accuracy of better than 2 nanoseconds.	ECP-150004	CSP, SADT, DSH	Demonstration

5.3.8.10 Multiple simultaneous timings

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2939	SKA1_Mid timing beams When performing Pulsar Timing, SKA1_Mid shall form multiple tied array beams within the same subarray, with independent sky coordinates such that each beam centre offset from the imaging delay centre is a maximum of half the HPBW of the antenna.	ECP-150004, ECP-160043	CSP, SDP	Analysis

5.3.8.11 Dispersion Measure

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2231	SKA1_Mid Pulsar timing Dispersion Measure. The SKA1_Mid shall time Pulsars with dispersion measures between 0 to 3000 pc cm^{-3} with an accuracy up to the Nyquist rate for the given channelisation.	ECP-150004	CSP	Analysis

5.3.8.12 SKA1_Mid Pulsar timing resolution

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2961	SKA1_Mid Pulsar Timing Resolution The SKA1_Mid, when commanded to time a pulsar, shall resolve that pulsar's pulse profile with up to 2048 equal-width, contiguous phase bins.	ECP-150004, ECP-150030	CSP	Test

Rationale provided in support document for ECP-150030 "SKA1 Pulsar Timing Resolutions - Ewan Barr, Willem van Straten- Nov 4th 2015"

5.3.8.13 SKA1_Mid Pulsar timing Pulsar period

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3533	SKA1_Mid Pulsar timing: pulsar period. The SKA1_Mid, when commanded, shall time Pulsars with periods between 0.4 milliseconds and 20 seconds.		CSP	Test

Rationale provided in support document for ECP-150030 "SKA1 Pulsar Timing Resolutions - Ewan Barr, Willem van Straten- Nov 4th 2015"

5.3.8.14 Dynamic Spectrum

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3195	SKA1_Mid Dynamic spectrum. The SKA1_Mid, when commanded, shall produce a dynamic spectrum for one or more pulsar timing beams, recording the amplitude of the signal as a function of time, frequency, and polarisation.	ECP-150011	SDP, CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3201	SKA1_Mid Dynamic spectrum and Pulsar timing total beams. SKA1_Mid, when commanded, shall simultaneously form and process data from up to a total of16 dual-polarization pulsar timing beams for pulsar timing and dynamic spectrum processing, constrained to a net, on-sky bandwidth of 20 GHz per polarisation.	ECP-150011	SDP, CSP, TM, SADT	Test

This constrains the total number and bandwidth of pulsar timing beams, summed across all subarrays, at any given time.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3534	SKA1_Mid dynamic spectrum parameterization. The spectral and temporal resolution of each SKA1_Mid dynamic spectrum shall be independently selectable, within the limitations imposed jointly by the corresponding pulsar timing beam's spectral and temporal responses.		SDP, CSP, TM	Test

5.3.9 SKA1_Mid Transient capture

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3078	SKA1_Mid transient buffer The SKA1_Mid shall provide a transient buffer of at least 32 gigabytes per dish, capable of recording at least 300-MHz of 2-bit dual-polarisation raw voltage data.	ECP-140026	CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3079	SKA1_Mid transient capture latency The SKA1_Mid shall have a system latency of at most 60 seconds from the time that the highest frequency component of a transient signal arrives at the telescope to the time when the transient buffer is recorded.	ECP-140026	CSP, SDP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3080	SKA1_Mid transient archiving The SKA1_Mid shall have the capacity of archiving at least 150 terabytes of transient buffer data per day.	ECP-140025	CSP, SDP, SaDT	Demonstrate

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3467	SKA1_Mid transient buffer SKA1_Mid shall generate and respond to real-time internal triggers by storing digitized voltage data, with 2-bit or better sampling, for at least 300 MHz of contiguous, tuneable observed bandwidth in both polarizations, from every dish within the triggering subarray, covering at least 2 seconds before and at least 20 seconds after the triggering event.		CSP, TM, SDP, SaDT	Test

Related to but not identical with SKA1-SYS_REQ-3078. Not sure whether this should be split into multiple requirements but thought it better to at least get it in for consideration.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3468	SKA1_Mid transient buffer: single-pulse trigger When commanded, SKA1_Mid shall archive all or part of the transient buffer based on the results of single-pulse searches, independently for each subarray.		CSP, SDP, TM, SaDT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3536	SKA1_Mid transient buffer: consecutive triggers SKA1_Mid shall record the transient buffer as often as every 2 minutes.		CSP, TM, SDP	Demonstration

Need some requirement on how frequently one may have to dump (although this is at least constrained by SKA1-SYS_REQ-3079 [transient capture latency]).

5.3.10 SKA1_Mid synchronised time stamping

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3390	SKA1_Mid synchronised time stamping Each dish shall provide to the correlator-beamformer a time stamp, synchronous with and locked to the sample clock and 1PPS.	ECP-160068	DISH	Test

The number of samples between 1PPS is deterministic.

6 Observing

6.1 Operational Modes

6.1.1 Normal observing

6.1.1.1 Continuum and Spectral Imaging

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2128	Continuum and spectral line imaging. Both SKA1_Mid and SKA1_Low shall have an imaging capability that will acquire continuum and spectral-line data concurrently.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	CSP, SDP, TM	Demonstration and Test

It is assumed that SDP will generate the continuum spectrum from the spectral line spectrum produced by CSP.

6.1.1.2 Mode transition

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2133	Mode transition The switching time between telescope observation modes shall take less than 30 seconds (not including dish slewing time).	Operations Requirements document	LFAA, SADT, CSP, SDP, TM, DSH	Test

6.1.1.3 Commensal Observing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3131	SKA1_Low Simultaneous Observing Modes SKA1_Low, when commanded, shall provide processing within a subarray for one of: 1. Simultaneous imaging and non-imaging observing. 2. Simultaneous imaging and VLBI observing.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-170017	TM, CSP, SDP	Demonstration

The OCD provides definition for different levels of commensality. In this context for this requirement: commensality is when more than one SB/project can use the same data stream from a subarray but with different science goals and science products.

Of course, this is always limited by available resources, but it should allow for NIP–imaging, imaging–imaging, NIP–NIP.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3622	SKA1_Mid Simultaneous Observing Modes When commanded SKA1_Mid shall provide: 1. Fully simultaneous processing for imaging, non-imaging and VLBI observations within and across all Bands to the extent that processing and communication bandwidth resources are available and 2. Sufficient processing and communication resources to provide any one individually of: imaging, non-imaging and VLBI observations at full bandwidth beam product.	ECP-170017	TM, CSP	Demonstration

The full bandwidth beam product specifications are each identified within these requirements.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3197	Simultaneous time domain and continuum observations The SKA1_Low and SKA1_Mid, when commanded, shall operate simultaneously for Pulsar Timing, Pulsar Search (both periodic and single pulse search), and imaging within the same subarray.	ECP-150011, ECP-160043, ECP-170017	CSP, SDP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3133	Process resource reporting Upon authorised request, all elements of the SKA1_Low and SKA1_Mid shall report a summary of available signal and data processing resources.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	CSP, SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3134	Target of Opportunity prioritisation Scheduling blocks which have been assigned override status shall, when triggered, interrupt current observations and signal/data processing, as necessary, to enable the override observations to commence.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	SDP, TM	Demonstration and Test

Interrupts will happen at the scan level. If an "abort" is received then execution of the scan (and associated Schedule Block) will immediately end. Any existing scans in the signal processing chain will be processed as per normal. If a "stop" is received, then the associated Scheduling Block will end its execution at the end of the current scan.

6.1.2 Observations on a fixed schedule

6.1.2.1 Specific epoch observations

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2681	Specific epoch observations The observatory shall have the capability of scheduling observations at a specific epoch.		TM	Demonstration

6.1.3 Sub arrays

6.1.3.1 Subarraying

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2127	Subarraying The SKA1_Mid and SKA1_Low, when commanded, shall form subarrays that can be configured and operated independently of each other.	ECP-140024, SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-160043	CSP, TM, SDP, LFAA	Demonstration, Test

SDP included as ingest needs to be scheduled. LFAA included for station configurations.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3136	Tied array beam independence The SKA1_Mid and SKA1_Low, when commanded, shall form tied-array beams that can be configured and operated independently of each other.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, CSP	Demonstration and Test

Generalisation of several Level 1 requirements. Note that tied-array beams can only be formed within subarrays.

6.1.3.1.1 Subarraying SKA1_Low

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2773	SKA1_Low subarray support The SKA1_Low, when commanded, shall concurrently correlate all station beams within a configurable set of up to sixteen subarrays.	ECP-140024, ECP-160043	CSP	Test, Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2988	SKA1_Low subarray membership Each SKA1_Low station beam shall be formed from one subarray at any given time.	ECP-140024, ECP-160043	CSP, TM, LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2990	SKA1_Low subarray granularity SKA1_Low subarrays shall be configurable to contain any integer number of stations between 0 (none) and all the stations.	ECP-140024, ECP-160043	CSP, TM, LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2992	SKA1_Low subarray independence SKA1_Low shall accept and execute commands for, and process data from, each subarray independently of and concurrently with all others.	ECP-140024, ECP-160043	CSP, SDP, TM, LFAA	Demonstration

This is a "low-level" requirement, ensuring that at any given moment subarrays are commanded independently, and data processing for one subarray does not rely on simultaneous inputs from others.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2994	SKA1_Low subarray configuration SKA1_Low stations within the same subarray shall be configured according to the Scheduling Block controlling that subarray.	ECP-140024, ECP-160043	CSP, TM, LFAA	Inspection

Scheduling Blocks are the schedulable entities and shall completely define the configuration of a subarray.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2996	SKA1_Low subarray tied-array beam station exclusion The SKA1_Low shall assign dynamic weights to stations within a subarray contributing to tied-array beams including the ability to exclude individual stations.	ECP-140024, ECP-160043	CSP, TM	Demonstration

The ability to control weights allows the exclusion of a station when there is some form of failure.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2998	SKA1_Low subarray station allocation The SKA1_Low, when performing observations, shall allocate stations to subarrays at Scheduling Block boundaries only.	ECP-140024, ECP-160043	CSP, TM, LFAA	Demonstration

See also SKA1-REQ_SYS-2994.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3000	SKA1_Low subarray station failure flagging The SKA1_Low, when performing observations, shall flag data from failed stations as soon as that failure is detected.	ECP-140024, ECP-160043	CSP, TM, LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3002	SKA1_Low Engineering subarrays SKA1_Low shall support the designation of any subarray as an engineering subarray at Scheduling Block boundaries.	ECP-140024, ECP-160043	TM	Demonstration

Intended to be used for testing, commissioning, and maintenance. Resources marked anything other than operational may only be allocated to engineering subarrays.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3287	SKA1_Low unique resource allocation Each SKA1_Low schedulable resource shall be allocated to no more than one subarray at a time.	ECP-140024, ECP-160043	CSP, TM, LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3008	SKA1_Low subarray pointings The station beams for each SKA1_Low subarray shall be individually and independently pointed.	ECP-140024	CSP, SDP, TM LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3016	SKA1_Low subarray logical control and monitoring SKA1_Low shall provide independent logical control and monitoring for each subarray.	ECP-140024, ECP-160043	CSP, TM, LFAA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3020	SKA1_Low subarray Scheduling Block set up time The time from selecting a Scheduling Block to required schedulable resources being configured shall be less than 30 seconds.	ECP-140024, ECP-160043	CSP, TM, LFAA, SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3029	SKA1_Low subarray independence of Scheduling Block The SKA1_Low shall form subarrays independent of the existence of a Scheduling Block.	ECP-140024, ECP-160043	TM	Demonstration

Subarrays are a scheduling concept and as such can exist independent of a Scheduling Block. For example, Engineering subarrays may be created without a Scheduling Block instance.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3528	SKA1_Low sub-array capability The SKA1_Low when commanded shall allocate at most 512 stations and substations to subarrays at any given time.	ECP-160015	TM	Test

The requirement is outside the scope of this document, although it might have been included. Essentially it says that sub-arrays will not be available when sub-stations are in use. This is a compromise to potentially simplify the correlator-beamformer system. It has not been very well researched. The implication is that the sub-station policies developed by RT for SKA1_Mid could be mapped on to SKA1_Low, but only for the 512 35-m diameter stations.

6.1.3.1.2 Subarraying SKA1_Mid

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2774	SKA1_Mid correlation subarray support The SKA1_Mid, when commanded, shall concurrently correlate all receptor signals within each of up to sixteen subarrays.	ECP-140024, ECP-160043	CSP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2989	SKA1_Mid subarray membership Each SKA1_Mid receptor may belong to at most one subarray at any given time.	ECP-140024, ECP-160043	CSP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2991	SKA1_Mid subarray granularity SKA1_Mid subarrays shall be configurable to contain any integer number of receptors between 0 (none) and all the receptors.	ECP-140024, ECP-160043	CSP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2993	SKA1_Mid subarray independence Unless explicitly stated otherwise, SKA1_Mid shall accept and execute commands for, and process data from, each subarray independently of and concurrently with all others.	ECP-140024, ECP-160043, ECP-170017	CSP, SDP, TM	Demonstration

This is a "low-level" requirement, ensuring that at any given moment subarrays are commanded independently, and data processing for one subarray does not rely on simultaneous inputs from others.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2995	SKA1_Mid subarray configuration SKA1_Mid receptors within the same subarray shall be configured according to the Scheduling Block controlling that subarray.	ECP-140024, ECP-160043	CSP, TM	Inspection

Scheduling Blocks are the entities that are schedulable and it will be up to the SB itself to configure the subarray in any way that it feasibly can.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2997	SKA1_Mid subarray tied-array beam receptor exclusion The SKA1_Mid shall assign dynamic weights to receptors within a subarray contributing to tied-array beams including the ability to exclude individual receptors.	ECP-140024, ECP-160043	CSP, SDP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2999	SKA1_Mid subarray receptor allocation The SKA1_Mid, when performing observations, shall allocate receptors to subarrays at Scheduling Block boundaries only.	ECP-140024, ECP-160043	TM	Demonstration

See also SKA1-REQ_SYS-2995. Scheduling Blocks are allowed to collect all resources that they need when the SB is scheduled and consequently change the subarrays configuration if necessary, e.g. for calibration.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3001	SKA1_Mid subarray receptor failure flagging The SKA1_Mid, when performing observations, shall flag data from failed receptors as soon as that failure is detected.	ECP-140024, ECP-160043	CSP, SDP, TM, DSH	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3003	SKA1_Mid Engineering subarrays SKA1_Mid shall support the designation of any subarray as an engineering subarray at Scheduling Block boundaries.	ECP-140024, ECP-160043	TM	Demonstration

Intended to be used for testing, commissioning, and maintenance. Resources marked anything other than operational may only be allocated to engineering subarrays.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3288	SKA1_Mid unique resource allocation Each SKA1_Mid schedulable resource shall be allocated to no more than one subarray at a time.	ECP-140024, ECP-160043	CSP, SDP, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3007	SKA1_Mid subarray frequency bands. The frequency band for each SKA1_Mid subarray shall be independently selectable.	ECP-140024	CSP, SDP, TM, SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3009	SKA1_Mid subarray pointings The receptor pointing for each SKA1_Mid subarray shall be commanded individually and independently.	ECP-140024, ECP-160043	TM	Demonstration

This does not preclude different pointings for different receptors within a single subarray.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3017	SKA1_Mid subarray logical control and monitoring SKA1_Mid shall provide independent logical control and monitoring for each subarray.	ECP-140024, ECP-160043	CSP, TM, DSH	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3021	SKA1_Mid subarray scheduling block set up time The time from selecting a Scheduling Block to required schedulable resources being configured shall be less than 30 seconds.	ECP-140024, ECP-160043	CSP, TM, SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3030	SKA1_Mid subarray independence of scheduling block The SKA1_Mid shall form subarrays independent of the existence of a Scheduling Block.	ECP-140024, ECP-160043	TM	Demonstration

Subarrays are a scheduling concept and as such can exist independent of a Scheduling Block. For example, Engineering subarrays may be created without a Scheduling Block instance.

6.2 Telescope Management

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3554	Imaging of moving astronomical objects SKA1_Low and SKA1_Mid shall, when commanded, acquire imaging data at a single, specified (RA, Dec or Galactic coordinates) position on the sky, or of astronomical objects that move relative to the sky, e.g. planets.	ECP-160037	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3555	Near field visibility corrections SKA1_Mid and SKA1_Low shall apply near-field corrections to visibilities measured towards celestial objects whose distance present phase errors on the longest baseline, due to wave-front curvature, of more than 0.1 radians.		SDP	Demonstration

6.2.1 General

6.2.1.1 General Principles

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3125	Flexible observation The SKA1_Mid and SKA1_Low telescopes, with the support of SKA1_Common, shall implement flexible scheduling.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration

Need for supporting flexibility in queuing Scheduling Blocks both manually and in an automated way.

6.2.1.2 Time accounting

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3187	Elapsed time tracking The SKA1_Mid and SKA1_Low shall log their usage and status within specified time accounting categories (TBD). These shall be stored at the telescopes and at the SKA1_Common.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration

(See SKA1-OPS-06).

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3237	Lifetime of SKA1 observing-related logs SKA1_Mid, SKA1_Low, and SKA1_Common shall archive all logs that directly relate to specific observations, including time accounting logs, for the duration of the observatory.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3188	Observation report SKA1_Mid and SKA1_Low, when commanded, shall generate a report of all their activity (at least observations carried out, events with manually entered operator logs, faults encountered, and remedial actions) over a specified period, normally 24 hours. The report will be made available to authorised personnel.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

6.2.1.3 Scheduled Maintenance Logs

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2278	Scheduled maintenance logs. A maintenance database for SKA1_Low and SKA1_Mid shall be established that logs all the scheduled maintenance and unexpected repairs.	Operational Requirements [AD1]	TM, INFRA, AIV, OMS	Demonstration

6.2.1.4 System error logs

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2279	System error logs. A failure database for the SKA1_Low and SKA1_Mid shall be established, which logs the errors of the system and its subsystems, including the corrective actions taken.	Operational Requirements [AD1]	TM, INFRA, OMS	Demonstration

6.2.1.5 System status

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2280	System status. The SKA1_Low and SKA1_Mid shall extract information about the current condition of the system from the science and calibration data streams, and log this information along with other relevant system and environmental status information. Based on this information, it will be possible to monitor, save, and analyse the technical performance of the system.		SDP, TM	Demonstration

6.2.1.6 Latency of TOO scheduling block initiation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2285	Latency of TOO scheduling block initiation. The SKA1_Mid and SKA1_Low shall initiate scheduling intervention within 1s of receiving external TOO triggers.		TM	Test

The initiation of scheduling intervention is determined by TM. Each Element's response time is covered by the Mode Transition requirement, SKA1-SYS_REQ-2133.

6.2.1.7 Time accounting categories

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3126	Time Accounting Categories On command, the SKA1_Common shall ascertain the usage and status of each subarray of SKA1_Mid or SKA1_Low, within specified time accounting categories as specified in the Operational Concept Document.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-160043	TM	Inspection, Demonstration

The time accounting categories are given in the OCD (SKA-TEL-SKO-0000307): Setup, Calibration, Science, Engineering, Commissioning, Fault, Weather, Other.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3128	Transient search SKA1_Mid and SKA1_Low, when commanded, shall search for, detect, process, and archive transients with durations greater than ~50 µsec.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	CSP, SDP	Demonstration

This requirement ensures that this capability is available for any astronomical target. See also SCI_REQ-49 and SCI_REQ- 50 [R19]. Detection and processing must be at least sufficient to characterise the kind of transient.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3130	Sky mapping The SKA1_Low and SKA1_Mid, when commanded, shall acquire imaging data while the telescope is either (a) driven across a region of sky defined in (Az, El), (RA, Dec), or Galactic coordinates to build a map of the sky, or (b) at a fixed (Az, El) position.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, TM, SDP	Demonstration

See also, SCI_REQ-47 and SCI_REQ-48 [R19]. Role of TM is providing support for sending the relevant paths, or static Az, El coordinates. Role of DSH/LFAA is being able to be steered to the relevant locations. Role of SDP is building imaging science data products from such paths. CSP not allocated, because no change of behaviour is required.

6.2.2 Telescope Scheduling

Scheduling Blocks are the indivisible executable units of a project and contain all the information necessary to execute a self-contained observation instance, including configuration, and scripts to be executed.

6.2.2.1 Proposal submission

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3139	SKA1 user accounts The SKA1_Common shall provide access rights, for authenticated and authorised users, to correspondence, tools, and resources for managing their projects and proposals.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration and Test

This requirements allows access to the relevant tools to PIs, CoIs, and Science Operations Staff, as per the SKA Authentication and Authorisation policy TBW.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3141	Tool for proposal submission The SKA1_Common shall provide the capability for the preparation, design, pre-validation, and submission of proposals through a single, platform-independent system.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration

Pre-validation are the proposal validation steps that can be performed automatically are part of proposal submission. They are not the technical validation or science validation to be performed during proposal evaluation.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3142	PI editing rights The SKA1_Common shall provide the capability for the PI of a proposal to configure editing rights to allow co-Investigators to edit their proposal.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3143	Central database for proposals The SKA1_Common shall provide a centrally maintained and managed database for authenticated and authorised users to prepare and submit proposals, and to retain a full history of previous proposals.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3145	Library of template configurations The SKA1_Common shall provide a library of template configurations for authorised users to browse and import into their proposals, and to tailor to their specific science objectives and requirements.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3146	Sensitivity calculator The SKA1_Common shall provide an interface to a Sensitivity Calculator that will be used to determine an estimate of the achievable sensitivity for a given telescope configuration, with the possibility of changing individual elements of the configuration (number of antennas, maximum baseline, correlator dump time, calibration strategy). The parameters and output of the Sensitivity Calculator will be a part of the submitted proposal. The list is TBC.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration, Analysis and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3235	Resolving names to astronomical coordinates On request during proposal creation and/or project design, the SKA1_Common shall resolve astronomical source names to obtain their astronomical coordinates in ICRS. In cases where the coordinates are ambiguous, the user shall be asked to select.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3147	Provision of known sources SKA1_Common, when commanded, during proposal preparation and/or project design, shall provide the coordinates to known astronomical sources within a specified search radius to a given astronomical source name or coordinate. In case of multiple results, the user shall be asked to select.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3148	Scientific justification submissions The SKA1_Common, during observation preparation, shall provide PIs and their delegates the possibility of providing both their science goal, and technical justifications of the chosen telescope setup. The proposal is not valid until that goal and those justifications have been provided.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3149	SKA1_Low and SKA1_Mid in single proposal The SKA1_Common shall accept single proposals to use both SKA1_Low and SKA1_Mid with separate technical justifications for each.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3150	Proposal verification When commanded, and before a proposal is allowed to be submitted, the SKA1_Common shall verify the contents of proposals against the known telescope and instrument constraints, as advertised in the Call for Proposals.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3151	Observation comparison to Key Science Projects As part of the proposal verification process, the SKA1_Common shall compare submitted proposals to the published Key Science Projects, identifying any potential conflicts.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3152	Proposal management system availability The SKA1_Common shall process up to 100 proposal submissions per minute for a maximum of 500 simultaneous unique users.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Analysis and Test

6.2.2.2 Scientific proposal review and time allocation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3153	Assignment of assessor and referee The SKA1_Common shall provide the capability for authorised personnel to assign assessors and referees to each proposal, with invitations automatically issued to those assessors and referees. In case of declination or lack of reply from the assessor/referee, a new assessor/referee can be assigned.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3154	Proposal grading During proposal assessment, the SKA1_Common shall provide the capability for nominated referees and assessors to review and comment on proposals, and provide a numerical grade on the scientific justification for those proposals	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3155	Proposal feasibility report During proposal assessment, the SKA1Common shall provide the capability for authorised (usually SKA) staff to submit a technical report on the feasibility of a proposal.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3156	Ranked list of proposals During proposal assessment, the SKA1_Common shall collate and normalise grades assigned to proposals across relevant boundaries, and produce a ranked list.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3157	Proposal grading feedback During proposal assessment, the SKA1_Common shall provide the capability for authorised users to submit feedback on each proposal, including a final grade and an indication of whether observing time has been awarded.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration

6.2.2.3 Observation Design

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3158	Design and adjustment of approved projects The SKA1_Common shall provide the capability for the detailed preparation, design and adjustment of approved projects through a single, platform-independent system.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3159	Extraction of technical information from proposals When creating a project, the SKA1_Common shall extract the relevant technical information from the technical details defined in a successful proposal, to aid in designing the Program and Scheduling Blocks for that project.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3160	Verification of technical configuration parameters The SKA1_Common, when commanded, shall create Scheduling Blocks from Projects that have been verified against the known telescope and instrument constraints, as advertised in the Call for Proposals.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3161	SDP pipeline list For each Scheduling Block, the SKA1_Common shall provide the capability of specifying SKA1_Mid and SKA1_Low data products and associated data processing parameters.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

6.2.2.4 Observation planning

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3167	Resource for Scheduling Block execution SKA1_Mid and SKA1_Low shall automatically select a Scheduling Block for execution, and execute it only if the necessary resources needed by that Scheduling Block are available, and all constraints are satisfied.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration, Analysis and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3168	Short-term plan adaptability The SKA1_Mid and SKA1_Low shall dynamically adapt the schedule in response to any sanctioned ToO, VOEvents, or other approved triggers or overrides. The associated Scheduling Block shall enter the schedule according to the trigger's priority.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3169	Scheduling Block status Once a Scheduling Block has finished executing, SKA1_Mid and SKA1_Low shall log the Scheduling Block's current status (i.e. completed, or some other QA-based status), including an update of the project time accounting.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3236	Scheduling Block status changes The SKA_Common, SKA1_Mid and SKA1_Low shall provide the capability for authorised Operations staff to manually change the status of a Scheduling Block.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Test

This will normally only happen following some review action. See SKA1-SYS_REQ-3169 for further context of Scheduling Block status.

6.2.2.5 Identifyiing Commensality

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3171	Commensal Scheduling Block identification SKA1_Common, when commanded, shall identify Scheduling Blocks that could be scheduled commensally.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3172	Commensal Project packaging The SKA1_Common shall package commensal projects for execution including the identification of corresponding data products against those projects.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3173	Commensal Scheduling Block ranking During creation of observing plans, the SKA1_Common shall prioritise groups of commensal projects, scoring each group with the score of the highest-ranked project within the group, within the constraints of the target telescopes.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration

6.2.2.6 User support

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3180	Help desk The SKA1_Common shall provide a Help Desk facility to log and trace any queries/problems/faults/bugs reported. The Help Desk facility will generate tickets that are assigned to authorised staff members.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	Operations	Demonstration and Test

6.2.2.7 Semester Queue (of duration related to the proposal cycle)

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3163	Planning of Scheduling Blocks SKA1_Common, when commanded, shall generate Observing Plans and Scheduling Block priorities for submission to SKA1_Mid and SKA1_Low for execution. The plans will be verified, and will take into account all scheduling constraints, including the coordination of Scheduling Blocks between SKA1_Low and SKA1_Mid, for any plan length between 24 hours and 1 year.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM, OMS	Demonstration and Test

Verification will be conducted by SKA1 Operations staff.

6.2.2.8 Short term schedule construction tool

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2293	Testing the schedule SKA1_Common, when commanded, shall construct Observing Plans for a user-specified length of time between 24 hours and 1 year, based on user-specified operational constraints.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration

This is for testing and investigating different scenarios (e.g. accidental loss of half of the array). This is thus a different requirement from SKA1-SYS_REQ_3163, which is based on the operational constraints.

6.2.2.9 API for construction of schedule

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2646	API for construction of schedule The SKA1_Low and SKA1_Mid shall provide a mechanism for implementing basic schedule building blocks.		TM	Test

It is likely that the mechanism will via a software API that supports Python or Java which may be common to the SB tool.

6.2.2.10 Simulated execution of scheduling blocks.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2294	Simulated execution of scheduling blocks. When commanded, the SKA1_Common shall simulate the execution of observing plans, to complete within one hour (TBC), in order to verify their efficiency and performance.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration

6.2.2.11 Operator control

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2735	Operator Control The SKA1_Mid and SKA1_Low shall provide the capability for authorised personnel to take manual control of the telescope, its subarrays, components and instrumentation.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-160043	TM	Demonstration, Test

6.2.2.12 Observing log

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3176	Observing log The SKA1_Mid and SKA1_Low shall each automatically populate an observing log, recording their status across the entire duration of the execution of Scheduling Blocks.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration

6.2.2.13 Appending log entries

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3177	Appending log entries When commanded, SKA1_Mid and SKA1_Low shall provide the capability for authorised personnel to append information to observing log entries, including time-stamped narrative comments.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

These are general comments that an operator may wish to enter into the observing log.

6.2.3 Response to internal detections of transients

6.2.3.1 Responses to transients

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2296	Responses to transients The SKA1_Mid or SKA1_Low, when commanded, shall respond to the detection of transient events via one or more of the following: (a) adjust the scheduling queue on the telescope of origin; (b) issuing a Virtual Observatory Event, VOEvent; (c) issuing a Target of Opportunity, ToO, announcement to SKA Telescopes.		TM	Demonstration

It shall be possible to perform no action on a transient, if the system is not commanded to do so. Telescope configuration also will determine which (if any) of the possible actions will be taken.

6.2.3.2 Rules for issuing VOEvents.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2298	Rules for issuing VOEvents Proposals to search for transient sources shall include rules for issuing VOEvents.		TM	Demonstration

6.2.4 Response to external detections of transients

6.2.4.1 VOEvent issue latency

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2301	VOEvent issue latency. A qualifying VOEvent within the SKA1_Mid and SKA1_Low shall lead to initiation of a response by the Telescope Manager within 1 second.		TM	Test

6.2.5 Telescope model

The telescope model is shared across the entire Telescope. It describes the telescope via:

- Structural and behavioural models
- Specific equations, such as geodetic, geometric, antennas, pointing
- Configuration parameters such as frequency setups, pointing, sky direction
- Labelling information such as names and ids.

6.2.5.1 Telescope Model

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2645	Telescope Model A dynamic computational model of the Telescope shall be used to answer all queries about the state of the Telescope. The telescope model shall consist of configuration information, numerical models, empirical parameters, and conventions.		TM, SDP	Demonstration

6.2.5.2 Single geodetic model

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2302	Single geodetic model (Telescopes). There shall be a single geodetic model for each of the SKA1_Mid and SKA1_Low published as part of the Telescope Model.		TM	Demonstration

6.2.5.3 Single geometric model

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2303	Single geometric model. There shall be a single geometric model for all receptor types, published by TM.		SPO, TM	Demonstration

6.2.5.4 Dish pointing model

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2304	Dish pointing model. The SKA1_Mid shall provide a dish pointing model that translates a pointing centre in ICRS coordinates at a given time to a mount orientation for a given dish. This will take into account astrometric effects, as well as location, and reference pointings. The pointing system at each dish shall include a model for pointing including structural model, thermal model, reference pointing model, gravitational model, and refraction model, published by TM.		SPO, TM, DSH	Demonstration

The absolute accuracy of the pointing model will be within the limits discussed in SKA-TEL-SKO-0000438.

6.2.5.5 AA element and station beam model

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2305	AA element and station beam model. The SKA1_Low shall provide a beam pointing model that translates a pointing centre in ICRS coordinates at a given time to a beam orientation in azimuth and elevation for a given beam, together with half-power bandwidth for the beam, and other beam metrics. This model shall take into account astrometric effects, as well as location, and reference pointings. The pointing system for each beam shall include a model for pointing including antenna element model, thermal model, reference pointing model, gravitational model, polarisation effects, and refraction model, published by TM.		LFAA, TM	Demonstration

6.2.6 Signal quality display

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3373	Provide signal quality display The SKA1_Low and SKA1_Mid shall provide a Signal Integrity Display which shall enable the operator to evaluate the quality of the data being collected in near real time.		TM	Demonstration

Quality data will typically include plots for:

- signal path
- radiometer
- periodogram
- power and phase (with baseline fit)
- cross-correlation power vs time
- cross-correlation power and phase spectrum per polarisation
- Data quality per Dish versus time (time scrolling)
- Data quality versus baseline (matrix display)
- Baseline spectrum with various integration options (time, baselines, etc.)
- Visibilities (amplitude and/or phase) as a function of time and baseline or time and frequency
- UV coverage, weight distribution and snapshot image
- Phase and amplitude closure for calibrators
- Dish-based complex gains (using source model and visibility data)
- Bandpass calibrations
- System temperatures

- Instrumental signal path delays
- Polarisation calibration
- Flux scale
- RFI masking
- All automatically flagged data.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3374	Provide signal quality display for each sub-array In case of simultaneously operating sub-arrays, the SKA1_Low and SKA1_Mid shall provide a Signal Integrity Display for each active sub-array.		TM	Demonstration

6.2.7 Forensic analysis of telescope behaviour

6.2.7.1 Forensic tool for telescope behaviour

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2306	Forensic tool for telescope behaviour There shall be an interactive forensic tool for evaluating and understanding the state and behaviour of the system at any one time.		TM	Demonstration

6.2.7.2 Forensic Tool Interface

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2307	Forensic Tool Interface. The interactive forensic tool shall have an Internet interface with availability on a range of platforms including desktop and mobile devices.		TM	Demonstration

6.2.7.3 Replay of sequences

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2308	Replay of sequences. The interactive forensic tool shall allow replay of selected sequences.		TM	Demonstration

6.2.8 Alarms

6.2.8.1 Active alarms

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2309	Active alarms. Alarm notification shall be active (via SMS, email, etc.) rather than passive (requiring an Operator query).		TM	Demonstration

6.2.8.2 Alarm filtering

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2310	Alarm filtering. It shall be possible to filter alarms individually or by group.	Operational Requirements [AD1]	TM	Demonstration

6.2.8.3 Alarm latency

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2312	Alarm latency. Latency from the time a measurement crosses an alarm set-point until the time it is signalled to the operator shall be no more than 1 second.	Operational Requirements [AD1]	LFAA, SADT, CSP, SDP, TM, DSH	Test

6.2.9 Data bases

6.2.9.1 Access to historical data

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2313	Access to historical data. The SKA1_Low and SKA1_Mid shall provide access to all current site and historic site data.		TM	Demonstration

6.2.9.2 Total Electron Content

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2314	Total electron content. The SKA1_Low and SKA1_Mid shall retrieve, store, and publish data on Total Electron Content (TEC) to an accuracy of 3 TECU*.		TM, SADT, INFRA	Inspection

*1 TECU = 10^{16} electrons/m^2.

It is anticipated that electron density will be estimated from a combination of dual band GPS (L1=1575.42 and L2=1227.6MHz) in combination with Ionospheric-weather Prediction Services.

6.2.9.3 Ionospheric Activity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2315	Ionospheric activity. The SKA1_Mid and SKA1_Low shall automatically retrieve and store space-weather and solar activity information from the Ionospheric Prediction Service, IPS, at the IPS update rate for use in calibration.		TM	Demonstration

6.2.9.4 Weather Station

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2316	Weather station database The SKA1_Mid and SKA1_Low shall maintain a data base for site weather including site weather station and Weather Information Services data.		TM	Demonstration

6.2.9.5 Satellites

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2317	Satellites. SKA1_Mid and SKA1_Low shall maintain a database of relevant satellite trajectories, including orbital information, emission characteristics and owner.		TM	Demonstration

6.2.9.6 Commercial flights

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2318	Commercial flights. SKA1_Low and SKA1_Mid shall maintain a data base of commercial flights in the neighbourhood of the site.		TM	Demonstration

6.2.9.7 RFI

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2734	RFI database SKA1_Low and SKA1_Mid shall maintain a database holding information about RFI including but not limited to RFI frequency, strength and occupancy as a function of date and time of day incorporating both SKA1 observational (astronomical) data and on-site RFI monitors.		TM	Demonstration

6.3 Science Data processing

6.3.1 Calibration and imaging formalism

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2729	Calibration and Imaging formalism The Calibration and Imaging formalism shall be based upon the Hamaker-Bregman-Sault [R4] Measurement Equation, with extensions for supporting large bandwidths as described by Rau et al. [R20]	Reference [R4]	SDP	Demonstration

6.3.2 Calibration model

6.3.2.1 Closed loop calibration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2319	Closed loop calibration. SKA1_Low and SKA1_Mid calibration shall include comparison of observed position, size and spectral intensity with Global Sky Model predictions in real-time to a time scale appropriate to the component and physical effect being calibrated.		SDP, TM	Demonstration

6.3.3 Ionospheric calibration interval

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3529	Ionospheric calibration interval The SKA1_Low, when commanded shall provide ionospheric calibration with up to the full resolution of the array at intervals of no less than every 10 seconds.	ECP-160015	SDP	Test

There must be a calibration calculation process which can run concurrently (and continuously) with imaging observations, using a subset of stations including the longest baselines and an evolving model of the ionosphere above the array. It must be able to produce correction outputs at up to 10 sec cadence, depending on conditions. TM must coordinate and configure, and SDP must implement.

6.3.4 Imaging model

6.3.4.1 Global Sky Model

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2322	Global sky model. Calibration and continuum subtraction within the SKA1_Low and SKA1_Mid shall use an iteratively refined Local Sky Model, derived from a Global Sky Model or a previous Local Sky Model with a fidelity of source structure representation better than 35dB relative to the peak surface brightness of that source, when not noise floor limited.	SKA Error Budgets [R18], ECP-160012	SDP, LFAA	Demonstration

ECP-160012 proposed the addition of the allocation to LFAA.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3551	Local Sky Model generation The Global Sky Model of each of the SKA1_Mid and SKA1_Low Telescopes shall support retrieval of subsets (a.k.a. Local Sky Models) through queries on RA/Dec ranges, frequency ranges, brightness ranges and/or polarisation parameters.	ECP-160012	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3552	Global Sky Model Refinement The SKA1_Mid and SKA1_Low Global Sky Model shall be updatable, allowing creation of new entries, and updates and removal of existing entries.	ECP-160012	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3553	Global Sky Model query response time The SKA1_Mid and SKA1_Low Global Sky Model shall respond (by starting the data transfer or report an error) in less than 500ms to a query. The completion time of data transfers will be dominated by the time taken to transfer the data.	ECP-160012	SDP	Demonstration

6.3.4.2 Multi-frequency synthesis imaging

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2324	Multi-frequency synthesis imaging. The SKA1_Low and SKA1_Mid, when commanded to do imaging, shall construct and make use of frequency dependent image models over sub-bands that jointly span the entire observed bandwidth.	Reference [AD1]	SDP	Demonstration

Sub-bands will have a maximum fractional bandwidth of 30%, and sub-band overlap shall not be precluded. Models per sub-band don't have to be forced to be continuous.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3281	SKA1_Mid spectral gain calibration accuracy SKA1_Mid, when performing imaging, shall have a spectral gain calibration accuracy of better than 35 dB.	SKA Error Budgets [R18]	SDP	Demonstration

For accuracy of the spectral gain calibration, residual modulations should not unduly degrade the imaging performance of deep integrations. The requirement pertains to spectral resolutions that span the full range from 10^{-4} to 0.3. [R18]

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3282	SKA1_Low spectral gain calibration accuracy SKA1_Low, when performing imaging, shall have a spectral gain calibration accuracy of better than 35 dB.	SKA Error Budgets [R18]	SDP	Demonstration

For accuracy of the spectral gain calibration, residual modulations should not unduly degrade the imaging performance of deep integrations. The requirement pertains to spectral resolutions that span the full range from 10^{-4} to 0.3. [R18]

6.3.4.3 Deconvolution of single channels

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2325	Scale sensitive deconvolution The SKA1_Mid and SKA1_Low shall, when commanded, provide image reconstruction methods that recover all relevant angular scales to 5% TBC fidelity.	Reference [R2]	SDP	Analysis

The relevant angular scales include the autocorrelation products, which are baselines greater than zero, but smaller than dish diameter.

6.3.4.4 Solution for pointing errors

Pointing self-calibration has been demonstrated on EVLA data.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2328	Solution for pointing errors. The SKA1_Low and SKA1_Mid, when commanded, shall solve for and correct pointing errors as a function of both time and dish/station, with accuracy and timescale limited by signal to noise ratio.	Reference [R2]	SDP, DSH, LFAA, TM	Demonstration

Pointing self-cal (i.e. solving for beam-shape correlated gain errors within the local sky model) shall be available as an option within SDP. This is computationally expensive, but may well be necessary for some applications. Pointing self-cal will be done per sub-band (up to 30% fractional bandwidth), and calculated during the processing of the observation data, not in real-time.

6.3.4.5 Peeling

Peeling is defined as the solution for and subtraction of both source model and calibration parameters for discrete extragalactic sources present in the GSM and/or LSM. Each such source is processed independently.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2330	Peeling. SKA1_Low and SKA1_Mid shall achieve thermal noise limited imaging performance in integrations in excess of 1000 hours.		SDP	Analysis

The SDP is not required to be able to integrate for up to 1000 hours, but imaging performance of the SKA1_Low and SKA1_Mid must allow for achieving that thermal noise limited performance from individual images. Hence Verification can only be performed by Analysis.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3283	SKA1_Mid: Depth of Peeling SKA1_Mid, when performing imaging, shall peel the brightest 1.0 dex of discrete extra galactic sources above the horizon at 350 MHz, declining linearly in log(frequency) to 0 dex (i.e., no sources being peeled) at 1 GHz.	SKA Error Budgets [R18]	SDP	Demonstration

Sources that are in the far side-lobe regime (as distinct from direction dependent calibration within the main beam and near-in side-lobes that is handled elsewhere). With this interpretation, we can suggest the following requirements that follow from document Science Budgets document SKA-TEL-SKO-0000641 [R18]. In all cases, one can refer to the relative depth of the all-sky source population that must be modelled in order to avoid image noise degradation in the deepest integrations.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3284	SKA1_Low: Depth of Peeling SKA1_Low, when performing imaging, shall peel the brightest 2.5 dex of discrete extra galactic sources above the horizon at 50 MHz, declining to 0.5 dex at 350 MHz.	SKA Error Budgets [R18]	SDP	Demonstration

Sources that are in the far side-lobe regime (as distinct from direction dependent calibration within the main beam and near-in side-lobes that is handled elsewhere). With this interpretation, we can suggest the following requirements that follow from document Science Budgets document [R18]. In all cases one can refer to the relative depth of the all-sky source population that must be modelled in order to avoid image noise degradation in the deepest integrations.

6.3.5 Direction dependent effects

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2321	Direction dependent effects. Self-calibration and image reconstruction algorithms for the SKA1_Low and SKA1_Mid shall be capable of dealing with direction dependent effects within each sub-band.		SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2724	Aperture Array DDE The SKA1_Low shall have a direction dependent model for the aperture array primary beam with an accuracy of 35dB at the half-power points to be used in calibration and imaging.	SKA Error Budgets [R18]	SDP, LFAA, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2727	Dish DDE The SKA1_Mid shall have a direction dependent model for the dish primary beam with an accuracy of 35dB at the half-power point to be used in calibration and imaging.	SKA Error Budgets [R18]	TM, SDP, DSH	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2725	Faraday Rotation DDE The SKA1_Low and SKA1_Mid shall have a direction dependent Faraday Rotation model for ionospheric contributions for use in calibration and imaging, in support of the polarisation dynamic range performance.		TM, LFAA, DSH, SDP	Test

The TEC measurement requirement relates to this requirement, as it is needed to bootstrap the TEC calculations from SDP.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3285	SKA1_Mid direction dependent calibration population depth SKA1_Mid, when performing direction dependent calibration, shall include the brightest 4 dex of the source population occurring within the main beam and the brightest 2 dex within the near-in side-lobes.	SKA Error Budgets [R18]	SDP	Demonstration

A clear indication of how extensive the self-cal model must be to insure that model incompleteness does not result in a significant degradation of the imaging noise performance of the deepest integrations. [R18] indicates that base functions for the sources probably need to be more complex than point or gaussian sources.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3286	SKA1_Low direction dependent calibration population depth SKA1_Low, when performing direction dependent calibration, shall include the brightest 4 dex of the source population occurring within the main beam and the brightest 3 dex within the near-in side-lobes.	SKA Error Budgets [R18]	SDP	Demonstration

A clear indication of how extensive the self-cal model must be to insure that model incompleteness does not result in a significant degradation of the imaging noise performance of the deepest integrations. [R18]

6.3.6 Image processing model

6.3.6.1 Continuum source finding

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2333	Continuum source finding. SKA1_Low and SKA1_Mid, when commanded, shall conduct source finding on images generated by Continuum Imaging.		SDP	Test

6.3.6.2 Spectral line source finding

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2334	Spectral line source finding. The SKA1_Low and SKA1_Mid, when commanded, shall conduct spectral line source finding on image cube generated by Spectral Line processing.		SDP	Test

6.3.6.3 Stacking

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2335	Stacking The SKA1_Low and SKA1_Mid, when commanded, shall add signals at user-supplied celestial coordinates to allow a statistical signal detection.	ECP-160045	SDP	Demonstration

For Commissioning and Science Verification, and the checking of different imaging algorithms, it shall be possible to select already processed data for co-adding. The interface for the co-adding capability will not be "public", and will be most likely a command-line like interface with all relevant parameters for the processing. Sizing of the SDP will not be dominated by the 1000h integration time.

6.3.7 Pipelines

6.3.7.1 Standard pipeline products

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2336	Standard pipeline products. All pipelines of the SKA1_Low and SKA1_Mid shall include as ancillary products a log detailing the processing configuration, and a logged quality assessment of the resultant Science Data Products.		SDP	Test

Ancillary products, and in particular processing logs and quality assessment metrics, are essential for interpretation of Science Data Products.

6.3.7.2 Calibration pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2338	Calibration pipeline. The SKA1_Low and SKA1_Mid shall have a Calibration pipeline that derives current telescope parameters using a recent observation and a Global Sky Model (GSM), either from a known GSM or the most recent GSM.		SDP	Test

6.3.7.3 Continuum imaging pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2339	Continuum imaging pipeline. The SKA1_Low and SKA1_Mid shall have a Continuum Imaging pipeline that constructs noise-limited wide-band images for observations up to 1000h integration time with polarisation available if requested or necessary for calibration or quality assurance. The integration may be carried out via multiple, widely-separated Scheduling Blocks.	OCD [AD1]	SDP	Test

Sizing of the SDP will not be dominated by the 1000h integration time.

6.3.7.4 Continuum imaging data products

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2340	Continuum imaging data products. The SKA1_Mid and SKA1_Low shall provide continuum data products which represent the Spectral Energy Distribution of all detected sources with a complexity commensurate with their signal to noise.	OCD [AD1]	SDP	Test

These are supposed to be modelled SEDs, with more terms in the model for high SNR SEDs. The form of the model is not prescribed. Each model can be per sub-band, up to the maximum allowed sub-band fractional bandwidth (30%).

6.3.7.5 SKA1_Low Spectral line emission pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2341	SKA1_Low Spectral line emission pipeline. The SKA1_Low shall have a Spectral Line Emission pipeline that is degraded by less than 20% with respect to the theoretical thermal noise in integrations up to 1000 hours in channel cubes of spectral line emission, either with continuum emission remaining or with continuum emission removed.	SKA Error Budgets [R18]	SDP	Analysis

The Verification has changed to Analysis because the 1000 hours requirement does not drive the sizing of the SDP, but drives the final imaging and spectral performance for science.

6.3.7.6 SKA1_Mid Spectral line emission pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3327	SKA1_Mid Spectral line emission pipeline. The SKA1_Mid shall have a Spectral Line Emission pipeline that is degraded by less than 20% with respect to the theoretical thermal noise in integrations up to 1000 hours in channel cubes of spectral line emission, either with continuum emission remaining or with continuum emission removed.	SKA Error Budgets [R18]	SDP	Analysis

The Verification has changed to Analysis because the 1000 hours requirement does not drive the sizing of the SDP, but drives the final imaging and spectral performance for science.

6.3.7.7 Spectral line emission data products

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2342	Spectral line emission data products. The data products of the SKA1_Low and SKA1_Mid shall include spectral line cube image, continuum model images, sensitivity image, and representative point spread function.		SDP	Test

6.3.7.8 Spectral line absorption pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2343	Spectral line absorption pipeline. The SKA1_Low and SKA1_Mid shall have a Spectral Line Absorption pipeline that is optimised for constructing noise-limited channel cubes of spectral line absorption with continuum sources removed.	OCD [AD1]	SDP	Demonstration

6.3.7.9 pectral line absorption data products

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2344	Spectral line absorption data products. The data products shall include spectral line cube image, continuum model images, sensitivity image, and representative point spread function.	OCD [AD1]	SDP	Test

6.3.7.10 Fast imaging/slow transient pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2345	Slow transient pipeline. The SKA1_Low and SKA1_Mid shall have a Slow Transient imaging pipeline that shall be capable of constructing a continuum image that has an estimate of the non-variable sky emission subtracted for every correlator integration time or slower, searching for transient sources, and producing a time-ordered catalogue of transient source candidates.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3601	Fast imaging transients timescales SKA1_Mid and SKA1_Low, when commanded, shall be able to search for transients with timescales of 1s, 2s, 4s, 8s, 16s, 32s, 64s, 128s, 256s, 512s, 1024s, 2048s, and 4096s in the fast-imaging products.	ECP-160041	SDP, TM	Analysis, Demonstration

Longer averaging times increment the load of SDP's real time imaging/calibration system and hence its cost.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3602	Slow transients finding SKA1_Mid and SKA1_Low, when commanded, shall be able to search for transients, with PI-defined timescales within the range from the correlator dump time up to half the duration of the observation, in calibrated imaging products.	ECP-160041	SDP, TM	Analysis, Demonstration

Allows for commensal processing of SDP data looking for transients at different timescales.

6.3.7.11 Fast imaging/slow transient data products

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2346	Slow transient data products. The SKA1_Low and SKA1_Mid, when commanded, shall compile a catalogue of found sources, and produce a sensitivity image or other suitable statistical representation, and representative PSF image for slow transient data products.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3603	Fast imaging transient notification SKA1_Mid and SKA1_Low, when commanded to search for transients, and upon detection of a transient in the real time imaging, shall: a) persist temporal and spatial information on the transient so that an exhaustive search in previous data could be performed; b) generate a light curve of the transient from data in the same observation; c) inform TM of the detection with enough data to populate a VOEvent. The actions are not mutually exclusive, and which one is selected depends on telescope configuration.	ECP-160041	SDP, TM	Demonstration

The persistence allows for potential later exhaustive search of relevant observations, and also relay to other observatories.

6.3.7.12 Ionospheric monitoring pipeline

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3604	Ionospheric Monitor Pipeline The SKA1_Low shall have an ionospheric monitoring pipeline which determines the current conditions and their suitability for continued observations.	ECP-160048	SDP, TM	Demonstration

6.3.7.13 Automated Quality Assessment

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2347	Automated Quality Assessment. All pipelines shall perform standardised, automated Quality Assessment of Image data products along the axes of astrometry, photometry, radiometry, polarimetry, and spectrometry.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2742	Performance assessment Performance assessment within the SKA1_Mid and SKA1_Low shall be based on a number of quantitative metrics computed from an observed Image and, optionally, a template Image.		SDP	Test

The list of quantitative metrics is TBD, through the Calibration Strategy work.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2743	Performance goals SKA1_Low and SKA1_Mid performance goals shall be based on a number of quantitative metrics computed from an observed Image and, optionally, a template Image.		SDP	Test

The list of quantitative metrics is TBD, through the Calibration Strategy work.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2744	Quality assessment SKA1_Low and SKA1_Mid quality assessment shall be based on the comparison of a Performance Assessment and a Performance Goal.		SDP	Test

6.3.7.13.1 Astrometry performance metric

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2745	Astrometry performance metric The SKA1_Low and SKA1_Mid Astrometric Performance Metric (APM) shall measure deviation (RMS, average offset, and median) of source positions from known standards.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3058	Astrometry performance metric storage SKA1_Mid and SKA1_Low, when commanded, shall store astrometric performance metric data in association with the Science Data Products.		SDP, TM	Test

TM does the general storage of the performance metric, but SDP does the association of the metric with the Science Data Products.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3063	Astrometry performance metric display SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of Astrometry performance metrics.		TM	Demonstration

6.3.7.13.2 *Photometric performance metric*

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2746	Photometric performance metric The SKA1_Low and SKA1_Mid photometric performance metric (PPM) shall measure deviation (RMS, average offset, and median) of source fluxes from known standards in the Global Sky Model.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3057	Photometric performance metric storage SKA1_Mid and SKA1_Low, when commanded, shall store photometric performance metric data in association with the Science Data Products.		SDP, TM	Test

TM does the general storage of the performance metric, but SDP does the association of the metric with the Science Data Products.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3062	Photometric performance metric display SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of photometric performance metrics.		TM	Demonstration

6.3.7.13.3 Radiometric performance metric

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2747	Radiometric performance metric The SKA1_Low and SKA1_Mid radiometric (detected power) performance metric (RPM) shall measure noise fluctuations (RMS, average offset, and median) in an Image.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3056	Radiometric Performance Metric storage The SKA1_Mid and SKA1_Low, when commanded, shall store radiometric performance metric data in association with the Science Data Products.		SDP, TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3061	Radiometric performance metric display SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of radiometric performance metrics.		TM	Demonstration

6.3.7.13.4 Polarimetric performance metric

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2748	Polarimetric performance metric The SKA1_Low SKA1_Mid polarimetric performance metric (OPM) shall measure deviation (RMS, average offset, and median) of source polarisation (polarisation degree and angle) from known standards in the Global Sky Model.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3055	Polarimetric performance metric storage SKA1_Mid and SKA1_Low, when commanded, shall store polarimetric performance metric data in association with the Science Data Products.		SDP, TM	Test

TM does the general storage of the performance metric, but SDP does the association of the metric with the Science Data Products.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3060	Polarimetric performance metric display SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of polarimetric performance metrics.		TM	Demonstration

6.3.7.13.5 *Spectrometric performance metric*

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2749	Spectrometric performance metric The SKA1_Low and SKA1_Mid spectrometric performance metric (SPM) shall measure deviation (RMS, average offset, and median) of source spectral lines from known standards.		SDP	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3054	Spectrometric performance metric storage SKA1_Mid and SKA1_Low, when commanded, shall store spectrometric performance metric data in association with the main data products.		SDP, TM	Test

TM does the general storage of the performance metric, but SDP does the association of the metric with the Science Data Products.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3059	Spectrometric performance metric display SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of spectrometric performance metrics.		TM	Demonstration

6.3.7.14 Pipeline quality assurance

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3175	Pipeline quality assessment SKA1_Mid and SKA1_Low shall log Quality Assessment reports. These should be traceable to the originating Scheduling Blocks.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	SDP	Demonstration

6.3.8 Data Products

6.3.8.1 Archive

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2821	Science Data Products long term preservation The SKA1_Low and SKA1_Mid telescopes shall preserve Science Data Products for the lifetime of the Observatory.	ECP-160046	SDP	Demonstration

6.3.8.2 Role of science processing centres

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2348	Role of science processing centres The Science Processing Centre will convert the output data from the CSP into Science Data Products to be preserved long term.	ECP-160046	CSP, SDP	Test

6.3.8.3 Mirror sites

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2350	Secondary copies of Science Data Products SKA1_Low and SKA1_Mid telescopes shall have at least one secondary copy of all Science Data Products located in a secure offsite location.	ECP-160046	SDP	Test

6.3.8.4 Web and VO interfaces

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2352	Web interface to Science Data Products The Science Data Products being long-term preserved by the SKA1_Low and SKA1_Mid telescopes shall be accessible via standard-based web interfaces. The interfaces to SKA1_Low and SKA1_Mid shall only allow access to authorised SKA staff TBC.	ECP-160046	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2353	Virtual Observatory interface The Science Data Products being long-term preserved by the SKA1_Low and SKA1_Mid telescopes shall be accessible via a set of International Virtual Observatory Alliance (IVOA) services and data models. The set includes SIA, TAP, SSA, DataLink and SODA services and the ObsCore data model. Access to SKA1_Low and SKA1_Mid Science Data Products shall only be possible for SKA staff users.	ECP-160046	SDP	Demonstration

6.3.8.5 QA annotation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2357	QA annotation The SKA1_Low and SKA1_Mid telescopes shall each facilitate the addition of Quality Assessment annotations to Science Data Products by SKA staff users.	ECP-160046	SDP, TM	Demonstration

Allows for some Quality Assessment specific metadata/observations be passed along with the Science Data Products.

6.3.8.6 Distribution of data products

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2366	Distribution of data products The SKA1_Mid and SKA1_Low telescopes, when commanded, shall deliver Science Data Products, including all metadata for A&A policies to be implemented, to approved off-site facilities, which may be globally distributed.	ECP-160046	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3408	Science Data Product location discovery The Science Data Products of the SKA1_Low and SKA1_Mid telescopes shall be browsable and discoverable, including the location of accessible instances of Science Data Products in the SKA1_Low and SKA1_Mid, but also in the approved off-site facilities.	ECP-160046	SDP	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3605	EoR/CD pipeline handover point The SDP shall be able to provide calibrated visibility data and corresponding metadata to an external user group following the calibration and data compression steps outlined in the "Interface between SDP and the EoR/CD Science Team Requirements" SDP memo by CathrynTrott et al.	ECP-160048	SDP, TM	Demonstration

6.3.8.7 Levels of access

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2739	Levels of access to Science Data Products The Science Data Products being long-term preserved by the SKA1_Low and SKA1_Mid telescopes, shall only be accessible to authorised users according to the Science Data Access policy (TBW). Authorisation will be done via SKA Authentication and Authorisation.	ECP-160046	SDP, TM	Test

7 Glass box calibration

7.1 SKA1_Low Glass box calibration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3033	SKA1_Low Glass Box Calibration The SKA1_Low, when commanded, shall deliver the applied calibration correction algorithms and parameters up to a time resolution of the data cadence.	ECP-140041	TM	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3042	SKA1_Low Glass Box Calibration: parameter application The SKA1_Low shall apply calibration correction parameters in a manner that they can be reconstructed.	ECP-140041	LFAA, CSP, SDP, SADT, TM	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3043	SKA1_Low Glass Box Calibration: parameter storage The SKA1_Low shall store necessary information for TBD duration such that calibration correction parameters can be reconstructed.	ECP-140041	LFAA,CSP, SDP, TM, SADT	Demonstration

7.2 SKA1_Mid Glass box calibration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3045	SKA1_Mid Glass Box Calibration: Parameter storage The SKA1_Mid shall store necessary information for TBD duration such that calibration correction parameters can be reconstructed.	ECP-140041	DSH, CSP, SDP,TM, SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3044	SKA1_Mid Glass Box Calibration: parameter application The SKA1_Mid shall apply calibration correction parameters in a manner that they can be reconstructed.	ECP-140041	DSH, CSP, SDP, TM, SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3034	SKA1_Mid Glass Box Calibration The SKA1_Mid, when commanded, shall deliver the applied calibration correction algorithms and parameters up to a time resolution of the data cadence.	ECP-140041	TM	Test

8 Synchronisation and Timing

8.1 Synchronisation

8.1.1 Coherence losses: 1s

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2268	SKA1_Mid coherence losses: 1s The SKA1_Mid Reference Frequency shall provide a 2% maximum coherence loss within a maximum integration period of 1 second and up to an operating frequency of 13.8 GHz.		SADT, DSH	Demonstration

The allocations for the Coherence Loss are defined in the Mid Coherence Budget document: SKA-TEL-SKO-0000632.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3242	SKA1_Low coherence losses 1s The SKA1_Low Reference Frequency shall provide a 2% maximum coherence loss within a maximum integration period of 1 second and up to an operating frequency of 350 MHz.		SADT, LFAA	Demonstration

The allocations for the Coherence Loss are defined in the Low System Timing Budget: SKA-TEL-SKO-0000637.

8.1.2 Coherence loss: 1 min.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2692	SKA1_Mid coherence loss: 1 minute The SKA1_Mid frequency reference shall provide a 2% maximum coherence loss for intervals of 1 minute and up to an operating frequency of 13.8 GHz.		SADT, DSH	Demonstration

The allocations for the Coherence Loss are defined in the Mid Coherence Budget document: SKA-TEL-SKO-0000632.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3243	SKA1_ Low Coherence loss: 1 minute The SKA1_Low Reference Frequency shall provide a 2% maximum coherence loss for interval of 1 minute and up to an operating frequency of 350 MHz.		SADT, LFAA	Test

The allocations for the Coherence Loss are defined in the Low System Timing Budget document: SKA-TEL-SKO-0000637.

8.1.3 Reference Frequency linear phase drift

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2693	SKA1_Mid Reference Frequency phase drift The SKA1_Mid Reference Frequency shall have a phase drift of less than 1 radian, over intervals of up to 10 minutes and up to an operating frequency of 13.8 GHz.		SADT	Demonstration

10 minutes period may be interval between calibrations.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3244	SKA1_Low Reference Frequency phase drift The SKA1_Low Reference Frequency shall have a phase drift of less than 1 radian, over intervals of up to 10 minutes and up to an operating frequency of 350 MHz.		SADT	Demonstration

10 minutes period may be interval between calibrations (TBC).

8.1.4 Pulse per Second precision

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2269	SKA1_Mid Pulse per Second Precision The SKA1_Mid shall have a 1PPS heartbeat signal with the pulse-to-pulse scatter being less than the inverse of the Nyquist frequency of the largest sampled bandwidth.	ECP-160068, ECP-170022	SADT	Test

The 1PPS is not ambiguous for the sampled data of the highest sampled bandwidth.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3617	SKA1_Low Pulse per Second Precision The SKA1_Low shall have a 1PPS heartbeat signal with the pulse-to-pulse scatter being less than the inverse of the Nyquist frequency of the largest sampled bandwidth.	ECP-160068, ECP-170022	SADT	Test

The 1PPS is not ambiguous for the sampled data of the highest sampled bandwidth.

8.1.5 Pulse per second synchronisation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3094	SKA1_Mid Pulse per Second synchronisation The SKA1_Mid shall provide a 1PPS heartbeat signal for synchronisation and array phase up.	ECP-160068, ECP-170022	SADT	Demonstration

Definition of the function of the 1PPS signal.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3618	SKA1_Low Pulse per Second Synchronisation The SKA1_Low shall provide a 1 pps heartbeat signal for synchronisation and array phase up.	ECP-160068, ECP-170022	SADT	Demonstration

Definition of the function of the 1PPS signal.

8.2 Timing

8.2.1 UTC(SKA) Uncertainty

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2274	SKA1_Mid UTC(SKA) uncertainty The SKA1_Mid timescales shall be traceable to UTC with an uncertainty of no more than 5 ns (1-sigma).	ECP-170022	SADT	Analysis

This requirement shall be valid at any moment, independent of timescale, and defines the maximum error between UTC and the local SKA timescale.

Ref. SKA1 System Budget - Mid System Timing Budget SKA-TEL-SKO-0000786.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3616	SKA1_Low UTC(SKA) uncertainty The SKA1_Low timescales shall be traceable to UTC with an uncertainty of no more than 9 ns (1-sigma).	ECP-170022	SADT	Analysis

This requirement shall be valid at any moment, independent of timescale, and defines the maximum error between UTC and the local SKA timescale.

Ref. SKA1 System Budget - Low System Timing Budget SKA-TEL-SKO-0000637.

8.2.2 Central Reference Frequency

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3280	SKA1_Low Central Reference Frequency In order to avoid large offsets, the SKA1_Low Central Reference Frequency shall be steered to UTC to within at least 1 microsecond, with a frequency drift of less than 10 ns/day (1-sigma).	ECP-170022	SADT	Demonstration

The 1-sigma condition indicates the 10ns/day specification is statistical and is not to mean as a value never to be exceeded.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2275	SKA1_Mid Central Reference Frequency In order to avoid large offsets, the SKA1_Mid Central Reference Frequency shall be steered to UTC to within at least 1 microsecond, with a frequency drift of less than 10 ns/day (1 sigma).	ECP-170022	SADT	Demonstration

The 1-sigma condition indicates the 10ns/day specification is statistical and is not to mean as a value never to be exceeded.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3095	SKA1_Mid VLBI Reference Frequency Stability		SADT	Test

The SKA1_Mid timescales shall have a frequency stability, expressed as Allan Deviation, of at least:

AVERAGING TIME [S]	STABILITY
1	$2.0\ 10^{-13}$
10	$5.0\ 10^{-14}$
100	$1.3\ 10^{-14}$
1000	$3.2\ 10^{-15}$
floor up to 10^{5}	$3.0\ 10^{-15}$

A frequency stability requirement of the SKA clock is required to limit decorrelation for VLBI observations.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3592	SKA1_Low VLBI Reference Frequency Stability	ECP-160040	SADT	Test

The SKA1_Low timescales shall have a frequency stability, expressed as Allan Deviation, of at least:

AVERAGING TIME [S]	STABILITY
1	$2.0\ 10^{-13}$
10	$5.0\ 10^{-14}$
100	$1.3\ 10^{-14}$
1000	$3.2\ 10^{-15}$
floor up to 10^{5}	$3.0\ 10^{-15}$

A frequency stability requirement of the SKA clock is required to limit decorrelation for VLBI observations.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3096	SKA1_Mid Common Delay Centre The SKA1_Mid shall determine each dish and effective sub-array position in absolute terms (i.e. relative to the centre of the earth, not each other) to an accuracy of better than 1 cm. At each of these geographical reference positions the time will be traceable to the SKA timescale with an accuracy as specified by the Time stamping requirement.		SDP, TM	Demonstration

Without specifying a geographical reference for the telescope data products their time stamps would be meaningless. The need for accurately knowing antenna and sub-array positions was already identified in ECP-140008, details to be found in section 8.1.3 of SKA Phase 1 VLBI Clarification ECP 140008 Analysis Document SKA-TEL-SKO-000044.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3593	SKA1_Low Common Delay Centre The SKA1_Low shall determine each effective sub-array position in absolute terms (i.e. relative to the centre of the earth, not each other) to an accuracy of better than 1 cm. At each of these geographical reference positions the time will be traceable to the SKA timescale with an accuracy as specified by the Time stamping requirement.	ECP-160040	SDP, TM	Demonstration

Without specifying a geographical reference for the telescope data products their time stamps would be meaningless. The need for accurately knowing antenna and sub-array positions was already identified in ECP-140008, details to be found in section 8.1.3 of SKA Phase 1 VLBI Clarification ECP 140008 Analysis Document SKA-TEL-SKO-000044.

8.3 Phase Referencing

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3261	Phase Referencing The SKA1_Mid shall, when commanded, provide in-band and cross-band instrument phase calibration using celestial phase reference sources.		TM, CSP, SDP.	Test

8.4 Synchronised Telescope Time

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3556	Centralised time server A centralised 'Stratum 1' network time server system shall be provided that is synchronised to the telescope UTC standard, and provide a telescope network time reference for all connected instrumentation.	ECP-160025	SADT	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3557	Network Time Protocol All client devices and applications that require synchronise telescope network time shall comply with the Network Time Protocol version 4 standard, RFC 5905.		DSH, LFAA, CSP, SADT, TM, SDP, INFRA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3558	Network Time Distribution A synchronous network time service shall be transparently distributed to all LMC/NSDN interface locations and be available to all subscribed end-element devices and applications.	ECP-160025	SADT	Demonstration

8.5 SKA_Mid Offset frequency scheme

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3383	Central timing reference distribution The central reference generator shall send to each dish when commanded a unique reference signal avoiding common frequencies at the dishes, settable independently and uniquely for each dish at observation time.	ECP-160042	SADT	Demonstration

Solutions other than central distribution and transmission of off-set frequencies are considered, but they must perform equal or better suppression of unwanted frequencies. The entity proposing the solution will have to demonstrate the effectiveness of such an implementation.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3385	Configurable sample rate It shall be possible to set the sample-clock frequency for each receptor for each band to the nominal sample rate plus or minus N times a frequency offset, where N is an integer, from zero up to half the number of dishes.	ECP-160042	SADT	Demonstration

Specifies the number of offset frequencies required.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3386	Integer clock cycles per second There shall be an identical integer number of samples between the time-stamped 1 second marks from each dish.	ECP-160042	DISH	Test

Functional requirement to check completeness of data by correlator.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3387	Frequency offset The frequency offset shall be such that there is at least 10 KHz of frequency difference to prevent unwanted cross-correlator output.	ECP-160042	SADT	Demonstration

Defines the interference suppression to be obtained by the frequency offset scheme.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3388	Maximum frequency offset The maximum of the frequency offset shall be 1% (TBC) of the science bandwidth.	ECP-160042	SADT	Demonstration

Maximum bandwidth used by the frequency offset scheme.

9 Infrastructure

9.1 Site Monitoring

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2370	Weather Monitoring. Weather monitoring stations (2 in each core and 2 outside the core) shall be provided as part of the infrastructure of SKA1_Mid and SKA1_Low - wind, temperature and humidity.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted).	INFRA, SADT, AIV, TM	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2371	Visual monitoring. 24 hour (day and night time) capability shall be provided for telescope operator(s) to visually monitor security access points [TBD] to the SKA1_Low and SKA1_Mid sites and also selected [TBD] other locations.	ECP-150008	INFRA	Inspection

Rationale for allocation is that it is likely to be COTS solution, and vendors can supply total solution, which means it is easier for a single consortium to specify/design/procure than splitting it down the middle between 2 consortia (INFRA and TM).

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2730	RFI Monitoring The SKA1_Mid and SKA1_Low sites shall be monitored for RFI in accordance with RFI standards document [AD2].	OCD [1]	INFRA, TM, SADT	Inspection

9.2 Tropospheric Monitoring

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2372	Tropospheric Monitoring. Existing Tropospheric monitoring stations shall be expanded as part of the SKA1_Low and SKA1_Mid infrastructure to provide at least 3 sensor units per telescope array site.		SADT, TM	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3053	Infrastructure for tropospheric monitoring The following infrastructure shall be provided at each of the sites. To accommodate 3 stations, design the same as described in the attached documents, equilateral triangle of 500m sides, sited (convenient to other infrastructure) near the core, no preferred azimuth: • Concrete pads of low precision, each provided with 500W of single phase power at a voltage convenient to a core location, and dedicated fibre networking from the signal processing building and to each other • I rack in the central building, 1kW power and cooling.		INFRA	Demonstration

9.3 Power

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2373	SKA1_Low RFI power delivery. The power delivery infrastructure for SKA1_Low shall comply with the SKA1 RFI levels documentation.		INFRA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3084	Low Power Mode SKA1_Low and SKA1_Mid shall have a low power mode that reduces power consumption to less than 5% of their nominal capacity.	Power Limited Use Case	DSH, CSP, TM, SDP, SADT, LFAA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3085	SKA1_Mid RFI power delivery. The power delivery infrastructure for SKA1_Mid shall comply with the SKA1 RFI levels documentation.		INFRA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3086	Low Power Mode on power application On start-up, the SKA1_Mid and SKA1_Low shall enter low power mode until commanded otherwise.	Power Limited Use Case	CSP, LFAA, SDP, TM, DSH, SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3087	Uninterrupted power All critical systems within the SKA1_Low and SKA1_Mid shall be provided with uninterrupted power for a minimum period of at least 5 minutes following a power failure.	Accepted practice	INFRA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3088	Power overload The SKA1_Mid and SKA1_Low shall ensure that power consumption remains below available power supply capacity at all times.	Power Limited Use Case	INFRA, TM	Demonstration

This ensures that the power delivery network is not overloaded.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3090	Power interruption survivability The SKA1_Low and SKA1_Mid shall survive a main power interruption, at an arbitrary time.	Power Limited Use Case	CSP, LFAA, SDP, TM, DSH, SADT, INFRA	Test

The allocation and flow down of this requirement should include both equipment, software, firmware and non-volatile data storage aspects of the telescopes.

It is envisaged this requirement could be verified against the NEN-EN 45511 standard or equivalent.

9.4 Access

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2374	Site Access. Roads and track-ways (including drainage) for the safe, secure and economic construction and operation of the SKA1_Low and SKA1_Mid shall be provided.		INFRA	Analysis and Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2375	Air-strip. There shall be access to an emergency air strip on each of the SKA1_Low and SKA1_Mid sites within 10 km road distance of the respective CPF.	ECP-170002	INFRA	Inspection

9.5 Water and Sanitation

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2376	Construction. Potable and non-potable water shall be available at SKA1_Low and SKA1_Mid construction camps. This will include foundation concrete plants, if present.		INFRA	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2377	Water supply: cooling. Sufficient water shall be continually available at SKA1_Low and SKA1_Mid facilities in support of equipment cooling for each telescope.		INFRA	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2378	Standards and Regulations. The delivery and disposal of water and all construction activity shall be compliant with local and national standards and regulations.	Regulatory	INFRA	Analysis

9.6 Buildings

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2382	Central Processing Facility RFI shielding. The Central Processing Facility for both SKA1_Low and SKA1_Mid shall provide RFI shielding greater than that derived from zoning specifications given in the SKA RFI levels documentation [AD2].		INFRA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2383	Central Processing Facility RFI penetrations. The Central Processing Facility for each of the SKA1_Low and SKA1_Mid shall provide penetrations for signal and power cables entering the facility and also for all other penetrations compliant with SKA-TEL-SKO-0000202-AG-RFI-ST-01-SKA EMI & EMC Standards and Procedures [AD2].		INFRA	Inspection

9.7 Dish earthing and bonding

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2397	SKA1_Mid Dish earthing. Each dish within SKA1_Mid shall have an earthing system that conforms to the requirements of IEC 62305 for the purpose of lightning protection. National standards shall take precedence.	Established precedent	INFRA, DSH	Test

9.8 Telephone network

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2398	Telephone Network. All populated facilities shall provide connectivity to the public telephone network.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted).	INFRA	Test

10 External Interfaces

10.1 Power

10.1.1 Site steady state power budget Africa

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2402	Site steady state power budget Africa. The total steady state power budget for the African site shall be within the limits specified in SKA Power Budget [R8].	SKA Power Budget [R8]	INFRA, DSH, CSP, TM, SADT	Test

10.1.2 Site steady state power budget Australia

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2404	Site steady state power budget Australia. The total steady state power budget for the Australian site shall be within the limits specified in SKA Power Budget [R8].	SKA Power Budget [R8]	INFRA	Test

10.2 VLBI

Provision of equipment for recording or capturing VLBI data is outside the scope of SKA1.

VLBI equipment and eVLBI connectivity beyond the interface boundary described in the ICD SKA-TEL-SKO-0000116 is outside the scope of supply of the SKA1 project.

VLBI processing, with the exception of beam-forming and SKA1 imaging in support of VLBI, is outside the scope of the SKA1.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3138	SKA1_Mid Standard VLBI formats SKA1_Mid VLBI data shall conform to the SKA-VLBI ICD (to be written).	SKA1 Operational Concept Document SKA-TEL-SKO-0000307, ECP-160040	TM	Demonstration, Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3610	SKA1_Low Standard VLBI formats SKA1_Low VLBI data shall conform to the SKA-VLBI ICD (to be written).	ECP-160040	TM	Demonstration, Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2838	SKA1_Mid VLBI data sources The SKA1_Mid telescope shall be a data source for VLBI data acquisition system. The interface between the SKA1_Mid telescope and the external VLBI data acquisition system will be compliant with the ICD SKA-TEL-SKO-0000116.		INFRA,CSP, TM, SADT	Demonstration

ECP-140008 - SKA-TEL-SKO-000044 - SKA Phase 1 VLBI Clarification ECP-140008 Analysis Document.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3594	SKA1_Low VLBI data sources The SKA1_Low telescope shall be a data source for VLBI data acquisition system. The interface between the SKA1_Low telescope and the external VLBI data acquisition system will be compliant with the ICD SKA-TEL-SKO-0000116.	ECP-160040	TM, INFRA, CSP, SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2841	SKA1_Mid Infrastructure for VLBI equipment: The following infrastructure shall be provided to allow eventual outfitting of SKA1_Mid with VLBI equipment: 1. Adequate access for the potential fitment of VLBI equipment 2. Equipment space 3. Power 4. Cooling 5. Cable trays.		INFRA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3597	SKA1_Low Infrastructure for VLBI equipment The following infrastructure shall be provided to allow eventual outfitting of SKA1_Low with VLBI equipment: 1. Adequate access for the potential fitment of VLBI equipment 2. Equipment space 3. Power 4. Cooling 5. Cable trays.	ECP-160040	INFRA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2843	SKA1_Mid Compatibility with existing VLBI terminal SKA1_Mid shall be able to output VLBI beam data with each individual stream limited to 512 MHz of signal bandwidth to ensure compatibility with existing VLBI terminal capability.		CSP,SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3611	SKA1_Low Compatibility with existing VLBI terminal SKA1_Low shall be able to output VLBI beam data with each individual stream limited to the entire SKA1_Low band to ensure compatibility with existing VLBI terminal capability.	ECP-160040	CSP, SADT	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2845	SKA1_Mid VLBI beam output data SKA1_Mid shall be able to produce VLBI beam output data with either dual or single polarization.		CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3599	SKA1_Low VLBI beam output data SKA1_Low shall be able to produce VLBI beam output data with either dual or single polarization.	ECP-160040	CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2846	SKA1_Mid Word length of VLBI beam output data SKA1_Mid shall be able to output VLBI beam data with configurable word formats, the allowed values being 2, 4, 8, and 16-bit integer.		CSP, TM, SADT	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3600	SKA1_Low Word length of VLBI beam output data SKA1_Low shall be able to output VLBI beam data with configurable word formats, the allowed values being 2, 4, and 8-bit integer TBC.	ECP-160040	CSP, TM, SADT	Test

11 Internal Interfaces

11.1 SKA1_Low

11.1.1 SKA1_Low Low Frequency Aperture Array

11.1.1.1 SKA1_Low LFAA to CSP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2420	SKA1_Low LFAA to CSP interface. The SKA1_Low interface between LFAA and CSP shall be compliant with the 100-000000-004 Interface Control Document.		LFAA, CSP	Test

11.1.1.2 SKA1_Low LFAA to Infra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2421	SKA1_Low LFAA to Infra interface. The SKA1_Low interface between LFAA and INFRA shall be compliant with the 100-000000-003 Interface Control Document.		LFAA, INFRA	Test

11.1.2 SKA1_Low Central Signal Processor

11.1.2.1 SKA1_Low CSP to Infra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3262	SKA1_Low CSP to Infra interface. The SKA1_Low interface between CSP and Infra shall be compliant with the 100-000000-020 Interface Control Document.		CSP, INFRA	Test

11.1.2.2 SKA1_Low CSP to SDP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3263	SKA1_Low CSP to SDP Interface The SKA1_Low interface between CSP and SDP shall be compliant with the 100-000000-002 Interface Control Document.		CSP, SDP	Test

11.1.3 SKA1_Low SADT

11.1.3.1 SKA1_Low SADT to LFAA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2423	SKA1_Low SADT to LFAA interface. The SKA1_Low interface between SADT and LFAA shall be compliant with the 100-000000-026 Interface Control Document.		LFAA, SADT	Test

11.1.3.2 SKA1_Low SADT to CSP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3266	SKA1_Low SADT to CSP interface. The SKA1_Low interface between SADT and CSP shall be compliant with the 100-000000-023 Interface Control Document.		SADT, CSP	Test

11.1.3.3 SKA1_Low SADT to SDP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3267	SKA1_Low SADT to SDP interface. The SKA1_Low interface between SADT and SDP shall be compliant with the 100-000000-025 Interface Control Document.		SADT, SDP	Test

11.1.3.4 SKA1_Low SADT to Infra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3268	SKA1_Low SADT to Infra interface. The SKA1_Low interface between SADT and Infra shall be compliant with the 100-000000-024 Interface Control Document.		SADT, INFRA	Test

11.1.4 SKA1_Low Telescope Manager

11.1.4.1 SKA1_Low TM to LFAA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2428	SKA1_Low TM to LFAA interface. The SKA1_Low interface between TM and LFAA shall be compliant with the 100-000000-028 Interface Control Document.		LFAA, TM	Test

11.1.4.2 SKA1_Low TM to SADT

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3271	SKA1_Low TM to SADT interface. The SKA1_Low interface between TM and SADT shall be compliant with the 100-000000-027 Interface Control Document.		SADT, TM	Test

11.1.4.3 SKA1_Low TM to CSP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3272	SKA1_Low TM to CSP interface. The SKA1_Low interface between CSP and TM shall be compliant with the 100-000000-021 Interface Control Document.		CSP, TM	Test

11.1.4.4 SKA1_Low TM to INFRA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3273	SKA1_Low TM to INFRA Interface The SKA1_Low interface between TM and INFRA shall be compliant with the 100-000000-022 Interface Control Document.		TM, INFRA	Test

11.1.5 SKA1_Low Science Data Processor

11.1.5.1 SKA1_Low SDP to TM

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3274	SKA1_Low SDP to TM interface. The SKA1_Low interface between SDP and TM shall be compliant with the 100-000000-029 Interface Control Document.		SDP, TM	Test

11.1.5.2 SKA1_Low SDP to INFRA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3275	SKA1_Low SDP to INFRA interface. The SKA1_Low interface between SDP and Infra shall be compliant with the SKA-TEL-SKO-0000484 Interface Control Document.		SDP, INFRA	Test

11.2 SKA1_Mid

11.2.1 SKA1_Mid AIV

11.2.1.1 SKA1_Mid AIV MeerKAT to CSP interface

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2410	SKA1_Mid AIV MeerKAT to CSP interface. The SKA1_Mid interface between AIV MeerKAT and CSP shall be compliant with SKA-TEL-AIV-2310001 interface specification.		CSP, AIV	Test

11.2.1.2 SKA1_Mid AIV MeerKAT to SADT

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2412	SKA1_Mid AIV MeerKAT to SADT interface. The SKA1_Mid interface between AIV MeerKAT and SADT shall be compliant with SKA-TEL--AIV-2310003 Interface Control Document.		SADT, AIV	Test

11.2.1.3 SKA1_Mid AIV MeerKAT to TM

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2414	SKA1_Mid AIV MeerKAT to TM interface. The SKA1_MId control and monitoring interface between AIV MeerKAT and TM shall be compliant with SKA-TEL-AIV-2310004 Interface Control Document.		TM, AIV	Test

11.2.1.4 SKA1_Mid AIV MeerKAT to INFRA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2775	SKA1_Mid AIV MeerKAT to INFRA The SKA1_Mid interface between AIV MeerKAT and INFRA shall be compliant with SKA-TEL-AIV-2310002 Interface Control Document.		AIV, INFRA, SADT, TM	Test

11.2.2 SKA1_Mid Central Signal Processor

11.2.2.1 SKA1_Mid CSP to Infra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2416	SKA1_Mid CSP to Infra interface. The SKA1_Mid interface between CSP and Infra shall be compliant with the 300-000000-020 Interface Control Document.		CSP, INFRA	Test

11.2.2.2 SKA1_Mid CSP to SDP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2738	SKA1_Mid CSP to SDP Interface The SKA1_Mid interface between CSP and SDP shall be compliant with the 300-000000-002 Interface Control Document.		CSP, SDP	Test

11.2.3 SKA1_Mid Dish

11.2.3.1 SKA1_Mid Dish to CSP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2418	Dish to CSP interface. The SKA1_Mid interface between CSP and Dish shall be compliant with the SKA-TEL-SKO-0000124 Interface Control Document.		CSP, DSH	Test

11.2.3.2 SKA1_Mid DSH to Infra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2419	SKA1_Mid Dish to Infra interface. The SKA1_Mid interface between Dish and Infra shall be compliant with the SKA-TEL-SKO-00000115 Interface Control Document.		INFRA, DSH	Test

11.2.4 SKA1_Mid SADT

11.2.4.1 SKA1_Mid SADT to DSH

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2422	SKA1_Mid SADT to DSH interface. The SKA1_Mid interface between SADT and DSH shall be compliant with the 300-000000-026 Interface Control Document.		SADT, DSH	Test

11.2.4.2 SKA1_Mid SADT to CSP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2424	SKA1_Mid SADT to CSP interface. The SKA1_Mid interface between SADT and CSP shall be compliant with the 300-000000-023 Interface Control Document.		SADT, CSP	Test

11.2.4.3 SKA1_Mid SADT to SDP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2425	SKA1_Mid SADT to SDP interface. The SKA1_Mid interface between SADT and SDP shall be compliant with the 300-000000-025 Interface Control Document.		SADT, SDP	Test

11.2.4.4 SKA1_Mid SADT to Infra

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2426	SKA1_Mid SADT to Infra interface. The SKA1_Mid interface between SADT and Infra shall be compliant with the 300-000000-024 Interface Control Document.		SADT, INFRA	Test

11.2.5 SKA1_Mid Telescope Manager

11.2.5.1 SKA1_Mid TM to DISH

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2427	SKA1_Mid TM to Dish interface. The SKA1_Mid interface between TM and Dish shall be compliant with the SKA-TEL-SKO-0000150 Interface Control Document.		TM, DSH	Test

11.2.5.2 SKA1_Mid TM to SADT

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2429	SKA1_Mid TM to SADT interface. The SKA1_Mid interface between TM and SADT shall be compliant with the 300-000000-027 Interface Control Document.		SADT, TM	Test

11.2.5.3 SKA1_Mid TM to CSP

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2430	SKA1_Mid TM to CSP interface. The SKA1_Mid interface between CSP and TM shall be compliant with the 300-000000-021 Interface Control Document.		CSP, TM	Test

11.2.5.4 SKA1_Mid TM to INFRA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2737	SKA1_Mid TM to INFRA Interface The interface between TM and INFRA shall be compliant with the 300-000000-022 Interface Control Document.		TM, INFRA	Test

11.2.6 SKA1_Mid Science Data Processor

11.2.6.1 SKA1_Mid SDP to TM

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2431	SKA1_Mid SDP to TM interface. The SKA1_Mid interface between SDP and TM shall be compliant with the 300-000000-029 Interface Control Document.		SDP, TM	Test

11.2.6.2 SKA1_Mid SDP to INFRA

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2432	SKA1_Mid SDP to INFRA interface. The SKA1_Mid interface between SDP and INFRA shall be compliant with the SKA-TEL-SKO-0000484 Interface Control Document.		SDP, INFRA	Test

11.3 SKA1_Common

This revision of the System Requirements does not yet include internal interfaces to SKA1_Common.

12 RFI and EMC

12.1 Electromagnetic Radiation

The levels and the verification procedures are described in the RFI/EMI Protection and Threshold Levels for the SKA document SKA-TEL-SKO-0000202-AG-RFI-ST-01-SKA EMI & EMC Standards and Procedures [AD2].

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2462	Electromagnetic Radiation Emissions of electromagnetic radiation from components of the SKA1_Mid and SKA1_Low, in any of the stated frequency intervals for broad band and narrow band cases, shall be within the SKA RFI/EMI Threshold Levels [AD2].	EMI/EMC Standards [AD2]	LFAA, SADT, CSP, TM, INFRA, DSH	Test

12.2 Self-induced RFI

The levels and testing and acceptance procedures are described in the RFI/EMI Protection and Threshold Levels for the SKA document [AD2].

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2463	Self-induced RFI The SKA1_Low and SKA1_Mid shall generate less self-induced RFI, within the Telescope's operating frequency bands, than the SKA RFI/EMI Protection Levels, for both broad band and narrow band cases, as specified in the "RFI/EMI Protection and Threshold Levels for the SKA" document. The SKA RFI/EMI Protection Levels are defined at the respective receiver input, and measured at the respective Telescope time series output.	EMI/EMC Standards [AD2]	LFAA, SADT, CSP, TM, INFRA, DSH	Test

12.3 Electromagnetic Compatibility Standards

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2464	Electromagnetic Compatibility Standards The SKA1 Telescopes shall be compliant with one or more of the following standards for emissions and one or more for susceptibility/immunity: *IEC EN 61000-6-2. Electromagnetic compatibility (EMC). Generic standards. Immunity standard for industrial environments. • IEC EN 61000-6-4 AMD2. Electromagnetic compatibility (EMC). Part 6-4. Generic standards. Emission standard for industrial environments. • IEC CISPR 14-1. Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus. Part 1. Emission. • MIL-STD-464C.	Root	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

12.4 Electricity network Electromagnetic Compatibility

The levels and verification procedures are described in the RFI/EMI Protection and Threshold Levels for the SKA document [AD2], which is part of the Level 1 Requirements.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2465	Electricity network Electromagnetic Compatibility The SKA1_Low and SKA1_Mid shall follow the code of practice for the application of Electromagnetic Compatibility (EMC) standards and guidelines in electricity utility networks [AD2].	EMI/EMC Standards[AD2]	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Analysis

12.5 EMC Compatibility Marking

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2466	EMC compatibility marking. All "off-the-shelf" equipment shall possess as a minimum the host country EMC marking.	EMI/EMC Standards [AD2]	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

12.6 Electromagnetic Susceptibility

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2467	Electromagnetic susceptibility. The SKA1_Low and SKA1_Mid shall not be susceptible to terrestrial electromagnetic radiation at any frequency that significantly interferes with its normal operation.	EMI/EMC Standards [AD2]	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Test

12.7 Receiver linearity - space borne RFI

The levels and testing and acceptance procedures are described in the Linearity SKA document, which is part of the Level 1 Requirements.

12.8 Receiver linearity airborne RFI

The levels and testing and acceptance procedures are described in the SKA linearity document, which is part of the Level 1 Requirements.

12.9 RFI flagging

An RFI mask identifies individual frequency data to the resolution of one channel and time data to the integration unit that is likely to be corrupted by RFI.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2472	RFI flagging The SKA1_Low and SKA1_Mid shall automatically flag frequency data with a resolution of one channel and time data to the resolution of the integration unit if the data is corrupted by RFI.	EMI/EMC Standards [AD2]	LFAA, CSP, SDP, TM, DSH	Test

12.10 RFI excision

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2473	RFI excision The SKA1 Telescopes, when commanded, shall automatically excise data that is corrupted by RFI. Corrupted data is either flagged (i.e., not used in the data products) or subtracted (i.e., the corruption is removed, allowing the residual to be used in the data products).	EMI/EMC Standards [AD2]	SDP	Test

12.11 RFI masking

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2474	RFI masking The SKA1_Low and SKA1_Mid shall flag data according to a pre-selected RFI Mask.	EMI/EMC Standards [AD2]	LFAA, CSP, SDP, TM, DSH	Demonstration

13 Environmental, Safety and Occupational Health (ESOH)

13.1 Environmental Protection

NOTE: This section states requirements for the protection of the environment from the impacts of SKA activities and facilities. A separate section of requirements provide details of the environmental conditions that could impact the SKA systems.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2484	SKA1_Mid environmental legislation and regulations The SKA1_Mid shall be compliant with all local, State and national environmental protection legislation and regulations. NOTE: Legislation takes precedence over project/contract documentation and requirements. Omission of a law from this requirement does not affect its enforceability. Legislation is also subject to amendment and so the Environmental Laws identified during the Request for Information (copied below) may be modified by the Hosting Agreements and subsequent Acts and Amendments.	Legislation. SA - NEMA.	SADT, CSP, SDP, TM, INFRA, DSH	Analysis

The intent of this requirement will be included into the Hosting Agreements. These will then become the Parent requirement once signed off.

Legislation and regulations identified during the response to Request for Information include:

- National Environmental Management Act, 1998 ("NEMA");
- National Water Act, 1998;
- National Environmental Management: Air Quality Act, 2004;
- National Environmental Management Waste Act, 2008;
- National Environment Management: Biodiversity Act, 2004;
- National Heritage Resources Act, 1999.*

*Other South African environmental statutes include:the Environment Conservation Act, 1989, various air pollution statutes, the National Heritage Resources Act, 1999, the Hazardous Substances Act, 1973, the Health Act, 1977, the Nuclear Energy Act, 1999, the National Nuclear Regulatory Act, 1999, the National Environmental Management: Protected Areas Act, 2003, the Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947, the Marine Living Resources Act, 1998, and the National Environmental Management: Integrated Coastal Management Act, 2008.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3257	SKA1_Low environmental legislation and regulations. The SKA1_Low shall be compliant with all local, State and national environmental protection legislation and regulations. NOTE: Legislation takes precedence over project/contract documentation and requirements. Omission of a law from this requirement does not affect its enforceability. Legislation is also subject to amendment and so the Environmental Laws identified during the Request for Information (copied below) may be modified by the Hosting Agreements and subsequent Acts and Amendments.	Legislation. Australia EPBC, WA EPA et al.	LFAA, SADT, CSP, SDP, TM, INFRA	Analysis

The intent of this requirement will be included into the Hosting Agreements. These will then become the Parent requirement once signed off.

Legislation and regulations identified during the response to Request for Information include:

- The Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act 1999.
- The Western Australian Environmental Protection Act 1986
- The Western Australian Land Administration Act 1997
- In addition, approvals will be required under the Western Australia Mining Act 1978, Heritage of Western Australia Act 1990, the Western Australian Aboriginal Heritage Act 1972 and the MRO Indigenous Land Use Agreement 2009.

13.2 Safety

The safety priorities of the system will be:

1. protection of persons,
2. guarding the technical integrity of the observatory and other equipment potentially affected by the operation of the observatory, and
3. protection of scientific data, in this order.li>

SKA Observatory hazard analysis and safety practices will be governed by an order of precedence as follows:

1. Design for Minimum Risk: The primary means for mitigation of risk will be to eliminate the hazard through design.
2. Incorporate Safety Devices: Fixed, automatic or other protective devices will be used in conjunction with the design features to attain an acceptable level of risk. Provisions will be made for periodic functional checks as applicable.
3. Provide Warning Devices: When neither design nor safety items can effectively eliminate or reduce hazards, devices will be used to detect the condition, and to produce an adequate warning to alert personnel of a hazard. Devices may include audible or visual alarms, permanent signs or movable placards.
4. Procedures and Training: Where it is impractical to substantially eliminate or reduce the hazard or where the condition of the hazard indicates additional emphasis, special operating procedures and training will be used.

13.2.1 Safe Design

13.2.1.1 Safety of equipment < 600V

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2820	Safety of equipment with rated voltage not exceeding 600V Equipment shall comply with the safety requirements of BS EN IEC 60950. NOTE: This includes electric shock, energy related hazards, fire, heat related hazards, mechanical hazards, radiation and chemical hazards.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	SPO, LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

13.2.1.2 Hazard analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2437	Design for hazard elimination. The System, while in any mode, shall present no hazard to either the system equipment or to operators or maintainers of the system equipment with categorization exceeding the levels defined in the SKA Project Safety Management Plan [AD6].	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Analysis

13.2.1.3 Hazard warning marking

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2579	Hazard warning marking. All items that present a potential hazard shall be labelled in accordance with BS EN ISO 7010.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2818	Marking of machinery - safety In accordance with ISO 61310_2, machinery shall bear all markings which are necessary • for its unambiguous identification; • for its safe use; and supplementary information shall be given, as appropriate: • permanently on the machinery; • in accompanying documents such as instruction handbooks; • on the packaging.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Demonstration

13.2.1.4 Fail-Safe Design

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2438	Fail safe design. Components and Equipment shall be designed to be locally fail-safe and not rely on external safety devices or measures to operate safely.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2788	Non-propagation of failures SKA1_Low and SKA1_Mid hardware failures and software errors shall not create a hazardous situation to interfacing systems.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Analysis

13.2.1.5 Emergency stop

Emergency stop buttons are to be provided as a backup for use in emergency only. They need to be robust, dependable and available at all positions where it might be necessary to operate them.

As guidance IEC EN 60204-1 [SR7] standard defines the categories of operation and IEC EN 60947-5-5 [SR8] the characteristics of the emergency stop switches.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2439	Emergency stop The SKA1 Elements shall have emergency stop switches or brakes for all electro-mechanical or mechanical systems that may pose a hazard to operators or maintainers of the system.	TBD	INFRA, DSH	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2733	Location of Emergency stop Emergency stop switches shall be located in such a way to minimize the risk of injury. (Verified by Analysis as 'minimisation' is unverifiable any other way.)	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	DSH, INFRA	Analysis

13.2.2 Electrical safety

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2446	Electrical safety Electrical risks and hazards shall be controlled in accordance with local, State and national legislation and Codes of Practice. NOTE: In South Africa, SANS 10142-1 and SANS 10142-2 shall apply. NOTE: In Australia, in addition to legislation, the following Codes of Practice shall be applied: AS/NZ 3000 Safe Work Australia 'Managing Electrical Risks at the Workplace'; Western Australia Director of Energy Safety 'Safe Low Voltage Work Practices by Electricians'.	Legislation	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

13.2.2.1 Safety grounding and bonding

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2444	Safety grounding and bonding. External conductive parts shall be grounded in compliance to: South Africa: • National Building Regulations and Building Standards Act, 1977 • Occupational Health and Safety act, 1993 • SANS 10313 Australia: • AS/NZ 3000, • AS/NZ 1768.	Legislation	LFAA, INFRA, DSH	Test

13.2.2.2 Electrical circuit interlocks

Guidance to safeguarding and complementary protective measures are provided in ISO 12100-2 clause 5 [SR14].

Monitoring of safety signals is available in ISO 13849-1 [SR10].

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2445	Electrical circuit interlocks. Electrical circuit inter-locks shall be provided to prevent personnel coming into contact with hazards that cannot otherwise be eliminated from design.	Legislation: AS/NZ 3000; SANS 10142	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

13.2.3 Emergency Communications

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2481	Emergency communication The SKA1_Low and SKA1_Mid shall provide an independent system to communicate with outside locations in emergencies.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted).	SADT, INFRA	Demonstration

13.2.3.1 Safety preparation for construction and operations

13.2.3.1.1 First aid stations

The location and capability for first aid stations is to be determined in association with the hazard analysis.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2453	First aid stations. First aid stations shall be provisioned.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations. Australian OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	INFRA	Inspection

13.3 Occupational Health

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2460	SKA1_Mid Occupational health legislation and regulations. The SKA1_Mid shall comply with all applicable local, State and national occupational health regulations and standards in force at the time.	Legislation. South African Occupational Health and Safety Act, 1993, and all its regulations.	SADT, CSP, SDP, TM, INFRA, DSH	Analysis

The intent of this requirement will be included into the Hosting Agreements. These will then become the Parent requirement once signed off.

Regulations include, but are not limited to:

- Occupational Health and Safety Act, 1993, and all its regulations.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3258	SKA1_Low Occupational health legislation and regulations. The SKA1_Low shall comply with all applicable local, State and national occupational health regulations and standards in force at the time.	Legislation. Occupational Safety and Health Act 1984; WA Harmonised OHS legislation, as approved by WA and Commonwealth Acts.	LFAA, SADT, CSP, SDP, TM, INFRA	Analysis

The intent of this requirement will be included into the Hosting Agreements. These will then become the Parent requirement once signed off.

Regulations include, but are not limited to:

- Commonwealth Occupational Health and Safety Act 1991;
- OHS (Safety Arrangements) Regulations 1991;
- OHS (Safety Standards) Regulations 1994;
- OHS Codes of Practice 2008.
- Western Australia:
- Occupational Safety and Health Act 1984;
- Harmonised OHS legislation (as enacted).

13.3.1 Illumination

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2457	Illumination. Personnel shall be provided with a working illumination level which is compliant with local and national regulations including the current issue of SANS 10114-1 in South Africa and the AS/NZS 1680 series in Australia.	Legislation. South African Occupational Health and Safety Act, 1993, and all its regulations. Australia - Occupational Safety and Health Act 1984; WA Harmonised OHS legislation, as approved by WA and Commonwealth Acts.	INFRA	Test

13.3.2 Clean air

Dust is likely to be a principal but not limited to driver of this requirement. Where the air quality cannot be managed, protective masks may be required. This is covered by the protective clothing requirement.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2458	SKA1_Mid Clean air standard Personnel of the SKA1_Mid shall be provided with air quality at least compliant with the current issue of SANS 10400-O (South Africa - The application of National Building Regulations Part O : Lighting and ventilation).	Legislation. South African Occupational Health and Safety Act, 1993, and all its regulations.	INFRA	Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3259	SKA1_Low Clean air standard Personnel of the SKA1_Low shall be provided with air quality at least compliant with the current issue of AS 1668 series of codes (Australia - The use of mechanical ventilation and air conditioning in buildings).	Legislation. Occupational Safety and Health Act 1984; WA Harmonised OHS legislation, as approved by WA and Commonwealth Acts.	INFRA	Test

13.3.3 Humidity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2649	SKA1_Mid Humidity SKA1_Mid working environments for personnel shall maintain an air quality that meets or exceeds the guidance provided in the Code of Practice for Managing the Work Environment and Facilities, National Building Code of TBD.	Legislation - RSA No. 85 of 1993: Occupational Health and Safety Act, as amended, and related Regulations.	INFRA	Test

NOTE: Building humidity required for computing facilities is specified in Req 2367.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3260	SKA1_Low Humidity SKA1_Low working environments for personnel shall maintain air quality that meets or exceeds the guidance provided in the Australian Code of Practice for Managing the Work Environment and Facilities, National Building Code of Australia and AS 1668.	Legislation - OH&S Act 1984, OH&S Regulations 1996. Western Australia WHS Regulations and Codes of Practice (as adopted)	INFRA	Test

NOTE: Building humidity required for computing facilities is specified in Req 2367.

14 Security

The SKA will be a very attractive target for criminals, including theft of infrastructure and cyber-attacks exploiting the HPC and networks. It will also be seen to be a 'soft' target with connections to the academic and research communities. The potential impacts include financial cost to replace equipment and to restore systems, loss of observing opportunities (telescopes could be rendered useless for weeks or months) and loss of reputation for the SKA and the host nations. The threats will exist from the outset and security will need to be established before physical installation starts (including security of information systems to deter Trojan horses from being installed early in the development phase).

There is currently no ISO Standard for a Security Management System, although DPC: 13 / 30278101 DC included Draft BS ISO 34001 Security Management System which forms the basis of the Security requirements. In addition, the UK Cabinet Office HMG Security Policy Framework (Version 11.0) has been used to derive requirements.

The security risk management system shall include:

1. personnel security,
2. physical security and counter terrorism, and
3. security of information.

14.1 Security Management

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2791	Security Management System The SKA shall provide a security management system that includes: 1. personnel security, 2. physical security (asset) 3. security of information.	EN 50600-2-5. Data centre facilities and infrastructures. Part 2-5. Security systems' and others	SPO, TM, INFRA	Inspection

14.2 Physical security

SKA assets must be safeguarded against a range of physical threats, including crime (theft, criminal damage, assaults on staff etc.), natural hazards (e.g. flooding), and security threats such as terrorism and exploitation by criminal and malicious groups (including hacktivists).

Physical security describes a range of controls that are intended to protect individuals from violence; prevent unauthorised access to sites and / and other valuable assets; and reduce the risk a range of physical threats and mitigate their impact to a levels that is acceptable to the organisation. Security must be incorporated into the initial stages of planning, selecting, designing or modifying any building or facility, using appropriate methodologies; putting in place integrated and proportionate control measures to prevent, deter, detect and/or delay attempted "physical attacks", and to trigger an appropriate response.

Host Country security organisations will need to be consulted to determine the terrorism threat to the SKA (currently negligible but may vary in time).

This section on physical security requirements will expand as the use cases are developed and the need for perimeter, interior and inter-site security is better understood.

14.2.1 Equipment Security

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2478	Equipment security The observatory shall provide a secure environment for equipment including protection of generators, fuel, solar cells equipment spare stores, and inter-station assets such as copper cables.	EN 50600-2-5. Information technology: Data centre facilities and infrastructures : Physical security	LFAA, SADT, INFRA, DSH	Analysis

14.3 Information security

The Information Security Management System will be based upon the ISO 27000 series, tailored for the SKA project. Information security is important to the SKA project in order to protect: availability of telescopes being impacted by attacks and viruses; legal, regulatory and reputational damage should SKA systems be exploited by criminal and malicious organisations; protection of IPR; and protection of personal and financial information stored on SKA business systems. Assets that have vulnerabilities that are exploitable include hardware, software, network, personnel, site and organisation.

14.3.1 Accessibility

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2482	Accessibility SKA1_Low, SKA1_Mid and SKA1_Common shall control on a per user basis which facilities and resources (both hardware and software) may be accessed by the user (as per EN 50600-2-5 (Data centre facilities and infrastructures. Part 2-5. Security systems.	EN 50600-2-5. Data centre facilities and infrastructures. Part 2-5. Security systems' and others	LFAA, SADT, INFRA, DSH, CSP, EMS, OMS, OPS, SDP	Demonstration

14.3.2 Archive Security

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2479	Science Data Product security The SKA1_Low and SKA1_Mid telescopes shall provide a secure environment for all Science Data Products preserved long term.	EN 50600-2-5. Data centre facilities and infrastructures. Part 2-5. Security systems' and others, ECP-160046	SDP, TM	Test

15 System Environment

	Threshold block average wind speed		Additional dynamic wind characteristics			
	$V_{avg\_1000sec}$ [m/s]	Cumulative % of All Time	μ_{cat} [m/s]	**σ_{cat} [m/s]**	***$Pr(V_{95\%}-V_{avg} \leq 3\sigma_{cat})$***	Cumulative % of All Time
Precision	**5.0**	68 %	2.7	**0.70**	86%	59%
Standard	**7.0**	87 %	5.9	**1.2**	98%	86%
Degraded	**10.0**	99 %	8.1	**1.5**	99%	99%

Table 8 Summary of Categories of Observing Conditions

Primary Environmental Conditions Common to All Categories
Precision & Standard Conditions a. Air Temperature • Minimum Air Temperature: -5°C • Maximum Air Temperature: 40°C • Maximum rate of change of Air Temperature: 3°C/1000 seconds. a. No rain, ice, hail, snow dew, or frost. b. No earthquake c. No lightning
Degraded Conditions a. Air Temperature • Minimum Air Temperature: -5°C • Maximum Air Temperature: 40°C • Maximum rate of change of Air Temperature: 4.5°C/1000 seconds. a. No rain, ice, hail, snow dew, or frost. b. No earthquake c. No lightning

Table 9 Primary Environmental Conditions Common to All Categories

15.1 Non-weather protected locations - protection of equipment

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2798	SKA1_Mid protection of equipment in stationary use at non-weather protected locations SKA1_Mid Equipment located at non-weather protected locations shall survive during, and perform to specification as defined herein, after exposure to the following environmental conditions as defined in BS EN IEC 60721-3-4: • Climatic conditions 4K4H with tailoring based on [AD7] Section 4.1 • Heat radiation conditions 4Z1 • Wind Speed conditions 4Z5 with tailoring based on [AD7] Section 4.1] • Water from other sources than rain 4Z7 with tailoring based on [AD7] Section 4.1 • Biological conditions 4B2 • Chemical conditions 4C1 • Dust and Sand conditions 4S2 (4S3) with tailoring based on [AD7] Section 4.1 • Mechanical conditions 4M1 with tailoring based on [AD7] Section 4.1.	ECP-150020	SADT, INFRA, DSH	Inspection

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3070	SKA1_Low protection of equipment in stationary use at non-weather protected locations SKA1_Low Equipment located at non-weather protected locations shall survive during, and perform to specification as defined herein, after exposure to the following environmental conditions as defined in BS EN IEC 60721-3-4: • Climatic conditions 4K4H with tailoring based on [AD7] Section 4.1 • Heat radiation conditions 4Z1 • Wind Speed conditions 4Z5 with tailoring based on [AD7] Section 4.1] • Water from other sources than rain 4Z7 with tailoring based on [AD7] Section 4.1 • Biological conditions 4B2 • Chemical conditions 4C1 • Dust and Sand conditions 4S2 (4S3) with tailoring based on [AD7] Section 4.1 • Mechanical conditions 4M1 with tailoring based on [AD7] Section 4.1.		SADT, INFRA, LFAA	Test

SKA1_Low variant of SKA1-SYS_REQ-2489.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3278	SKA1_Mid general operational environmental conditions for equipment located at non-weather protected locations SKA1_Mid Equipment located at non-weather protected locations shall perform to specification, except for those requirements where it is indicated otherwise herein, during exposure to the survival environmental conditions as defined in requirement SKA1-SYS_REQ-2798. Note: The exceptions here are some of the Dish Element performance requirements. These requirements will refer in their text to the sub-set of environmental conditions applicable to the specified level of performance.	ECP-160008	DSH, SADT, INFRA	Test

The extreme expected environmental conditions at the RSA site is actually not very severe and most SKA1_Mid equipment will be able to meet their operational specifications under these conditions without incurring unreasonable cost.

The notable exception here is the Dish where compliance to a number of its performance requirements is severely influenced by weather phenomena.

For this reason sub-sets of the Operational Environmental conditions have been defined in the Dish pointing ECP 160008 namely Precision, Standard and Degraded. The new Dish Pointing and Motion Behaviour performance requirements have been defined in terms of these environmental condition definitions.

It is important that all other Dish performance requirements, which are also weather dependant, should also be defined in terms of Precision, Standard and Degraded environmental conditions. This is not currently the case for e.g. the Level 1 Dish Sensitivity requirements.

15.1.1 SKA1_Low Air temperature operation range

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3069	SKA1_Low air temperature operation range. SKA1_Low equipment located at the aperture arrays or outside the central processing and operating facilities shall be able to operate within specification if the outside air temperature is within the range of -5 ºC to +50 ºC. Note this takes precedence over IEC60721-3-4 4K4H.		LFAA, SADT, TM	Test

This is a SKA1_Low specific version of REQ2488.which retains the -5 to +50 degrees Centigrade temperature range. REQ-2488 was updated as a result of an ECP coupled to a site Environmental conditions report.

15.2 Weather protected locations - protection of equipment

The environment for weather protected locations will be negotiated as part of the appropriate Interface Control Document.

15.3 Transport environmental conditions

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2501	SKA1_Low Transport environmental conditions All components and spares of the SKA1_Low, in their transport packaging, shall not be damaged while, and shall perform to specification as defined herein, after being transported under conditions as defined in "Class 2.2: careful transportation" of the ETSI EN 300 019-1-2 standard [SR13] and defined in BS EN IEC 60721-3-2: • Climatic conditions 2K5H with tailoring based on [AD7] Section 6.1 • Biological conditions 2B3 changed based on [AD7] Section 6.2 • Chemical conditions 2C1 changed based on [AD7] Section 6.3 • Dust and Sand conditions 2S3 changed based on [AD7] Section 6.4 • Shock & Vibration conditions 2M3 changed based on [AD7] Section 6.5.	OCD, ETSI ETS 300 0019-1-2 class 2.2	LFAA, SADT, CSP, SDP, TM, INFRA	Analysis

Tailoring from Mid read across. If and when specific environmental data report from Australia is available this is to be updated.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3298	SKA1_Mid Transport environmental conditions All components and spares of the SKA1_Mid, in their transport packaging, shall not be damaged while, and shall perform to specification as defined herein, after being transported under conditions as defined in "Class 2.2: careful transportation" of the ETSI EN 300 019-1-2 standard [SR13] and defined in BS EN IEC 60721-3-2: • Climatic conditions 2K5H with tailoring based on [AD7] Section 6.1 • Biological conditions 2B3 changed based on [AD7] Section 6.2 • Chemical conditions 2C1 changed based on [AD7] Section 6.3 • Dust and Sand conditions 2S3 changed based on [AD7] Section 6.4 • Shock & Vibration conditions 2M3 changed based on [AD7] Section 6.5.	OCD, ETSI ETS 300 0019-1-2 class 2.2	SADT, CSP, SDP, TM, INFRA, DSH	Analysis

15.4 Storage of equipment

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2801	Storage of SKA1_Mid equipment SKA1_Mid equipment, while in its storage packaging, shall withstand, and shall operate to specification as defined herein after exposure to, the storage environmental conditions as defined in “Class 1.1: Weather protected, partly temperature-controlled storage locations” of the ETSI EN 300 019-1-1 standard and defined in BS EN IEC 60721-3-1. • Climatic Conditions 1K3 based on [AD7] • Biological Conditions 1B2 based on [AD7] • Chemical conditions 1C2 based on [AD7] • Dust and Sand conditions 1S2 based on [AD7] • Shock & Vibration Conditions 1M2 based on [AD7].	ECP-150020	SADT, CSP, SDP, TM, INFRA, DSH	Inspection

ECP-150020 identifies applicable storage environment for South Africa it is assumed these are also applicable to Australia.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3071	Storage of SKA1_Low equipment. SKA1_Low equipment, while in its storage packaging, shall withstand, and shall operate to specification as defined herein after exposure to, the storage environmental conditions as defined in “Class 1.1: Weather protected, partly temperature-controlled storage locations” of the ETSI EN 300 019-1-1 standard and defined in BS EN IEC 60721-3-1. • Climatic Conditions 1K3 based on [AD7] • Biological Conditions 1B2 based on [AD7] • Chemical conditions 1C2 based on [AD7] • Dust and Sand conditions 1S2 based on [AD7] • Shock & Vibration Conditions 1M2 based on [AD7].	Concept of Operations Section 5	LFAA, SADT, CSP, SDP, TM, INFRA	Inspection

Tailoring from Mid read across. If and when specific environmental data report from Australia is available this is to be updated.

15.5 Seismicity

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2491	Safety. SKA1 equipment and buildings shall be designed and built in compliance with national and State regulations including AS 1170.4 (Importance level 3, design life 50 years) and SANS 10160-4 for seismic events resulting in a maximum peak ground acceleration of 1 m/s^2.	Legislation	LFAA, SADT, INFRA, DSH	Analysis

Assumes Infra provides appropriate shock and vibration protection for CSP, TM and SDP. Both the Australian and the SA Standards (AS 1170.4 and SANS 10160-4) quantify the seismic severity design input as “peak ground movement” in g (gravity acceleration).

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2650	Seismic resilience SKA1 structures and equipment shall survive and be fully operational after seismic events resulting in a maximum peak ground acceleration of 1 m/s^2. Note: Seismic events includes underground collapses in addition to earthquakes.	Council for Geoscience Internal report no.: 2005-0121 Section 4	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Analysis

16 Availability, Reliability, and Maintainability

High availability of the telescopes to conduct science will be a key user requirement in measuring the success of the SKA. In turn, availability is dependent upon both the reliability and maintainability of the telescopes. Both of these factors may have considerable impact on the whole life costs of the observatory. Therefore, although the Level 0 requirements should be targeting availability, the Level 1 requirements will need to allocate reliability and maintainability constraints on the elements.

BS 5760-0:1986 defines the following terms:

- **Availability:** the ability of an item (under combined aspects of its reliability, maintainability and maintenance support) to perform its required function at a stated instant of time or over a stated period of time.
- **Reliability:** the ability of an item to perform a required function under stated conditions for a stated period of time.
- **Maintainability:** the ability of an item, under stated conditions of use, to be retained in, or restored to, a state in which it can perform its required functions, when maintenance is performed under stated conditions and using prescribed procedures and resources.

16.1 Availability, Reliability, and Maintenance Plan

The availability, reliability and maintenance plan for the SKA1 telescopes will be developed concurrently so as to fit within the allocated capital and operating (maintenance) budgets. The plans and designs will be developed in accordance to:

- SKA-TEL-SKO-0000103 - SKA Support Concept
- SKA-TEL-SKO-0000104 - SKA Integrated Logistic Support Plan (ILSP).

16.2 Availability

The following applies to each of SKA1_Low and SKA1_Mid telescopes separately. In general available means that the telescope or a fraction there of as defined below is available to an operator to be scheduled for science or other operations.

Availability is defined as A=MTBF' / (MTBF' + MTTR'), where MTBF’ is the mean time between failures (based on the conditional probability of failure), given that regular inspection or preventative maintenance is done, and MTTR' is the total time spent on these two activities plus any repair time.

- Availability Fraction is defined as (N Ae) / (Nmax Ae_max), where N is the number of schedulable major modes and Ae is the effective area available; Nmax is the number of major modes in the full set of defined modes; Ae_max is the maximum effective area of the telescope.
- Major modes correspond to the main categories of observations that the telescope is designed to carry out. For each frequency band defined for the telescope they are:
    - Spectral line observations.
    - Pulsar search observations.
    - Pulsar timing observations.
    - Continuum observations.
    - Transient detection.

The telescope system will have three availability states:

1. Available: The availability fraction is 95%
2. Degraded: The availability fraction is between 50 and 95%.
3. Unavailable: The availability fraction is less than 50%.

In a running average over a year, the design requirement is:

- Unavailable for <5% of the time, corresponding to ~18 days per year.
- Degraded for <5% of the time, corresponding to ~18 days per year.
- Available >90% of the time, corresponding to ~329 days per year.

Natural disturbances of severity outside design boundaries are not counted against availability, unless the system does not behave according to design. The availability state depends only on the telescope, itself.

The operational state of all sub-systems will be defined as 'failed', 'degraded' or 'available'. It will be possible to sense and log the operational state (failed, degraded, or available) of every sub-system at the system level.

16.2.1 Operational availability

Availability includes Available and Degraded availability states.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2716	Operational availability The SKA1_Mid and SKA1_Low shall each have an operational availability of at least 95%.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, CSP, SADT, TM, SDP, INFRA	Analysis

Operational Availability: Operational availability is the probability that a system is operationally capable at any point in time when used in a realistic support environment, i.e., one in which repair cannot commence until sometime after the failure has occurred. It is thus a measure of not only reliability and maintainability, but also of the response time of the support system.

16.2.2 Inherent availability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3245	Inherent availability The SKA1_Mid shall have an Inherent Availability of more than 99%.	SKA Logistic Engineering Management Plan	INFRA, DSH, CSP, SADT, SDP, TM	Analysis

Inherent availability is the probability that the telescope is operationally capable at any point in time when used in an ideal support environment, i.e., one in which repair commences instantaneously upon failure.

Operational Capable: A telescope is operationally capable when it can perform astronomical observations. It is assumed that the telescope will be capable if more than 95% of its collecting area, signal processing and data reduction capabilities are available. i.e:

- For SKA1_Low: “2 out of 40 stations” (or equivalent signal processing or data reduction capabilities) can be in a failed state and the telescope will still be operationally capable; or
- For SKA_Mid: “9 out of 197 dishes” (or equivalent signal processing or data reduction capabilities) can be in a failed state and the telescope will still be operationally capable.

16.3 Reliability

16.3.1 Fail safe provisions

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2525	Fail safe provisions. The SKA1_Mid and SKA1_Low shall not exhibit safety hazards in Categories I or II (ISO 45001) following an unplanned loss of main electrical power or main control functions.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, CSP, SADT, TM, SDP, INFRA	Analysis

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3238	Fail safe state SKA1_Mid and SKA1_Low equipment that would otherwise present a safety hazard when subjected to an unplanned loss of main electrical power or main control function, shall enter a designated fail safe state.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, CSP, SADT, TM, SDP, INFRA	Demonstration

Safe state needs to be entered in the glossary i.e. a definition of what safe state entails.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3239	Fail safe warnings Where transitioning to a designated fail safe state represents a hazard, components of the SKA1_Mid and SKA1_Low shall issue continued warnings for the duration of the transition.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, CSP, SADT, TM, SDP, INFRA	Demonstration

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3240	Fail safe recovery Once transitioning to or in a designated safe state, the SKA1_Mid and SKA1_Low shall remain in the designated safe state (or the transition to it) until commanded otherwise.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, CSP, SADT, TM, SDP, INFRA	Demonstration

The objective is to prevent equipment automatically resuming normal operation once main power and main control are resumed.

16.4 Maintainability

(Con Ops Section 5.1) There are SKA-specific factors beyond standard availability requirements that require particular attention and for which additional design effort and capital expenditure is justified. These are needed mainly to keep human occupancy on the sites to a minimum, as well as to enhance maintenance efficiency:

- Remote diagnostic and repair: In practice, this means that the monitor and control systems allow for a deep level of interrogation of sensor values and system state.
- Line-replaceable units: On-site repair will be particularly difficult and expensive at the remote sites. Systems should be designed to contain line replaceable units where feasible.
- Configuration Management System: Configuration management is a systems engineering process for managing the logistics of maintenance, tracking system documentation, and supplying real-time information to inform the system model. For this to work properly the system model must be tailored to SKA requirements.

Due to the geographically distributed nature of the SKA observatory there will be echelons or levels of maintenance for components of the observatory. Traditionally these have included:

- Site
- Operations centre
- Supplier

The maintenance functions for components at each level need to be defined along with their turnaround time (TAT) for repair.

The logistics pipeline time and Level of repair policies will be defined in an SKA1 Logistics Engineering Management Plan. This is assumed to include personnel quantities and skills at each level of maintenance.

16.4.1 SKA1_Low Maintenance hours

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3276	SKA1_Low maintenance hours The SKA1_Low shall require less than 1600 Direct Maintenance Hours per month.	SKA Logistic Engineering Management Plan	INFRA, LFAA, CSP, SADT, SDP, TM	Analysis

Direct Maintenance Hours (DMH): Direct Maintenance Hours includes corrective, preventative, scheduled and inspections tasks and is limited to on-equipment/1st line maintenance. It provides a measure of the amount of maintenance personnel hours required but excludes management, administrative, leave and training hours.

16.4.2 SKA1_Mid Maintenance hours

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3246	SKA1_Mid maintenance hours The SKA1_Mid shall require less than 1600 Direct Maintenance Hours per month.	SKA Logistic Engineering Management Plan	INFRA, DSH, CSP, SADT, SDP, TM	Analysis

Direct Maintenance Hours (DMH): Direct Maintenance Hours includes corrective, preventative, scheduled and inspections tasks and is limited to on-equipment/1st line maintenance. It provides a measure of the amount of maintenance personnel hours required but excludes management, administrative, leave and training hours.

16.4.3 Maintenance Provisions

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2595	Maintenance provisions. Repairable items shall be designed to include maintenance provisions such as test points, accessibility, and plug-in components.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.4 Component removal

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2599	Component removal. Modules and components shall be mounted such that removal of any single item will not require the removal of other items (component stacking to be avoided where possible).		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.5 Mounting preclusion

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2602	Mounting preclusion. Provisions for the preclusion of mounting the wrong module shall be provided (key coding of connectors etc.) where there is the possibility of damage.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.6 Stand-offs and handles

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2448	Stand-off and handles. Stand-offs and handles shall be used to protect system components from damage during out-of-system repair and maintenance.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.7 Mounting guides

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2603	Mounting guides. Mounting guides and location pins shall be provided on SKA1_Mid and SKA1_Low equipment to facilitate maintenance.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.8 Module labelling

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2604	Module labelling. SKA1_Low and SKA1_Mid labelling of modules shall be in a conspicuous location, such that it is readable when the module is removed or installed in its intended operating environment.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.9 Label robustness

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2605	Label robustness. Labels used within the SKA1_Low and SKA1_Mid shall be affixed for at least 50 years or the lifetime of the equipment, whichever is the smaller, and unlikely to come off during maintenance or as a result of the environment.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.10 Disposable item labelling

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2606	Disposable LRU labelling. Disposable line replaceable units should be labelled as such.		LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

16.4.11 Software updates

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3247	Software updates SKA1_Low and SKA1_Mid equipment shall facilitate updates of major software updates within the system availability allocations.	SKA Logistic Engineering Management Plan	INFRA, DSH, CSP, SADT, SDP, TM	Test

Software Updates: Software is defined in this context as the update of major software components which will require frequent updates and exclude low level and imbedded software components.

17 Quality Factors Requirements

17.1 Fault reporting

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3182	Logging of operational state SKA-Mid and SKA-Low shall log their operational states at all times.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	DSH, LFAA, SADT, CSP, TM, SDP, INFRA	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3183	Reporting of alarms SKA1_Mid and SKA1_Low shall provide monitoring to log all alarms, alerts and warnings, with a human readable report presented to authorised personnel.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration and Test

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3184	Fault database The SKA1_Common shall log new, open and closed faults, with the repair and corrective actions archived for future and continual reference.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	TM	Demonstration

17.2 Testability

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3249	Testability SKA1_Low and SKA1_Mid shall each test (for), detect, isolate and report failures to the operational and maintenance personnel. a. SKA1_Mid shall detect more than 99% of all Critical Failures. b. SKA1_Mid shall isolate and log more than 95% of all failures down to a LRU level.	SKA Logistic Engineering Management Plan	INFRA, DSH, CSP, SADT, SDP, TM	Analysis

Fault Detection: Is the ability to detect malfunctions in real time, as soon and as surely as possible.

Critical Failure: Is a failure which may cause injury, damage, or the telescope not been available. A critical failure in this context also includes failures, which may result in loss of redundancy or degradation, and if not detected or repaired could result in the telescope not been available.

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-3192	Remote diagnostic capability The SKA1_Common shall provide the capability to remotely identify faults within the SKA1_Mid and SKA1_Low down to LRU level.	SKA1 Operational Concept Document SKA-TEL-SKO-0000307	OMS	Demonstration

18 Configuration Management

18.1 Product configuration information

Product configuration information comprises both product definition and product operational information. This typically includes requirements, specifications, design drawings, parts lists, software documents and listings, models, test specifications, maintenance and operating handbooks.

Product configuration information should be relevant and traceable. Numbering conventions should be established that are unique and ensure proper control of configuration items. These should take into consideration the existing numbering conventions of the organization and the change control information, such as revision status.

18.1.1 Materials

Use is to be made of adequate and permissible materials (including, where possible, minimisation of environmental impact), deviations to be approved by the consortia leads (or their nominated authority), including management of applied materials.

The objectives are the following:

a. To ensure that all requirements of the program are met,

b. To verify the Materials, Parts and Processes activity of equipment suppliers,

c. To control and monitor the status of Materials, Parts and Processes in accordance with program milestones and regulations.

18.1.2 Nameplates and Marking

Components, (sub) systems, instruments, equipment, and materials shall be marked for configuration control purposes and maintenance support purposes.

18.1.2.1 Serial and part numbers

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2573	Serial and part numbers. All items identified in the Logistics Analysis and Configuration Item Plan as needing individual characterisation shall be marked with a label displaying a unique Serial Number and Part Number. The label should normally be in an easily visible location but may also include embedded identification for items such as embedded firmware/ software.	Established Precedent, ref to logistics analysis and configuration item documents to be added	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

The labelling of items is specific to items and could include part and or serial numbers

18.1.2.2 Marking method

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2575	Marking method. Where items used on SKA1_Mid and SKA1_Low require labelling, the method of marking shall be compliant with the Logistic Analysis Plan. The nature of the item, its environment and its use will determine the method.	Operational Requirements [AD1], Logistics Analysis Plan [R10]	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

18.1.2.3 Electronically readable or scannable ID

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2576	Electronically readable or scannable ID Items used within the SKA1_Low and SKA1_Mid shall be marked with a unique electronically readable or scannable ID, in accordance with the Logistic Analysis Plan and Configuration Plan. The ID may be both serial number and part number or in some cases may not be needed.	Established Precedent, Logistics Analysis Plan, Configuration Plan, EMC/ EMI Control plan	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

18.1.2.4 Packaging part and serial number marking

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2577	Package marking. All packaging of items used on the SKA1_Mid and SKA1_Low shall be marked to uniquely identify the contents in accordance with the Logistics Analysis Plan. The identification will be by part number and serial number.	Established Precedent, Logistics Analysis plan	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

18.1.2.5 LRU electrostatic warnings

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2580	LRU electrostatic warnings All LRUs with electrostatic sensitive components shall be fitted with ESD warning labels.	Established Precedent	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

18.1.2.6 Cable identification

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2583	Cable identification. All ends of cables used within the SKA1_Low and SKA1_Mid shall carry a unique identifier.	SKA Electrical Installation Standard SKA-TEL.OFF.SE-SKO-ST-001	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

18.1.2.7 Connector plates

ID	Requirement description	Parent	Allocation	Verification
SKA1-SYS_REQ-2584	Connector plate identification All connector plates used within the SKA1_Low and SKA1_Mid shall carry identification labels for connectors.	SKA Electrical Installation Standard SKA-TEL.OFF.SE-SKO-ST-001	LFAA, SADT, CSP, SDP, TM, INFRA, DSH	Inspection

19 Verification Provisions

19.1 Methods

Demonstration (D): Operation of the system, subsystem or a part of the system that relies on observable, functional operation, not requiring use of instrumentation, special test equipment or subsequent analysis.

Test (T): Operation of the system, subsystem or a part of the system using instrumentation or other special test equipment to collect data for later analysis.

Analysis (A): Processing of accumulated data obtained from other qualification methods. Examples are reduction interpolation or extrapolation of test results.

Inspection (I): Visual examination of system components, documentation, certifications etc.

Special Verification Methods: Special verification methods for the system or subsystem, for example, special tools, techniques, procedures, facilities, acceptance limits, use of standard samples, preproduction or periodic production samples, pilot models or pilot lots.

20 Definitions

20.1 Sky Temperature

T_sky (in Kelvin) = 2.73 + 20.0*(0.408/ν)**2.75 + 288.*(0.005+0.1314*exp((lg(ν)-lg(22.23))*8.)).

It should be noted that the leading constant of 20K is approximately the 25th percentile of the all-sky distribution. The 10th percentile is 17K and the 50th percentile is 25K.

20.2 Channelisation

From Interferometry and Synthesis in Radio Astronomy, 3rd edition, by Thompson Moran and Swenson [ISRA3]:

For a receiving bandpass being a Gaussian:

$R_b = 1/\mathrm{sqrt}(1 + (0.939\ r_l\ \Delta\nu/\theta_b\nu_0)^2)$ [ISRA3; Equation 6.76]

where R_b is the peak response to a point source at a distance r_l from the origin of the *l*,*m* plane;

$\Delta\nu$ is the bandpass width;

θ_b is the half-power beam-width; and

ν_0 is the observing frequency.

20.3 Visibility dump time

A simplified form of the dump time is:

$\tau_i = D/(2k_N B_{max} \Omega_E)$,

where τ_i is the dump time,

D is the diameter of the aperture,

B_{max} is the longest baseline,

Ω_E is the rotation rate of the Earth (7.2 x 10^{-5} rad/s).

The formula is based on the amount of time it takes the aperture to rotate through half its width when tracking a polar field (approximately Nyquist sampling of the aperture). k_N is a factor to account for multiples of the Nyquist rate to account for time smearing, and also to account for fields-of-view larger than the Θ_{FWHM}. Thus k_N is ~2 to remove time smearing; the radius of the second zero for a 'pill-box' aperture is ~$2\Omega_{FWHM}$ (another factor of 2) so that k_N should be ~4.

With B_{max} = 65 km; D = 35 m, $\tau_i \cong$ 1 sec for the longest spacing.

20.4 SKA1_Mid Sensitivity

MID Sensitivity= (N_{dishes})*(per DSH A_e/T_{sys})*(correlator efficiency)

21 Glossary

Term	Definition
1PPS	Short for One Pulse-per-second, a signal that has a width of less than one second, and a sharply rising edge that accurately repeats once per second.
A&A	Authorisation and Authentication.
Actor	A natural person, organisation, or other system, outside of a given subject system, that interacts with it.
AEOC	Australian Engineering Operations Centre
Alarm	An alarm is an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a timely response. (ISO/IEC 62682)
Alert	An Alert is a notification of a condition which has already occurred. It provides information to an operator or personnel to attract attention and require an investigation, action or rework. (eg. "file transfer failed", "power outage and running on backup power", "wind speed above xx knots", "non-critical failure"). An Alert is the means by which an Alarm is reported to the operator, and **not a different level of severity** for an Alarm.
APM (performance metric)	Astrometry Performance Metric, a measurement on the RMS, average, and median pointing deviation of the SKA1_Mid and SKA1_Low when pointed to known astrometry standards.
Array Assembly	A package of hardware and software delivered to the AIV contractor, consisting of all components that make up an Array Release. An Array Assembly is characterised by the number of Dishes/Stations included in the array, and by its capability as an end-to-end Telescope System with pre-defined functionality. See Array Release.
Array Release	An Array Assembly that has been released by the AIV contractor, after it has been integrated into an end-to-end Telescope System, and after it has undergone extensive verification testing. The term “released” requires further clarification, but it essentially signals that a significant integration and verification (I&V) milestone has been reached by the AIV contractor regarding the current array. The current array is essentially handed-over to the SKA Observatory. This hand-over will require some form of agreement between the AIV contractor and the SKA Observatory. A similar agreement will be needed for the hand-back of the array to the AIV contractor for further integration and verification towards the next Array Release. See Array Assembly.

Term	Definition
ASOC	Australian Science Operations Centre
Astrometric accuracy	Fractional error in the position, $\Delta\rho/\Delta\theta$, for the centroid of compact objects (smaller in size than the PSF's FWHM, $\Delta\theta$) relative to the adopted celestial reference frame.
astronomical coordinates	The position of objects in the sky, considered as a celestial sphere. That position can be defined in different reference systems, depending of the choice of the centre point, its poles, and primary direction. The main astronomical coordinate system for the SKA is the International Celestial Reference System (ICRS).
Availability	Availability is the probability that a system is operating satisfactorily at any point in time under stated conditions. It is a measure of how often an item fails (reliability) and how quickly it can be restored to operation (maintainability). **Note that this is different from the BS 5760-0:1986** definition, which is more aligned with the SKA definition of Operational availability.
Band (of a SKA1_Mid receiver)	Namely Band 1, Band 2, Band 5...
Bandpass stability	Residual fractional error in the brightness, $\Delta I/I$, as function of frequency for a specified frequency interval over a specified time. Sufficient bandpass stability must be realised to permit a calibration strategy that provides the specified Spectral Dynamic Range.
Baseline (of a system)	A specification or system that has been formally reviewed and agreed upon, that thereafter serves as the basis for further development and can be changed only through formal change control procedures. (IEEE Std 610.12-1990)
Baseline (of an interferometric array)	Makes reference to a pair of entities which are coherently combined. Stations for SKA1_Low, Dishes for SKA1_Mid.
Cadence	The rate of repeated observations.
Calibration	The process whereby the output of a measurement is related back to the value of the measure and, in order that absolute measurements are possible.
Calibration Table (Data Product)	A database containing values for calibration (q.v.) parameters, usually as a function of time.
Capability	Capabilities are the different type of tasks, activities or functions that resources are able to perform. These may include, but are not limited to: subarrays, spectral zoom modes, imaging pipelines.

Term	Definition
celestial coordinates	See astronomical coordinates.
celestial sphere	Imaginary sphere of arbitrarily large radius, concentric with Earth (or other suitable, well defined point, such as the Solar System barycentre, or the centre of the galaxy). Definition of the poles and equator of the sphere with respect to the centre is required. Objects in the sky are considered projected upon the inside surface of the celestial sphere, using spherical coordinates.
Central Area	An area 1700 m in radius with a centre at the centre of the array.
Central Processing Facility	A building of closely associated group of buildings, including associated infrastructure and services, whose primary function is to accommodate the Central Processing functions of SKA telescopes (c.f. CSP).
Central Signal Processor	The Signal Processing equipment located at a (putative) Central Processing Facility which may include or constitute the Correlator, Central Beamformer, and Non-Imaging Processor.
Clean Model (Data Product)	Model Image (q.v.) formed by the Clean algorithm.
Cluster	A group of six stations placed randomly around a cluster location, defined for stations outside the core area. The value of six arises to provide sufficient collecting area over the range of interferometer spacings outside the core.
Cluster diameter	The diameter of the area within which individual station belonging to the cluster are located.
Cluster location	The position of a cluster outside the core area. Positions are defined in the WGS84 coordinate system.
Co-Polarisation	That polarisation that the antenna is intended to radiate [receive].
Commensal observations	Two or more Scheduling Blocks that simultaneously utilise the same resources that result in two or more Science Data Products. The Scheduling Blocks may originate from the same, or different, projects. The telescope resources can be dishes/stations/beams, signal and data processing bandwidth, or data processing resources. There is no sharing of the elapsed time between commensal projects, i.e. if 6 hours elapsed time are used executing an observation for two commensal projects, they are each charged with 6 hours (not 3). See also Concurrent Observations, Data Commensality, Observing Commensality, and Multiplexed Commensality.

Term	Definition
Compound Block	A scheduling construct that contains a set of scheduling blocks to be executed in parallel on a defined set of compatible subarrays within the context of a single project. The compound scheduling block is scheduled as a whole, but the contained scheduling blocks are executed in parallel. The compound scheduling block also includes special tasks to configure the required subarrays and recombine afterwards.
Concurrent Observations	Two or more observing programmes that simultaneously utilise different resources of a particular telescope for different science goals and awards of observing time (resources are split). The telescope resources can be antennas, data paths, signal processors, data-sets or other resources. See also Commensal Observations.
Configuration	1. The geometrical arrangement of receptors in an interferometric array, equivalent to 'Array Configuration'. 2. A list of entities in a system and a description of their relationships, together with their key attributes, such as design status, build status, maintenance status and operating status, equivalent to 'System Configuration'. The use of the qualified forms Array Configuration, or System Configuration, as appropriate, is recommended. See also Topology.
Constraint	A statement that expresses measurable bounds for an element or function of the system. That is, a constraint is a factor that is imposed on the solution by force or compulsion and may limit or modify the design changes.
Context Diagram	System Context Diagrams are diagrams used in systems design to represent all external factors and actors that interact with the system at hand. This type of diagram pictures the system at the centre, with no details of its interior structure, surrounded by all its interacting systems, environment and activities. The objective of a system context diagram is to focus attention on external factors and events that should be considered in developing a complete set of system requirements and constraints.
Core	An area 1000 m in diameter within which the individual stations are randomly located with no overlap.
Correlatable Entity	A station, substation or superstation which has been beam-formed to produce a data stream to be correlated.
Critical Failure	Failure which may cause injury, damage, or lack of availability of the telescope. Failures which may result in loss of redundancy, or in performance degradation, and that could result in the telescope becoming available if not detected or repaired, are also included.
Cross Polarisation	Metric to express polarisation purity, defined as the ratio of the polarisation component orthogonal to a reference polarisation. The ratio is often defined in dB.

Term	Definition
Customer(s)	The entity or entities for whom the requirements are to be satisfied in the system being defined and developed. This can be an end-user of the completed system, an organization within the same company as the developing organization (e.g., System Management), a company or entity external to the developing company, or some combination of all of these. This is the entity to which the system developer must provide proof that the system developed satisfies the system requirements specified.
Data Commensality	Data Commensality is the ability for more than one Scheduling Block (from more than one project) to use the same subarray resources (and field of sky) to generate the same science data products for different scientific goals. Each of the projects is granted data rights to exploit the data product for their own approved science goals. See also Commensal Observing.
Data Product	In the context of the SKA, a Data Product is a dataset, which when combined with other (SKA originated) datasets provides spectrally, temporally and/or spatially resolved measurements of phenomena of astronomical interest or of sectors of the celestial sphere. Typically a Data Product arises from the operation of a processing pipeline on a datastream of finite duration. SKA Data Products are very specific to the capabilities and performance of SKA telescopes and to the processes employed in the pipelines implemented in SKA Science Data Processing. For each SKA1 observation use case, they are identified, defined and described in a Level 1 Data Products document (to be written). See also other entries marked as (Data Product).
dB	deciBel, or 1/10 of a Bel. Without further qualification, corresponds to ten times the logarithm ratio of two power measurements, dB = $10 \times \log(P_1/P_2)$. If using any other units for the ratio, it needs to be qualified with the unit[5]. For instance, dB (V) corresponds to $10 \times \log(V_1/V_2)$, with voltages in volts, and dB (A) corresponds to $10 \times \log(I_1/I_2)$, with intensities in amperes. dBm is the relative power measurement against 1milliwatt, dB = $10 \times \log(P_1/ 1\text{mW})$.
DDE	Direction Dependent Effects
Dec	When speaking about coordinates, typical abbreviation of Declination.
Derived Requirement	A requirement deduced or inferred from the collection and organisation of requirements into a particular system configuration and solution.

[5] See https://www.rohde-schwarz.com/uk/applications/db-or-not-db-educational-note_230850-15534.html for usage guidelines.

Term	Definition
dex	Adimensional unit corresponding to the decimal logarithm of a ratio. A ratio of 1000000 to 1, for instance, corresponds to 6 dex, while 1 to 1000000 is -6 dex. In astrophysics, the phrase "the brightest n dex of sources" means "the brightest source, and those which are up to 10^n less bright". "The brightest 0 dex sources" means just the brightest source.
Direct Maintenance Hours (DMH)	Direct Maintenance Hours includes corrective, preventative, scheduled and inspections tasks and is limited to on-equipment/1st line maintenance. It provides a measure of the amount of maintenance personnel hours required but excludes management, administrative, leave and training hours.
Dirty Image (Data Product)	An approximate image of the sky brightness constructed by Inverse Fourier Transform of weighted visibilities. Can be shown to be the convolution of the true sky with the point spread function.
Dynamic range	A measure of the maximum contrast visible in an image. Often computed as the ratio of the brightest source to the noise level away from a source. Since calibration errors concentrate close to bright sources, the DR calculation is often fudged by measuring the noise far from a bright source. For spectral observations, the ratio is often computed to the same location spatially but a different frequency. Ultimately the definition should be driven by science considerations.
Elapsed Time	The real time that has passed while conducting an observation or a series of observations. This time will include any overheads/inefficiencies incurred due to moving the telescope, calibrations, etc.
EMI	Electro-Magnetic Interference
End user	The person or persons who will ultimately be using the system for its intended purpose.
Environment	The circumstances, objects, and conditions that will influence the completed system; they include political, market, cultural, organizational, and physical influences as well as standards and policies that govern what the system must do or how it must do it.
Execution Time	The elapsed time taken to carry out the observation(s) defined in a Scheduling Block.
Failure	The event in which any part of an item does not perform as required in its specification. Used as synonymous with fault.
Fault Detection	Ability to detect malfunctions in real time, as soon and as surely as possible.
Fault Isolation	Ability to identify the root cause for a fault, by isolating the LRUs whose operation mode is not nominal.

Term	Definition
Fidelity	The degree of exactness with which something is copied or reproduced.
Field of view	A region, generally measured by angle, half angle or solid angle, within which useful signals may be received. The angle signifies a boundary position away from a nominal centre or boresight, at which the signal falls below a value expressed as a ratio to the peak, a signal to noise figure or an absolute intensity value. Within the region a signal will be received with a sensitivity that varies by a small amount, typically 3dB.
Flexible Scheduling	Flexible scheduling (also known as dynamic scheduling) is a method of executing a prioritised list of observations that allows science operations to continue with high efficiency as constraints and/or priorities (due to triggered alerts and Targets-of-Opportunity, for instance) change in real time. An automatic decision is made on whether the resources are available and sufficient to execute the next observation in the schedule. This decision is informed by the dish/station availability, signal and data processing capacity, and includes environmental constraints e.g. wind speed, ionosphere, RFI, etc. If the observation cannot be executed within these constraints, the system will automatically select the next item in the schedule, and repeat the decision-making process before sending any observation for execution.
Frequency accuracy	Frequency accuracy is defined here as the fractional error in the frequency, $\Delta\nu/\nu$, relative to an adopted frequency standard over a specified time interval. One of the instances in which frequency accuracy is vital is in a measurement of the time evolution of cosmological red-shifts (as documented RD1) which yields a 0.1 Hz frequency shift at 1 GHz over 10 years.
Function	A task, action, or activity that must be accomplished to achieve a desired outcome.
Functional Requirement	A requirement that dictates the functionality or performance that must be provided in direct support of the functional objective of the system without considering physical constraints. [Glinz, Martin. 'On Non-Functional Requirements' Proc. 15 th IEEE International Requirements Eng. Conf.]
Global Sky Model (GSM)	A model of the sky brightness over some region of the sky, for some selection criteria such as frequency and source strength. A subset of the GSM is used as a model in SKA calibration. The GSM will be initialised by observations with other telescopes, and continually improved as observations continue. The subset is often called the Local Sky Model but LSM and GSM are acceptable synonyms.

Term	Definition
Image fidelity	Image fidelity is defined here as the anticipated fractional error in the image brightness, ΔI/I, relative to a matched resolution reference image. It is generally acknowledged that this quantity is exceedingly difficult to estimate in practise, since only well-understood effects can be included in a simulation, while it's likely that poorly understood effects may dominate.
Inherent availability	Inherent availability is the probability that the telescope is operationally capable at any point in time when used in an ideal support environment, i.e., one in which repair commences instantaneously upon failure.
Interface	A shared boundary between two functional units, defined by functional characteristics, common physical interconnection characteristics, signal characteristics, or other characteristics, as appropriate. (ISO 2382-1)
Interface Control Document	Interface control documents are a key element of systems engineering that define and control the interface(s) of a system, and thereby bound its requirements. An ICD provides a complete definition of a physical interface to some external potential or actual user of that item such that the interface can be designed against the document. The physical interface includes data formats and transmission protocols. The document is primarily based on the derived requirements for the interface including traceability and supportive text and diagrams.
IXR	Intrinsic Cross-polarisation Ratio
Line Replaceable Unit	A product that may be replaced using procedures, skills, tools and facilities available on site, i.e. without the removal of a higher level product that incorporates it.
LRU	Line-Replaceable Unit
Maintainability	The ability of an item, under stated conditions of use, to be retained in, or restored to, a state in which it can perform its required functions, when maintenance is performed under stated conditions and using prescribed procedures and resources. (BS 5760-0:1986)
Maintenance	All actions necessary for retaining an item in or restoring it to a specified serviceable condition. It includes inspection, testing, classification in terms of serviceability, repair, modifications and recovery.
Major Software components	Major Software Components are defined in this context as software which will require frequent updates and therefore exclude low level imbedded software.
Model	A representation of a real world process, device, or concept.

Term	Definition
Model Image (Data Product)	Full resolution image, usually constructed by a deconvolution algorithm. Ideally the image should represent the actual sky brightness distribution. For the Clean image, this is generated by placing the clean components on an image grid.
Multi-Frequency Synthesis Image (Data Product)	An image representing radiometric brightnesses across a field over a range of frequencies; usually formed by a Multi-Frequency Synthesis deconvolution algorithm.
Multiplexed Commensality	Multiplexed Commensality is the ability to operate subarrays to observe different fields of the sky independently from each other. See also Commensal Observing.
Non Functional Requirement	A requirement other than a Functional Requirement ref [3].
OHS	Occupational Health and Safety (in personnel health/safety context)
On-source Commensality	On-source Commensality is the ability for more than one Scheduling Block (from one or more project) to use the same subarray resources (and field of sky) to generate different science data products (e.g. imaging and pulsar timing). See also Commensal Observing.
Operational availability	Operational availability is the probability that a system is operationally capable at any point in time when used in a realistic support environment, i.e., one in which repair cannot commence until sometime after the failure has occurred. It is thus a measure of not only reliability and maintainability, but also of the response time of the support system. Compare with the BS 5760-0:1986 definition of Availability as “the ability of an item (under combined aspects of its reliability, maintainability and maintenance support) to perform its required function at a stated instant of time or over a stated period of time.”
Operationally Capable	An SKA telescope is defined to be operationally capable when it can perform astronomical observations, including single processing and data reduction, with at least 95% of its collecting area. • For SKA1_Low: at most 25 out of 512 field nodes (or equivalent signal processing or data reduction capabilities) can be in a failed state and the SKA1_Low telescope will still be operationally capable. • For SKA1_Mid: at most 9 out of 197 dishes (or equivalent signal processing or data reduction capabilities) can be in a failed state and the SKA1_Mid telescope will still be operationally capable.

Term	Definition
Override Status	A special status granted to projects (and/or Scheduling Blocks) deemed by the Time Allocation Committee to be of high scientific merit and time critical (either for specific periods known ahead of time, or events that are yet to be triggered). When activated, a Scheduling Block with override status will have the authority to gather sufficient resources so that it can be executed immediately. This may mean that observations that are currently being executed on the telescope will need to be aborted and observed at some other time.
Peeling	The adaptive removal of a bright source from an image by identifying the source in the corresponding visibility data, fitting antenna gains to minimise the fit, and thereafter removing the modelled visibility. Via this approach non-isoplanatic effects can to some degree be countered.
Photometric accuracy	Fractional error in the flux scale, ΔS/S, relative to an adopted celestial flux standard for the integrated brightness of compact objects (smaller than the PSF FWHM).
PhPM (performance metric)	Photometric Performance Metric, a measurement of the RMS, average, and median deviation of source fluxes from known photometric standards.
Point Spread Function (Data Product)	An image representation of the spatial response to a point source, usually calculated as the Inverse Fourier Transform of weights.
Polarisation (of an electromagnetic wave radiated by an antenna in a specified direction)	In a specified direction from an antenna, and at a point in its far field, the polarisation of the (locally) plane wave that is used to represent the radiated wave at that point.
Polarisation dynamic range	Polarisation dynamic range is defined here as the ratio of peak Stokes I brightness to the residual instrumental polarised response, I/ΔP, at the source location. Specified values apply to both the target pointing direction as well as everywhere within the half power point of the dish or station beam.
PPM (performance metric)	Polarimetric Performance Metric, a measurement on the RMS, average, and median deviation of source polarisation (polarisation degree and angle) from known polarimetric standards.
Programme Block	A series of related observations within a single project. The Programme Block holds the details of an entire series of Scheduling Blocks, such as a list of target fields or the cadence of observations, which may imply additional constraints on the scheduling of individual observations. The current status of the Programme Block is also maintained and recorded in schedule history.

Term	Definition
Proto-requirement	A high level statement regarding required performance or functionality which does not necessarily pass the test of a formal requirement, namely singularity, independence, verifiability, traceability, lack of ambiguity and completeness.
Prototype	An experimental model, either functional or non-functional, of the system or part of the system. A prototype is used to get feedback from users for improving and specifying a complex human interface, for feasibility studies, or for identifying requirements.
Pulsar search	Pulsar Search is defined to mean the complete digital signal processing for detecting pulsars and transients. This includes, but is not limited to: • Beam-forming of tied-array beams at specified sky locations over a specified continuous bandwidth. • Channelisation and temporal averaging of beamformed data to a specified number of channels and sampling interval. • Averaging/correlating polarisation beams to form Stokes vectors. • De-dispersion of beamformed data at specified dispersion measures, to produce de-dispersed time-series. • Detection of individual pulses in the de-dispersed time-series. • Detection of periodic signals in the de-dispersed time-series, including corrections for binary motion of pulsars over a specified range of accelerations. • Selection of candidates. • Output of Pulsar Candidates and Non-imaging Transient Candidates into the SKA archive.
Quality Assessment	Application of a set of metrics to science data products to determine the quality of the product or products. Typical cases would be the off-source noise, the dynamic range (peak brightness/off-source noise), flux and position fidelity relative to known standards, etc.
Quality Assurance	A discipline which is intended to provide consistency of performance, functionality and behaviour in an organisation.
RAM (systems engineering context)	Reliability, Availability, and Maintainability
Raw requirement	An environmental or customer requirement that has not been analysed and formulated as a well-formed requirement.
Receiver (in the context of Receptors, q.v.)	From a functional perspective, the receiver subsystem is that part of the radio frequency chain that begins at the output of the Feed Package subsystem, and ends at the point of digitisation.

Term	Definition
Receptor	The ensemble of receiving passive element or elements, optics, electronics for detection, amplification, and electronic pointing, that provides digital data streams that can be correlated. See Receptor (SKA1_Low) and Receptor (SKA1_Mid).
Receptor (SKA1_Low)	An SKA1_Mid Receptor is the ensemble of the dish optics, RF chain, dish supporting structure, foundation, and the electronics, networking, and control equipment hosted in the dish structure.
Receptor (SKA1_Mid)	An SKA1_Mid Receptor is the ensemble of the dish optics, RF chain, dish supporting structure, foundation, and the electronics, networking, and control equipment hosted in the dish structure.
Reliability	The ability of an item to perform a required function under stated conditions for a stated period of time. (BS 5760-0:1986).
Representation	A likeness, picture, drawing, block diagram, description, or symbol that logically portrays a physical, operational, or conceptual image or situation.
Requirement	a) A condition or capability needed by a user to solve a problem or achieve an objective. b) A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document. c) A documented representation of a condition or capability as in definition a) or b). (IEEE Std 610.12-1990)
Residual Image (Data Product)	A Dirty Image (q.v.) constructed from visibilities after the subtraction of a Model (q.v.).
Resources	Resources are pieces of equipment or hardware that are capable of being controlled to perform certain tasks. In the context of the SKA, examples of resources are dishes, stations and the correlator.
Restored Image (Data Product)	Image constructed primarily for analysis and visualisation; usually formed by the addition of the smoothed Model Image to the corresponding Residual Image.
RF	Radio Frequency
RFI	Radio Frequency Interference
RFI mask	A RFI Mask is a specification or list of frequency channels at a resolution of one frequency channel or time-series integration period, which are assumed to be contaminated by RFI (determined for a particular science case) and will be marked (flagged) as RFI-contaminated regardless of their actual values.

Term	Definition
RPM (performance metric)	Radiometric Performance Metric, a measurement of the RMS, average, and median noise fluctuations in an Image.
Scan	An atomic unit of execution during which data taking is normally continuous, but can be briefly paused for an operational reason. The Telescope Configuration stays the same during a scan. There are different types of Scan depending on the Telescope motion pattern on the sky: tracking celestial object, raster from start position to end position at a specified rate, series of pointings around a celestial position, etc.
Scheduling Block	A Scheduling Block (sometimes referred to as a Schedule Block) is an atomic unit of observing from the viewpoint of scheduling. Scheduling will be performed on the Scheduling Block level. A Scheduling Block consists of a series of instructions to the control system of a given telescope (namely, TM) that are required in order to carry out a series of tasks that, when performed together, result in the taking of a Dataset. In the Square Kilometre Array (SKA) data model this is known as the Observing Sequence. A Scheduling Block may be stopped and cancelled, and it can be paused and resumed. A Scheduling Block will be executed on a single subarray, which may include the full array.
Scheduling block boundaries	The temporal boundary between the end of the execution of a scheduling block, and the start of execution of the next. Multiple integrations/scans fall within a scheduling block.
Science archive	Facility in which selected Science Data Products are stored, permanently or with some known expiry date, and made accessible for download by interested parties. Different policies will constrain the setup and use of the archive.
Science data product	A specific Data Product of the observing or processing that is of direct relevance to the stated goals of the project. Typical examples include images, image cubes, source catalogs, pulsar detections. There may also be supporting products such sensitivity maps, and others.
Scientific Use Cases	Uses cases (in the Systems Engineering context) that clarify the Science Requirements of the SKA1 system, and can help in the design, flow down, and clarification of further requirements.
Sensitivity Image (Data Product)	An image of the inverse of noise variance.
Signal Integrity Display	User interface display that can show the operators of an SKA1 telescope, or the engineers of a particular Element/sub-system, if there are artefacts being introduced in the signal.
Sky Coordinates	Coordinates on the celestial sphere. See astronomical coordinates.

Term	Definition
Slow transient	Transient source detected from snapshot images made from the visibility data. The maximum cadence is set by the correlator integration time.
Software Updates	Software is defined in this context as the update of major software components which will require frequent updates and exclude low level and imbedded software components.
Source Catalogue (Data Product)	As a Data Product of the SKA, a catalogue database containing source parameters, as measured by the SKA, as used for example in source finding. Otherwise a similar database derived from measurements made by other Observatories.
Sparse-dense transition frequency	The frequency at which the antenna elements in an array are $\lambda/2$ apart on average.
Specification	Synonymous with engineering document. For instance, a Requirement Specification is the engineering document that collects a set of requirements.
Spectral dynamic range	The ratio of peak brightness to the residual instrumental spectral response, $I/\Delta I$, at the source location over a specified spectral interval. Specified values apply to both the target pointing direction as well as everywhere within the half power point of the dish or station beam.
Spectral Line Image (Data Product)	A series of images (a 'cube') showing variation with frequency.
SPM (performance metric)	Spectrometric Performance Metric, a measurement of the RMS, average, and median deviation of source spectral lines from known standards.
Spurious spectral features	Fractional amplitude, $\Delta I/I$, of residual spurious features that are a consequence of a spectral signal of strength I. Spurious spectral feature levels must be low enough to satisfy the Spectral Dynamic Range specification.
Stacking	Stacking is an analysis technique for extracting information below the noise level. It involves the summation of all signals at the location of known e.g. optical sources. It allows detection of a class of sources in circumstances when a single source cannot be detected.
Station	A circular array of antenna elements that has a clear physical boundary defined by the station diameter, whose output signals are connected individually to the SKA1_Low beamformer. Compare with Receptor (SKA1_Low).
Station diameter	The diameter of a circle that is a best-fit circle to the outer boundary of the array of antenna elements that make up a station.

Term	Definition
Stokes (polarisation parameters, or vector)	Set of values that describe the polarisation state of electromagnetic radiation, as defined by George Gabriel Stokes in 1852. The Stokes vector has four components with values between in the range -1 to 1, and spans the all potential polarisation states, from unpolarised light to fully polarised light, and mixed states in between.
Sub-station	An array of adjacent antenna elements contained within a station which can be beam-formed to produce a data-stream that can be correlated. Sometimes referred to as a virtual station.
Subarray	A subarray (also referred to as sub-array) is a subdivision of an SKA telescope that can be scheduled and be operated independently of other subarrays. A subarray constitutes a set of resources (i.e. receptors, correlator slices…) and can be as large as the whole telescope array, or a single constituent item. A subarray is only prevented from being created by resource constraints. Resources in this context include, but are not limited to: number of available dishes/stations (receptors), power availability, data transport bandwidth, signal processing, or data processing capacity. An Engineering subarray may not need an entire system slice, but this is not precluded. For instance, a set of dishes without the need of signal or data processing may constitute and Engineering subarray. Conversely, an Astronomy subarray requires end-to-end capability, i.e. a full system "slice".
Super-station	A group of stations in close proximity or even sharing a boundary which can be beam-formed to produce a data-stream that can be correlated.
System	An interdependent group of people, objects, and procedures constituted to achieve defined objectives or some operational role by performing specified functions. A complete system includes all of the associated equipment, facilities, material, computer programs, Firmware, technical documentation, services, and personnel required for operations and support to the degree necessary for self-sufficient use in its intended environment.
System Requirement Specification (SyRS)	A structured collection of information that embodies the requirements of the system.
TECU	Total Electron Content Unit, unit of electron density, equivalent to a column density of 10 16 electrons per square metre.
Telescope Model (TelMod)	A model of all aspects of a Telescope affecting observations and processing, including both table-based quantities, such as antenna locations, names, installed band receivers; and calculation-based quantities such as primary beam models, or geodetic coordinates, among others.

Term	Definition
Testability	The degree to which a requirement is stated in terms that permit establishment of test criteria and performance of tests to determine whether those criteria have been met. (IEEE Std 610.12-1990).
Thermal noise limited	(of performance, particularly sensitivity) – the property whereby a system is capable of delivering more performance if it were not for the presence of thermal noise (either electromagnetic or current).
Time Allocation Committee	The Time Allocation Committee (TAC) will be responsible for determining the science programme to be carried out by the SKA Observatory through the review and assessment of scientific proposals. They will be comprised of members from the radio astronomy community and will be sufficiently experienced to judge the scientific merit, impact and urgency of proposals that the observatory receives to use its resources.
Timing accuracy	Time error, $\Delta\tau$, relative to an adopted time standard over an indicated time interval. Timing accuracy is of particular importance in the context of enabling precision pulsar timing.
Topology	The spatial arrangement of entities described in such a way as to emphasise the connections between them rather than their geometrical relationships or locations. c. f. 'Configuration'. Used particularly in the design of networks (power, data, etc).
Topology (of the Observatory)	The physical location of items in the observatory and the interconnectivity between them.
Traceability	The degree to which a relationship can be established between two or more products of the development process, especially products having a predecessor-successor or master-subordinate relationship to one another; e.g., the degree to which the requirements and design of a given system element match.(IEEE Std 610.12-1990)
Traceable	Having characteristics whose origin can be objectively determined.
Transfer Function (Data Product)	The Fourier Transform of the Point Spread Function (q.v.).
Use Case	In UML, a complete task of a system that provides a measurable result of value for an actor.
User	A person or organisation that proposes a project for the SKA, plans an accepted observing project, assists with observing (except as a GHQ or host country staff member), or receives data from the SKA archive for a scientific purpose. (Operation Concept Document).

Term	Definition
Validation	The process whereby Requirements are shown to lead to the expected functionality and performance.
Validation (of a System/Sub-system)	Confirmation, through the provision of objective evidence, that a given System (Sub-system) meets the needs of the stakeholders. Validation only occurs at the top level of the system (or sub-system, when building modularly) hierarchy. It answers the question: “Was the right system built?”
Variability	A measure of the range of values a parameter might be within when the precise value is not known.
Verification	1. The process whereby the design or the manufacture/construction of a Product is shown to be compliant with Requirements. 2. A programme of progressively specifying, developing and demonstrating aspects of a design deemed to be high risk and therefore worthy of early development effort. The process involves the rational selection of design and technology options. The overall design is initiated against assumptions which are progressively replaced by traceable requirements.
Verification by Analysis	Verification (q.v.) whereby the proof of compliance to requirements (generally of a design) is provided by analyses. Such analyses rely upon the characteristics that are subject to requirements are faithfully represented in a mathematical model. The fidelity (and in particular the precision) of models used in this way are subject to formal requirements. The models themselves are subject to formal validation and stringent configuration control coupled to that of the design itself. The risks associated with reliance upon verification by analysis must be actively managed.
Verification by Inspection	Verification whereby formal inspection processes are employed, such as metrology, basic electrical measurements, basic environmental measurements, etc.
Verification by Similarity	Verification (q.v.) whereby the proof of compliance to requirements (generally of a design) is provided by claiming and demonstrating that the design is the same in relevant respects, and the environment of exposure is the same, and the requirements are the same as those of a previously, formally verified design. The robustness of such verification depends upon a substantial understanding of what aspects of design, environment and requirements are relevant and which are not.
Very Long Baseline Interferometry Terminal	A combination of hardware and software which provides a robust and standardised interface to allow a telescope to act as a component in a VLBI array. The interface may, or may not, function in accordance with the VLBI Standard Interface (http://www.haystack.mit.edu/tech/vlbi/vsi/index.html), but it provides a fully defined port which makes telescope resources available in accordance with VLBI use cases and allows the transmission of data streams in accordance with VLBI protocols.

Term	Definition
VLBI	Very Long Baseline Interferometry
Warning	In TANGO, an attribute has a Warning quality attribute when the value of that attribute is above or below the warning threshold, but still has not reached the maximum or minimum error values. A attribute being in warning does not necessarily generate an Alarm, but might affect how the health of the system is reported, and might contribute to the triggering of an Alarm. A Warning is not a different level of severity than an Alarm or an Alert (see those terms).
Weighting	1. (Systems engineering context) A multiplicative factor combined with a key attribute score in a Trade Study, in order to provide priority or emphasis to that key attribute over others. 2. (algorithmics, signal processing) a value used to control the relative effect of a factor.
“When commanded”	In a Requirement, *when commanded* indicates that the requirement only applies when the system is commanded to do something in particular.

22 Appendix: Requirements Traceability Matrices

This appendix contains tabularized requirements traceability to the source documentation and to the next lower tier documentation where known.

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3547 The SKA1_Mid telescope, when commanded, shall operate simultaneously with any combination of the following observing modes: • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search • VLBI	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3549 SKA1_Mid subarrays, when commanded, shall operate simultaneously with any combination of observing modes within each of the following configurations: Configuration 1 • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search Configuration 2 • Imaging (in support of VLBI) • Transient Search • VLBI	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3548 The SKA1_Low telescope, when commanded, shall operate simultaneously with any combination of the following observing modes: • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search • VLBI	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3550 SKA1_Low subarrays, when commanded, shall operate simultaneously with any combination of the following observing modes: • Imaging • Pulsar Search • Pulsar Timing • Dynamic Spectrum • Transient Search	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3563 All software and hardware description language related deliverables shall comply with the "Fundamental SKA Software and Hardware Description Language Standards" (SKA-TEL-SKO-0000661) [RS16]	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3091 The SKA1_Mid and SKA1_Power quality shall be compliant with the SKA1 Power Quality Standard Specification : SKA-TEL-SKO-00000293 [RS12]	
SKA1-SYS_REQ-3564 SK1_MID and SKA1_Low shall be compliant with SKA EMI/EMC Standards and Procedures SKA-TEL-SKO-0000202 [AD2]	
SKA1-SYS_REQ-2671 The SKA1_Low shall utilise dual, orthogonally polarised antenna elements.	**SCI_REQ-24** SKA1_Low perpendicular polarisation states **SCI_REQ-20** SKA1_Low polarisation dynamic range
SKA1-SYS_REQ-3340 The SKA1_Low average spacing between antenna elements within a station shall be the same for each of the stations.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2673 The SKA1_Low configuration shall maintain a sensitivity within a factor of 2 TBC over 2 orders of magnitude of spatial resolution.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2621 On a maximum time scale of 600 seconds, and within the envelope of the listed spline points with TBD frequency smoothness, SKA1_Low shall have a station beam bandpass stability, post calibration and RFI mitigation, of: • 0.05 % at 50 MHz • 0.02 % at 110 MHz • 0.03 % at 160 MHz • 0.03 % at 220 MHz • 0.05 % at 280 MHz • 0.08 % at 350 MHz compared to the full polarization parameterized beam model.	**SCI_REQ-22** SKA1_Low spectral dynamic range
SKA1-SYS_REQ-3407 The SKA1_Low station shall operate at all possible azimuth and elevation angles.	**SCI_REQ-31** SKA1_Low local azimuth angles

L1 System Requirement	**L0 Science Requirement(s)**

SKA1-SYS_REQ-3368

The SKA1_Low shall be configurable for one of the following:.

1. 1024 sub-stations randomly distributed within stations.
   - Stations are populated with 4 randomly-located substations in the core and 4 randomly-located substations in one of the 6 stations at each cluster location.
   - 75 MHz of bandwidth is available.
2. 1024 sub-stations regularly distributed within stations.
   - Stations are populated with 6 substations in the core and 4 substations in one of the 6 stations at each cluster location.
   - 75 MHz of bandwidth is available.
3. 2048 sub-stations randomly distributed within stations.
   - Stations are populated with 4 randomly located substations in all of the 512 stations.
   - 19 MHz of bandwidth is available.
4. 2048 sub-stations regularly distributed within stations.
   - Stations are populated with 6 substations in the core and 6 substations in 3 of the 6 stations at each cluster location.
   - 19 MHz of bandwidth is available.

SCI_REQ-01
SKA1_Low scientific performance

SKA1-SYS_REQ-3358

The SKA1_Low, when commanded, shall form dual polarisation beams from up to six sub-stations for any station.

SCI_REQ-01
SKA1_Low scientific performance

SKA1-SYS_REQ-2964

The SKA1_Low intrinsic cross polarisation ratio shall be at least 15 dB over the whole observing band within the half power beam width up to observing angles of 45 degrees.

SCI_REQ-49
SKA1_Low non-imaging observation modes

SKA1-SYS_REQ-2135

Assuming a sky noise temperature defined in the definitions section of this system requirements specification document, the SKA1_Low array shall have sensitivity per polarization at zenith corresponding to the following values interpolated by a 'not-a-knot' cubic spline function and not deviating by more than +/-5% from the spline interpolation spanning the following points:

- 68 m2K-1 at 50MHz
- 70 m2K-1 at 55 MHz
- 232 m2 K-1 at 80 MHz
- 531 m2K-1 at 110MHz
- 588 m2 K-1at 140 MHz
- 610 m2K-1 at 160MHz
- 614 m2K-1 at 220 MHz
- 576 m2K-1 at 280 MHz
- 522 m2K-1 at 340 MHz
- 515 m2K-1 at 345 MHz
- 516 m2K-1 at 350 MHz

SCI_REQ-35
SKA1_Low array sensitivity as a function of frequency
SCI_REQ-01
SKA1_Low scientific performance
SCI_REQ-45
SKA1_Low survey depth
SCI_REQ-43
SKA1_Low survey speed

SKA1-SYS_REQ-2622

SKA1_Low shall have a degradation of peak sensitivity of less than 30% at local elevation angle of 60 deg and less than 50% degradation at local elevation angle of 45 deg for all local azimuthal angles, 0 – 360 deg.

SCI_REQ-33
SKA1_Low azimuthal noise performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3339 Placement of Antenna within each SKA1_Low station shall be independently randomised in two dimensions (within the constraints of antenna and station size) so as not to form a regular grid. Polarisations of antenna elements should be aligned for all antennas.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2139 Each station of the SKA1_Low shall be made up of 256 antennas which are in randomised positions.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-2140 The maximum distance between any two antennas contributing to a SKA1_Low station shall be the same for each station being less than or equal to 45 metres. The optimal value is less than 35 metres.	**SCI_REQ-43** SKA1_Low survey speed
SKA1-SYS_REQ-2142 The SKA1_Low shall be composed of 512 stations.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-2143 The SKA1_Low station and antenna placement will be as specified in the SKA1_Low Configuration Coordinates document [AD4].	**SCI_REQ-04** SKA1_Low locations **SCI_REQ-39** SKA1_Low PSF quality (snapshot) **SCI_REQ-41** SKA1_Low PSF quality (tracking) **SCI_REQ-37** SKA1_Low relative collecting area **SCI_REQ-45** SKA1_Low survey depth **SCI_REQ-43** SKA1_Low survey speed
SKA1-SYS_REQ-3331 Each station of the SKA1_Low shall be uniquely identifiable. This will include both the identity of the cluster and the individual station as defined in SKA-TEL-SKO-0000422 SKA1_Low Configuration Co-ordinates document [AD4].	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2817 The maximum distance between station centres of SKA1_Low shall be 65 km.	**SCI_REQ-39** SKA1_Low PSF quality (snapshot) **SCI_REQ-41** SKA1_Low PSF quality (tracking) **SCI_REQ-37** SKA1_Low relative collecting area

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2147 The SKA1_Low, when commanded, shall process 300 MHz of aggregate bandwidth per polarisation.	**SCI_REQ-26** SKA1_Low instantaneous bandwidth
SKA1-SYS_REQ-2674 Digitisation of SKA1_Low antenna signals shall be to at least 8 bits.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-06** SKA1_Low effective noise level **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2639 SKA1_Low data acquisition shall clip less than 5% of the time for the RFI levels specified within the SKA EMI/EMC standards [AD2].	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-06** SKA1_Low effective noise level **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2640 SKA1_Low and SKA1_Mid shall flag clipped data within the data stream.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-06** SKA1_Low effective noise level **SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-19** SKA1_Mid brightness dynamic range **SCI_REQ-07** SKA1_Mid effective noise level
SKA1-SYS_REQ-2653 The level of spurious products generated by the SKA1_Low, in the presence of signals representative of the expected RFI environment [AD2], shall degrade the expected thermal noise floor of a 1000 hour integration by no more than 10%.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-06** SKA1_Low effective noise level **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3621 SKA1_Low shall perform observations of the Sun. During these observations the instrument response shall be linear.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2824 The SKA1_Low shall have an absolute flux density scale with an accuracy better than 5% across the band.	**SCI_REQ-10** SKA1_Low photometric accuracy
SKA1-SYS_REQ-2966 SKA1_Low shall provide 45 dB polarisation dynamic range for imaging, after calibration, at all spatial and at all fractional bandwidths across the full band.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3073 SKA1_LOW, when performing calibration imaging in support of Pulsar Search, shall provide better than 25 dB polarisation dynamic range for the configured bandwidth.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3074 SKA1_LOW, when performing Pulsar Timing, shall provide better than 40 dB polarisation dynamic range across each Pulsar Timing tied array at their bore sight for the configured bandwidth/ time resolution. This implies 40 dB out to the HPBW for the station primary beam as a pulsar timing tied array beam can be located anywhere in that area.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3294 Each SKA1_Low subarray shall have a common delay centre at or near its centre with a time accurate to the SKA timescale and a precision of better than 2ns (1σ) over periods of one observation and at least 10 years.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3459 SKA1_Low shall provide at least 50 dB brightness dynamic range at 300 arcsec spatial and 1 MHz spectral resolution.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3542 When commanded, SKA1_Low shall transfer calibration seamlessly across frequency changes, band changes, and/or source changes, such that the any change in calibration due to the telescope (as compared to the environment or the source) shall be less than 0.1% in amplitude and 0.001 radians in phase.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2629 On a maximum time scale of 600 seconds, for each SKA1_Low station beam at zenith angles less than 45 degrees, the rms difference between the parameterized model and the actual station beam, relative to the main beam peak power, after calibration, shall remain smaller than the envelope of the listed spline points to a frequency smoothness of TBD: • 0.07 % at 50 MHz • 0.03 % at 110MHz • 0.04 % at 160MHz • 0.05% at 220MHz • 0.07 % at 280MHz • 0.1 % at 350MHz	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-27** SKA1_Low simultaneous station beams
SKA1-SYS_REQ-2634 The SKA1_Low shall provide calibration update calculation cycle rates of up to once every correlator dump time.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-06** SKA1_Low effective noise level **SCI_REQ-01** SKA1_Low scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2635 The SKA1_Low shall provide on-line station beam calibration functions with an update period of 10 minutes or faster.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-06** SKA1_Low effective noise level **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3039 SKA1_Low shall process up to 8 independent beams from each station within a subarray, each with potentially independent pointings, such that the sum of bandwidths over these beams is at most 300 MHz.	**SCI_REQ-27** SKA1_Low simultaneous station beams
SKA1-SYS_REQ-3040 SKA1_Low, when forming station beams, shall steer them independently in both azimuth and elevation to an accuracy of better than 1/1000 of the half power beam width.	**SCI_REQ-31** SKA1_Low local azimuth angles
SKA1-SYS_REQ-3041 SKA1_Low, when commanded, shall form multiple station beams that have bandwidths independent of each other (where independence allows identical, overlapping or non-overlapping). The independence allows each of one of the 8 beams to have non-contiguous bandwidth and divergent pointing.	**SCI_REQ-26** SKA1_Low instantaneous bandwidth **SCI_REQ-29** SKA1_Low spectral windows
SKA1-SYS_REQ-3400 Each station beam shall provide to the correlator-beamformer a time stamp, synchronous with and locked to the sample clock and 1PPS.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-47** SKA1_Low pointing modes
SKA1-SYS_REQ-3035 For all stations belonging to a given subarray,SKA1_Low, when commanded, shall deliver full-polarisation autocorrelation spectra, with frequency coverage, spectral resolution, and spectral and temporal response matching that of the cross-correlation spectra from that subarray.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3047 The SKA1_Low, when commanded, shall generate calibrated autocorrelation spectra. Cross-correlation spectra may be used as part of this calibration.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3037 SKA1_Low, when commanded, shall provide full Stokes polarisation products (I, Q, U, V) as part of all observing modes including continuum imaging.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2149 The SKA1_Low shall have a transition band for adjacent visibility spectra frequency channels that is monotonically decreasing from -3.01 (+/- 0.01) dB at the channel edge, to -60 dB or better at the next adjacent channel centre frequency.	**SCI_REQ-22** SKA1_Low spectral dynamic range

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2810 The upper envelope of the noise leakage power for non-adjacent visibility spectra frequency channels for SKA1_Low shall fall off as 1/f or better as a function of frequency offset from the centre of a given frequency channel, for frequency offsets up to half the input bandwidth.	**SCI_REQ-22** SKA1_Low spectral dynamic range
SKA1-SYS_REQ-2811 The post-calibration amplitude response of SKA1_Low imaging shall vary by at most +/-0.01 dB across the band.	**SCI_REQ-22** SKA1_Low spectral dynamic range
SKA1-SYS_REQ-3296 The spectral and temporal response of the individual SKA1_Low visibility spectra frequency channels shall not change by more than 1% as a function of time, unless explicitly commanded to do so.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3565 For each subarray, SKA1_Low, when commanded, shall produce correlated visibilities and autocorrelations for all polarization products, in full bandwidth resolution or in higher spectral resolution over limited bandwidth.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2148 SKA1_Low, when performing spectral line imaging, shall form a fixed number of least 52,500 and no more than 65,536, dependent on implementation, linearly spaced frequency channels across the frequency band in total normal fine spectral channels.	**SCI_REQ-26** SKA1_Low instantaneous bandwidth **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2975 For each subarray, SKA1_Low, when commanded, shall produce correlated visibilities and autocorrelations for all polarization products, for up to four zoom windows, each with bandwidth selected independently from values within 10% of 4 MHz, 8 MHz, 16 MHz, 32, 64, 128 and 256 MHz , such that the entire zoom window lies entirely within the processed observing band.	**SCI_REQ-29** SKA1_Low spectral windows
SKA1-SYS_REQ-2976 Zoom windows for SKA1_Low shall have centre frequencies independently selectable from each other with a step size within that is 10% of 781kHz such that the full window is contained within the available processed frequency band and with the option of overlapping any or all windows.	**SCI_REQ-29** SKA1_Low spectral windows
SKA1-SYS_REQ-2977 When generating zoom windows, SKA1_Low shall on command provide, for each zoom window, 16384 (+/- 10%) linearly spaced frequency channels fully covering the zoom windows.	**SCI_REQ-29** SKA1_Low spectral windows
SKA1-SYS_REQ-3048 The maximum noise leakage from a non adjacent channel into SKA1_Low zoom window channels from all frequencies outside the window shall be less than 60dB.	**SCI_REQ-29** SKA1_Low spectral windows
SKA1-SYS_REQ-3049 The SKA1_Low post-calibration amplitude response variation across the full (concatenated) frequency range covered by overlapped zoom windows of the same frequency resolution shall be within +/-0.01 dB of the nominal.	**SCI_REQ-29** SKA1_Low spectral windows
SKA1-SYS_REQ-3462 SKA1_Low shall, when commanded, configure zoom windows, and generate the corresponding data products, completely independently, for any and all subarrays.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3543 When commanded, for each subarray individually, SKA1_Low shall transfer calibration between zoom windows and standard (non-zoom) spectral channels which are observed commensally, without introducing additional errors (beyond those of transferring calibration between different frequencies and/or times) above 0.1% in amplitude and 0.001 radians in phase.	
SKA1-SYS_REQ-2678 SKA1_Low correlation shall not degrade the Signal to Noise ratio by more than 2 % compared to ideal analogue correlation for the same inputs.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-3454 When flagging on timescales shorter than the correlation integration time, SKA1_Low shall flag all polarizations and polarization products if any are found to be bad.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-2150 The visibility integration period for each SKA1_Low subarray shall be independently configurable, with allowed values being an integer multiple of 0.25 seconds (±2%) to a maximum of 36 seconds (±2%).	**SCI_REQ-39** SKA1_Low PSF quality (snapshot) **SCI_REQ-41** SKA1_Low PSF quality (tracking)
SKA1-SYS_REQ-3539 SKA1_Mid shall flag both polarizations of any beamforming input for which one polarization is flagged (or marked invalid).	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-3540 When commanded, SKA1_Low shall form pulsar search, pulsar timing, and VLBI tied-array beams that each have a coherence within 5% of that allowed by the current atmospheric conditions.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3472 The spectral distortion of pulsar search beams, compared to an ideal analogue beamformer provided with the same inputs, shall be less than • -40 dB in amplitude • 0.01 radians in phase.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2890 SKA1_Low shall have a continuous Pulsar Search bandwidth of no less than 96 MHz per beam	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2942 SKA1_Low, when performing Pulsar Search for unaccelerated pulsars with dispersion measures within the range 0 to 500 pc cm^{-3}, shall space dispersion measure trials such that the recovered signal-to-noise ratio of any signal lying between trials are more than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2944 SKA1_Low shall retain time resolution in the Pulsar Search such that any increase in sampling interval at high dispersion measure trials does not degrade the signal-to-noise ratio below 95% relative to the configured time resolution.	**SCI_REQ-49** SKA1_Low non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2946 SKA1_Low, when commanded, shall perform the Pulsar Search with an observation time configurable between 180 and 1800 seconds. The SKA1_Low will restrict the observing time to be the same for all beams in a subarray in fixed multiples of the sampling interval.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2948 SKA1_Low, when performing Pulsar Search for individual pulses with dispersion measures in the range 0 to 3000 pc cm^{-3} and with widths 100 microseconds to 1 second, shall space dispersion measure trials such that the recovered the signal-to-noise ratio of any signal lying between trials shall be more than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3241 SKA1_Low shall obtain a signal-to-noise ratio for a pulse in a de-dispersed time-series that is more than 85% compared to using a Gaussian matched filter of the correct width.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2936 When commanded, for each pulsar search beam with pulsar search duration less than 600s, SKA1_Low shall perform acceleration correction as part of the pulsar search, over a configurable range of acceleration values from 0 to no less than 350 m/s^2, for no fewer than 500 configurable dispersion measure trials, such that the degradation in signal-to-noise ratio due to coarse acceleration sampling is less than 34% everywhere in the acceleration range.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2885 Each SKA1_Low subarray, when performing Pulsar Search, shall form Pulsar Search beams using any or all stations within that subarray, which are separated by up to 20 km.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2888 SKA1_Low, when commanded, shall perform the Pulsar Search on a contiguous bandwidth located anywhere within the SKA1_Low band.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3476 SKA1_Low, when commanded, shall form multiple Pulsar Search beams at the same sky coordinates, within a single subarray.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2892 The SKA1_Low, when commanded, shall offset the centre frequency of the Pulsar Search of specified beams by a specified multiple of the Pulsar Search bandwidth, provided that the entire frequency range lies within the current SKA1_Low band.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2894 SKA1_Low, shall concurrently perform the Pulsar Search function in a total of up to 500 independently steerable beams, each of which may be assigned to any sub-array which is configured for Pulsar Search.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2896 The SKA1_Low, when forming beams for the Pulsar Search, shall achieve a signal-to-noise of more than 97% relative to an ideal analogue beam-forming for the same inputs.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2898 SKA1_Low, when performing the Pulsar Search, shall generate Pulsar Candidates and Non-imaging Transient Candidates as defined in TBD.	**SCI_REQ-49** SKA1_Low non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2917 SKA1_Low shall perform Pulsar Search and Single Pulse Search with on spectral channels with an effective time resolution shorter than 100 microseconds. (effective time resolution - full width at 10% maximum of the channeliser power response).	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2918 SKA1_Low, when commanded, shall perform the Pulsar Search with a configurable sampling interval that is 1, 2, 3 or 4 times the minimum sampling interval.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2919 SKA1_Low, when commanded, shall perform the Pulsar Search for a Pulsar Search beam with a configurable bandwidth from the full pulsar search bandwidth for that beam, down to 0.25 times that bandwidth.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2920 SKA1_Low shall restrict the choices of the sampling rate and bandwidth for Pulsar Search to integer sub-multiples of a the fundamental sampling rate.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3473 The spectral distortion of SKA1_Low Pulsar timing beams, compared to an ideal analogue beamformer provided with the same inputs, shall be no more than -60 dB in amplitude and 0.001 radians in phase.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2922 Each SKA1_Low subarray, when configured for Pulsar Timing, shall form pulsar timing beams using all stations within that sub-array, which are separated by at most 20 km.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2924 The SKA1_Low, when commanded, shall form beams for each of the Pulsar timing subarrays with a selectable observing band for each subarray anywhere in the SKA1_Low band.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2926 The SKA1_Low, when performing Pulsar Timing, shall for each pulsar timing beam process a bandwidth which is independently selectable to a fixed granularity of *1 MHz ± 25%, up to the full bandwidth of the entire SKA1_Low band.*	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2930 The SKA1_Low, when forming pulsar timing beams, shall have a Signal to Noise ratio greater than or equal to 98% TBC of an ideal beam former, given the same digitized inputs and calibration.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3530 The spatial offset of each SKA1_Low pulsar timing beam from the imaging delay centre of the corresponding subarray shall be at most half of the half-power beam width of the corresponding station beam of that subarray, evaluated at the highest observing frequency used by the pulsar timing beam.	**SCI_REQ-01** SKA1_Low scientific performance Off-axis beamforming and pointing errors
SKA1-SYS_REQ-2954 The observation duration for each SKA1_Low Pulsar timing subarray shall be set independently with a value between 10 seconds and 300 minutes with a granularity of 10 seconds.	**SCI_REQ-49** SKA1_Low non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2956 Each SKA1_Low pulsar timing and dynamic spectrum measurement shall be directly traceable to the time at the common delay centre of the SKA1_Low telescope, with an accuracy of better than 2 nanoseconds (TBC).	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-16** SKA1_Low timing accuracy
SKA1-SYS_REQ-2940 The SKA1_Low pulsar timing beamformer shall be capable of forming multiple tied array beams within the same subarray, with the same sky coordinates and contiguous bandwidth.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2958 The SKA1_Low, when commanded, shall time Pulsars with dispersion measures between 0 to 3000 pc cm^{-3} such that residual dispersive smearing is less than 500 ns or as limited by the precision of the supplied dispersion measure.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2962 The SKA1_Low, when commanded to time a pulsar, shall resolve that pulsar's pulse profile with up to 2048 equal-width, contiguous phase bins with the minimum possible phase bin width being no longer than 2.5 micro sec.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3546 The SKA1_Low, when commanded, shall time Pulsars with periods between 0.4 milliseconds and 20 seconds.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3196 The SKA1_Low, when commanded, shall produce a dynamic spectrum for one or more pulsar timing beams, recording the amplitude of the signal as a function of time, frequency, and polarisation.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3202 SKA1_Low, when commanded, shall simultaneously form and process data from up to a total of16 dual-polarization pulsar timing beams for pulsar timing and dynamic spectrum processing.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3531 The spectral and temporal resolution of each SKA1_Low dynamic spectrum shall be independently selectable, within the limitations imposed jointly by the corresponding pulsar timing beam's spectral and temporal responses.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3081 SKA1_Low, when commanded, shall generate and respond to real-time internal triggers by storing digitized voltage data, with 2-bit or better sampling, for at least 300 MHz of contiguous, tuneable observed bandwidth in both polarizations, from every station within the triggering subarray, covering at least 10 seconds before (TBC) and at least 500 seconds after (TBC) the triggering event.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3082 The SKA1_Low shall have a system latency of at most 900 seconds from the time that the highest frequency component of a transient signal arrives at the telescope to the time when the transient buffer is forwarded for storage.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3083 The SKA1_Low shall have the capacity of archiving at least 150 terabytes of transient buffer data per day.	**SCI_REQ-01** SKA1_Low scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3524 When commanded, SKA1_Low shall archive all or part of the transient buffer based on the results of single-pulse searches, independently for each subarray.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3578 Each SKA1_Low VLBI data sample shall be directly traceable to the time at the common delay centre of the SKA1_Low telescope, with an accuracy of better than 2 nanoseconds.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3579 The SKA1_Low, when forming VLBI beams, shall have a signal-to-noise performance better than 90% of that achievable by an ideal signal chain, given the same inputs, instrumental calibration and excluding RFI.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3580 SKA1_Low, when forming VLBI beams, shall output them with a sampling rate selectable between Nyquist and at least a factor of two oversampling for the selected bandwidth.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3581 SKA1_Low, when commanded, shall weight the Field Station beams, which are inputs into the VLBI tied-array sums, based on relative sensitivity and coherence losses.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3582 SKA1_Low, when commanded, shall change the pointing, centre frequency, and bandwidth of each VLBI tied-array beam independently, on scan boundaries.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3583 SKA1_Low, when commanded, shall provide, through configuration, 1, 2, 3, or 4 separate VLBI specific beams, each with independently selectable centre frequency, bandwidth, frequency resolution and pointing.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3584 SKA1_Low shall, when commanded, reconfigure the centre frequency, frequency band, and bandwidth for each VLBI beam, in less than 30 seconds.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3585 SKA1_Low shall, when commanded, generate VLBI beams with a spectral resolution different from the spectral resolution used for imaging within the same subarray.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3586 SKA1_Low shall be able to generate VLBI beam data with a selectable channel width of: 256, 128, 64, 32, 16, 8, 4, 2, or 1 MHz TBC.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3587 SKA1_Low, when commanded, shall simultaneously generate both VLBI beams and SKA1_Low imaging data for all polarization products and all baselines (including autocorrelations) with a spectral resolution no worse than 1 MHz, covering at least the larger of 100 MHz TBC or the frequency range(s) covered by the VLBI beam(s) within the associated subarray.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3588 SKA1_Low, when commanded, shall generate VLBI beams with a transition band that is monotonically decreasing from -3dB at the channel edge, to -60dB at a frequency offset from the centre frequency by the channel bandwidth.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3589 SKA1_Low shall be able to allocate individual VLBI beams to different subarrays.	**SCI_REQ-49** SKA1_Low non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3590 The SKA1_Low VLBI array phase centre shall be within 100km (TBC) of one of the SKA1_Low stations.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3591 Spectral distortion, after calibration, for SKA1_Low VLBI shall be below: • -30dB in amplitude • 0.01 radians in phase.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3606 The SKA1_Low correlator shall have the capability of producing 4 dual polarisation tied-array VLBI beams TBC for one SKA1_Low sub-array.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3607 The SKA1_Low correlator shall be capable of forming 4 beams TBC across all stations within the VLBI sub-array to a distance of up to 100,000 TBC metres from the sub-array centre.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3608 The SKA1_Low VLBI beams shall have a centre frequency selectable anywhere within the SKA1_Low observing band.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-3609 The SKA1_Low VLBI beams shall have a contiguous processing bandwidth up to the full bandwidth of the SKA1_Low array.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2153 SKA1 dishes shall have a projected diameter of larger than 15m and smaller than 16.5m.	**SCI_REQ-38** SKA1_Mid relative collecting area **SCI_REQ-44** SKA1_Mid survey speed
SKA1-SYS_REQ-2155 For SKA1_Mid aperture efficiency, while operating under Precision and Standard environmental conditions, shall be above a lower limit linearly interpolated between the following specification points: • 60% at 350MHz • 65% at 400MHz • 78% from 600MHz to 8000MHz • 70% from 8 to 15 GHz • 65% from 15 to 20 GHz Aperture efficiency is the ratio of the maximum effective area to the physical aperture area (these are terms defined in IEEE Std 145 where the same ratio is referred to as Antenna Efficiency) calculated for a Gaussian feed illumination pattern with taper chosen to maximize aperture efficiency.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency **SCI_REQ-44** SKA1_Mid survey speed

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3203 When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 36 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3204 When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 72 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3205 When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 144 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3206 When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 9 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3207 When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 18 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3208 When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 36 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, without any metrology and/or calibration, under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3209 When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 20 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3210 When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 40 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3211 When the SKA1_Mid receptor is ready to Observe, its boresight shall remain within a Pointing error circle, centred on the commanded direction, with a diameter less than 80 arcsec, from commanded direction, in any possible combination of Az and El within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3212 When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 5 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3213 When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 10 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3214 When the SKA1_Mid receptor is ready to Observe, its boresight shall differ less than a residual of 20 arcsec RMS from commanded direction, in any possible combination of Az and El, within its specified range of motions, after all long term repeatable errors have been compensated, including any metrology and/or calibration, under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3215 While tracking, SKA1_Mid receptor elevation motion range shall be within 15 to 85 degrees.	**SCI_REQ-32** SKA1_Mid local azimuth angles
SKA1-SYS_REQ-3216 While tracking, SKA1_Mid receptor azimuth motion range shall be within -270 to 270 degrees.	**SCI_REQ-32** SKA1_Mid local azimuth angles
SKA1-SYS_REQ-3217 The SKA1_Mid Receptor pointing Error Circle diameter, within a time interval of 100 seconds and between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 6.5 (arcsec), under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3218 The SKA1_Mid Receptor pointing Error Circle diameter, within a time interval of 100 seconds and between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 13 (arcsec), under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3219 The SKA1_Mid Receptor pointing Error Circle diameter, within a time interval of 100 seconds and between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 26 (arcsec), under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3220 The SKA1_Mid Receptor RMS Relative Pointing Error, within a time interval of 100 seconds under Standard conditions and computed between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 1.3 (arcsec) RMS, under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3221 The SKA1_Mid Receptor RMS Relative Pointing Error, within a time interval of 100 seconds under Standard conditions and computed between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 2.6 (arcsec) RMS, under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3222 The SKA1_Mid Receptor RMS Relative Pointing Error, within 100 seconds under Degraded conditions and computed between a reference measurement taken towards any point up to a maximum of 75° in elevation and any second point separated by up to 10° (great circle) distance anywhere within its specified range of motions shall be ≤ 5.2 (arcsec) RMS, under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3223 The SKA1_Mid Receptor pointing Error Circle diameter, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 9 (arcsec), under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3224 The SKA1_Mid Receptor pointing Error Circle diameter, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 18 (arcsec), under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3225 The SKA1_Mid Receptor pointing Error Circle diameter, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 36 (arcsec), under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3226 The SKA1_Mid Receptor RMS Relative Pointing Error, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 2.3 (arcsec) RMS, under Precision Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3227 The SKA1_Mid Receptor RMS Relative Pointing Error, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 4.6 (arcsec) RMS, under Standard Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3228 The SKA1_Mid Receptor RMS Relative Pointing Error, maintained while tracking a celestial target anywhere within its specified range of motions, over a time interval of 1000 seconds shall be ≤ 9.2 (arcsec) RMS, under Degraded Observing condition.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance
SKA1-SYS_REQ-3229 The SKA1_Mid Receptor maximum Azimuth speed during Tracking shall be 0.3 deg/sec.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3230 The SKA1_Mid Receptor maximum elevation speed during Tracking shall be 0.08 deg/sec.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3231 The SKA1_Mid Receptor shall be capable of slewing in elevation at a rate of 1 deg/sec under Precision and Standard Operating Conditions. Degradation of up to 50% will be allowed under Extreme or Degraded Operating Conditions.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3232 The SKA1_Mid Receptor shall be capable of slewing in azimuth at a rate of 3 deg/sec under Precision and Standard Operating Conditions. Degradation of up to 50% will be allowed under Extreme or Degraded Operating Conditions.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3233 The SKA1_Mid Receptor shall be able to achieve maximum azimuth and elevation slew rates simultaneously.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-2162 There shall be space at the Gregorian focus of SKA1_Mid dishes for five single pixel feeds (SPF).	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states
SKA1-SYS_REQ-3077 SKA1_Mid DSH shall make mechanical and optical provision on the structure to exchange the SPF Band 1 with a PAF. The PAF shall be constrained to a physical size of a cylindrical volume with of maximum diameter of TBD m and a maximum depth of TBD m and a maximum mass of TBD kg.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2165 The intrinsic cross polarisation ratio, IXR, for SKA1 Mid shall be better than 15 dB over the whole observing bandwidth within the HPBW.	**SCI_REQ-21** SKA1_Mid polarisation dynamic range
SKA1-SYS_REQ-2170 The SKA1_Mid shall operate at all elevations greater than 15 degrees.	**SCI_REQ-34** SKA1_Mid azimuthal noise performance **SCI_REQ-32** SKA1_Mid local azimuth angles
SKA1-SYS_REQ-2171 The SKA1_Mid shall have a continuous useable azimuth observation range from -270° to +270°, inclusive measured relative to true North defined as 0° and with East defined as +90°.	**SCI_REQ-32** SKA1_Mid local azimuth angles

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2833 The SKA1_Mid shall incorporate the 64 MeerKAT receptors *so that each one individually may be treated as functionally equivalent to the SKA1_Mid dishes.*	**SCI_REQ-40** SKA1_Mid PSF quality (snapshot) **SCI_REQ-42** SKA1_Mid PSF quality (tracking) **SCI_REQ-38** SKA1_Mid relative collecting area **SCI_REQ-46** SKA1_Mid survey depth **SCI_REQ-44** SKA1_Mid survey speed
SKA1-SYS_REQ-2173 SKA1 MID Telescope Manager shall be able to control and Monitor all Meerkat Receptors independently.	**SCI_REQ-38** SKA1_Mid relative collecting area
SKA1-SYS_REQ-3535 SKA1_Mid, when commanded, shall include both MeerKAT and SKA1 dishes in any or all tied-array beam sums.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2825 The SKA1_Mid, under standard weather conditions, shall have an absolute flux density scale accurate to better than 5% across the band.	**SCI_REQ-11** SKA1_Mid photometric accuracy **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2826 The SKA1_Mid, under precision weather conditions, shall have an absolute flux density scale accurate to better than 3% across the band. It is envisioned test at several distributed points across the band with an analysis to interpolate across the full band. The **Flux density scale** is transferred from a celestial calibrator to the target source. It includes the atmospheric extinction as well as all receptor-based system temperatures and gains.	**SCI_REQ-11** SKA1_Mid photometric accuracy **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3458 The bandpass of SKA1_Mid, on timescales of 600 seconds or less and for all processed bandwidths, post-calibration and RFI mitigation, shall be stable to better than 0.03%.	**SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2174 The SKA1_Mid shall have the configuration defined in the SKA1_Mid Configuration Co-ordinates document [AD5].	**SCI_REQ-05** SKA1_Mid locations **SCI_REQ-40** SKA1_Mid PSF quality (snapshot) **SCI_REQ-42** SKA1_Mid PSF quality (tracking) **SCI_REQ-38** SKA1_Mid relative collecting area **SCI_REQ-46** SKA1_Mid survey depth **SCI_REQ-44** SKA1_Mid survey speed
SKA1-SYS_REQ-3072 The maximum distance between SKA1_Mid (including MeerKAT) Receptors shall be at most 160km.	**SCI_REQ-40** SKA1_Mid PSF quality (snapshot) **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3064 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid array (excluding the MeerKAT array), while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization above a line that increases linearly from 272 m^2/K at 350 MHz to 545 m^2/K at 650 MHz and then stays constant at this level up to 1050 MHz over pointing angles from zenith down to 30° above the horizon. Sky temperature is defined for a feed with boresight directed towards an elevation angle where ground illumination is minimized, observed at a time when no significant sources appear within the beam.	**SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3065 Assuming a sky noise temperature defined in the definitions section of this document, Mid Band 2, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 916 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the unweighted average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	**SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3066 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 3, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 916 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the unweighted average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	**SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3067 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 4, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 833 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the unweighted average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	**SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3614 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 5a, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 1110 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	**SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3615 Assuming a sky noise temperature defined in the definitions section of this document, the SKA1_Mid Band 5b, while operating under Precision and Standard environmental conditions, shall have a sensitivity per polarization greater than 805 m^2/K for the SKA1_Mid excluding the MeerKAT array taken as the average over the entire frequency band and over pointing angles from zenith down to 30° above the horizon.	**SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2965 SKA1_Mid shall provide 40 dB polarisation dynamic range at all fractional bandwidths across the full band for the field of view to the half power band width.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3075 SKA1_Mid, when performing Pulsar Search, shall provide better than 25 dB polarisation purity across tied array beams for the configured bandwidth.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3076 SKA1_Mid, when performing Pulsar Timing, shall provide better than 40 dB polarisation dynamic range across tied array beams for the configured bandwidth.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3460 SKA1_Mid shall provide at least 60 dB brightness dynamic range at 0.5 arcsec spatial and 1 MHz spectral resolution.	
SKA1-SYS_REQ-2224 The SKA1_Mid, when commanded, shall change from observing in any frequency band, to observing in any other frequency band in: • Less than 10 s from any band to band 5a or band 5b • Less than 20s between all other bands.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3453 When commanded, SKA1_Mid shall transfer calibration seamlessly across frequency changes, band changes, and/or source changes, such that the any change in calibration due to the telescope (as compared to the environment or the source) shall be less than 0.1% in amplitude and 0.001 radians in phase on timescales of TBD minutes.	**SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3293 Each SKA1_Mid subarray shall have a common delay centre at or near its centre with a time accurate to the SKA timescale and a precision of better than 2ns (1σ) over periods of one observation and at least 10 years.	**SCI_REQ-40** SKA1_Mid PSF quality (snapshot) **SCI_REQ-42** SKA1_Mid PSF quality (tracking)
SKA1-SYS_REQ-3566 The SKA1_Mid Telescope shall have a source of excess thermal noise (e.g. a noise diode), that is injected into the signal path and can be turned ON and OFF independently for each receptor.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3567 The SKA1_Mid excess thermal noise signal, when commanded ON for a given Receptor, shall occupy the entire bandwidth of the selected Band.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3568 The SKA1_Mid excess thermal noise sources, when commanded to do periodic firing, shall support configurable switching cycles with a minimum dwell time of not more than 5 microsec and a maximum dwell time of not less than 5 sec.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3569 When ON, the unbalance between the signal injected in the SKA1_Mid Telescope Receptors in each polarisation by the excess thermal noise sources shall be less than 1.5 degree in phase, between the coupling points.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3570 When operating, the phase unbalance of SKA1 MID telescope calibration signal, between the two orthogonal polarisations, shall remain stable to < 0.3° RMS, measured over time, at any frequency in the band.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3571 SKA1_Mid, when commanded to do pseudo-random firing, shall inject excess thermal noise following a pseudo-random ON-OFF pattern, with a pattern seed that is independently programmable per receptor.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3572 The SKA1_Mid measurement of the excess thermal noise source signals shall have a frequency resolution of 10 MHz or finer.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3573 The SKA1_Mid excess thermal noise ON as well as the OFF state shall be independently programmed.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3574 The SKA1_ -Mid, when commanded to do periodic firing, shall inject excess thermal noise with duty cycles ranging from 5 to 50% that is independently programmable per receptor.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3575 None of the transitions (ON-OFF or OFF-ON) of the calibration signal, measured from the edge of the accompanying status flags till the calibration signal reaches within 10% of its final value, shall exceed 5 microsec.	**SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3576 When ON, the SKA1_Mid excess thermal noise sources shall contribute between 5 and 15% of Tsys when the noise source is OFF, at all frequencies within the observed bandwidth of the selected Band, averaged over any 1 MHz bandwidth across the specified frequency range and with Tsys computed for Cold sky at the lowest specified elevation angle.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3577 The SKA1_Mid excess thermal noise source output level shall remain stable so that its standard deviation, computed from samples integrated over 10 MHz and 500 milliseconds, shall not exceed 0.05% over intervals extending up to 30 minutes, and 1% on timescales up to 1 week.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2712 The SKA1_Mid array shall consist of 133 Receptors plus 64 MeerKAT receptors centred in the same location as the MeerKAT array.	**SCI_REQ-05** SKA1_Mid locations
SKA1-SYS_REQ-2179 Each Receptor of SKA1_Mid shall produce data from at most a single frequency band at any one time.	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-3392 There shall be no change in phase in any band induced by intervening band changes.	**SCI_REQ-54** SKA1_Mid observation mode change time
SKA1-SYS_REQ-2180 The SKA1_Mid Receptors, when the band 1 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 0.35 to 1.050 GHz for each polarisation.	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states
SKA1-SYS_REQ-2181 The SKA1_Mid receptors, when the band 2 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 0.95 to 1.76 GHz for each polarisation.	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states
SKA1-SYS_REQ-2182 The SKA1_Mid Receptors, when the band 3 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 1.65 to 3.05 GHz for each polarisation.	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states
SKA1-SYS_REQ-2183 The SKA1_Mid Receptors, when the band 4 capability is selected, shall be able to receive condition and digitise signals over a frequency range from 2.80 to 5.18 GHz for each polarisation.	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states
SKA1-SYS_REQ-3612 The SKA1_Mid receptors, when the band 5a capability is selected, shall be able to receive condition and digitise signals over a frequency range from 4.6 to 8.5 GHz for each polarisation.	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states
SKA1-SYS_REQ-3613 The SKA1_Mid receptors, when the band 5b capability is selected, shall be able to receive condition and digitise signals over a frequency range from 8.3 to 15.4 GHz for each polarisation.	**SCI_REQ-25** SKA1_Mid perpendicular polarisation states

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2185 The instantaneous sampled bandwidth for SKA1_Mid band 1 shall be 700MHz for each polarisation.	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-2186 The instantaneous sampled bandwidth for SKA1_Mid band 2 will be 810 MHz for each polarisation.	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-2187 The instantaneous sampled bandwidth for SKA1_Mid band 3 will be 1,400 MHz for each polarisation.	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-2188 The instantaneous sampled bandwidth for SKA1_Mid band 4 will be 2,380 MHz for each polarisation.	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-2189 The SKA1_Mid band 5a and band 5b, shall each provide two independent bands of 2.5 GHz for each polarisation, tuneable across the whole respective band's RF frequency range.	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-2190 Digitisation for each polarisation of SKA1_Mid shall be: • band 1 - 8 effective number of bits • band 2 - 8 effective number of bits • band 3 - 6 effective number of bits • band 4 - at least 4 effective number of bits • band 5a - 2 streams of at least 3 effective number of bits • band 5b - 2 streams of at least 3 effective number of bits ***Where Effective Number of Bits (ENOB)*** is the number of bits that an ideal Analogue-to-Digital Converter provides between full scale input and the input-referred noise floor, excluding harmonic distortion & spurs. This relates to the actual number of bits from the Analogue-to-Digital Converter which may not correspond to the number of bits forwarded.	**SCI_REQ-07** SKA1_Mid effective noise level
SKA1-SYS_REQ-3036 SKA1_Mid, when commanded, shall generate full polarisation autocorrelation spectra from all receptors within a subarray, with characteristics matching those of the cross-correlation spectra.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3046 The SKA1_Mid, when commanded, shall generate autocorrelation spectra. Crosscorrelation spectra may be used as part of this calibration.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3038 The SKA1_Mid, when commanded, shall provide full Stokes polarisation products (I, Q, U, V) as part of all observing modes including Continuum Imaging.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2196 The SKA1_Mid shall have a transition band for adjacent visibility spectra frequency channels that is monotonically decreasing from -3.01 dB (or better) at the channel edge, to -60 dB (or better) at the next adjacent channel centre frequency.	**SCI_REQ-23** SKA1_Mid spectral dynamic range

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2803 The maximum noise leakage power for SKA1_Mid shall be better than -60 dB for non-adjacent fine frequency channels.	**SCI_REQ-23** SKA1_Mid spectral dynamic range
SKA1-SYS_REQ-2805 The post-calibration amplitude response of SKA1_Mid imaging shall vary by at most +/-0.05 dB across the band.	**SCI_REQ-23** SKA1_Mid spectral dynamic range
SKA1-SYS_REQ-3297 The spectral and temporal response of the individual SKA1_Mid visibility spectra frequency channels shall not change by more than 1% as a function of time, unless explicitly commanded to do so.	**SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2195 For each subarray, SKA1_Mid, when commanded, shall form a fixed (but band-dependent) number of at least 51,180 and at most 65,536, linearly spaced frequency channels across the frequency band in total. For each of band 5a and band 5b, the total sampled bandwidth is 5 GHz (2 * 2.5 GHz).	**SCI_REQ-28** SKA1_Mid instantaneous bandwidth
SKA1-SYS_REQ-2968 When commanded, for each subarray independently, the SKA1_Mid, shall produce correlated visibilities and autocorrelations for all polarization products for zoom imaging such that: 1.The total bandwidth across Zoom Windows is configurable up to that of the processed band in any variant of contiguous, overlapped or separated frequency coverage. 2.The maximum Zoom window bandwidth is 256 MHz + 35% 3.Zoom windows can each be individually configurable to one of 1, 1/2, 1/4, 1/8, 1/16, 1/32, or 1/64 of the maximum zoom window bandwidth. 4.Each zoom window contains at least between 14,000 and 16,384 linearly spaced frequency channels fully covering the zoom window bandwidth. 5.The number of simultaneously available windows in each sub-array is constrained by the available processing and communication resources within the telescope.	**SCI_REQ-30** SKA1_Mid spectral windows
SKA1-SYS_REQ-2969 Zoom windows for SKA1_Mid shall have centre frequencies which are independently selectable from each other with a step size within 0.01MHz, such that the full window is contained within the available frequency band and with the option of overlapping any or all windows. For Band 5 zoom windows are contained within the individual 2.5 GHz streams.	**SCI_REQ-30** SKA1_Mid spectral windows
SKA1-SYS_REQ-2971 Whilst retaining the ability to operate simultaneously within all Bands to the extent that processing and communication resources are available, the SKA1_Mid shall, when commanded, generate up to the full frequency band at continuum resolution simultaneously with the zoom windows to provide a coarse context for the fine resolution.	**SCI_REQ-30** SKA1_Mid spectral windows
SKA1-SYS_REQ-3050 The maximum noise leakage power, for a flat passband and with no RFI, into SKA1_Mid Zoom Window channels from frequencies outside the window shall be less than 60dB.	**SCI_REQ-30** SKA1_Mid spectral windows
SKA1-SYS_REQ-3051 The SKA1_Mid post-calibration amplitude response variation across the full concatenated bandwidth of overlapped zoom windows of the same frequency resolution shall be within +/-0.05 dB of the nominal.	**SCI_REQ-30** SKA1_Mid spectral windows

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3463 SKA1_Mid shall, when commanded, configure zoom windows, and generate the corresponding data products, completely independently, for any and all subarrays.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3537 When commanded, for each subarray individually, SKA1_Mid shall transfer calibration between zoom windows and standard (non-zoom) spectral channels which are observed commensally, without introducing additional errors (beyond those of transferring calibration between different frequencies and/or times) above 0.1% in amplitude and 0.001 radians in phase.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2679 The SKA1_Mid correlation shall maintain the Signal to Noise ratio better than 98% for Bands 1, 2, 3 and 4 and at least 96% or better for each of band 5a and band 5b, compared to ideal analogue correlation for the same inputs.	**SCI_REQ-07** SKA1_Mid effective noise level
SKA1-SYS_REQ-3538 When flagging on timescales shorter than the correlation integration time, SKA1_Mid shall flag all polarizations and polarization products if any are found to be bad.	**SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2197 The minimum visibility integration period for each SKA1_Mid subarray shall be independently configurable, with allowed values being an integer multiple of 0.14 seconds to a maximum of 1.4 seconds.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2616 The SKA1_Mid, for each subarray, shall allow for pulse phase-resolved observations supporting the product of the number of phase bins, channel and polarisation products up to 262,144 (e.g. 4 x 65,536).	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2830 SKA1_Mid, when producing phase-binned correlations, shall provide individual phase bins with widths as small as 1 microsecond.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2831 The SKA1_Mid shall be capable of synchronising phase bins to the ephemeris to limit drift to less than 10% of the selected bin width within the selected correlator integration period.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3464 SKA1_Mid, when commanded, shall produce phase-binned visibilities with a maximum of 256 phase bins.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3465 SKA1_Mid shall when commanded produce phase-binned visibilities with equal-temporal-width, contiguous phase bins spaced linearly in pulsar longitude.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3466 The use of phase bins on SKA1_Mid shall not lead to the loss of any additional time on-source during the phase-binning observations.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2740 SKA1_Mid, when commanded, shall form real-time cross-correlation products between all dishes within the SKA1_Mid combined array, including between MeerKAT and SKA1 dishes.	**SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3292 Each SKA1_Mid VLBI data sample shall be directly traceable to the time at the common delay centre of the SKA1_Mid telescope, with an accuracy of better than 2 nanoseconds.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2689 SKA1_Mid, when commanded, shall produce a total of up to four VLBI beams, spread across one or more subarrays.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2759 SKA1_Mid, when commanded, shall generate VLBI beams from any or all receptors within a subarray which are separated by at most 100km.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2760 When commanded, for each VLBI beam, SKA1_Mid shall tune the centre frequencies of each of its derived beam channels independently with: 1.Beam channels of 128 MHz bandwidth or less, to an accuracy of 0.01 MHz or better, such that their bandwidth falls entirely within the fixed boundaries of beam channels greater than 128 MHz. 2.Beam channels of greater than 128 MHz bandwidth having fixed offset centre frequencies within the processed bandwidth of the observing Band.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2761 The bandwidth for each SKA1_Mid VLBI beam shall be independently configurable, with a contiguous processing bandwidth up to the full bandwidth of the selected Band. For Band 5 this applies to each of the two 2.5 GHz streams, and not across streams -- that is, a single Band 5 VLBI beam can produce two 2.5 GHz -wide outputs.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2762 The SKA1_Mid, when forming VLBI beams, shall have a signal-to-noise performance better than 90% of that achievable by an ideal signal chain, given the same inputs, instrumental calibration and excluding RFI.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2847 SKA1_Mid shall store the time-dependent dish weights used for each tied-array beam sum.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2849 SKA1_Mid, when forming VLBI beams, shall output them with a sampling rate selectable between Nyquist and at least a factor of two oversampling for the selected bandwidth.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2851 SKA1_Mid, when commanded, shall weight the dish inputs into the VLBI tied-array sums based on relative sensitivity and coherence losses.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2852 SKA1_Mid, when commanded, shall change the pointing, centre frequency, and bandwidth of each VLBI tied-array beam independently, on scan boundaries.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2853 When commanded, SKA1_Mid shall form up to at least 4 separate VLBI tied-array beams up to a beams-bandwidth product of 10 GHz, distributed across one or more subarrays, each beam having independently configurable sky coordinates.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2854 SKA1_Mid shall, when commanded, reconfigure the centre frequency, frequency band, and bandwidth for each tied-array beam, in less than 30 seconds.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2855 SKA1_Mid shall, when commanded, generate VLBI beams with a spectral resolution different from the spectral resolution used for imaging within the same subarray.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2856 SKA1_Mid, when commanded, shall generate VLBI beam channel data with a selectable channel width of: 128, 64, 32, 16, 8, 4, 2, 1 MHz, or a single wideband option, with channel width greater than (128 + 2n + 2m MHz) and less than or equal to 512MHz. Where n and m are non-negative integers.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2857 SKA1_Mid, when commanded, shall simultaneously generate both VLBI beams and VLBI imaging data for the same subarray. VLBI imaging data shall include all polarization products and all baselines (including autocorrelations), with a spectral resolution no worse than 1 MHz, covering a bandwidth of at least 100 MHz, and spanning the full frequency range(s) covered by the VLBI beam(s) generated within the same subarray.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2859 SKA1_Mid, when commanded, shall generate VLBI beams with a transition band that is monotonically decreasing from -3dB at the channel edge, to -60dB at a frequency offset from the centre frequency by the channel bandwidth.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3469 The SKA1_Mid VLBI array phase centre shall be within 100km of one of the SKA1_Mid receptors.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3474 Spectral distortion, after calibration, for SKA1_Mid VLBI shall be below: • -30dB in amplitude • 0.01 radians in phase.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3470 SKA1_Mid and SKA1_Low, when commanded, shall form tied-array beams for pulsar search and pulsar timing (and VLBI, for SKA1_Mid), whose half-power contour fits entirely within the half-power primary beam width of the largest receptors in use, calculated at the highest frequency within the frequency range covered by the tied-array beam in question.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3471 SKA1_Mid shall flag both polarizations of any beamforming input for which one polarization is flagged (or marked invalid).	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3525 When commanded, SKA1_Mid shall form pulsar search, pulsar timing, and VLBI tied-array beams that each have a coherence within 5% of that allowed by the current atmospheric conditions.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3541 The spectral distortion of SKA1_Mid pulsar search beams, compared to an ideal analogue beamformer provided with the same inputs, shall be no more than -40 dB in amplitude and 0.01 radians in phase.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2767 The maximum pulsar search bandwidth for SKA1_Mid shall be no less than 295MHz.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2212 SKA1_Mid, when performing Pulsar Search for unaccelerated pulsars with dispersion measures within the range 0 to 3000 pc cm^{-3}, shall space dispersion measure trials such that the recovered signal-to-noise ratio of any signal lying between trials shall be no worse than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2216 The SKA1_Mid shall retain time resolution in the Pulsar Search such that any increase in sampling interval at high dispersion measure trials does not degrade the signal-to-noise ratio below 95% relative to the maximum time resolution.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2218 SKA1_Mid, when commanded, shall perform the Pulsar Search with an observation time configurable between 180 and 1800 seconds. The SKA1_Mid may restrict the observing time to be the same for all beams in a subarray in fixed multiples of the sampling interval.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2219 SKA1_Mid, when performing Pulsar Search for individual pulses with dispersion measures in the range 0 to 3000 pc cm^{-3} and with widths 100 microseconds to 1 second, shall space dispersion measure trials such that the recovered the signal-to-noise ratio of any signal lying between trials shall be no worse than 85% of the signal-to-noise ratio that the signal would have had when dedispersed to its true dispersion measure.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3289 SKA1_Mid shall obtain a signal-to-noise ratio for a pulse in a de-dispersed time-series that is more than 85% compared to using a Gaussian matched filter of the correct width.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2220 When commanded, for each pulsar search beam with pulsar search duration less than 600s, SKA1_Mid shall perform acceleration correction as part of the pulsar search, over a configurable range of acceleration values from 0 to no less than 350 m/s^2, for no fewer than 500 configurable dispersion measure trials, such that the degradation in signal-to-noise ratio due to coarse acceleration sampling is less than 34% everywhere in the acceleration range.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2202 Each SKA1_Mid subarray, when performing Pulsar Search, shall form beams using any and all constituent receptors within that subarray, which are separated by up to 20,000 metres.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2755 SKA1_Mid, when commanded, shall perform the Pulsar Search on an operator configured continuous bandwidth located anywhere within the current subarray band.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2756 For each subarray, the SKA1_Mid, when commanded, shall independently set up to two Search Window centre frequencies of the Pulsar Search such that each Search Window lies entirely within the current subarray Band.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3477 SKA1_Mid, when commanded, shall form multiple Pulsar Search beams at the same sky coordinates, within a single subarray.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2203 SKA1_Mid, shall concurrently perform the Pulsar Search function in a total of up to 1500 independently steerable beams, each of which may be assigned to any sub-array which is configured for Pulsar Search.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2205 The SKA1_Mid when forming beams for the Pulsar Search, shall achieve signal-to-noise more than 98% relative to an ideal analogue beam-former for the same inputs.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2897 SKA1_Mid, when performing the Pulsar Search, shall generate Pulsar Candidates and Non-imaging Transient Candidates as defined in TBD.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2900 SKA1_Mid shall perform Pulsar Search and Single Pulse Search with on spectral channels with an effective time resolution shorter than 100 microseconds. (effective time resolution - full width at 10% maximum of the channeliser power response).	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2901 SKA1_Mid, when commanded, shall perform the Pulsar Search with a configurable sampling interval that is 1, 2, 3 or 4 times the minimum sampling interval.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2902 SKA1_Mid, when commanded, shall perform the pulsar search for a pulsar search beam, with a configurable bandwidth from the full pulsar search bandwidth for that beam, down to 0.25 times the available bandwidth of the current observing band (if that is less than the full pulsar search bandwidth for the beam).	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2903 SKA1_Mid shall restrict the choices of the sampling rate and bandwidth for Pulsar Search to integer sub-multiples of a the fundamental sampling rate.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3544 The spectral distortion of SKA1_Mid Pulsar timing beams, compared to an ideal analogue beamformer provided with the same inputs, shall be no more than -60 dB in amplitude and 0.001 radians in phase.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2206 Each SKA1_Mid subarray, when configured for Pulsar Timing, shall form pulsar timing beams using all receptors within that sub-array, which are separated by at most 20,000 metres.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2757 The SKA1_Mid, when commanded, shall form beams for each of the Pulsar timing subarrays with a selectable Pulsar timing band for each subarray anywhere in the selected SKA1_Mid band.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2207 The SKA1_Mid, when commanded, shall form and process the data from a total of up to 16 (dual polarization) pulsar timing beams constrained to a net bandwidth (on sky) of 20 GHz per polarization, independently and concurrently. These pulsar timing beams may be spread across one or more subarrays.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2208 The SKA1_Mid, when forming pulsar timing beams, shall have a Signal to Noise ratio greater than or equal to 98% TBC of an ideal beam former, given the same digitized inputs and calibration.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3532 The spatial offset of each SKA1_Mid pulsar timing beam from the imaging delay centre of the corresponding subarray shall be at most half of the half-power beam width of the largest dish in that subarray, evaluated at the highest observing frequency used by the pulsar timing beam.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2768 The SKA1_Mid, when performing Pulsar timing, shall have a contiguous processing bandwidth up to the full bandwidth of the selected band limited to a maximum of 2.5 GHz for each timing subarray.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2766 The observation duration for each SKA1_MID Pulsar timing subarray shall be set independently with a value configurable between 10 seconds and 300 minutes with a granularity of 10 seconds.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2764 Each SKA1_Mid pulsar timing and dynamic spectrum measurement shall be directly traceable to the time at the common delay centre of the SKA1_Mid telescope, with an accuracy of better than 2 nanoseconds.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2939 When performing Pulsar Timing, SKA1_Mid shall form multiple tied array beams within the same subarray, with independent sky coordinates such that each beam centre offset from the imaging delay centre is a maximum of half the HPBW of the antenna.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2231 The SKA1_Mid shall time Pulsars with dispersion measures between 0 to 3000 pc cm^{-3} with an accuracy up to the Nyquist rate for the given channelisation.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-2961 The SKA1_Mid, when commanded to time a pulsar, shall resolve that pulsar's pulse profile with up to 2048 equal-width, contiguous phase bins.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3533 The SKA1_Mid, when commanded, shall time Pulsars with periods between 0.4 milliseconds and 20 seconds.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3195 The SKA1_Mid, when commanded, shall produce a dynamic spectrum for one or more pulsar timing beams, recording the amplitude of the signal as a function of time, frequency, and polarisation.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3201 SKA1_Mid, when commanded, shall simultaneously form and process data from up to a total of16 dual-polarization pulsar timing beams for pulsar timing and dynamic spectrum processing, constrained to a net, on-sky bandwidth of 20 GHz per polarisation.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3534 The spectral and temporal resolution of each SKA1_Mid dynamic spectrum shall be independently selectable, within the limitations imposed jointly by the corresponding pulsar timing beam's spectral and temporal responses.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes **SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3078 The SKA1_MID shall provide a transient buffer of at least 32 gigabytes per dish, capable of recording at least 300-MHz of 2-bit dual-polarisation raw voltage data.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3079 The SKA1_MID shall have a system latency of at most 60 seconds from the time that the highest frequency component of a transient signal arrives at the telescope to the time when the transient buffer is recorded.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3080 The SKA1_MID shall have the capacity of archiving at least 150 terabytes of transient buffer data per day.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3467 SKA1_Mid shall generate and respond to real-time internal triggers by storing digitized voltage data, with 2-bit or better sampling, for at least 300 MHz of contiguous, tuneable observed bandwidth in both polarizations, from every dish within the triggering subarray, covering at least 2 seconds before and at least 20 seconds after the triggering event.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3468 When commanded, SKA1_Mid shall archive all or part of the transient buffer based on the results of single-pulse searches, independently for each subarray.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3536 SKA1_Mid shall record the transient buffer as often as every 2 minutes.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3390 Each dish shall provide to the correlator-beamformer a time stamp, synchronous with and locked to the sample clock and 1PPS.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes **SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-2128 Both SKA1_Mid and SKA1_Low shall have an imaging capability that will acquire continuum and spectral-line data concurrently.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-2133 The switching time between telescope observation modes shall take less than 30 seconds (not including dish slewing time).	**SCI_REQ-53** SKA1_Low observation mode change time **SCI_REQ-54** SKA1_Mid observation mode change time
SKA1-SYS_REQ-3131 SKA1_Low, when commanded shall provide processing within a subarray for one of: 1. Simultaneous imaging and non-imaging observing. 2. Simultaneous imaging and VLBI observing.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3622 When commanded SKA1_Mid shall provide: 1.Fully simultaneous processing for imaging, non-imaging and VLBI observations within and across all Bands to the extent that processing and communication bandwidth resources are available and 2.Sufficient processing and communication resources to provide any one individually of: imaging, non-imaging and VLBI observations at full bandwidth beam product.	**SCI_REQ-52** SKA1_Mid commensal observation **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3197 The SKA1_Low and SKA1_Mid, when commanded, shall operate simultaneously for Pulsar Timing, Pulsar Search (both periodic and single pulse search), and imaging within the same subarray.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3133 Upon authorised request, all elements of the SKA1_Low and SKA1_Mid shall report a summary of available signal and data processing resources.	
SKA1-SYS_REQ-3134 Scheduling blocks which have been assigned override status shall, when triggered, interrupt current observations and signal/data processing, as necessary, to enable the override observations to commence.	
SKA1-SYS_REQ-2681 The observatory shall have the capability of scheduling observations at a specific epoch.	
SKA1-SYS_REQ-2127 The SKA1_Mid and SKA1_Low, when commanded, shall form subarrays that can be configured and operated independently of each other.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3136 The SKA1_Mid and SKA1_Low, when commanded, shall form tied-array beams that can be configured and operated independently of each other.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2773 The SKA1_Low, when commanded, shall concurrently correlate all station beams within a configurable set of up to sixteen subarrays.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-2988 Each SKA1_Low station beam shall be formed from one subarray at any given time.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-2990 SKA1_Low subarrays shall be configurable to contain any integer number of stations between 0 (none) and all the stations.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-2992 SKA1_Low shall accept and execute commands for, and process data from, each subarray independently of and concurrently with all others.	**SCI_REQ-51** SKA1_Low commensal observation

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2994 SKA1_Low stations within the same subarray shall be configured according to the Scheduling Block controlling that subarray.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-2996 The SKA1_Low shall assign dynamic weights to stations within a subarray contributing to tied-array beams including the ability to exclude individual stations.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-2998 The SKA1_Low, when performing observations, shall allocate stations to subarrays at Scheduling Block boundaries only.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3000 The SKA1_Low, when performing observations, shall flag data from failed stations as soon as that failure is detected.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3002 SKA1_Low shall support the designation of any subarray as an engineering subarray at Scheduling Block boundaries.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3287 Each SKA1_Low schedulable resource shall be allocated to no more than one subarray at a time.	
SKA1-SYS_REQ-3008 The station beams for each SKA1_Low subarray shall be individually and independently pointed.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3016 SKA1_Low shall provide independent logical control and monitoring for each subarray.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3020 The time from selecting a Scheduling Block to required schedulable resources being configured shall be less than 30 seconds.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3029 The SKA1_Low shall form subarrays independent of the existence of a Scheduling Block.	**SCI_REQ-51** SKA1_Low commensal observation
SKA1-SYS_REQ-3528 The SKA1_Low when commanded shall allocate at most 512 stations and substations to subarrays at any given time.	
SKA1-SYS_REQ-2774 The SKA1_Mid, when commanded, shall concurrently correlate all receptor signals within each of up to sixteen subarrays.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-2989 Each SKA1_Mid receptor may belong to at most one subarray at any given time.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-2991 SKA1_Mid subarrays shall be configurable to contain any integer number of receptors between 0 (none) and all the receptors.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-2993 Unless explicitly stated otherwise, SKA1_Mid shall accept and execute commands for, and process data from, each subarray independently of and concurrently with all others.	**SCI_REQ-52** SKA1_Mid commensal observation

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2995 SKA1_Mid receptors within the same subarray shall be configured according to the Scheduling Block controlling that subarray.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-2997 The SKA1_Mid shall assign dynamic weights to receptors within a subarray contributing to tied-array beams including the ability to exclude individual receptors.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-2999 The SKA1_Mid, when performing observations, shall allocate receptors to subarrays at Scheduling Block boundaries only.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3001 The SKA1_Mid, when performing observations, shall flag data from failed receptors as soon as that failure is detected.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3003 SKA1_Mid shall support the designation of any subarray as an engineering subarray at Scheduling Block boundaries.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3288 Each SKA1_Mid schedulable resource shall be allocated to no more than one subarray at a time.	
SKA1-SYS_REQ-3007 The frequency band for each SKA1_Mid subarray shall be independently selectable.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3009 The receptor pointing for each SKA1_Mid subarray shall be commanded individually and independently.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3017 SKA1_Mid shall provide independent logical control and monitoring for each subarray.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3021 The time from selecting a Scheduling Block to required schedulable resources being configured shall be less than 30 seconds.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3030 The SKA1_Mid shall form subarrays independent of the existence of a Scheduling Block.	**SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3554 SKA1_Low and SKA1_Mid shall, when commanded, acquire imaging data at a single, specified (RA, Dec or Galactic coordinates) position on the sky, or of astronomical objects that move relative to the sky, e.g. planets.	
SKA1-SYS_REQ-3555 SKA1_Mid and SKA1_Low shall apply near-field corrections to visibilities measured towards celestial objects whose distance present phase errors on the longest baseline, due to wave-front curvature, of more than 0.1 radians.	
SKA1-SYS_REQ-3125 The SKA1_Mid and SKA1_Low telescopes, with the support of SKA1_Common, shall implement flexible scheduling.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3187 The SKA1_Mid and SKA1_Low shall log their usage and status within specified time accounting categories (TBD). These shall be stored at the telescopes and at the SKA1_Common.	
SKA1-SYS_REQ-3237 SKA1_Mid, SKA1_Low, and SKA1_Common shall archive all logs that directly relate to specific observations, including time accounting logs, for the duration of the observatory.	
SKA1-SYS_REQ-3188 SKA1_Mid and SKA1_Low, when commanded, shall generate a report of all their activity (at least observations carried out, events with manually entered operator logs, faults encountered, and remedial actions) over a specified period, normally 24 hours. The report will be made available to authorised personnel.	
SKA1-SYS_REQ-2278 A maintenance database for SKA1_Low and SKA1_Mid shall be established that logs all the scheduled maintenance and unexpected repairs.	
SKA1-SYS_REQ-2279 A failure database for the SKA1_Low and SKA1_Mid shall be established, which logs the errors of the system and its subsystems, including the corrective actions taken.	
SKA1-SYS_REQ-2280 The SKA1_Low and SKA1_Mid shall extract information about the current condition of the system from the science and calibration data streams, and log this information along with other relevant system and environmental status information. Based on this information, it will be possible to monitor, save, and analyse the technical performance of the system.	
SKA1-SYS_REQ-2285 The SKA1_Mid and SKA1_Low shall initiate scheduling intervention within 1s of receiving external TOO triggers.	
SKA1-SYS_REQ-3126 On command, the SKA1_Common shall ascertain the usage and status of each subarray of SKA1_Mid or SKA1_Low, within specified time accounting categories as specified in the Operational Concept Document.	
SKA1-SYS_REQ-3128 SKA1_Mid and SKA1_Low, when commanded, shall search for, detect, process, and archive transients with durations greater than ~50 µsec.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3130 The SKA1_Low and SKA1_Mid, when commanded, shall acquire imaging data while the telescope is either (a) driven across a region of sky defined in (Az, El), (RA, Dec), or Galactic coordinates to build a map of the sky, or (b) at a fixed (Az, El) position.	**SCI_REQ-47** SKA1_Low pointing modes **SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3139 The SKA1_Common shall provide access rights, for authenticated and authorised users, to correspondence, tools, and resources for managing their projects and proposals.	

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-3141
The SKA1_Common shall provide the capability for the preparation, design, pre-validation, and submission of proposals through a single, platform-independent system.

SKA1-SYS_REQ-3142
The SKA1_Common shall provide the capability for the PI of a proposal to configure editing rights to allow co-Investigators to edit their proposal.

SKA1-SYS_REQ-3143
The SKA1_Common shall provide a centrally maintained and managed database for authenticated and authorised users to prepare and submit proposals, and to retain a full history of previous proposals.

SKA1-SYS_REQ-3145
The SKA1_Common shall provide a library of template configurations for authorised users to browse and import into their proposals, and to tailor to their specific science objectives and requirements.

SKA1-SYS_REQ-3146
The SKA1_Common shall provide an interface to a Sensitivity Calculator that will be used to determine an estimate of the achievable sensitivity for a given telescope configuration, with the possibility of changing individual elements of the configuration (number of antennas, maximum baseline, correlator dump time, calibration strategy). The parameters and output of the Sensitivity Calculator will be a part of the submitted proposal. The list is TBC.

SKA1-SYS_REQ-3235
On request during proposal creation and/or project design, the SKA1_Common shall resolve astronomical source names to obtain their astronomical coordinates in ICRS. In cases where the coordinates are ambiguous, the user shall be asked to select.

SKA1-SYS_REQ-3147
SKA1_Common, when commanded, during proposal preparation and/or project design, shall provide the coordinates to known astronomical sources within a specified search radius to a given astronomical source name or coordinate. In case of multiple results, the user shall be asked to select.

SKA1-SYS_REQ-3148
The SKA1_Common, during observation preparation, shall provide PIs and their delegates the possibility of providing both their science goal, and technical justifications of the chosen telescope setup. The proposal is not valid until that goal and those justifications have been provided.

SKA1-SYS_REQ-3149
The SKA1_Common shall accept single proposals to use both SKA1_Low and SKA1_Mid with separate technical justifications for each.

SKA1-SYS_REQ-3150
When commanded, and before a proposal is allowed to be submitted, the SKA1_Common shall verify the contents of proposals against the known telescope and instrument constraints, as advertised in the Call for Proposals.

SKA1-SYS_REQ-3151
As part of the proposal verification process, the SKA1_Common shall compare submitted proposals to the published Key Science Projects, identifying any potential conflicts.

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3152 The SKA1_Common shall process up to 100 proposal submissions per minute for a maximum of 500 simultaneous unique users.	
SKA1-SYS_REQ-3153 The SKA1_Common shall provide the capability for authorised personnel to assign assessors and referees to each proposal, with invitations automatically issued to those assessors and referees. In case of declination or lack of reply from the assessor/referee, a new assessor/referee can be assigned.	
SKA1-SYS_REQ-3154 During proposal assessment, the SKA1_Common shall provide the capability for nominated referees and assessors to review and comment on proposals, and provide a numerical grade on the scientific justification for those proposals.	
SKA1-SYS_REQ-3155 During proposal assessment, the SKA1Common shall provide the capability for authorised (usually SKA) staff to submit a technical report on the feasibility of a proposal.	
SKA1-SYS_REQ-3156 During proposal assessment, the SKA1_Common shall collate and normalise grades assigned to proposals across relevant boundaries, and produce a ranked list.	
SKA1-SYS_REQ-3157 During proposal assessment, the SKA1_Common shall provide the capability for authorised users to submit feedback on each proposal, including a final grade and an indication of whether observing time has been awarded.	
SKA1-SYS_REQ-3158 The SKA1_Common shall provide the capability for the detailed preparation, design and adjustment of approved projects through a single, platform-independent system.	
SKA1-SYS_REQ-3159 When creating a project, the SKA1_Common shall extract the relevant technical information from the technical details defined in a successful proposal, to aid in designing the Program and Scheduling Blocks for that project.	
SKA1-SYS_REQ-3160 The SKA1_Common, when commanded, shall create Scheduling Blocks from Projects that have been verified against the known telescope and instrument constraints, as advertised in the Call for Proposals.	
SKA1-SYS_REQ-3161 For each Scheduling Block, the SKA1_Common shall provide the capability of specifying SKA1_Mid and SKA1_Low data products and associated data processing parameters.	
SKA1-SYS_REQ-3167 SKA1_Mid and SKA1_Low shall automatically select a Scheduling Block for execution, and execute it only if the necessary resources needed by that Scheduling Block are available, and all constraints are satisfied.	
SKA1-SYS_REQ-3168 The SKA1_Mid and SKA1_Low shall dynamically adapt the schedule in response to any sanctioned ToO, VOEvents, or other approved triggers or overrides. The associated Scheduling Block shall enter the schedule according to the trigger's priority.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3169 Once a Scheduling Block has finished executing, SKA1_Mid and SKA1_Low shall log the Scheduling Block's current status (i.e. completed, or some other QA-based status), including an update of the project time accounting.	
SKA1-SYS_REQ-3236 The SKA_Common, SKA1_Mid and SKA1_Low shall provide the capability for authorised Operations staff to manually change the status of a Scheduling Block.	
SKA1-SYS_REQ-3171 SKA1_Common, when commanded, shall identify Scheduling Blocks that could be scheduled commensally.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3172 The SKA1_Common shall package commensal projects for execution including the identification of corresponding data products against those projects.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3173 During creation of observing plans, the SKA1_Common shall prioritise groups of commensal projects, scoring each group with the score of the highest-ranked project within the group, within the constraints of the target telescopes.	**SCI_REQ-51** SKA1_Low commensal observation **SCI_REQ-52** SKA1_Mid commensal observation
SKA1-SYS_REQ-3180 The SKA1_Common shall provide a Help Desk facility to log and trace any queries/problems/faults/bugs reported. The Help Desk facility will generate tickets that are assigned to authorised staff members.	
SKA1-SYS_REQ-3163 SKA1_Common, when commanded, shall generate Observing Plans and Scheduling Block priorities for submission to SKA1_Mid and SKA1_Low for execution. The plans will be verified, and will take into account all scheduling constraints, including the coordination of schedule blocks between SKA1_Low and SKA1_Mid, for any plan length between 24 hours and 1 year.	
SKA1-SYS_REQ-2293 SKA1_Common, when commanded, shall construct Observing Plans for a user-specified length of time between 24 hours and 1 year, based on user-specified operational constraints.	
SKA1-SYS_REQ-2646 The SKA1_Low and SKA1_Mid shall provide a mechanism for implementing basic schedule building blocks.	
SKA1-SYS_REQ-2294 When commanded, the SKA1_Common shall simulate the execution of observing plans, to complete within one hour (TBC), in order to verify their efficiency and performance.	
SKA1-SYS_REQ-2735 The SKA1_Mid and SKA1_Low shall provide the capability for authorised personnel to take manual control of the telescope, its subarrays, components and instrumentation.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3176 The SKA1_Mid and SKA1_Low shall each automatically populate an observing log, recording their status across the entire duration of the execution of Scheduling Blocks.	
SKA1-SYS_REQ-3177 When commanded, SKA1_Mid and SKA1_Low shall provide the capability for authorised personnel to append information to observing log entries, including time-stamped narrative comments.	
SKA1-SYS_REQ-2296 The SKA1_Mid or SKA1_Low, when commanded, shall respond to the detection of transient events via one or more of the following: (a) adjust the scheduling queue on the telescope of origin; (b) issuing a Virtual Observatory Event, VOEvent; (c) issuing a Target of Opportunity, ToO, announcement to SKA Telescopes.	
SKA1-SYS_REQ-2298 Proposals to search for transient sources shall include rules for issuing VOEvents.	
SKA1-SYS_REQ-2301 A qualifying VOEvent within the SKA1_Mid and SKA1_Low shall lead to initiation of a response by the Telescope Manager within 1 second.	
SKA1-SYS_REQ-2645 A dynamic computational model of the Telescope shall be used to answer all queries about the state of the Telescope. The telescope model shall consist of configuration information, numerical models, empirical parameters, and conventions.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-08** SKA1_Low image fidelity **SCI_REQ-20** SKA1_Low polarisation dynamic range **SCI_REQ-19** SKA1_Mid brightness dynamic range **SCI_REQ-09** SKA1_Mid image fidelity **SCI_REQ-21** SKA1_Mid polarisation dynamic range
SKA1-SYS_REQ-2302 There shall be a single geodetic model for each of the SKA1_Mid and SKA1_Low published as part of the Telescope Model.	**SCI_REQ-39** SKA1_Low PSF quality (snapshot) **SCI_REQ-41** SKA1_Low PSF quality (tracking) **SCI_REQ-40** SKA1_Mid PSF quality (snapshot) **SCI_REQ-42** SKA1_Mid PSF quality (tracking)

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2303 There shall be a single geometric model for all receptor types, published by TM.	**SCI_REQ-39** SKA1_Low PSF quality (snapshot) **SCI_REQ-41** SKA1_Low PSF quality (tracking) **SCI_REQ-40** SKA1_Mid PSF quality (snapshot) **SCI_REQ-42** SKA1_Mid PSF quality (tracking)
SKA1-SYS_REQ-2304 The SKA1_Mid shall provide a dish pointing model that translates a pointing centre in ICRS coordinates at a given time to a mount orientation for a given dish. This will take into account astrometric effects, as well as location, and reference pointings. The pointing system at each dish shall include a model for pointing including structural model, thermal model, reference pointing model, gravitational model, and refraction model, published by TM.	**SCI_REQ-19** SKA1_Mid brightness dynamic range **SCI_REQ-09** SKA1_Mid image fidelity **SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-2305 The SKA1_Low shall provide a beam pointing model that translates a pointing centre in ICRS coordinates at a given time to a beam orientation in azimuth and elevation for a given beam, together with half-power bandwidth for the beam, and other beam metrics. This model shall take into account astrometric effects, as well as location, and reference pointings. The pointing system for each beam shall include a model for pointing including antenna element model, thermal model, reference pointing model, gravitational model, polarisation effects, and refraction model, published by TM.	**SCI_REQ-18** SKA1_Low brightness dynamic range **SCI_REQ-08** SKA1_Low image fidelity
SKA1-SYS_REQ-3373 The SKA1_Low and SKA1_Mid shall provide a Signal Integrity Display which shall enable the operator to evaluate the quality of the data being collected in near real time.	
SKA1-SYS_REQ-3374 In case of simultaneously operating sub-arrays, the SKA1_Low and SKA1_Mid shall provide a Signal Integrity Display for each active sub-array.	
SKA1-SYS_REQ-2306 There shall be an interactive forensic tool for evaluating and understanding the state and behaviour of the system at any one time.	
SKA1-SYS_REQ-2307 The interactive forensic tool shall have an Internet interface with availability on a range of platforms including desktop and mobile devices.	
SKA1-SYS_REQ-2308 The interactive forensic tool shall allow replay of selected sequences.	
SKA1-SYS_REQ-2309 Alarm notification shall be active (via SMS, email, etc.) rather than passive (requiring an Operator query).	
SKA1-SYS_REQ-2310 It shall be possible to filter alarms individually or by group.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2312 Latency from the time a measurement crosses an alarm set-point until the time it is signalled to the operator shall be no more than 1 second.	
SKA1-SYS_REQ-2313 The SKA1_Low and SKA1_Mid shall provide access to all current site and historic site data.	
SKA1-SYS_REQ-2314 The SKA1_Low and SKA1_Mid shall retrieve, store, and publish data on Total Electron Content (TEC) to an accuracy of 3 TECU*.	
SKA1-SYS_REQ-2315 The SKA1_Mid and SKA1_Low shall automatically retrieve and store space-weather and solar activity information from the Ionospheric Prediction Service, IPS, at the IPS update rate for use in calibration.	
SKA1-SYS_REQ-2316 The SKA1_Mid and SKA1_Low shall maintain a data base for site weather including site weather station and Weather Information Services data.	
SKA1-SYS_REQ-2317 SKA1_Mid and SKA1_Low shall maintain a database of relevant satellite trajectories, including orbital information, emission characteristics and owner.	
SKA1-SYS_REQ-2318 SKA1_Low and SKA1_Mid shall maintain a data base of commercial flights in the neighbourhood of the site.	
SKA1-SYS_REQ-2734 SKA1_Low and SKA1_Mid shall maintain a database holding information about RFI including but not limited to RFI frequency, strength and occupancy as a function of date and time of day incorporating both SKA1 observational (astronomical) data and on-site RFI monitors.	
SKA1-SYS_REQ-2729 The Calibration and Imaging formalism shall be based upon the Hamaker-Bregman-Sault [R4] Measurement Equation, with extensions for supporting large bandwidths as described by Rau et al. [R20]	
SKA1-SYS_REQ-2319 SKA1_Low and SKA1_Mid calibration shall include comparison of observed position, size and spectral intensity with Global Sky Model predictions in real-time to a time scale appropriate to the component and physical effect being calibrated.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3529 The SKA1_Low, when commanded shall provide ionospheric calibration with up to the full resolution of the array at intervals of no less than every 10 seconds.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2322 Calibration and continuum subtraction within the SKA1_Low and SKA1_Mid shall use an iteratively refined Local Sky Model, derived from a Global Sky Model or a previous Local Sky Model with a fidelity of source structure representation better than 35dB relative to the peak surface brightness of that source, when not noise floor limited.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-12** SKA1_Low astrometric accuracy **SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-13** SKA1_Mid astrometric accuracy **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3551 The Global Sky Model of each of the SKA1_Mid and SKA1_Low Telescopes shall support retrieval of subsets (a.k.a. Local Sky Models) through queries on RA/Dec ranges, frequency ranges, brightness ranges and/or polarisation parameters.	
SKA1-SYS_REQ-3552 The SKA1_Mid and SKA1_Low Global Sky Model shall be updatable, allowing creation of new entries, and updates and removal of existing entries.	
SKA1-SYS_REQ-3553 The SKA1_Mid and SKA1_Low Global Sky Model shall respond (by starting the data transfer or report an error) in less than 500ms to a query. The completion time of data transfers will be dominated by the time taken to transfer the data.	
SKA1-SYS_REQ-2324 The SKA1_Low and SKA1_Mid, when commanded to do imaging, shall construct and make use of frequency dependent image models over sub-bands that jointly span the entire observed bandwidth.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3281 SKA1_Mid, when performing imaging, shall have a spectral gain calibration accuracy of better than 35 dB.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3282 SKA1_Low, when performing imaging, shall have a spectral gain calibration accuracy of better than 35 dB.	**SCI_REQ-01** SKA1_Low scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2325 The SKA1_Mid and SKA1_Low shall, when commanded, provide image reconstruction methods that recover all relevant angular scales to 5% TBC fidelity.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2328 The SKA1_Low and SKA1_Mid, when commanded, shall solve for and correct pointing errors as a function of both time and dish/station, with accuracy and timescale limited by signal to noise ratio.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2330 SKA1_Low and SKA1_Mid shall achieve thermal noise limited imaging performance in integrations in excess of 1000 hours.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3283 SKA1_Mid, when performing imaging, shall peel the brightest 1.0 dex of discrete extra galactic sources above the horizon at 350 MHz, declining linearly in log(frequency) to 0 dex (i.e., no sources being peeled) at 1 GHz.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3284 SKA1_Low, when performing imaging, shall peel the brightest 2.5 dex of discrete extra galactic sources above the horizon at 50 MHz, declining to 0.5 dex at 350 MHz.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2321 Self-calibration and image reconstruction algorithms for the SKA1_Low and SKA1_Mid shall be capable of dealing with direction dependent effects within each sub-band.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2724 The SKA1_Low shall have a direction dependent model for the aperture array primary beam with an accuracy of 35dB at the half-power points to be used in calibration and imaging.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-2727 The SKA1_Mid shall have a direction dependent model for the dish primary beam with an accuracy of 35dB at the half-power point to be used in calibration and imaging.	**SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2725 The SKA1_Low and SKA1_Mid shall have a direction dependent Faraday Rotation model for ionospheric contributions for use in calibration and imaging, in support of the polarisation dynamic range performance.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3285 SKA1_Mid, when performing direction dependent calibration, shall include the brightest 4 dex of the source population occurring within the main beam and the brightest 2 dex within the near-in side-lobes.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3286 SKA1_Low, when performing direction dependent calibration, shall include the brightest 4 dex of the source population occurring within the main beam and the brightest 3 dex within the near-in side-lobes.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2333 SKA1_Low and SKA1_Mid, when commanded, shall conduct source finding on images generated by Continuum Imaging.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2334 The SKA1_Low and SKA1_Mid, when commanded, shall conduct spectral line source finding on image cube generated by Spectral Line processing.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2335 The SKA1_Low and SKA1_Mid, when commanded, shall add signals at user-supplied celestial coordinates to allow a statistical signal detection.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2336 All pipelines of the SKA1_Low and SKA1_Mid shall include as ancillary products a log detailing the processing configuration, and a logged quality assessment of the resultant Science Data Products.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2338 The SKA1_Low and SKA1_Mid shall have a Calibration pipeline that derives current telescope parameters using a recent observation and a Global Sky Model (GSM), either from a known GSM or the most recent GSM.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2339 The SKA1_Low and SKA1_Mid shall have a Continuum Imaging pipeline that constructs noise-limited wide-band images for observations up to 1000h integration time with polarisation available if requested or necessary for calibration or quality assurance. The integration may be carried out via multiple, widely-separated Scheduling Blocks.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-45** SKA1_Low survey depth **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-46** SKA1_Mid survey depth
SKA1-SYS_REQ-2340 The SKA1_Mid and SKA1_Low shall provide continuum data products which represent the Spectral Energy Distribution of all detected sources with a complexity commensurate with their signal to noise.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2341 The SKA1_Low shall have a Spectral Line Emission pipeline that is degraded by less than 20% with respect to the theoretical thermal noise in integrations up to 1000 hours in channel cubes of spectral line emission, either with continuum emission remaining or with continuum emission removed.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-45** SKA1_Low survey depth **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-46** SKA1_Mid survey depth
SKA1-SYS_REQ-3327 The SKA1_Mid shall have a Spectral Line Emission pipeline that is degraded by less than 20% with respect to the theoretical thermal noise in integrations up to 1000 hours in channel cubes of spectral line emission, either with continuum emission remaining or with continuum emission removed.	**SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2342 The data products of the SKA1_Low and SKA1_Mid shall include spectral line cube image, continuum model images, sensitivity image, and representative point spread function.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2343 The SKA1_Low and SKA1_Mid shall have a Spectral Line Absorption pipeline that is optimised for constructing noise-limited channel cubes of spectral line absorption with continuum sources removed.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2344 The data products shall include spectral line cube image, continuum model images, sensitivity image, and representative point spread function.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2345 The SKA1_Low and SKA1_Mid shall have a Slow Transient imaging pipeline that shall be capable of constructing a continuum image that has an estimate of the non-variable sky emission subtracted for every correlator integration time or slower, searching for transient sources, and producing a time-ordered catalogue of transient source candidates.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3601 SKA1_Mid and SKA1_Low, when commanded, shall be able to search for transients with timescales of 1s, 2s, 4s, 8s, 16s, 32s, 64s, 128s, 256s, 512s, 1024s, 2048s, and 4096s in the fast-imaging products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3602 SKA1_Mid and SKA1_Low, when commanded, shall be able to search for transients, with PI-defined timescales within the range from the correlator dump time up to half the duration of the observation, in calibrated imaging products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2346 The SKA1_Low and SKA1_Mid, when commanded, shall compile a catalogue of found sources, and produce a sensitivity image or other suitable statistical representation, and representative PSF image for slow transient data products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3603 SKA1_Mid and SKA1_Low, when commanded to search for transients, and upon detection of a transient in the real time imaging, shall: a) persist temporal and spatial information on the transient so that an exhaustive search in previous data could be performed; b) generate a light curve of the transient from data in the same observation; c) inform TM of the detection with enough data to populate a VOEvent. The actions are not mutually exclusive, and which one is selected depends on telescope configuration.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3604 The SKA1_Low shall have an ionospheric monitoring pipeline which determines the current conditions and their suitability for continued observations.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2347 All pipelines shall perform standardised, automated Quality Assessment of Image data products along the axes of astrometry, photometry, radiometry, polarimetry, and spectrometry.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2742 Performance assessment within the SKA1_Mid and SKA1_Low shall be based on a number of quantitative metrics computed from an observed Image and, optionally, a template Image.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2743 SKA1_Low and SKA1_Mid performance goals shall be based on a number of quantitative metrics computed from an observed Image and, optionally, a template Image.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2744 SKA1_Low and SKA1_Mid quality assessment shall be based on the comparison of a Performance Assessment and a Performance Goal.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2745 The SKA1_Low and SKA1_Mid Astrometric Performance Metric (APM) shall measure deviation (RMS, average offset, and median) of source positions from known standards.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3058 SKA1_Mid and SKA1_Low, when commanded, shall store astrometric performance metric data in association with the Science Data Products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3063 SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of Astrometry performance metrics.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2746 The SKA1_Low and SKA1_Mid photometric performance metric (PPM) shall measure deviation (RMS, average offset, and median) of source fluxes from known standards in the Global Sky Model.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3057 SKA1_Mid and SKA1_Low, when commanded, shall store photometric performance metric data in association with the Science Data Products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3062 SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of photometric performance metrics.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2747 The SKA1_Low and SKA1_Mid radiometric (detected power) performance metric (RPM) shall measure noise fluctuations (RMS, average offset, and median) in an Image.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3056 The SKA1_Mid and SKA1_Low, when commanded, shall store radiometric performance metric data in association with the Science Data Products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3061 SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of radiometric performance metrics.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2748 The SKA1_Low SKA1_Mid polarimetric performance metric (OPM) shall measure deviation (RMS, average offset, and median) of source polarisation (polarisation degree and angle) from known standards in the Global Sky Model.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3055 SKA1_Mid and SKA1_Low, when commanded, shall store polarimetric performance metric data in association with the Science Data Products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3060 SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of polarimetric performance metrics.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2749 The SKA1_Low and SKA1_Mid spectrometric performance metric (SPM) shall measure deviation (RMS, average offset, and median) of source spectral lines from known standards.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3054 SKA1_Mid and SKA1_Low, when commanded, shall store spectrometric performance metric data in association with the main data products.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3059 SKA1_Low and SKA1_Mid, when commanded, shall provide visual indication of spectrometric performance metrics.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3175 SKA1_Mid and SKA1_Low shall log Quality Assessment reports. These should be traceable to the originating Scheduling Blocks.	
SKA1-SYS_REQ-2821 The SKA1_Low and SKA1_Mid telescopes shall preserve Science Data Products for the lifetime of the Observatory.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2348 The Science Processing Centre will convert the output data from the CSP into Science Data Products to be preserved long term.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2350 SKA1_Low and SKA1_Mid telescopes shall have at least one secondary copy of all Science Data Products located in a secure offsite location.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2352 The Science Data Products being long-term preserved by the SKA1_Low and SKA1_Mid telescopes shall be accessible via standard-based web interfaces. The interfaces to SKA1_Low and SKA1_Mid shall only allow access to authorised SKA staff TBC.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2353 The Science Data Products being long-term preserved by the SKA1_Low and SKA1_Mid telescopes shall be accessible via a set of International Virtual Observatory Alliance (IVOA) services and data models. The set includes SIA, TAP, SSA, DataLink and SODA services and the ObsCore data model. Access to SKA1_Low and SKA1_Mid Science Data Products shall only be possible for SKA staff users.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-2357 The SKA1_Low and SKA1_Mid telescopes shall each facilitate the addition of Quality Assessment annotations to Science Data Products by SKA staff users.	
SKA1-SYS_REQ-2366 The SKA1_Mid and SKA1_Low telescopes, when commanded, shall deliver Science Data Products, including all metadata for A&A policies to be implemented, to approved off-site facilities, which may be globally distributed.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3408 The Science Data Products of the SKA1_Low and SKA1_Mid telescopes shall be browsable and discoverable, including the location of accessible instances of Science Data Products in the SKA1_Low and SKA1_Mid, but also in the approved off-site facilities.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3605 The SDP shall be able to provide calibrated visibility data and corresponding metadata to an external user group following the calibration and data compression steps outlined in the "Interface between SDP and the EoR/CD Science Team Requirements" SDP memo by CathrynTrott et al.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2739 The Science Data Products being long-term preserved by the SKA1_Low and SKA1_Mid telescopes, shall only be accessible to authorised users according to the Science Data Access policy (TBW). Authorisation will be done via SKA Authentication and Authorisation.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3033 The SKA1_Low, when commanded, shall deliver the applied calibration correction algorithms and parameters up to a time resolution of the data cadence.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3042 The SKA1_Low shall apply calibration correction parameters in a manner that they can be reconstructed.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-3043 The SKA1_Low shall store necessary information for TBD duration such that calibration correction parameters can be reconstructed.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-3045 The SKA1_Mid shall store necessary information for TBD duration such that calibration correction parameters can be reconstructed.	**SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3044 The SKA1_Mid shall apply calibration correction parameters in a manner that they can be reconstructed.	**SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3034 The SKA1_Mid, when commanded, shall deliver the applied calibration correction algorithms and parameters up to a time resolution of the data cadence.	**SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2268 The SKA1_Mid Reference Frequency shall provide a 2% maximum coherence loss within a maximum integration period of 1 second and up to an operating frequency of 13.8 GHz.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3242 The SKA1_Low Reference Frequency shall provide a 2% maximum coherence loss within a maximum integration period of 1 second and up to an operating frequency of 350 MHz.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2692 The SKA1_Mid frequency reference shall provide a 2% maximum coherence loss for intervals of 1 minute and up to an operating frequency of 13.8 GHz.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-3243 The SKA1_Low Reference Frequency shall provide a 2% maximum coherence loss for interval of 1 minute and up to an operating frequency of 350 MHz.	**SCI_REQ-01** SKA1_Low scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2693 The SKA1_Mid Reference Frequency shall have a phase drift of less than 1 radian, over intervals of up to 10 minutes and up to an operating frequency of 13.8 GHz.	**SCI_REQ-14** SKA1_Low frequency accuracy **SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-15** SKA1_Mid frequency accuracy **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3244 The SKA1_Low Reference Frequency shall have a phase drift of less than 1 radian, over intervals of up to 10 minutes and up to an operating frequency of 350 MHz.	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2269 The SKA1_Mid shall have a 1PPS heartbeat signal with the pulse-to-pulse scatter being less than the inverse of the Nyquist frequency of the largest sampled bandwidth.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3617 The SKA1_Low shall have a 1PPS heartbeat signal with the pulse-to-pulse scatter being less than the inverse of the Nyquist frequency of the largest sampled bandwidth.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3094 The SKA1_Mid shall provide a 1PPS heartbeat signal for synchronisation and array phase up.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3618 The SKA1_Low shall provide a 1 pps heartbeat signal for synchronisation and array phase up.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-01** SKA1_Low scientific performance

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2274 The SKA1_Mid timescales shall be traceable to UTC with an uncertainty of no more than 5 ns (1-sigma).	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-16** SKA1_Low timing accuracy **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-17** SKA1_Mid timing accuracy
SKA1-SYS_REQ-3616 The SKA1_Low timescales shall be traceable to UTC with an uncertainty of no more than 9 ns (1-sigma).	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-3280 In order to avoid large offsets, the SKA1_Low Central Reference Frequency shall be steered to UTC to within at least 1 microsecond, with a frequency drift of less than 10 ns/day (1-sigma).	**SCI_REQ-01** SKA1_Low scientific performance
SKA1-SYS_REQ-2275 In order to avoid large offsets, the SKA1_Mid Central Reference Frequency shall be steered to UTC to within at least 1 microsecond, with a frequency drift of less than 10 ns/day (1 sigma).	**SCI_REQ-14** SKA1_Low frequency accuracy **SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-16** SKA1_Low timing accuracy **SCI_REQ-15** SKA1_Mid frequency accuracy **SCI_REQ-02** SKA1_Mid scientific performance **SCI_REQ-17** SKA1_Mid timing accuracy
SKA1-SYS_REQ-3095 The SKA1_Mid timescales shall have a frequency stability, expressed as Allan Deviation, of at least:	**SCI_REQ-50** SKA1_Mid non-imaging observation modes

AVERAGING TIME [S]	STABILITY
1	$2.0.10^{-13}$
10	$5.0.10^{-14}$
100	$1.3.10^{-14}$
1000	$3.2.10^{-15}$
floor up to 10^5	$3.0.10^{-15}$

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3592 The SKA1_Low timescales shall have a frequency stability, expressed as Allan Deviation, of at least:	**SCI_REQ-49** SKA1_Low non-imaging observation modes

AVERAGING TIME [S]	STABILITY
1	$2.0.10^{-13}$
10	$5.0.10^{-14}$
100	$1.3.10^{-14}$
1000	$3.2.10^{-15}$
floor up to 10^5	$3.0.10^{-15}$

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3096 The SKA1_Mid shall determine each dish and effective sub-array position in absolute terms (i.e. relative to the centre of the earth, not each other) to an accuracy of better than 1 cm. At each of these geographical reference positions the time will be traceable to the SKA timescale with an accuracy as specified by the Time stamping requirement.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3593 The SKA1_Low shall determine each effective sub-array position in absolute terms (i.e. relative to the centre of the earth, not each other) to an accuracy of better than 1 cm. At each of these geographical reference positions the time will be traceable to the SKA timescale with an accuracy as specified by the Time stamping requirement.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-47** SKA1_Low pointing modes
SKA1-SYS_REQ-3261 The SKA1_Mid shall, when commanded, provide in-band and cross-band instrument phase calibration using celestial phase reference sources.	**SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3556 A centralised 'Stratum 1' network time server system shall be provided that is synchronised to the telescope UTC standard, and provide a telescope network time reference for all connected instrumentation.	
SKA1-SYS_REQ-3557 All client devices and applications that require synchronise telescope network time shall comply with the Network Time Protocol version 4 standard, RFC 5905.	
SKA1-SYS_REQ-3558 A synchronous network time service shall be transparently distributed to all LMC/NSDN interface locations and be available to all subscribed end-element devices and applications.	
SKA1-SYS_REQ-3383 The central reference generator shall send to each dish when commanded a unique reference signal avoiding common frequencies at the dishes, settable independently and uniquely for each dish at observation time.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes **SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3385 It shall be possible to set the sample-clock frequency for each receptor for each band to the nominal sample rate plus or minus N times a frequency offset, where N is an integer, from zero up to half the number of dishes.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes **SCI_REQ-48** SKA1_Mid pointing modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3386 There shall be an identical integer number of samples between the time-stamped 1 second marks from each dish.	**SCI_REQ-50** SKA1_Mid non-imaging observation modes **SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3387 The frequency offset shall be such that there is at least 10 KHz of frequency difference to prevent unwanted cross-correlator output.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-3388 The maximum of the frequency offset shall be 1% (TBC) of the science bandwidth.	**SCI_REQ-48** SKA1_Mid pointing modes
SKA1-SYS_REQ-2370 Weather monitoring stations (2 in each core and 2 outside the core) shall be provided as part of the infrastructure of SKA1_Mid and SKA1_Low - wind, temperature and humidity.	
SKA1-SYS_REQ-2371 24 hour (day and night time) capability shall be provided for telescope operator(s) to visually monitor security access points [TBD] to the SKA1_Low and SKA1_Mid sites and also selected [TBD] other locations.	
SKA1-SYS_REQ-2730 The SKA1_Mid and SKA1_Low sites shall be monitored for RFI in accordance with RFI standards document [AD2].	
SKA1-SYS_REQ-2372 Existing Tropospheric monitoring stations shall be expanded as part of the SKA1_Low and SKA1_Mid infrastructure to provide at least 3 sensor units per telescope array site.	
SKA1-SYS_REQ-3053 The following infrastructure shall be provided at each of the sites. To accommodate 3 stations, design the same as described in the attached documents, equilateral triangle of 500m sides, sited (convenient to other infrastructure) near the core, no preferred azimuth: • Concrete pads of low precision, each provided with 500W of single phase power at a voltage convenient to a core location, and dedicated fibre networking from the signal processing building and to each other • I rack in the central building, 1kW power and cooling.	
SKA1-SYS_REQ-2373 The power delivery infrastructure for SKA1_Low shall comply with the SKA1 RFI levels documentation.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency
SKA1-SYS_REQ-3084 SKA1_Low and SKA1_Mid shall have a low power mode that reduces power consumption to less than 5% of their nominal capacity.	
SKA1-SYS_REQ-3085 The power delivery infrastructure for SKA1_Mid shall comply with the SKA1 RFI levels documentation.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3086 On start-up, the SKA1_Mid and SKA1_Low shall enter low power mode until commanded otherwise.	
SKA1-SYS_REQ-3087 All critical systems within the SKA1_Low and SKA1_Mid shall be provided with uninterrupted power for a minimum period of at least 5 minutes following a power failure.	
SKA1-SYS_REQ-3088 The SKA1_Mid and SKA1_Low shall ensure that power consumption remains below available power supply capacity at all times.	
SKA1-SYS_REQ-3090 The SKA1_Low and SKA1_Mid shall survive a main power interruption, at an arbitrary time.	
SKA1-SYS_REQ-2374 Roads and track-ways (including drainage) for the safe, secure and economic construction and operation of the SKA1_Low and SKA1_Mid shall be provided.	
SKA1-SYS_REQ-2375 There shall be access to an emergency air strip on each of the SKA1_Low and SKA1_Mid sites within 10 km road distance of the respective CPF.	
SKA1-SYS_REQ-2376 Potable and non-potable water shall be available at SKA1_Low and SKA1_Mid construction camps. This will include foundation concrete plants, if present.	
SKA1-SYS_REQ-2377 Sufficient water shall be continually available at SKA1_Low and SKA1_Mid facilities in support of equipment cooling for each telescope.	
SKA1-SYS_REQ-2378 The delivery and disposal of water and all construction activity shall be compliant with local and national standards and regulations.	
SKA1-SYS_REQ-2382 The Central Processing Facility for both SKA1_Low and SKA1_Mid shall provide RFI shielding greater than that derived from zoning specifications given in the SKA RFI levels documentation [AD2].	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2383 The Central Processing Facility for each of the SKA1_Low and SKA1_Mid shall provide penetrations for signal and power cables entering the facility and also for all other penetrations compliant with SKA-TEL-SKO-0000202-AG-RFI-ST-01-SKA EMI & EMC Standards and Procedures [AD2].	
SKA1-SYS_REQ-2397 Each dish within SKA1_Mid shall have an earthing system that conforms to the requirements of IEC 62305 for the purpose of lightning protection. National standards shall take precedence.	
SKA1-SYS_REQ-2398 All populated facilities shall provide connectivity to the public telephone network.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2402 The total steady state power budget for the African site shall be within the limits specified in SKA Power Budget [R8].	
SKA1-SYS_REQ-2404 The total steady state power budget for the Australian site shall be within the limits specified in SKA Power Budget [R8].	
SKA1-SYS_REQ-3138 SKA1_Mid VLBI data shall conform to the SKA-VLBI ICD (to be written).	
SKA1-SYS_REQ-3610 SKA1_Low VLBI data shall conform to the SKA-VLBI ICD (to be written).	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2838 The SKA1_Mid telescope shall be a data source for VLBI data acquisition system. The interface between the SKA1_Mid telescope and the external VLBI data acquisition system will be compliant with the ICD SKA-TEL-SKO-0000116.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3594 The SKA1_Low telescope shall be a data source for VLBI data acquisition system. The interface between the SKA1_Low telescope and the external VLBI data acquisition system will be compliant with the ICD SKA-TEL-SKO-0000116.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2841 The following infrastructure shall be provided to allow eventual outfitting of SKA1_Mid with VLBI equipment: 1. Adequate access for the potential fitment of VLBI equipment 2. Equipment space 3. Power 4. Cooling 5. Cable trays.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3597 The following infrastructure shall be provided to allow eventual outfitting of SKA1_Low with VLBI equipment: 1. Adequate access for the potential fitment of VLBI equipment 2. Equipment space 3. Power 4. Cooling 5. Cable trays.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2843 SKA1_Mid shall be able to output VLBI beam data with each individual stream limited to 512 MHz of signal bandwidth to ensure compatibility with existing VLBI terminal capability.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3611 SKA1_Low shall be able to output VLBI beam data with each individual stream limited to the entire SKA1_Low band to ensure compatibility with existing VLBI terminal capability.	**SCI_REQ-49** SKA1_Low non-imaging observation modes

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2845 SKA1_Mid shall be able to produce VLBI beam output data with either dual or single polarization.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3599 SKA1_Low shall be able to produce VLBI beam output data with either dual or single polarization.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2846 SKA1_Mid shall be able to output VLBI beam data with configurable word formats, the allowed values being 2, 4, 8, and 16-bit integer.	**SCI_REQ-49** SKA1_Low non-imaging observation modes **SCI_REQ-50** SKA1_Mid non-imaging observation modes
SKA1-SYS_REQ-3600 SKA1_Low shall be able to output VLBI beam data with configurable word formats, the allowed values being 2, 4, and 8-bit integer TBC.	**SCI_REQ-49** SKA1_Low non-imaging observation modes
SKA1-SYS_REQ-2420 The SKA1_Low interface between LFAA and CSP shall be compliant with the 100-000000-004 Interface Control Document.	
SKA1-SYS_REQ-2421 The SKA1_Low interface between LFAA and INFRA shall be compliant with the 100-000000-003 Interface Control Document.	
SKA1-SYS_REQ-3262 The SKA1_Low interface between CSP and Infra shall be compliant with the 100-000000-020 Interface Control Document.	
SKA1-SYS_REQ-3263 The SKA1_Low interface between CSP and SDP shall be compliant with the 100-000000-002 Interface Control Document.	
SKA1-SYS_REQ-2423 The SKA1_Low interface between SADT and LFAA shall be compliant with the 100-000000-026 Interface Control Document.	
SKA1-SYS_REQ-3266 The SKA1_Low interface between SADT and CSP shall be compliant with the 100-000000-023 Interface Control Document.	
SKA1-SYS_REQ-3267 The SKA1_Low interface between SADT and SDP shall be compliant with the 100-000000-025 Interface Control Document.	
SKA1-SYS_REQ-3268 The SKA1_Low interface between SADT and Infra shall be compliant with the 100-000000-024 Interface Control Document.	
SKA1-SYS_REQ-2428 The SKA1_Low interface between TM and LFAA shall be compliant with the 100-000000-028 Interface Control Document.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-3271 The SKA1_Low interface between TM and SADT shall be compliant with the 100-000000-027 Interface Control Document.	
SKA1-SYS_REQ-3272 The SKA1_Low interface between CSP and TM shall be compliant with the 100-000000-021 Interface Control Document.	
SKA1-SYS_REQ-3273 The SKA1_Low interface between TM and INFRA shall be compliant with the 100-000000-022 Interface Control Document.	
SKA1-SYS_REQ-3274 The SKA1_Low interface between SDP and TM shall be compliant with the 100-000000-029 Interface Control Document.	
SKA1-SYS_REQ-3275 The SKA1_Low interface between SDP and Infra shall be compliant with the SKA-TEL-SKO-0000484 Interface Control Document.	
SKA1-SYS_REQ-2410 The SKA1_Mid interface between AIV MeerKAT and CSP shall be compliant with SKA-TEL-AIV-2310001 interface specification.	**SCI_REQ-38** SKA1_Mid relative collecting area
SKA1-SYS_REQ-2412 The SKA1_Mid interface between AIV MeerKAT and SADT shall be compliant with SKA-TEL--AIV-2310003 Interface Control Document.	**SCI_REQ-38** SKA1_Mid relative collecting area
SKA1-SYS_REQ-2414 The SKA1_MId control and monitoring interface between AIV MeerKAT and TM shall be compliant with SKA-TEL-AIV-2310004 Interface Control Document.	**SCI_REQ-38** SKA1_Mid relative collecting area
SKA1-SYS_REQ-2775 The SKA1_Mid interface between AIV MeerKAT and INFRA shall be compliant with SKA-TEL-AIV-2310002 Interface Control Document.	**SCI_REQ-38** SKA1_Mid relative collecting area
SKA1-SYS_REQ-2416 The SKA1_Mid interface between CSP and Infra shall be compliant with the 300-000000-020 Interface Control Document.	
SKA1-SYS_REQ-2738 The SKA1_Mid interface between CSP and SDP shall be compliant with the 300-000000-002 Interface Control Document.	
SKA1-SYS_REQ-2418 The SKA1_Mid interface between CSP and Dish shall be compliant with the SKA-TEL-SKO-0000124 Interface Control Document.	
SKA1-SYS_REQ-2419 The SKA1_Mid interface between Dish and Infra shall be compliant with the SKA-TEL-SKO-00000115 Interface Control Document.	
SKA1-SYS_REQ-2422 The SKA1_Mid interface between SADT and DSH shall be compliant with the 300-000000-026 Interface Control Document.	
SKA1-SYS_REQ-2424 The SKA1_Mid interface between SADT and CSP shall be compliant with the 300-000000-023 Interface Control Document.	

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2425 The SKA1_Mid interface between SADT and SDP shall be compliant with the 300-000000-025 Interface Control Document.	
SKA1-SYS_REQ-2426 The SKA1_Mid interface between SADT and Infra shall be compliant with the 300-000000-024 Interface Control Document.	
SKA1-SYS_REQ-2427 The SKA1_Mid interface between TM and Dish shall be compliant with the SKA-TEL-SKO-0000150 Interface Control Document.	
SKA1-SYS_REQ-2429 The SKA1_Mid interface between TM and SADT shall be compliant with the 300-000000-027 Interface Control Document.	
SKA1-SYS_REQ-2430 The SKA1_Mid interface between CSP and TM shall be compliant with the 300-000000-021 Interface Control Document.	
SKA1-SYS_REQ-2737 The interface between TM and INFRA shall be compliant with the 300-000000-022 Interface Control Document.	
SKA1-SYS_REQ-2431 The SKA1_Mid interface between SDP and TM shall be compliant with the 300-000000-029 Interface Control Document.	
SKA1-SYS_REQ-2432 The SKA1_Mid interface between SDP and INFRA shall be compliant with the SKA-TEL-SKO-0000484 Interface Control Document.	
SKA1-SYS_REQ-2462 Emissions of electromagnetic radiation from components of the SKA1_Mid and SKA1_Low, in any of the stated frequency intervals for broad band and narrow band cases, shall be within the SKA RFI/EMI Threshold Levels [AD2].	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2463 The SKA1_Low and SKA1_Mid shall generate less self-induced RFI, within the Telescope's operating frequency bands, than the SKA RFI/EMI Protection Levels, for both broad band and narrow band cases, as specified in the "RFI/EMI Protection and Threshold Levels for the SKA" document. The SKA RFI/EMI Protection Levels are defined at the respective receiver input, and measured at the respective Telescope time series output.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2464 The SKA1 Telescopes shall be compliant with one or more of the following standards for emissions and one or more for susceptibility/immunity: *IEC EN 61000-6-2. Electromagnetic compatibility (EMC). Generic standards. Immunity standard for industrial environments. • IEC EN 61000-6-4 AMD2. Electromagnetic compatibility (EMC). Part 6-4. Generic standards. Emission standard for industrial environments. • IEC CISPR 14-1. Electromagnetic compatibility. Requirements for household appliances, electric tools and similar apparatus. Part 1. Emission. • MIL-STD-464C.	
SKA1-SYS_REQ-2465 The SKA1_Low and SKA1_Mid shall follow the code of practice for the application of Electromagnetic Compatibility (EMC) standards and guidelines in electricity utility networks [AD2].	
SKA1-SYS_REQ-2466 All "off-the-shelf" equipment shall possess as a minimum the host country EMC marking.	
SKA1-SYS_REQ-2467 The SKA1_Low and SKA1_Mid shall not be susceptible to terrestrial electromagnetic radiation at any frequency that significantly interferes with its normal operation.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2472 The SKA1_Low and SKA1_Mid shall automatically flag frequency data with a resolution of one channel and time data to the resolution of the integration unit if the data is corrupted by RFI.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2473 The SKA1 Telescopes, when commanded, shall automatically excise data that is corrupted by RFI. Corrupted data is either flagged (i.e., not used in the data products) or subtracted (i.e., the corruption is removed, allowing the residual to be used in the data products).	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency
SKA1-SYS_REQ-2474 The SKA1_Low and SKA1_Mid shall flag data according to a pre-selected RFI Mask.	**SCI_REQ-35** SKA1_Low array sensitivity as a function of frequency **SCI_REQ-36** SKA1_Mid sensitivity as a function of frequency

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-2484
The SKA1_Mid shall be compliant with all local, State and national environmental protection legislation and regulations.
NOTE: Legislation takes precedence over project/contract documentation and requirements. Omission of a law from this requirement does not affect its enforceability. Legislation is also subject to amendment and so the Environmental Laws identified during the Request for Information (copied below) may be modified by the Hosting Agreements and subsequent Acts and Amendments.

SKA1-SYS_REQ-3257
The SKA1_Low shall be compliant with all local, State and national environmental protection legislation and regulations.
NOTE: Legislation takes precedence over project/contract documentation and requirements. Omission of a law from this requirement does not affect its enforceability. Legislation is also subject to amendment and so the Environmental Laws identified during the Request for Information (copied below) may be modified by the Hosting Agreements and subsequent Acts and Amendments.

SKA1-SYS_REQ-2820
Equipment shall comply with the safety requirements of BS EN IEC 60950. NOTE: This includes electric shock, energy related hazards, fire, heat related hazards, mechanical hazards, radiation and chemical hazards.

SKA1-SYS_REQ-2437
The System, while in any mode, shall present no hazard to either the system equipment or to operators or maintainers of the system equipment with categorization exceeding the levels defined in the SKA Project Safety Management Plan [AD6].

SKA1-SYS_REQ-2579
All items that present a potential hazard shall be labelled in accordance with BS EN ISO 7010.

SKA1-SYS_REQ-2818
In accordance with ISO 61310_2, machinery shall bear all markings which are necessary

- for its unambiguous identification;
- for its safe use;

and supplementary information shall be given, as appropriate:

- permanently on the machinery;
- in accompanying documents such as instruction handbooks;
- on the packaging.

SKA1-SYS_REQ-2438
Components and Equipment shall be designed to be locally fail-safe and not rely on external safety devices or measures to operate safely.

SKA1-SYS_REQ-2788
SKA1_Low and SKA1_Mid hardware failures and software errors shall not create a hazardous situation to interfacing systems.

SKA1-SYS_REQ-2439
The SKA1 Elements shall have emergency stop switches or brakes for all electro-mechanical or mechanical systems that may pose a hazard to operators or maintainers of the system.

SKA1-SYS_REQ-2733
Emergency stop switches shall be located in such a way to minimize the risk of injury. (Verified by Analysis as 'minimisation' is unverifiable any other way.)

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-2446
Electrical risks and hazards shall be controlled in accordance with local, State and national legislation and Codes of Practice.
NOTE: In South Africa, SANS 10142-1 and SANS 10142-2 shall apply.
NOTE: In Australia, in addition to legislation, the following Codes of Practice shall be applied:
AS/NZ 3000
Safe Work Australia 'Managing Electrical Risks at the Workplace';
Western Australia Director of Energy Safety 'Safe Low Voltage Work Practices by Electricians'.

SKA1-SYS_REQ-2444
External conductive parts shall be grounded in compliance to:
South Africa:

- National Building Regulations and Building Standards Act, 1977
- Occupational Health and Safety act, 1993
- SANS 10313

Australia:

- AS/NZ 3000,
- AS/NZ 1768.

SKA1-SYS_REQ-2445
Electrical circuit inter-locks shall be provided to prevent personnel coming into contact with hazards that cannot otherwise be eliminated from design.

SKA1-SYS_REQ-2481
The SKA1_Low and SKA1_Mid shall provide an independent system to communicate with outside locations in emergencies.

SKA1-SYS_REQ-2453
First aid stations shall be provisioned.

SKA1-SYS_REQ-2460
The SKA1_Mid shall comply with all applicable local, State and national occupational health regulations and standards in force at the time.

SKA1-SYS_REQ-3258
The SKA1_Low shall comply with all applicable local, State and national occupational health regulations and standards in force at the time.

SKA1-SYS_REQ-2457
Personnel shall be provided with a working illumination level which is compliant with local and national regulations including the current issue of SANS 10114-1 in South Africa and the AS/NZS 1680 series in Australia.

SKA1-SYS_REQ-2458
Personnel of the SKA1_Mid shall be provided with air quality at least compliant with the current issue of SANS 10400-O (South Africa - The application of National Building Regulations Part O : Lighting and ventilation).

SKA1-SYS_REQ-3259
Personnel of the SKA1_Low shall be provided with air quality at least compliant with the current issue of AS 1668 series of codes (Australia - The use of mechanical ventilation and air conditioning in buildings).

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-2649
SKA1__Mid working environments for personnel shall maintain an air quality that meets or exceeds the guidance provided in the Code of Practice for Managing the Work Environment and Facilities, National Building Code of TBD.

SKA1-SYS_REQ-3260
SKA1_Low working environments for personnel shall maintain air quality that meets or exceeds the guidance provided in the Australian Code of Practice for Managing the Work Environment and Facilities, National Building Code of Australia and AS 1668.

SKA1-SYS_REQ-2791
The SKA shall provide a security management system that includes:

1. personnel security,
2. physical security (asset)
3. security of information.

SKA1-SYS_REQ-2478
The observatory shall provide a secure environment for equipment including protection of generators, fuel, solar cells equipment spare stores, and inter-station assets such as copper cables.

SKA1-SYS_REQ-2482
SKA1_Low, SKA1_Mid and SKA1_Common shall control on a per user basis which facilities and resources (both hardware and software) may be accessed by the user (as per EN 50600-2-5 (Data centre facilities and infrastructures. Part 2-5. Security systems.

SKA1-SYS_REQ-2479
The SKA1_Low and SKA1_Mid telescopes shall provide a secure environment for all Science Data Products preserved long term.

SKA1-SYS_REQ-2798
SKA1_Mid Equipment located at non-weather protected locations shall survive during, and perform to specification as defined herein, after exposure to the following environmental conditions as defined in BS EN IEC 60721-3-4:

- Climatic conditions 4K4H with tailoring based on [AD7] Section 4.1
- Heat radiation conditions 4Z1
- Wind Speed conditions 4Z5 with tailoring based on [AD7] Section 4.1]
- Water from other sources than rain 4Z7 with tailoring based on [AD7] Section 4.1
- Biological conditions 4B2
- Chemical conditions 4C1
- Dust and Sand conditions 4S2 (4S3) with tailoring based on [AD7] Section 4.1
- Mechanical conditions 4M1 with tailoring based on [AD7] Section 4.1.

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-3070
SKA1_Low Equipment located at non-weather protected locations shall survive during, and perform to specification as defined herein, after exposure to the following environmental conditions as defined in BS EN IEC 60721-3-4:

- Climatic conditions 4K4H with tailoring based on [AD7] Section 4.1
- Heat radiation conditions 4Z1
- Wind Speed conditions 4Z5 with tailoring based on [AD7] Section 4.1]
- Water from other sources than rain 4Z7 with tailoring based on [AD7] Section 4.1
- Biological conditions 4B2
- Chemical conditions 4C1
- Dust and Sand conditions 4S2 (4S3) with tailoring based on [AD7] Section 4.1
- Mechanical conditions 4M1 with tailoring based on [AD7] Section 4.1.

SKA1-SYS_REQ-3278
SKA1_Mid Equipment located at non-weather protected locations shall perform to specification, except for those requirements where it is indicated otherwise herein, during exposure to the survival environmental conditions as defined in requirement SKA1-SYS_REQ-2798.
Note: The exceptions here are some of the Dish Element performance requirements. These requirements will refer in their text to the sub-set of environmental conditions applicable to the specified level of performance.

SKA1-SYS_REQ-3069
SKA1_Low equipment located at the aperture arrays or outside the central processing and operating facilities shall be able to operate within specification if the outside air temperature is within the range of -5 ºC to +50 ºC.
Note this takes precedence over IEC60721-3-4 4K4H.

SKA1-SYS_REQ-2501
All components and spares of the SKA1_Low, in their transport packaging, shall not be damaged while, and shall perform to specification as defined herein, after being transported under conditions as defined in “Class 2.2: careful transportation” of the ETSI EN 300 019-1-2 standard [SR13] and defined in BS EN IEC 60721-3-2:

- Climatic conditions 2K5H with tailoring based on [AD7] Section 6.1
- Biological conditions 2B3 changed based on [AD7] Section 6.2
- Chemical conditions 2C1 changed based on [AD7] Section 6.3
- Dust and Sand conditions 2S3 changed based on [AD7] Section 6.4
- Shock & Vibration conditions 2M3 changed based on [AD7] Section 6.5.

SKA1-SYS_REQ-3298
All components and spares of the SKA1_Mid, in their transport packaging, shall not be damaged while, and shall perform to specification as defined herein, after being transported under conditions as defined in “Class 2.2: careful transportation” of the ETSI EN 300 019-1-2 standard [SR13] and defined in BS EN IEC 60721-3-2:.

- Climatic conditions 2K5H with tailoring based on [AD7] Section 6.1
- Biological conditions 2B3 changed based on [AD7] Section 6.2
- Chemical conditions 2C1 changed based on [AD7] Section 6.3
- Dust and Sand conditions 2S3 changed based on [AD7] Section 6.4
- Shock & Vibration conditions 2M3 changed based on [AD7] Section 6.5.

L1 System Requirement	L0 Science Requirement(s)
SKA1-SYS_REQ-2801 SKA1_Mid equipment, while in its storage packaging, shall withstand, and shall operate to specification as defined herein after exposure to, the storage environmental conditions as defined in “Class 1.1: Weather protected, partly temperature-controlled storage locations” of the ETSI EN 300 019-1-1 standard and defined in BS EN IEC 60721-3-1. • Climatic Conditions 1K3 based on [AD7] • Biological Conditions 1B2 based on [AD7] • Chemical conditions 1C2 based on [AD7] • Dust and Sand conditions 1S2 based on [AD7] • Shock & Vibration Conditions 1M2 based on [AD7].	
SKA1-SYS_REQ-3071 SKA1_Low equipment, while in its storage packaging, shall withstand, and shall operate to specification as defined herein after exposure to, the storage environmental conditions as defined in “Class 1.1: Weather protected, partly temperature-controlled storage locations” of the ETSI EN 300 019-1-1 standard and defined in BS EN IEC 60721-3-1. • Climatic Conditions 1K3 based on [AD7] • Biological Conditions 1B2 based on [AD7] • Chemical conditions 1C2 based on [AD7] • Dust and Sand conditions 1S2 based on [AD7] • Shock & Vibration Conditions 1M2 based on [AD7].	
SKA1-SYS_REQ-2491 SKA1 equipment and buildings shall be designed and built in compliance with national and State regulations including AS 1170.4 (Importance level 3, design life 50 years) and SANS 10160-4 for seismic events resulting in a maximum peak ground acceleration of 1 m/s^2.	
SKA1-SYS_REQ-2650 SKA1 structures and equipment shall survive and be fully operational after seismic events resulting in a maximum peak ground acceleration of 1 m/s^2. Note: Seismic events includes underground collapses in addition to earthquakes.	
SKA1-SYS_REQ-2716 The SKA1_Mid and SKA1_Low shall each have an operational availability of at least 95%.	**SCI_REQ-01** SKA1_Low scientific performance **SCI_REQ-02** SKA1_Mid scientific performance
SKA1-SYS_REQ-3245 The SKA1_Mid shall have an Inherent Availability of more than 99%.	
SKA1-SYS_REQ-2525 The SKA1_Mid and SKA1_Low shall not exhibit safety hazards in Categories I or II (ISO 45001) following an unplanned loss of main electrical power or main control functions.	
SKA1-SYS_REQ-3238 SKA1_Mid and SKA1_Low equipment that would otherwise present a safety hazard when subjected to an unplanned loss of main electrical power or main control function, shall enter a designated fail safe state.	

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-3239
Where transitioning to a designated fail safe state represents a hazard, components of the SKA1_Mid and SKA1_Low shall issue continued warnings for the duration of the transition.

SKA1-SYS_REQ-3240
Once transitioning to or in a designated safe state, the SKA1_Mid and SKA1_Low shall remain in the designated safe state (or the transition to it) until commanded otherwise.

SKA1-SYS_REQ-3276
The SKA1_Low shall require less than 1600 Direct Maintenance Hours per month.

SKA1-SYS_REQ-3246
The SKA1_Mid shall require less than 1600 Direct Maintenance Hours per month.

SKA1-SYS_REQ-2595
Repairable items shall be designed to include maintenance provisions such as test points, accessibility, and plug-in components.

SKA1-SYS_REQ-2599
Modules and components shall be mounted such that removal of any single item will not require the removal of other items (component stacking to be avoided where possible).

SKA1-SYS_REQ-2602
Provisions for the preclusion of mounting the wrong module shall be provided (key coding of connectors etc.) where there is the possibility of damage.

SKA1-SYS_REQ-2448
Stand-offs and handles shall be used to protect system components from damage during out-of-system repair and maintenance.

SKA1-SYS_REQ-2603
Mounting guides and location pins shall be provided on SKA1_Mid and SKA1_Low equipment to facilitate maintenance.

SKA1-SYS_REQ-2604
SKA1_Low and SKA1_Mid labelling of modules shall be in a conspicuous location, such that it is readable when the module is removed or installed in its intended operating environment.

SKA1-SYS_REQ-2605
Labels used within the SKA1_Low and SKA1_Mid shall be affixed for at least 50 years or the lifetime of the equipment, whichever is the smaller, and unlikely to come off during maintenance or as a result of the environment.

SKA1-SYS_REQ-2606
Disposable line replaceable units should be labelled as such.

SKA1-SYS_REQ-3247
SKA1_Low and SKA1_Mid equipment shall facilitate updates of major software updates within the system availability allocations.

SKA1-SYS_REQ-3182
SKA-Mid and SKA-Low shall log their operational states at all times.

SKA1-SYS_REQ-3183
SKA1_Mid and SKA1_Low shall provide monitoring to log all alarms, alerts and warnings, with a human readable report presented to authorised personnel.

L1 System Requirement	L0 Science Requirement(s)

SKA1-SYS_REQ-3184
The SKA1_Common shall log new, open and closed faults, with the repair and corrective actions archived for future and continual reference.

SKA1-SYS_REQ-3249
SKA1_Low and SKA1_Mid shall each test (for), detect, isolate and report failures to the operational and maintenance personnel.

a. SKA1_Mid shall detect more than 99% of all Critical Failures.
b. SKA1_Mid shall isolate and log more than 95% of all failures down to a LRU level.

SKA1-SYS_REQ-3192
The SKA1_Common shall provide the capability to remotely identify faults within the SKA1_Mid and SKA1_Low down to LRU level.

SKA1-SYS_REQ-2573
All items identified in the Logistics Analysis and Configuration Item Plan as needing individual characterisation shall be marked with a label displaying a unique Serial Number and Part Number. The label should normally be in an easily visible location but may also include embedded identification for items such as embedded firmware/ software.

SKA1-SYS_REQ-2575
Where items used on SKA1_Mid and SKA1_Low require labelling, the method of marking shall be compliant with the Logistic Analysis Plan. The nature of the item, its environment and its use will determine the method.

SKA1-SYS_REQ-2576
Items used within the SKA1_Low and SKA1_Mid shall be marked with a unique electronically readable or scannable ID, in accordance with the Logistic Analysis Plan and Configuration Plan. The ID may be both serial number and part number or in some cases may not be needed.

SKA1-SYS_REQ-2577
All packaging of items used on the SKA1_Mid and SKA1_Low shall be marked to uniquely identify the contents in accordance with the Logistics Analysis Plan. The identification will be by part number and serial number.

SKA1-SYS_REQ-2580
All LRUs with electrostatic sensitive components shall be fitted with ESD warning labels.

SKA1-SYS_REQ-2583
All ends of cables used within the SKA1_Low and SKA1_Mid shall carry a unique identifier.

SKA1-SYS_REQ-2584
All connector plates used within the SKA1_Low and SKA1_Mid shall carry identification labels for connectors.

23 Appendix: Power Budget Allocation

The Power allocations from the System level are defined in the SKA1 Power Budget SKA-TEL-SKO-0000035 {RD8}

24 Appendix: Availability, Reliability Maintainability Allocations

24.1 SKA1_Low and SKA1_Mid availability allocations

The Availability allocations from the System level are defined in the RAM Allocation document SKA-TEL-SKO-0000102 [R12]

25 Appendix: Changes in this Release

This section provides an overview of the changes between revision 10 and this revision 11 of the System requirements. Detailed changes are provided in the base line comparison export provided as support documentation. However, the contents of this document takes precedence.

This revision includes the following sequence of updates, that where provided in previous revisions:

- **Revision 6:** RBS Board decision (ECP-150001)
- **Revision 6A:** Removal of Process documents from requirements document (ECP-150002)
- **Revision 6B:** Outstanding and well developed ECPs
- **Revision 6C:** Implementation of outstanding comments from Revision 5
- **Revision 7:** System review release
- **Revision 8:** The main changes in this revision is the inclusion of the operation requirements.
- **Revision 9:** SKA1_Mid pointing requirements, other minor updates.
- **Revision 10:** This revision is intended to be revision of the L1 requirements before forming the last requirements baseline for Consortia to work against before CDR. Further revisions will be created beyond revision 10 to incorporate future ECPs.
    - SKA1_Low Configuration constraints have introduced configuration changes to LFAA in support of calibration. This includes the concept of sub-stations which changes the number of correlatable entities within the system within the same correlation processing bandwidth
    - Incorporates new requirements identified by Consortia to close out their assumptions and identified gaps
    - Improves existing requirement wording based on Consortia comments.
    - Resolves the ambiguity of channelization when generating Zoom windows and how this relates to the generation of Continuum
    - Implements mature ECPs at Implementation phase at the time:
        - ECP-160011: A total electron content monitor for SKA1_MID
        - ECP-160012: Allocation of the development of the Global Sky Model to SDP
        - ECP-150015: SKA LOW Configuration Coordinates
        - ECP-160025: Synchronised Telescope Network Time
        - ECP-160037: Near-Field Phase Corrections
        - ECP-160047: Adoption of Fundamental SKA Software Standards
        - ECP-160057: SKA Observatory Systems: PBS re-alignment
        - ECP-160070: Revision to SKA-TEL-SKO-0000202 "SKA EMI/EMC STANDARDS AND PROCEDURES"
    - ECP-150007 “Gridded Visibilities to Enable Precision Cosmology with Radio Weak Lensing” was considered for inclusion. However, it was classified as a “Custom Experiment”. There are ECPs covering Custom Experiments submitted at the time of

release of this document (ECP-160049 through ECP-160056) but these have not reached implementation phase.

    - ECP-160022 “SKA-MID Band 5 split into two bands” was at implementation phase. However the impact at system level has not yet been evaluated in sufficient detail for inclusion.
    - Synchronisation and Timing requirement updates are to be addressed via a separate ECP.

- **Revision 11:** This version merges all the gathered requirement from the document SKA-TEL-SKO-0000692, “Appendix to System Requirements Rev 10” into the main requirement document body and into Jama.
    - Moreover, it implements the following ECPs:
        - ECP-160022: SKA-MID Band 5 split into two bands
        - ECP-170002: Emergency Airstrip at LOW site
        - ECP-170022: Precision Pulsar Timing Requirements on SKA1_Mid
        - ECP-170026: Linear System Response for Direct Solar Observing with SKA1 Low
        - ECP-170017: CSP_Mid.CBF Frequency Slice Approach
        - ECP-170027: Cover ECP to update SKA1 System Requirements to Rev 11
    - The SKA1 System Requirements Glossary has been updated.
    - Appendices B and C have been merged into the body of the document. Each requirement is now in a tabular format with ID, Requirement, Priority, Parent Requirement, Allocation, and Verification in the same row.